

Genetically Modified Foods: Benefits and Risks



For six seasons, millions of students came to understand, appreciate and enjoy the exploration of science through the series, *Bill Nye the Science Guy*. Bill returns with *The Eyes of Nye*, a more in-depth look at science subjects making news, changing lives, and impacting policy. From the future of alternate fuel sources and genetic engineering to population growth trends and issues of race, Bill and his expert cohorts bring science to life right in your classroom, helping you **Motivate** investigation; **Assess** available information; and **Propose** lines of argumentation.

This Educator's Guide includes:

- An **Introduction** that clearly defines the subject and offers an overview of the issue objectives of the guide; how it relates to science from both a social and personal perspective; as well as pertinent questions and insights regarding the topic.
- A listing of all **National Science Education Standards Addressed**.
- Detailed procedures highlighted in the MAP Framework (**Motivate, Assess, Propose**).
- Illustrative **Video Clips** from *The Eyes Of Nye* DVDs with pinpoint chapter cues.
- **Web Site Resources** to help students further investigate and locate research, charts, data as well as experts featured in the program material.
- Easily downloadable **Support Materials** that include articles, transparencies, charts, and much more.

Introduction:

"Genetically modified foods" refer to foods produced by a plant whose genetic make-up, or DNA, has been altered. *The Eyes of Nye - Genetically Modified Foods: Benefits and Risks* describes basic types, purposes, and processes involved in genetic modification of food-producing plants, distinguishing between these and traditional hybridization and breeding processes, along with questions surrounding the use of genetically modified (GM) foods.

The issue of GM foods is primarily one of regulation—with the planting of the one billionth acre in the spring of 2005 (according to the Biotechnology Industry Organization), over two-thirds of which is in the United States, questions whether "to genetically modify or not" have become moot. What students will face—and what this guide addresses—is the

Check the **MAP Teaching and Learning Framework** to explore the phases (motivate, assess, and propose) used in this guide.

need to explore the meaning and benefits of genetic modification of food-producing plants, the processes that do or do not produce these benefits, and the most effective means for safeguarding health and preventing potential environmental damage while pursuing these benefits.

National Science Education Standards Addressed

Science As Inquiry

- Abilities necessary to do scientific inquiry
 - Identify questions and concepts that guide scientific investigations
 - Recognize and analyze alternative explanations and models
 - Communicate and defend a scientific argument
- Understanding about scientific inquiry

Life Science

- The cell
- The molecular basis of heredity
- The interdependence of organisms

Science in Personal and Social Perspectives

- Personal and community health
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science

- Science as a human endeavor
 - Nature of scientific knowledge
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On the DVD:

Genetically Modified Foods: Benefits and Risks – Chapters

Chapter 1: GM Foods Preview

Beginning through 1:42
Ends with title screen.

Chapter 2: Genetically Modified Foods

2:06—3:40
Ends with Bill saying, “I’m just making my lunch.”

Chapter 3: Traditional Breeding

3:41—6:19
Starts with interview with Dr. Steven Jones. Ends with Bill saying, “There’s nothing blue here.”

Chapter 4: Genetic Engineering: Processes and Hopes

6:19—11:57
Starts with broccoli commercial. Ends after Golden Rice talk show.

Chapter 5: Benefits, Effects, and Prevalence of Modified Crops

11:59—16:15
Starts with Bill saying, “Imagine being a farmer...” Ends with Bill saying “...you probably won’t see the words genetically modified in the fine print.”

Chapter 6: Ongoing Social Debates

6:18 through end of program
Starts with Bill’s interview with Dr. Hake. Ends with the close of the program.

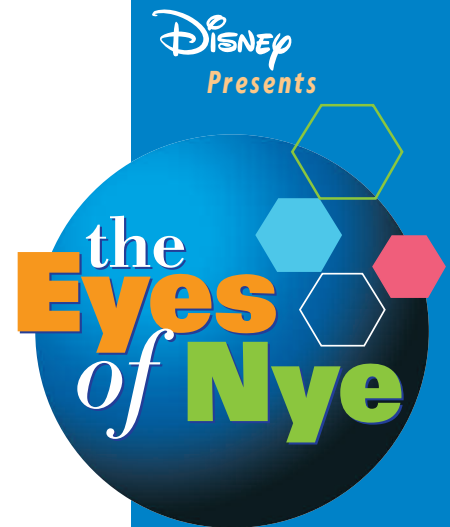
Genetically Modified Foods: Benefits and Risks – Activity Clips

From Shelf to Table: GM Foods Everywhere

14:19—16:15
(referenced in Educator’s Guide step 2)
Starts with Bill saying, “One small gene to feed a man...” Ends with Bill saying “...you probably won’t see the words genetically modified in the fine print.”

