
The Goal Is Nutritionally Adequate Diets: How Do We Get There?

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Biotechnology has been held up as a critical key to solving the world's nutrition problems. Recent worldwide media coverage of "Golden Rice™" fueled the view that changing a few foods would alleviate world hunger. Unfortunately, this is not likely to be reality. Biotechnology can be an important tool in the world's effort to address malnutrition when used in combination with other important tools.

WORLDWIDE NUTRITION PROBLEMS

An important initial step in realizing the benefit of biotechnology is to fully understand the nature of malnutrition in the world today. Undernutrition (*i.e.*, protein-calorie malnutrition and micronutrient deficiencies) remains an important public-health issue in the developing world. The Food and Agriculture Organization of the United Nations estimates using food-supply data that 17% of the populations in the developing world are undernourished (FAO, 2003). Table 1 provides selected examples of undernutrition and current prevalence figures. Undernutrition has a significant impact on development capacity because it reduces education attainment and worker productivity.

**TABLE 1. PREVALENCE OF NUTRITION-RELATED HEALTH INDICATORS
FOR CHILDREN IN DEVELOPING COUNTRIES.**

Nutrition Related Health Problem	Prevalence Estimates in 2005
Underweight children (0–5 years old)	126.5 million (22.7 %)¹
Stunted children (0–5 years old)	147.5 million (26.5 %)¹
Vitamin A deficient children (0–5 years old)	127.3 million (25.3 %)²
Low birth weight infants	17% of live births³
Iron deficient anemic children (0–5 years old)	45%⁴
Overweight children (0–5 years old)	18.5 million (3.4%)¹

¹SCN (2004). ²2002 figure (West, 2002). ³2004 figure (UNICEF, 2004). ⁴UNICEF/MI (2004).

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As important as undernutrition is, overnutrition is now taking over the spotlight as the world's primary nutrition problem. The number of overweight and obese individuals is now greater worldwide than the number underweight. This is the first time in human history that such a statement could be made. Unfortunately, the health sequelae of obesity are just as serious as those from undernutrition, and the rising cost of healthcare to manage obese individuals with diabetes and cardiovascular disease is rapidly becoming a significant economic burden in many countries. Many developing countries are seeing both over- and under-nutrition in their populations and are ill equipped to deal with either.

In September 2000, 189 members of the United Nations adopted a series of Millennium Development Goals (MDGs) aimed at reducing poverty and hunger. Nutritional status is an indicator for poverty and hunger in several of the eight goals to be met by 2015 (Table 2).

**TABLE 2. UN MILLENNIUM DEVELOPMENT GOALS
(UN GENERAL ASSEMBLY, 2001)**

Eradicate extreme poverty and hunger
Achieve universal primary education
Promote gender equality and empower women
Reduce child mortality
Improve maternal health
Combat HIV/AIDS, malaria and other diseases
Ensure environmental sustainability
Develop a global partnership for development

Various strategies are available to improve nutritional status, including:

- poverty reduction through food-assistance programs, education and training,
- improved food availability through increased production and enhanced trade,
- enhanced food quality through biofortification, fortification and improved food processing,
- dietary diversification through education and improved food-preparation skills.

These strategies are interrelated and must involve broad segments of the population to ensure their sustainability. Those individuals around the world who are suffering from malnutrition—either under- or over-nutrition—require:

- adequate nutrients and other bioactive compounds,
- adequate quantities of food year-round,
- safe, clean food and water,
- enough—but not too many—calories.

LESSONS FROM ILSI WORKSHOPS

The International Life Sciences Institute (ILSI) has been working for more than 25 years to improve the health of people worldwide. Nutrition is one of our primary areas of interest. ILSI is a nonprofit, worldwide foundation that brings together scientists from academia, government, and industry to solve problems with broad implications for the well-being of the general public. Its funding comes from industry, governments and foundations. Additional information is available at <http://www.ilsi.org>.

The potential of biotechnology to help alleviate malnutrition has been a focus within ILSI, using a variety of approaches including international workshops, creation of databases and development of technical guidance. ILSI has also been involved for some time in developing the science base for safety assessment of food derived from biotechnology and providing training seminars for scientists in government, academia, and industry in developing countries. More information about these activities is available on the ILSI Web-site.

