Food, energy, and the environment[1]

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ABSTRACT During the 2009 annual meeting of the Poultry Science Association, a symposium entitled "Global Views of New Agriculture: Food, Energy, and the Environment" was held that focused on several major issues affecting agriculture. Issues included future funding for basic agricultural research, sustainability, bioenergy, and their effects on global food markets. In many ways, a subtitle for the symposium could have been "Agriculture—Why What We Do Matters." It matters because of the fiscal and physical realities the planet will face in the coming decades relative to human population growth and the increasing demands to feed a hungry world. The challenges are daunting and the technologies to address them will require us to reevaluate the structure and policies we have established relative to agricultural research. In this case, change is all the more difficult because the traditional model of agricultural research has been so successful. One only needs to note the remarkable increases in productivity of the past half century of commodities such as corn and soybeans or feed efficiencies among broilers, laying hens, and turkeys to recognize the significant advancements that have been achieved. However, these historic gains have frequently required increased inputs, most notably fossil fuels. Food production in the future will likely be confronted with concerns involving energy, water, climate change, and the threat of agroterrorism. For example, we will need to develop crops that are more drought-resistant and more tolerant to a wider range of salinities as access to fresh water becomes more problematic. Animal agriculture will also need to adapt to diets composed of atypical feedstuffs. Whether future generations will inherit a world described by Paul Roberts in his books *The End of Oil* and *The End of Food* will be in part determined by the research model we adopt in the near term.

Key words: agricultural research, population growth, food security, public funding

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THE GLOBAL FOOD EQUATION

Projections for human population growth (Figure 1) suggest that by 2050, more than 9 billion people will inhabit the earth (US Census Bureau, 2009). Not only has the absolute number of humans grown dramatically, but the time interval required for each subsequent billion individuals has markedly decreased (Figure 2). The interval required for the addition of another billion humans was 127, 33, 14, 13, and 12 years for 1 to 2 billion, 2 to 3 billion, 3 to 4 billion, 4 to 5 billion, and 5 to 6 billion, respectively (Nova, 2004). Given these population projections, the need for a second transformational shift in agriculture that rivals the "green revolution" pioneered by Norman Borlaug grows more apparent. According to United Nations secretary-general Ban Ki-moon's remarks at the Food and Agriculture Organization of the United Nations High-Level Conference on World Food Security, "The world needs to produce more food. Food production needs to rise by 50 percent by the year 2030 to meet the rising demand" (Ki-moon, 2008). At that same conference, representatives for Pope Benedict XVI remarked that "...one must strongly repeat that hunger and malnutrition are unacceptable in a world that, in reality, possesses production levels, resources and sufficient knowledge to put an end to these dramas and their consequences" (FAO, 2008).

Ironically, the world is faced with two very different sides of the food coin: hunger and obesity (Table 1). In one sense, each condition is an example of malnutrition. However, the global distribution of these nutritional states is far from uniform. A recent World Health Organization report highlights the seeming contradictory aspects of these 2 extremes of the dietary spectrum where: "Paradoxically coexisting with undernutrition, an escalating global epidemic of overweight and obesity—"globesity"—is taking over many parts of the world" (WHO, 2008). As nations transform from "third world" (least developed) to "first world" (developed) status, the frequency of underweight individuals declines significantly (Figure 3). Concomitantly, that

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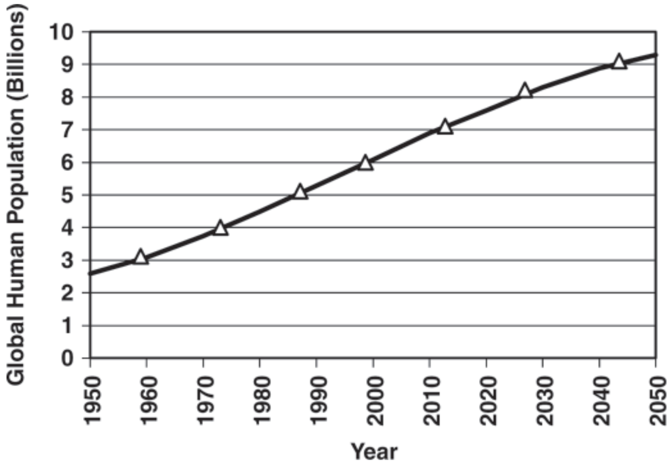

Figure 1. Global population projections. Adapted from US Census Bureau (2009).

transition is also accompanied by a nearly 10-fold increase in obesity.