Transgenic Modification

7:39—8:45
(referenced in Educator’s Guide step 6)
Starts with Bill walking down the stairs with Dr. Pam Ronald.
Ends with Dr. Ronald saying “...we would inoculate it.”



Rice and Vitamin A

8:45—10:26

(referenced in Educator's Guide step 8)
Ends with "Critics Charge" on Golden Rice.
Toward Insect and Weed-free Crops

Toward Insect and Weed-free Crops

11:59—14:19

(referenced in Educator's Guide step 9)
Starts with Bill saying, "Imagine being a farmer..." Ends with statistics from Ronnie Cummins, OCA.

Labeling and Mislabeling

16:18—18:18

(referenced in Educator's Guide step 15)
Starts with interviewing Dr. Hake and asking, "So, do you think we should have labeling on genetically engineered foods?" Ends with her saying that "...it all sounds pretty bad to people who don't know what it is."

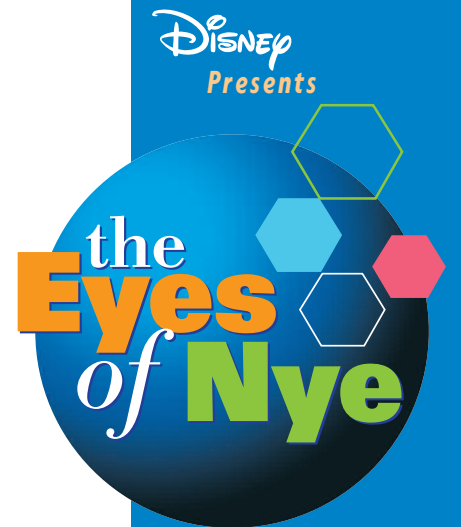
This Land is My Land

19:43—21:15

(referenced in Educator's Guide step 16)
Starts with Bill saying, "Corporations say that genetically modified food is the greatest thing, if I may, since sliced bread." Ends with Dr. Stevens saying "...stick a single gene into it and you own it."

Procedure: Motivate Phase

- 1) Ask students if they have eaten corn in the last week; do the same for students who have eaten margarine. Then ask those who have an infant in their family.
- 2) Play "**From Shelf to Table: GM Foods Everywhere,**" and discuss with students the prevalence of genetically modified foods in our diet. Ask if this concerns them; some will indicate concern, and some will begin to ask *why* we are doing this, and what is a genetically modified food? Focus on these questions; ask them *why they need to know* the answers to these questions. Discuss responses briefly, then suggest we face a real issue with GM foods, and we clearly have some questions.
- 3) Play "**Chapter 1: GM Foods Preview**" Recall questions students asked in last step and reiterate those posed in the preview—what is it, do we need it, and is it safe? Explain though GM foods are a reality, there are many ways we (they) can help decide what should happen with the development and use of GM foods. Suggest, however, their questions tell us that part of the answer has to do with finding out what can happen (a more scientific endeavor).
- 4) Pose the broad question, "What should we do to help ensure we obtain the most benefit and the least possible danger from genetically modified foods?" Work with students'



previous questions and points that emerge through discussion to outline at least two scientific and one social question to help structure students' investigation of the broad question (see possibilities below).

Potential scientific questions

- a) What are genetically modified foods and how do they differ from traditional foods?
- b) What *can* happen—potentially good or bad—due to production and consumption of genetically modified foods?

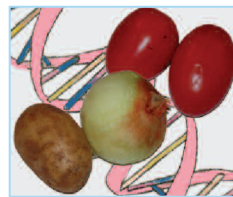
Potential social questions

- c) What *should* happen due to production and consumption of genetically modified foods, and how can we make that a reality?



Procedure: Assess Phase

- 5) Tell students that investigating the initial scientific question above requires exploration of both “traditional” and “transgenic” processes for developing and growing food-producing plants. Explain “transgenic” processes involve taking a gene from one organism and placing it in another. Remind them of the preview and that humans have been modifying—and improving—food-producing plants for over 10,000 years. Mention several farm-grown food types and ask students how often they see these plants (and foods) in the wild. Play “**Chapter 3: Traditional Plant Breeding**” (end with Bill musing about something old and something new). Ask students to note the process for improving food-producing plants (wheat) described by Dr. Steven Jones. Briefly review the method and resulting product.
- 6) Ask students to note the procedure for genetic modification described by Dr. Pam Ronald as you play “**Transgenic Modification.**” Review the main points, then divide students into groups of 3-4. Ask them to outline each process and create one list of distinctions—points of difference and/or similarity between each. Discuss the points using suggestions and information from “Traditional and Transgenic” (see sidebar), or allow each group to present their list, amending their list as they listen and discuss input from each group.



