

Golden Rice

A Sixty Minute Play in One Act

by Bob Goldberg

(Adapted from an original script by Bob Goldberg, Kathy McElroy, and Esther Hsu)

Honors Collegium 70A
Genetic Engineering in Medicine, Agriculture, and the Law
Discussion - Week 3
Winter 2004

Based on the Scientific American Articles:
 “Edible Vaccines”
 “Seeds of Contention”
 &
 Short Supplementary Articles
 &
The Actual Research and Odyssey of Professor Ingo Potrykus

CAST

World Health Organization:

Dr. Gro Harland Bruntland
Director-General of the World Health Organization

Dr. Cynthia Rand
World Health Organization Field Researcher

Rockefeller Foundation:

Dr. Ngu Triton
Director of the Tainapan Vitamin A Project

Dr. Jon Johansen
Senior Scientific Advisor, Rockefeller Foundation

Dr. Sam T. Mann
Senior Cultural Advisor, Rockefeller Foundation

AgTech Plant Biotechnology, Inc.:

Dr. Moe Munroy
AgTech Chief Executive Officer (CEO)

Dr. Kay Plantain
AgTech Chief Scientific Officer (CSO)

Dr Greta Nelson
AgTech Researcher - Gene Discovery Division

Fred Melroy
Leader of "Friends of the Land"

Wilma Wallace
Television Anchor, "50 Minutes"

Minister Hanna
Tainapan Minister of Agriculture

Cast Continued

Nikki L. Tinsley
Inspector General of the Environmental Protection Agency

Dr. Joan Smith
Attending Physician & Professor of Immunology - UCLA

Dr. Brown Greenfield
Ecologist - US Department of Ecology

Bob A. Gent
FDA Inspector

Members of the WHO

"Friends of the Land" Activists

EPA Genetic Engineering Control Board

Scene 1:

World Health Organization (WHO) Headquarters

(3 minutes)

A WHO field researcher gives a brief presentation on the extent and effects of Vitamin A deficiency in Tainapan, a poor developing country in Southeast Asia. A visiting representative from the Rockefeller Foundation announces that his organization will take on this public health threat.

Concept Questions:

- ◆ What problems does Tainapan face, resulting in poor health conditions for its people?
- ◆ What is the major food source in Tainapan? What essential vitamin is deficient in the diet of the people of Tainapan because of their major food source? How do people elsewhere in the world combat this deficiency?
- ◆ What are the health problems related to the vitamin A deficiency?

Scene 2:

Rockefeller Foundation Headquarters

(3 minutes)

The appointed Director of the Tainapan Vitamin A project discusses possible courses of action with his senior scientific advisor and senior cultural advisor. Several suggestions are brought up, including the issuance of vitamin A supplements to all at-risk individuals in Tainapan, and the genetic modification of Tainapan's major food staple, rice, to produce Vitamin A. *The scientific advisor* suggests contacting a major Agricultural Biotechnology company, AgTech about the possibility of genetically modifying the crop. *The cultural advisor* advises against this strategy because of Tainapan's cultural resistance to any tampering with the "sacred" rice supply of the rural farming communities, and the difficulties of passing such technology by environmental protection groups. *Nevertheless, the three decide to explore the possibility, and call AgTech to schedule a meeting for the next day.*

Concept Questions:

- ◆ How would the genetically engineered rice improve the health of the people of Tainapan?
- ◆ Are there alternative ways to improve the health of the people of Tainapan other than using GMOs?
- ◆ How does the culture of Tainapan restrict the methods by which you could introduce Vitamin A into the diets of the population?

Scene 3:

AgTech Corporate Headquarters (the next day)

(3 minutes)

The Director of the Tainapan Vitamin A project meets with the CEO and CSO (Chief Scientific Officer) of AgTech. The Director proposes a collaboration between AgTech, the Rockefeller Foundation, and the World Health Organization to address the problem of Vitamin A deficiency in the developing world. The AgTech CEO is immediately interested in the proposition, in part because of the positive publicity his company would most likely receive.

