Agricultural Biotechnology
An Educational Workshop

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Agriculture, Biotechnology, and GMOs: Informing the Debate

Introduction-Humans invented agriculture. The origin of agriculture is widely understood as a crucial event in human history that has been truly one of the most significant and impactful for humanity. Humans have been cultivating plants for a sustainable source of food for over 10,000 years, moving from hunting and gathering societies into civilization. The accumulation of surplus food supplies correlates all the other achievements of Neolithic civilization including writing, developments in mathematics, philosophy, and science, property law, and government.

Now nearly all the plants, fruits, vegetables and grains, available in our grocery store do not grow in the wild. All cultivated plants are the result of human intervention. Most of these plants would not exist if not for humans, and would not persist without them. The development of plant cultivation for food by humans has grown increasingly sophisticated, starting with selection of wild plants and domestication, to the use of genetics, hybrid plant development, and directed crosses, making wide crosses and the use of mutagenesis and ploypoidy, and now more recently the application of genomics, bioinformatics, association genetics, marker assisted breeding, advanced tissue culture, modern conventional genetics and transgenics.

It is estimated that one half of the world's population lives on rice, and one half of them live on less than two cups of rice a day . Since worldwide population now exceeds 7 billion and is projected to increase to over 9 billion in the next three decades, the need to improve agricultural production has been considered by some to be a 'morally imperative'. The major role that cereal crops play in world agriculture, human health and nutrition and world economic stability is as obvious as its projected need for increased growth. Cereal crops feed the world, providing more food energy worldwide, grown in greater quantities on more land, and across more diverse ecosystems than any other type of crop (Borlaug 2002; FAO 2013). To reach the maximum potential of agricultural output required to meet these needs, the power of advanced genomics and biotechnology tools need to be brought fully to bear on the improvement of major food crops. Genetic improvement of the most widely used crops, are anticipated by current agricultural advances in all aspects of biotechnology from genomics to genetic modification.

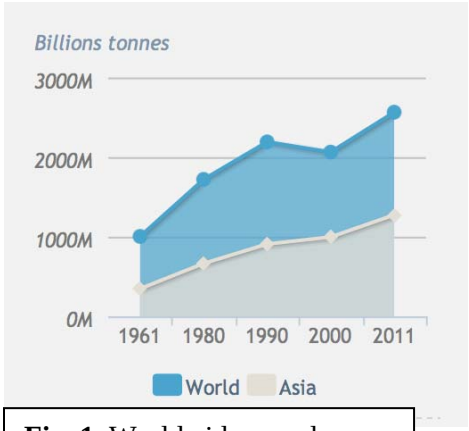

Fig. 1. Worldwide cereal crop production (FAO 2013).

The applications and developments in biotechnology are among the most provocative and socially relevant topics today. Currently there is a wide disparity

between the knowledge of the general public about DNA and biotechnology and the actual science and its applications. This gap is growing wider every day and has created a current educational crisis about DNA, how life works and biotechnology. A working knowledge of DNA, genetics and biotechnology has become as fundamental to a basic education as an understanding of the solar system. Biotechnology education has not kept pace with its science. Biotechnology has now reached an exponential growth phase, growing much faster than society can assimilate it or its implications, with many important decisions reached by default. Isaac Asimov wrote that "science gathers knowledge faster than society gathers wisdom" and in no other field is this more apparent and dangerous than biotechnology.

The largest challenges in biotechnology right now are not technological, but those of public perception. The rapidity of new discoveries in biotechnology has exceeded the ability of the general public to assimilate this knowledge, inhibiting meaningful debate on important social and moral issues. The anti-GMO mentality that has persisted for the last two decades cannot stand in the face of such growing need as Giddings et al (2012) so aptly point out, "To our knowledge, every claim of a negative consequence to health or the environment from the use of these crops has failed to withstand scrutiny"; "Although Europe is sufficiently wealthy to buy its food, the indirect effects of European regulations and attitudes (towards GMOs) have had a unconscionably inhibitory effect on the introduction of biotech crops in less developed countries in most need of them, particularly on the African continent" and, later, "It is imperative that the impediments now obstructing innovations in these critical areas be examined, and those that cannot be justified must be removed." where every tool in the box is now important. Biotechnology is not a threat. Starvation is.