Teacher Note: *The process and result of traditional versus transgenic modification of food-producing plants is briefly presented in the Issue Support mentioned above. You may use the opportunity to encourage deeper exploration into the complexities of the science content and concepts associated with each.*

Likewise, the volume of information and opposing views—scientific and social—related to the information that follows is overwhelming, presenting an opportunity to focus heavily on aspects that are mentioned and/or those that most pique students' interest. The extent of material also provides an excellent opportunity to learn about the nature of social influences on scientific progress, but use caution—most of the material is biased (from corporate sponsors to government to advocacy groups), heavily influenced by the organizations involved, and inflammatory and emotional. Ask students to deeply consider the experts.

For more, go to eyesofnye.org.

See **The Eyes of Nye**
Issue Support
Traditional and Transgenic

- 7) Ask (or remind from earlier discussions) *why* we are using transgenic processes, given that we have for millennia worked to develop plants that produce useful food. Students may suggest (if not, point out) the answer is partially in the question—direct genetic modification is much faster. Suggest it also presents a potential means of rapidly addressing agricultural problems, and therefore hunger problems that take many years through traditional means. Recall Dr. Jones’ mention of the time needed to develop a new variety through traditional means.
- 8) Ask students to suggest problems that may be solved by modifying food-producing plants by either method. Many students, especially in rural areas, will be familiar with the need to control crop pests and disease, as well as weeds or “competition” for food-bearing plants. If not mentioned, suggest that improving nutrition, though not usually considered in the U.S., is the major reason for food production. Play *“Rice and Vitamin A,”* in which Dr. Ronald extends her discussion to the value of transgenic Golden Rice in underdeveloped countries. Review the numbers of people (below right) affected by vitamin A deficiency, and inform students the project never really materialized. Pause before asking what they think about this.

Claims suggest that:

- *Vitamin A deficiencies cause 500,000 children to go blind each year and are associated with 1-2 million deaths each year.*

- 9) Discuss Golden Rice using the information provided in “Rice and Reality.” Tell students there are many opposing views on the potential of Golden Rice, and some claim companies producing transgenic crops overplayed their value in order to promote their agenda. Ask, however, if this necessarily means there was *not* value in Golden Rice. Recall the criticism provided near the end of the above segment that the product would only supply 10% of the required amount of vitamin A, but ask students if 10% is better than nothing. Read the comments in “Golden Statements,” and follow by explaining another type of rice—Bt rice, from a plant modified by a gene of the bacterium *Bacillus thuringiensis*—is being grown and eaten regularly. Recall the advantage of insect-resistant crops and weed prevention. Ask students to note the advantages of these new modifications as you play *“Toward Insect and Weed-free Crops.”*
- 10) Review the claims by Dr. Harvey Glick, director of scientific affairs for Monsanto. Suggest that based on his statements we now know that modified herbicide-resistant soybeans have been studied and found safe by 31 regulatory agencies in 17 countries. Pause to allow discussion, then ask which countries and agencies these might be—they are not mentioned. Suggest again, however, since a scientist assures us they are safe then it must be so. Students will question this; if not, ask if we are ready to accept that. Distribute “Something Old, Something New” and contrast claims related to use of genes from the bacterium *Bacillus thuringiensis*.

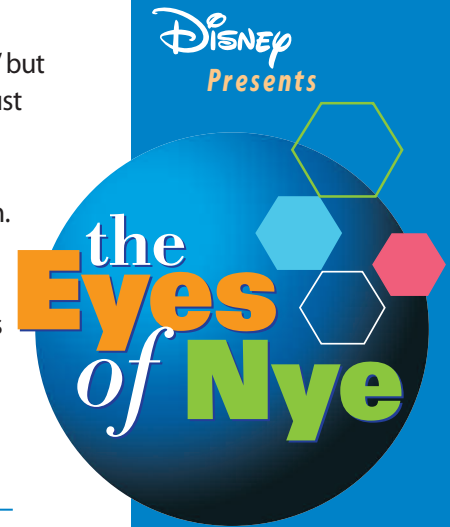
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See *The Eyes of Nye* Issue Support *Rice and Reality* and *Golden Statements*

Check out opposing claims. See *The Eyes of Nye* Issue Support *Something Old, Something New*



- 11) Ask students if this means that information provided regarding the countries and regulatory agencies are just made up by Monsanto. Some will say “yes,” some “no,” but most will say we do not know. Explain that much of this information is available, just difficult to verify given the range of opinions and the stakes—environmental and financial. Tell students we have explored just a few of the many things that can happen—good and bad—due to the use of transgenic plants for food production. Ask them how we can possibly address the social question posed in the first section (What *should* happen in order to gain the most benefit *and* protection?) when there are such oppositional views, and when even the research often seems designed to coerce? Suggest it is too easy to disregard claims, and bias does not necessarily mean evil intent.