The CSO is also excited by the proposition because of the scientific and social challenges it presents. *The meeting ends with a formal collaboration agreement, including a promise of substantial funding for the work by the Rockefeller Foundation.*

Scene 4:

WHO Headquarters

(15 minutes)

After many months of difficult science, the AgTech researchers working with grants from the Rockefeller Foundation and the WHO have identified a wild orange-colored carrot plant that synthesizes large amounts of beta-carotene in its roots. In addition, they have also identified a different wild white-colored carrot plant that does not make beta-carotene because of lacking the gene specifying beta-carotene biosynthesis enzyme. Using these two different types of carrots, the AgTech researchers are able to isolate the gene and transform the rice. *The AgTech researchers present genetically-modified rice grains to the WHO.* Several days of research talks follow, as the scientists describe the methods by which they created a transgenic rice plant capable of producing beta-carotene.

The first presentation is given by Dr. Pamela C. Ronald, who discusses how the gene responsible for Vitamin A production was found and cloned.

Concept Questions:

- ◆ How can you genetically engineer plants? What materials are required to genetically engineer plants?
- ◆ What is *Agrobacterium tumefaciens*? Where does *A. tumefaciens* live in nature? How does *A. tumefaciens* cause the crown gall disease in plant? What is the tumor-inducing plasmid? What genes are present in the tumor-inducing plasmid?
- ◆ How can you genetically engineer *A. tumefaciens* to use it as a vehicle for gene transfer to plant without causing the crown gall disease? What genes would you remove from *A. tumefaciens*? What genes would you keep so that the *A. tumefaciens* has the ability to transfer gene(s) into plant cells? What gene/marker would you use to select for the transformed plant cells?
- ◆ What are the steps to generate a genetically engineered carrot plant? Once a plant cell is transformed by the gene of interest, how do you produce an entire plant from that single cell?
- ◆ Are plant cells totipotent? Can you regenerate a plant from a leaf cell? How? What materials are required to regenerate a plant from a leaf cell?

The second presentation is given by Dr. Greta Nelson, who describes the ways in which the gene was modified for introduction into rice, and the method for introduction.

Concept questions:

- ◆ How would you genetically engineer rice to express the gene specific for carrot root beta-carotene biosynthesis enzyme in the rice grains? What materials do you need?
- ◆ How would you genetically engineer the carrot root beta-carotene gene so that the gene will be expressed in the rice grain? What switches are required to allow the gene to be expressed in the rice grains?

- ◆ How would you select for the transformed rice cells/plants? Where do you want the kanamycin resistant gene to be expressed? How would you genetically engineer the resistant gene so that it will not be expressed in the rice grains? What switches would you use?
- ◆ How would you transform rice plants? Can you use *A. tumefaciens* as a gene delivery vehicle? Why or why not?
- ◆ What plant transformation technique would you use to obtain transgenic rice plants? What is DNA particle gun method? What is the DNA particle? How does the DNA get into the plant cell? What materials are required for DNA particle gun method?
- ◆ How would you know if there is any rearrangement or damage of the genetically engineered beta-carotene gene during transformation? What experiment would you do to show unambiguously that the gene is intact? What experiment would you do to show unambiguously that the gene is expressed in the rice grains? How would you determine if beta-carotene is made in the rice grains?

These scientific discussions are followed by a brief discussion by Director of the Tainapan Vitamin A project of how the seeds will be distributed to the nation of Tainapan.

Scene 5:

The Street outside of the WHO Headquarters

(2 minutes)

The powerful environmental group, "Friends of the Land", pickets in the street in front of the WHO Headquarters. A television news anchor for "50 Minutes" shows up at the protest, and asks the "Friends of the Land" Leader to appear on the national news show to talk about issue. He accepts, and the interview is scheduled for the next day.