Concerning the labeling of GMO crops and their ingredients we need to review both the regulatory processes and the information that shows that genetic modification as a process does not pose a health threat. An educated consumer would appreciate the benefits of GMOs as a part of agricultural improvement. But labeling food won't enlighten, educate or inform shoppers. Instead a broader appreciation of biology and biotechnology would be the best approach. A label will not provide an adequate education. We need way more than that now.

This workshop has been designed to provide an educational foundation for understanding modern agriculture and the use of biotechnology. In this forum we will examine **Agricultural Biotechnology** in five Parts including: **Part I. Where Does Our Food Come From?; Part II DNA-based Biotechnology And Modern Agriculture; Part III. Issues, Controversies and Concerns**: **a. Setting the Stage about Food and Agriculture:**; **b. Issues, Controversies and Concerns; and, c. The Organic Food Debate Part IV. The Ethics of Agriculture; and Part V. Renewable Energy and the Future of Humanity.** We hope this puts modern DNA-based biotechnology in context and also addresses the concerns and misconceptions about Genetically Modified Organisms (GMOs) and their application in agriculture.

Agriculture, Biotechnology and GMOs: Informing the Debate

Contents and Workshop Schedule

This intensive workshop can be self taught using the online materials at the lifeedu.us website at the viewers own pace, or through the attached workshop materials.

It can also be presented live by Dr. Albert Kausch (on request). The Worksop live is best accomplished over a 3-5 day period.

Content

Contents

This Entire Lecture Series is available for Free to the Public as YouTube videos. The powerpoint slides are also available for free as an Educational and Teaching Resource at the lifeedu.us website under the Educational Materials Tab (lifeedu.us)

Agricultural Biotechnology

Agriculture: A History and Context

Agriculture Part I. Where Does Our Food Come From?;

Dr. Albert Kausch, University of Rhode Island

YouTube Lecture 13 at http://youtu.be/2dLfA6DCdDQ

Almost none of the foods, fruits, vegetables or grains in our grocery stores existed without human intervention. Most would rapidly go extinct if humans were to suddenly vanished. Corn was invented by humans in Mexico about 9,600 years ago and could not exist without cultivation. In this lecture we look at the history of agriculture and the process of plant domestication and selection from wild relatives. First using dog breeding as an example we can relate the same processes to the breeding of modern apple and *Brassica* varieties. The importance wild plants, plant domestication, varietal selection and modern plant breeding, including the use of hybrids, wide crosses, triploids to make seedless varieties, mutagenesis provide a backdrop to the tools of genetic modification (GM) technologies that some people view as more controversial. The point is that humans have already intervened and that all cultivated plants are the products of that intervention without which we would still be hunting and gathering for our food.