In 2002, ILSI, working with the Joint Institute for Food Safety and Applied Nutrition (JIFSAN) at the University of Maryland and with the Institute for Food Policy Research, sponsored a workshop in Cancun, Mexico, on *Biotechnology-Derived Nutritious Foods for Developing Countries: Needs, Opportunities, and Barriers*. Scientists with expertise in nutrition or plant breeding from developing countries in Asia, Africa, of Latin America were invited to participate in a series of plenary sessions and small-group discussions. The objective was to engender innovative thinking about the nutrition problems faced in these countries and feasible solutions to address them.

The workshop format was particularly important to fostering the innovative thinking needed to develop solutions. The important components of the format were:

- the majority of participants were scientists from developing countries,
- participants were evenly divided in expertise between nutrition and plant breeding,
- there was a mix of plenary presentations and small-group discussions.

The proceedings were published in the *Food and Nutrition Bulletin* (Bouis *et al.*, 2002). The small-group discussions generated ideas that the whole group endorsed. These ideas can be segregated into those that relate (i) to the science of

improving nutritional status in developing countries and (ii) to the process of utilizing the science base.

The group described modern biotechnology as an array of tools that provide flexibility and new approaches to improving crops. They strongly recommended a total food-systems approach to addressing nutritional problems, rather than focusing on a single crop or nutrient. Biotechnology should be considered along with traditional breeding practices in finding ways to enhance nutrient content.

The answer will not always involve the transfer of genes. Biotechnology offers the ability to quickly screen cultivars for higher nutrient content or needed agronomic traits, such as resistance to drought or pests. Tissue culture, diagnostics, and trait markers are all part of the biotechnology tool kit. Gene transfer is another valuable tool, but should not be the exclusive focus. The output of such research could be an entirely new crop or a locally used crop that has been adapted in a novel way.

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Bouis (2002) simulated the cost effectiveness of biofortification using data from India and Bangladesh for iron- and zinc-enhanced varieties of rice and wheat. Using conservative assumptions in his simulations, he demonstrated that the return on an investment of \$42 million in conventional breeding would be \$4.9 billion over 10 years in improved nutrition and higher agricultural production. Biotechnology could increase this return by speeding the selection process.

The group of experts expressed interest in finding ways to increase the use of indigenous crops that are currently underutilized. The nutritional quality of these crops could be enhanced, agronomic traits could be improved thereby increasing yields, or improvements could be made to enhance food safety. Specific examples given at this and a follow-up workshop held in Bali, Indonesia, in early 2004, included:

- increased lysine and tryptophan in maize,
- increased beta-carotene in sweet potato,
- increased protein, iron and folic acid in cassava,
- improved disease resistance for papaya and cocoa,
- increased iron and zinc in wheat.

All of these examples focus on undernutrition, but there is a need also to identify approaches to modifying the food supply to address growing obesity worldwide.

Of equal importance to these scientific issues in the minds of the participants were those related to exchange of knowledge about biotechnology. It was readily apparent from the workshop that nutrition experts and plant breeders in developing countries do not often interact. Fostering multidisciplinary exchange is essential to improving nutrient availability. Support for so-called “South-South” exchange—scientists in developing countries exchanging practical scientific knowledge—is vital. There is a real need to develop sustainable networks among interested scientists to facilitate knowledge-exchange.

The workshop participants also acknowledged the need in developing countries to continue to foster broader dialogue about biotechnology—what it is and what it is not—with farmers, food processors, consumers and policymakers. Having specific success stories, *e.g.*, increased profits for local farmers and increased availability of affordable, nutritious foods for consumers, is very helpful in building this dialogue.

ILSI followed up on these recommendations by holding the second workshop, in Bali, Indonesia. *Biotechnology-Derived Nutritious Foods—Challenges and Opportunities in Asia* was cosponsored by the Institut Pertanian Bogor in Indonesia and JIFSAN. Participants were primarily from Asian countries and were again a mixture of experts in nutrition and plant breeding. Rice was a major focus of discussion. Need for sustained dialogue within developing countries was again pointed to as an important requirement for progress.