Scene 6:

On the Set of "50 Minutes"

(7 minutes)

*The "Friends of the Land" Leader is interviewed on "50 Minutes," a highly-rated television news show. The leader discusses the dangers of GMOs, including the possibility of gene transfer between closely related plants and the possibility of causing severe allergic reactions in people eating the genetically modified rice. He claims that AgTech is attempting to take over the food supply of developing countries for its own financial gain. To prevent this from happening, the Leader announces that his group will use their fleet of boats to block all shipments of this genetically-modified rice into Tainapan, and will file an injunction with the Environmental Protection Agency to halt all work on genetically-modified organisms. At this point, the television interviewer brings out a surprise guest, the Minister of Agriculture of Tainapan. **The Leader of "Friends of the Land" and the Minister from Tainapan get into a heated debate over whether the putative risks of farming GMOs overshadows the potential benefit of the Vitamin A-infused rice.***

Concept questions:

- ◆ Would the genetically engineered rice harm the environment by creating "super rice?" What is "super rice?"

- ◆ Would the kanamycin resistance protein used to select for transformed plants harm the environment/ecosystem? Could microorganisms in the environment “pick up” the kanamycin resistance gene from the genetically engineered rice and become kanamycin resistant?
- ◆ Would the GM varieties spread unchecked and corrupt “natural” crops?
- ◆ Would eating the genetically-engineered rice cause an allergic reaction?
- ◆ Would AgTech ultimately control the Tainapan rice supply?
- ◆ Is GM rice “natural?”
- ◆ What are the risks and benefits of selling genetically-modified rice seed to the people of Tainapan?

Scene 7:

Conference Room at the WHO Headquarters

(2 minutes)

Appalled at the way their work was presented on national television, as well as the injunction served against them, the heads of the Rockefeller Foundation, WHO, and AgTech file a petition to the Environmental Protection Agency against the "Friends of the Land" injunction. The leaders of all four organizations are called to present their cases the following week at the Environmental Protection Agency in Washington, D.C.

Scene 8:

Environmental Protection Agency

(15 minutes)

The Inspector General of the Environmental Protection Agency and the Genetic Engineering Control Board preside over this injunction hearing. First, the "Friends of the Land" environmental coalition presents its evidence that the use of genetically-modified organisms in agriculture is detrimental to the health and well-being of the environment and people. Then, the Vitamin A Coalition rebuts their arguments, and presents scientific evidence of the safety & benefit of these GMOs.

Friends of the Land:

The first witness is a medical doctor and professor of Immunology at UCLA. She discusses the possibility of inducing allergic reactions in individuals due to the novel proteins introduced into the body through the ingestion of genetically-modified food. *The second witness is an esteemed ecologist from the US Department of Ecology,* who discusses the environmental impact of using genetically-modified plants in agriculture. He cites several examples of how genetically-modified plants might affect the organisms present in the environment, including other plants, animals, and humans.

Concept questions:

- ◆ How might the introduction of a novel protein cause an immune response in the body? What is the risk of a strong allergic reaction?

- ◆ What is the potential environmental impact of introducing a genetically-modified plant into the environment? Is there any risk that nearby wild species of rice might "take up" the modified gene?
- ◆ What are the risks involved in introducing a genetically-modified plant to a new environment? What potential effects could it have on the animals or bacteria in the new area?

Vitamin A Coalition:

The first witness is the CSO of AgTech, who provides a very general overview of how the genetically-modified rice was produced. The next witness is a federal food inspector from the FDA. He testifies as to the safety tests performed on the Vitamin-A enriched rice plant, as well as the regulations which must be surpassed by all genetically-modified foods. He then rebuts the arguments of the medical doctor and environmentalist, providing clear scientific evidence that allergenicity and gene transfer concerns are unfounded.

Concept questions:

- ◆ What kinds of studies and tests should be performed to ensure the safety of the vitamin A rice for the consumer and for the environment?
- ◆ Are allergenicity and environmental impact studies conducted by the FDA in order for a genetically-modified product to be released? What were the results of these studies?

The Inspector General of the EPA turns the proceedings over to the ***Genetic Engineering Control Board, who weigh the evidence presented in the hearing.*** They then conduct a poll to determine whether they will grant the injunction served by the "Friends of the Land."