Part II. DNA-based Biotechnology And Modern Agriculture

Dr. Albert Kausch, University of Rhode Island

YouTube Lecture 14 at http://youtu.be/CbLbEsQYyB0

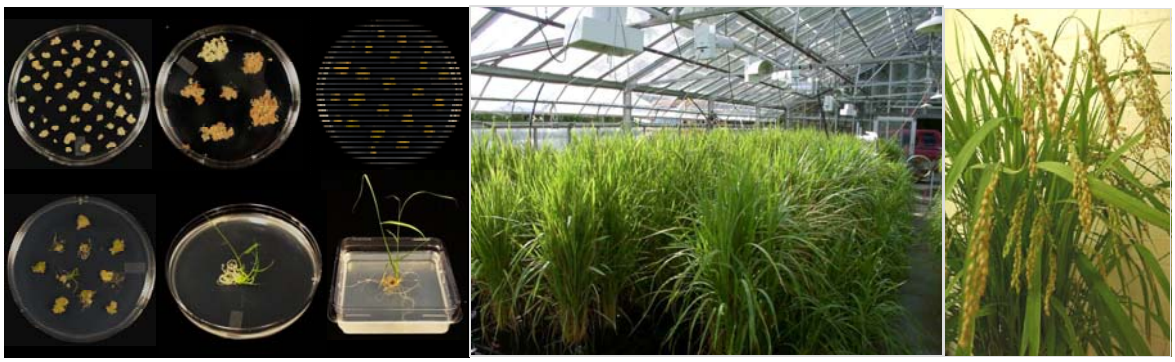

Fig. 2. Genetic Modification of Rice. A. Transgenic events from tissue culture. B. Greenhouse maintenance of lines. C. Mature flowering plant.

Humans have been involved with agriculture for over 10,000 years. Wild plants have been selected and breed specifically by and for human benefit. The tools of modern agriculture include conventional breeding, hybrid plant development, tissue culture mutagenesis breeding, genomics, marker assisted breeding and now, genetic modification as another important tool in the box. Next, we consider GMOs in Food and agriculture; that is- DNA-based Biotechnology And Modern Agriculture: How is DNA-based biotechnology used for crop improvement? (Fig 2). What are the techniques for genetic modification in plants? How is it done? We examine how the techniques and review

gene cloning and construction of transgenes that are applied to agriculture. What is the history of plant gene transfer and genetic engineering? But this section will examine the technical aspects of agricultural biotechnology including:

- **How is it done?**
- **What are the goals?**
- **What has been done so far?**
- **What is in the future?**
- **What are the controversies and concerns**

Ultimately we hope this section shows that gene modification is one more (important) tool in the box for modern agriculture. We also hope that by doing so, this section takes some of the mystery away from Genetically Modified plants, while we are sure it will also raise questions which we hope to address in the next part on Issues, Controversies and Concerns.

Part III. Issues, Controversies and Concerns

Part III. a. Setting the Stage about Food and Agriculture

YouTube Lecture 15 at http://youtu.be/MCgXgvZ7h_Q

The techniques for genetic modification of crop plants has been in place for thirty years and commercialized for over twenty years. The technology has been shown overwhelmingly to be a substantial benefit to world agriculture, has been widely adopted nearly globally, and show to be safe in all regards to human health. After hundreds of studies on human and environmental safety much misinformation still is prevalent in the public appreciation. GMOs have been widely prohibited or banned in Europe; Why? GMOs are not allowed in Organic Food: Why? Are they indeed safe? What about the environment? These are only some of the questions raised by their application. We have already examined how GMOs are made, but this part provides a background to some of the issues, controversies and concerns we develop further in part IIIb.

Part IIIb. Issues, Controversies and Concerns

YouTube Lecture 16 at http://youtu.be/CfEzIgUUGwo

When the public thinks about GMOs in Food many controversies arise. Many of these are the result of a lack of knowledge about the technology and agriculture in general. Hopefully, given the previous parts on this topic the debate is now reasonably informed. Agriculture is a big topic here because many of the applications are already in the market place. Food is something we are all involved with daily. Food is a sensitive topic and every culture has their own food. Many of the applications in agriculture will have parallels in the other applications of biotechnology. The largest challenges in agricultural biotechnology right now are not technological, but those of public perception. The rapidity of new discoveries in biotechnology has exceeded the ability of

the general public to assimilate this knowledge, inhibiting meaningful debate on important social and moral issues.

In these part we consider the basis of some of the issues and controversies, which have merit, which are myth, and which need further consideration. These include:

- **Uncertainty about safety**
- **Regulatory issues**
- **Right of choice: Labeling of GMOs**
- **Environmental concerns**
- **Globalization**
- **Big science, big companies**
- **Distrust of Science**
- **Food culture**
- **"Crossing the line"**

Please contact us via the Forum or email with your questions and comments, and about concerns which we did not address in this part of the series.