Potential social question:

- Does a governmental “okay” ensure safety?

Encourage students to locate information on Professor Ingo Potrykus (Swiss Federal Institute of Technology, Zurich) and Dr. Peter Beyer (University of Freiburg, Germany), the original inventors of Golden Rice (for instance, Dr. Beyer’s interview with The Hindu in 2002 “Can Golden Rice Keep Vitamin A Deficiency at Bay?”) for a check on potential assumptions that things are never done to help people.

For more on exploring claims and claimants, go to eyesofnye.org.

Procedure: Propose Phase

- 12) Tell students as we discovered earlier, we *have* and *eat* genetically modified foods every day. Suggest what we believe *should* happen—what we *can* still influence—depends largely on our own circumstances. Recall the countering views in “Something Old, Something New.” Ask them if this is the way things should be (not necessarily), and tell them because of this you would like for each of them to play an unusual role in an imaginary scenario, because it is important for each of them to have an opportunity to think about this situation from another point of view.

- 13) Introduce Shady Acres. Use the following scenario.

Situation in Shady Acres: Shady Acres is a medium-sized, semi-rural town with beautiful weather and a long growing season. It is called Shady Acres partly because it is a stress-free place to live. Recently, the citizens of Shady Acres have been notified that ModGrow Foods, Inc., a large corporation that produces genetically engineered foods, has acquired a large area of farmland in surrounding Sunnyville County. Their farms will begin just outside the boundary of Shady Acres.

- 14) Distribute “Welcome to Shady Acres!” and discuss each possible role— Shady Acres resident, ModGrow scientist, and independent Sunnyville farmer. Ask students not to choose a stance. Tell them they will have a chance afterward to suggest courses of action, but first they are to describe their character and his/her view of the situation, including concerns or opportunities this character may consider most heavily. They should each select and build a character they think is very different from what they would consider their normal personality or role.

See *The Eyes of Nye*
Issue Support
Welcome to Shady Acres!

Teacher Note: General roles are provided, but students should decide on their character's traits and views. For instance, an "independent Sunnyville farmer" may or may not be successful using past techniques, male or female, older or younger, close or far from ModGrow, and either interested, or not, in working with them in the farm business. Check the support for student role cards that can be printed, cut out, and laminated.



- 15) Ask students to discuss the concerns and/or opportunities they saw for their character, and discuss the feeling of being in an unfamiliar role or considering viewpoints from a perspective not their own. Ask about actions students may have already considered, even if not yet required. Explain many very thoughtful viewpoints come from people who have faced real situations—some like Shady Acres. Ask them to consider how they might feel if they were an employee with a food-producing biotech firm as you play *"Labeling and Mislabeling"* in which Dr. Sarah Hake, director of the USDA Plant Gene Expression Center at Berkeley, discusses her view of requiring labels for genetically modified foods as well as her reaction to the destruction of her fields. Ask students if there are times we can be the most helpful when we understand others' views.
- 16) Ask for volunteers to describe their concerns or possible opportunities they saw as farmers, and ask everyone what they thought about the patent issue and potential for loss of seed crops due to lack of containment. Play *"This Land is My Land"* in which Dr. Steven Jones, introduced in step 5, discusses his view on the topic.
- 17) Ask each student to find one or two other students who have worked in a similar role. Ask each new partnership to combine their considerations together and create two questions they would like answered, one by each of the other characters. Announce that Shady Acres is holding a town meeting—the recent furor over ModGrow's arrival has been overwhelming. Shady Acres' officials have decided therefore to hold a panel question-and-answer session. Ask for two representatives from each role to sit on the panel, and devise a brief set of town meeting rules (how students with questions will be recognized, if other panel members can answer a question should the member addressed not respond, how long the meeting will be, how many questions students in the "town audience" may ask, and so forth). Allow students to have a large role in determining these rules, and be sure to consider how to make certain all students have the opportunity to fully participate. At the completion of the meeting, charge the panel with the responsibility of proposing a plan of action. It should contain at least three points, and may include such items as making requests of state or federal government officials, further studying a certain issue, scheduling another meeting, and so forth.