ILSI CROP COMPOSITION DATABASE

ILSI has developed two additional tools to help to improve nutrient content of the world's food. The first is the Crop Composition Database, which is comprehensive, up-to-date, globally accessible and searchable (www.cropcomposition.org). It was developed by the ILSI International Food Biotechnology Committee (IFBiC) (Ridley *et al.*, 2004). One of the challenges in understanding nutrient composition is to develop valid estimates for natural variation in concentration. Using data from conventional crops grown for comparison purposes, the IFBiC has compiled composition ranges for nutrients and other bio-active compounds for corn, soybean and cotton. More data will be added as they become available.

With more than 70,000 data points, each linked to the validated, analytical method used to generate it, this database complements existing food and nutrient databases, such as the US Department of Agriculture's National Nutrient Database and the Food and Agriculture Organization's INFOODS database. The IFBiC database provides individual measurements (sample from a single plot at one location) as well as summary data including minimum, maximum and average values. The data are from multiple worldwide locations, collected from 1995 to the present.

Specific requests can be made for comprehensive data—all proximates for all years and all locations—or more refined data, for example, a single amino acid in

a particular geography in a single year. Data are available for the whole plant and its parts expressed in terms of fresh and dry weights.

FRAMEWORK FOR NUTRITIONAL AND SAFETY ASSESSMENT OF BIOTECHNOLOGY-DERIVED FOODS

ILSI, through IFBiC, has also published a framework for *Nutritional and Safety Assessments of Foods and Feeds Nutritionally Improved through Biotechnology* (ILSI, 2004). This document discusses scientific approaches and methods needed for such evaluations and provides scientific underpinnings and recommendations. The framework was developed by an expert working group comprised of international academic experts. Their draft was externally reviewed by a larger group of international experts and presented for comment at an international workshop in Paris in December 2003. The revised document was then published.

The key conclusion presented is that existing comprehensive safety and nutritional assessment processes used for agronomic traits are also appropriate for improved nutritional traits. On a case-by-case basis, additional studies may be needed, such as metabolite analysis or nutrient bioavailability and efficacy data. Comparative assessment provides the framework for identifying similarities and differences between a new food and its conventional counterpart. The identified differences become the focus of additional scientific studies.

ILSI will continue to use these tools in training workshops worldwide to transfer scientific knowledge about biotechnology and its safe use to improve the nutritional adequacy of diets. These efforts, combined with those of many others, generate new ideas and share existing scientific knowledge. More research, which will require more resources—financial and human—will be needed as will the continued involvement of the broader community in areas where diets are not nutritionally adequate.

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CONCLUSIONS

Biotechnology offers significant potential for enhancing nutritional quality of foods and for improving agronomic characteristics to increase food availability. Coupled with adequate public-health guidance on scientifically sound dietary patterns and other strategies, real progress can be made toward eliminating malnutrition.

The challenge to make this potential a reality is large, but the benefit is even greater in terms of improving the lives of millions worldwide.

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In January 2004, **SUZANNE HARRIS** assumed the role of executive director for the International Life Sciences Institute, a nonprofit, worldwide foundation established in 1978 to advance the understanding of scientific issues relating to nutrition, food safety, toxicology, risk assessment, and the environment by bringing together scientists from academia, government, industry, and the public sector. She is also executive director of the Human Nutrition Institute



(HNI) of the ILSI's Research Foundation, a position she has held since 1989. HNI is the arm of ILSI responsible for implementing long-term nutrition research programs.

Prior to joining ILSI, Harris was the Deputy Assistant Secretary of Agriculture for Food and Consumer Services from 1985 to 1989. While with the USDA, she assisted in the development of national nutrition and consumer policies, as well as in the oversight of the Food and Nutrition Service, the Human Nutrition Information Service, and the Office of Consumer Advisor.

Prior to joining the USDA, she held faculty positions at the University of Alabama at Birmingham where her primary research interest was in vitamin A and bone formation. She holds a PhD in biochemistry from the University of Alabama at Birmingham and a BA in chemistry from Vanderbilt University.