Part IIIc. The Organic Food Debate

YouTube Lecture 17 at http://youtu.be/wyvk3HOuULg

The Organic Food industry has been growing steadily in the US for many years. This growth is correlated to increasing consumer awareness regarding food safety, pesticides, health, environmental protection, agriculture, and animal welfare reforms. The organic Food Industry posted a 5.1% year growth in 2009 and the "US Organic Food Market Analysis", released by the RNCOS Institute, reveals that the industry will achieve a 12.2% Compound Annual Growth Rate (CAGR) during 2010-2014. The fruit and vegetables segment is the most dominant organic foods segment in the US as 38% of the total organic food market. Also, the US Organic Food Industry one of the fastest developing markets during our forecast period. Between 1997 and 2011, U.S. sales of organic foods increased from $3.6 billion to $24.4 billion, and many consumers are willing to pay a premium for these products. Organic foods are often twice as expensive as their conventionally grown counterparts.

Organic food is mostly characterized by using no synthetic fertilizers, no synthetic pesticides and no GMOs. But are organic foods any better for you? Dr. Dena Bravata, MD a senior affiliate with Stanford's Center for Health Policy, and Dr. Crystal Smith-Spangler, MD, MS, an instructor in the school's Division of General Medical Disciplines and a physician-investigator at VA Palo Alto Health Care System, used existing studies to compare organic and conventional foods. Their analysis published in the Sept. 4 2012 issue of *Annals of Internal Medicine*, is the most comprehensive meta-analysis to date, commonly referred to now as the Stanford Study, of existing studies comparing the health benefits of organic foods. They did not find strong evidence that organic foods are more nutritious or carry fewer health risks than conventional alternatives, though consumption of organic foods can reduce the risk of pesticide exposure. Are Organic Foods really better for you or does the Emperor where new clothes? Is Organic Food safe? or this just

another marketing ploy? Is organic agriculture sustainable? Can it provide the amount of food required for the growing world population? Why does it cost more than conventionally grown foods? These are some of the questions posed in this section on the debate on organic food.

Part IV. The Ethics of Agriculture

YouTube Lecture 18 at http://youtu.be/DvEI8YdLCjs

The world population is now 7 billion, and will become 9 billion during the coming generation. World population is growing faster than increases in food supplies and water and arable land are becoming limiting. Over 90% of the population increases will occur in the cities of developing countries. Over 40,000 people die from starvation each day; 1,000,000 people die from vitamin A deficiency each year; it has been said that *"The man who has bread has many problems. The man who has no bread has one."* Who will feed these people? The Northern hemisphere? or themselves? Can biotechnology be used to feed the world? Should biotechnology be used to feed the poor? These are just some of the questions regarding the implementation of global agricultural biotechnology. it has been said however, that "It is imperative that the impediments now obstructing innovations in these critical areas be examined, and those that cannot be justified must be removed".

Part V. Renewable Energy and the Future of Humanity.

YouTube Lecture 19 at http://youtu.be/VsejULxtk3k

What is the carrying capacity of the planet? How many people can we put here until there is a *Tragedy of the Commons?* Oil and fossils fuels took millions of years to make and are a finite resource that we are burning at an alarming rate and probably contributing to global climate change. What are the possible solutions for the future that are renewable and sustainable?

We have seen the far reaching implications of these advancements in how we perceive ourselves and our natural world. We have seen that for much good, much bad can also result from the dual use dilemma of science. "We should not do, just because we can." "In much knowledge there is sorrow, in much wisdom there is pain."; "Once you know, you cannot unknow."; "To whom much is given, much is required" and so "now that you know, know that you now." We have glimpsed the future and ourselves. Hopefully this course has answered as many questions as it has raised and dispelled some myths and misconceptions. Hopefully, this course has also raised some curiosity and inspiration for innovation about how these technologies will be used in the future. Thanks you for your participation! We hope you have really enjoyed this workshop.

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