Explain to students that expressing views and deciding on courses of action can be tough, even if some amount to "wait and see" or "study this further."

- 18) Review and discuss the action items that emerged during the meeting. Tell students to consider for a moment the scenario is real. Ask them what types of information they need to propose a plan of action a government—national, state, or local—could consider regarding production of genetically modified foods. Discuss as well what sources they may look toward to acquire this information. Ask them if they think they are ready—one day they may need to do just that.

Read on responsible action in the "propose" phase of MAP Framework

Final Teacher Note: *The Shady Acres scenario is based on numerous situations that are presently taking place across the United States. The social complexities of the issue create a unique opportunity for students to delve as deeply into the role of economics and politics as you wish. The investigation of claimants can be engrossing, emotional, and an excellent challenge for students as they attempt to learn to look past the rhetoric and the “blame game.”*

For more, go to eyesofnye.org.

Further Research

Investigating the Issue: GM Foods

The issue of genetically modified foods represents a heated example of the difficulties posed by issues in which social aspects overwhelm and even cloud the science. As with most issues, much of the science is fairly new—frontier science or science-in-the-making as compared to accepted and consensual (agreed upon) science. It experiences enough difficulties in its normal progression toward consensual science without the deep shadows of distrust cast by opponents on both sides of the issue. Nevertheless, this is also part of the power of this issue for student learning—the difficult but necessary struggle that must sometimes take place to reach the stage where real decisions can be made and action proposed as a result of those decisions.

The information and claims presented in *The Eyes of Nye - Genetically Modified Foods* represent a sampling of both sides of the issue, in the science as well as the social aspects involved. Teachers may encourage students to access information on these aspects, but may also wish to encourage critique of the veracity of the information, even more so than may be required with other emotionally charged socio-scientific issues. The following represents a select assortment of aspects to investigate—each leads to further “trails” of enlightenment.

Exploring the Science of Genetically Modified Foods

The “assess” phase of *The Eyes of Nye - Genetically Modified Foods* focuses on understanding the basic science of genetically modified foods—what it means, how it differs from food developed through traditional means, and its potential benefits and costs from a scientific perspective. Students may further explore:

Meaning and terminology:

- genetically modified foods (food products that result from or contain some amount of a genetically modified organism)
- genetically modified organisms (organisms that produce the food)
- genetic engineering (broader term, subject of debate regarding applicability to many genetically modified organisms)
- transgenic (preferred term as opposed to genetically engineered)

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Several available methods for transferring DNA into a plant:

- Agrobacterium
- Particle bombardment
- Viral transformation

Principal purposes, both at center of controversies surrounding potential benefits and effectiveness:

- insect resistance
- herbicide resistance

Exploring Social Aspects of Genetically Modified Foods

During the “assess” and “propose” phases students encounter questions related to ethics, regulatory requirements and patents, as well as the claimants themselves indicated in the next section.

Students should explore:

- Cartagena Protocol on Biosafety (2003)
- patents, intellectual property rights, and court suits
- labeling (requirements, and requirements in Europe vs. United States)

Exploring Genetically Modified Food Claims and Claimants

An important aspect of dealing with socio-scientific issues involves looking beneath the evidence and viewpoints that are expressed by acquiring additional information on the experts themselves as well as the organizations for whom they work or with whom they are affiliated. Through such exploration, students are better able to infer social (contextual) factors that may influence the claims. This is especially revealing in *The Eyes of Nye - Genetically Modified Foods*, in the case of the principal providers of information in the program (Doctors Jones, Ronald, Glick, and Hake), but even more so from the general perspectives and opinions espoused by the various advocacy groups, corporations and governmental agencies that follow.

Dr. Steven Jones, wheat breeder	School of Agriculture, Washington State University
Dr. Pam Ronald, scientist	Department of Plant Pathology, University of California, Davis
Dr. Harvey Glick, scientist	Director of Scientific Affairs, Monsanto Company
Dr. Sarah Hake, scientist	Director, USDA Plant Expression Center, U.C. Berkeley



Advocacy Groups

- Friends of the Earth
- Greenpeace
- Organic Consumers Association

Corporations

- Monsanto
- Calgene
- Syngenta
- Zeneca

U.S. Government Regulatory or Informational Agencies

- Department of Agriculture
- Food and Drug Administration (FDA)
- Environmental Protection Agency (EPA)

