**Teacher Notes for**

**Golden Rice – Evaluating the Pros and Cons**[[1]](#footnote-1)

This activity engages students in evaluating the evidence and arguments related to Golden Rice and other possible strategies for preventing vitamin A deficiency. Students use this information to develop evidence-based conclusions about Golden Rice and the prevention of vitamin A deficiency. Students also develop questions that could provide important additional information for evaluating the arguments in favor of and opposed to Golden Rice and related policy proposals. In addition, students analyze how two reasonably accurate articles can present totally opposing points of view on this complex policy issue.

**Learning Goals**

In accord with A Framework for K-12 Science Education[[2]](#footnote-2), students engage in scientific practices (asking questions; engaging in argument from evidence; evaluating and communicating information).

This activity will also help students meet Common Core English Language Arts Standards for Science and Technical Subjects[[3]](#footnote-3), including "determine the central ideas or conclusions of the text; summarize complex concepts, processes or information presented in a text by paraphrasing them in simpler but still accurate terms" and "integrate and evaluate multiple sources of information".

Specific learning goals include:

* Developing skills for evaluating conflicting arguments
* Understanding the kinds of information needed to evaluate a complex policy issue (e.g., What are the pros and cons of the various proposed solutions to a problem?)
* Understanding the complexity of policy decisions, including multiple relevant scientific questions, controversy concerning scientific findings, and multiple non-scientific issues
* Understanding how different authors can arrive at opposite conclusions by emphasizing different aspects of the relevant evidence and arguments

**Suggestions for Implementation and Background Information**

As background for this activity, you may want to provide:

* an introduction to the biology of the genetic engineering used in the development of Golden Rice; for this purpose I recommend "Genetic Engineering Challenge – How can scientists develop a type of rice that could prevent vitamin A deficiency?" (available at <http://serendipstudio.org/exchange/bioactivities/geneticengineer>; this activity includes the important concept that a grain-based diet can provide adequate calories, but inadequate amounts of micronutrients such as vitamins and minerals)
* an introduction to the practice of scientific argumentation, including distinctions between scientific and non-scientific arguments or questions and the importance of identifying key questions and unbiased evidence to answer these questions; an introductory activity ("Let's Get Into an Argument") and an article about points to emphasize in teaching scientific argumentation ("Evaluating Scientific Arguments with Slow Thinking") are both available at <http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/html/ci_tm_1213.html>.

I recommend that you have your students work in pairs to answer questions 1-4 and then have a class discussion of their answers. I recommend that you have your students write the answers to these questions before you have a class discussion; this should motivate students to evaluate both sides of the arguments based on the evidence presented before they get caught up in a potentially emotional discussion that might make it more difficult for them to be objective and balanced. Then, have the students work in pairs to answer questions 5-7 and end with a class discussion of students' answers to these questions.

Please consult the key for answers to questions 1-4, together with supplementary information. The key is available upon request to Ingrid Waldron, iwaldron@sas.upenn.edu. Some additional general points are included below.

One important goal of this activity is to foster students' abilities to formulate meaningful questions that would provide additional information that would help to evaluate the arguments related to Golden Rice and other proposed policy approaches. The questions I have proposed in column 4 of the key are based on rather extensive knowledge and therefore are more sophisticated than the questions that your students are likely to develop. After you have discussed the questions proposed by the students, you may want to use the question in the key to illustrate how increased knowledge and experience can lead to increasingly sophisticated questions that may elicit crucial information for evaluating policy proposals.

The key does not include my own personal conclusions. I encourage you to think about your own conclusions based on the reading and the evidence presented (or in some cases the lack of evidence). You and your students will probably have additional opinions, not based on these readings; it will be important to try to identify any evidence to support these opinions and the reliability of the sources of this evidence.

With regard to the amount of pro-vitamin A in Golden Rice, the initial varieties of Golden Rice which had relatively low levels of pro-vitamin A. Repeated experimentation and improvements have increased the amount of pro-vitamin A in Golden Rice at least 20-fold (a good example of the iterative nature of progress in science generally and genetic engineering specifically).

With respect to the hypothesized harmful health and ecological effects of Golden Rice, it should be noted that these effects are possible, but have not been demonstrated. The challenge is to balance the possibility of harmful effects of Golden Rice versus the possibility of harmful effects of not making Golden Rice available if other approaches are insufficient to alleviate the widespread vitamin A deficiency that frequently results in blindness, severe infectious diseases and mortality. Also, it should be noted that many "natural" foods can have harmful health effects (see e.g. the second paragraph of page 3 of the Student Handout).

I recommend that in your discussion of other approaches for preventing vitamin A deficiency, you include the concept that the various approaches probably should be thought of as complementary approaches rather than alternative approaches. For example, promoting home gardening of diverse sources of nutrition may be feasible for rural families with enough land to grow plant or animal foods rich in vitamin A, whereas distribution of supplements is logistically more feasible for urban families.

With regard to the three major approaches to policy-making, the approach of cost-benefit analysis appears to provide a more balanced evaluation that utilizes a broad range of information, as opposed to the Precautionary Principle (which places heavy emphasis on the possibility of risk and little emphasis on the possibility of benefit) or the "generally recognized as safe" approach (which does the reverse).

It is important for the students to identify which of the readings was the source of each item in their responses to questions 1-3, so they can see the patterns that will allow them to understand how these two readings can advocate for such different positions with regard to Golden Rice. The first source focuses on the potential advantages of Golden Rice, rebutting disadvantages, and criticizing other approaches to reducing vitamin A deficiency. In contrast, the second source focuses on possible problems that might be caused by Golden Rice, counterarguments to the potential benefit, and the advantages of other possible approaches. Notice that in order to evaluate an article, it is important to think about what has been omitted as well as what has been included. It should be noted that many commentaries on this topic are highly partisan and less accurate than the two articles chosen for this activity.

In your class discussion of questions 6 and 7, it will be important for students to present the arguments and evidence that support their conclusions. It seems likely that student opinions will vary, and this will provide the opportunity to discuss how valid arguments can be made for different policies, particularly when the issues are complex and there is uncertainty about important questions, as is often the case for public policy questions. Individual policy preferences depend not only on scientific evidence, but also nonscientific factors such as values, risk tolerance, etc. Discussion of this controversial topic will provide the opportunity to help your students learn how to have respectful and informative discussions despite opposing points of view.

Additional Sources of Information

* "Golden Rice: An Intimate Debate Case" (<http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=279&id=279>)

This case study includes informative resources that cover a broad range of evidence and arguments, including references.

* "Gene Manipulation in Plants – Golden Rice: a case study" (<http://www.open.edu/openlearn/science-maths-technology/science/biology/gene-manipulation-plants/content-section-4.1> )

This includes an informative and balanced discussion of the science and public policy issues related to Golden Rice, with some embedded questions to challenge students.

* "Tough Lessons from Golden Rice"

(<http://fbae.org/2009/FBAE/website/news_tough-lessons-from-golden-rice.html> )

This article provides a balanced overview of major disputes concerning Golden Rice.

* Multiple arguments and evidence in favor of Golden Rice are presented at <http://www.goldenrice.org/> .
* Multiple arguments and evidence against Golden Rice are presented at <http://www.greenpeace.org/international/en/campaigns/agriculture/problem/genetic-engineering/Greenpeace-and-Golden-Rice/> .
1. By Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, 2014. These Teacher Notes and the related Student Handouts are available at <http://serendipstudio.org/exchange/bioactivities/GoldenRice> . [↑](#footnote-ref-1)
2. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (available at <http://www.nap.edu/catalog.php?record_id=13165> ). [↑](#footnote-ref-2)
3. Common Core Standards Initiative (available at <http://www.corestandards.org/>) [↑](#footnote-ref-3)