In the United States, the Centers for Disease Control have monitored the increase in national obesity. In 1985, using a body mass index (kg/m^2) of 30 or more to define obesity, no state in the country had more than 14% of its adults classified as obese (Figure 4). In 2008, only 1 state, Colorado, had less than 20% of its adult population categorized as obese (Figure 5). The South has the greatest prevalence of obesity, with Mississippi (32.8%) and Alabama (31.4%) recording the highest incidences (CDC, 2008). The coexistence of hunger and obesity on a global scale, challenges food producers and processors, public health and policy makers, and nongovernmental organizations to develop effective strategies to address this dichotomy.

THE SUMMER OF OUR DISCONTENT

Whether we ascribe this literal inversion of the opening line of Shakespeare's Richard III or John Steinbeck's final novel, the summer of 2008 was one of crisis and chaos relative to worldwide food and commodity prices. From the Caribbean to Africa to Asia, exploding food prices spawned riots, protests, and instability (Walt, 2008). Historic highs in basic foodstuffs (Figure 6; FAO, 2009) devastated the ability of many in the developing world to obtain adequate nutrition. In the United States, the average consumer has spent less than 10% of their disposable income on food for nearly a decade (USDA, 2008a). In contrast, food costs exceeded 25% of disposable income in 1933. Although the increased cost of food was significant in the industrialized nations, it was in comparison a mere inconvenience relative to the impact felt in the developing world. According to the World Bank, residents in poorer nations often spend up to 50% of their disposal income on food (World Bank, 2008). When the price of a staple foodstuff such as rice more than tripled in August 2008 (Table 2; FAO, 2009), consumers in the third world had few options.

Coinciding with the historic highs in food prices were other elements of the economic storm of the summer

Table 1. National body mass indices (BMI) for adults (WHO, 2008)

Ranking	Nation	%
Obese (BMI ≥30.00)		
1	Nauru	78.5
2	Tonga	56.0
3	French Polynesia	40.9
4	Saudi Arabia	35.6
5	United Arab Emirates	33.7
6	United States of America	32.2
7	Bahrain	28.9
8	Kuwait	28.8
9	Macedonia	25.1
10	Seychelles	25.1
Underweight (BMI <18.50)		
1	India	32.9
2	Pakistan	31.2
3	Ghana	16.4
4	Philippines	13.9
5	Laos	13.5
6	Malaysia	12.3
7	Japan	11.5
8	China	9.5
9	South Africa	8.6
10	Cuba	7.3

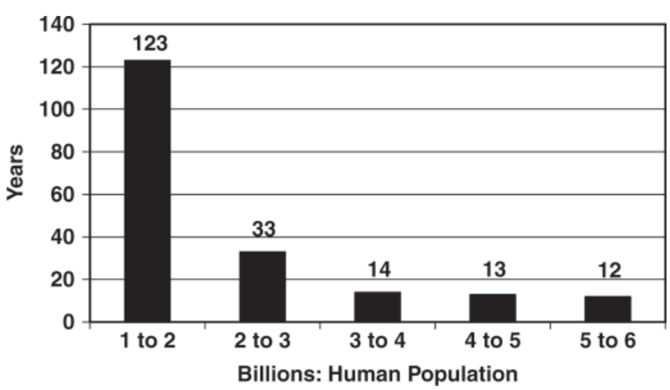

Figure 2. Number of years required for the addition of 1 billion individuals to the human population. Data from Nova (2004).

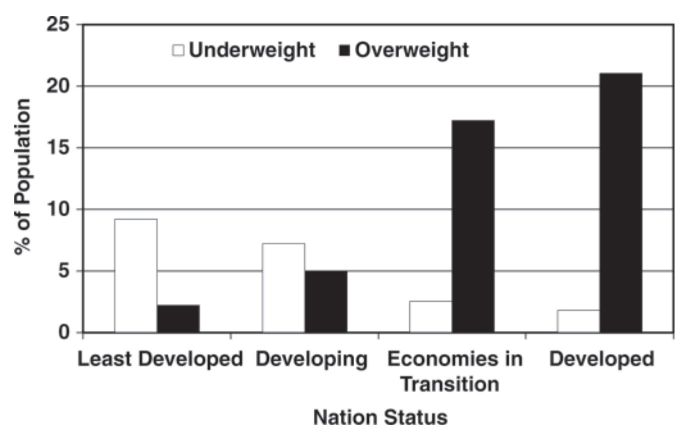

Figure 3. Influence of nation status on the frequency of underweight and overweight individuals. Data from WHO (2008).

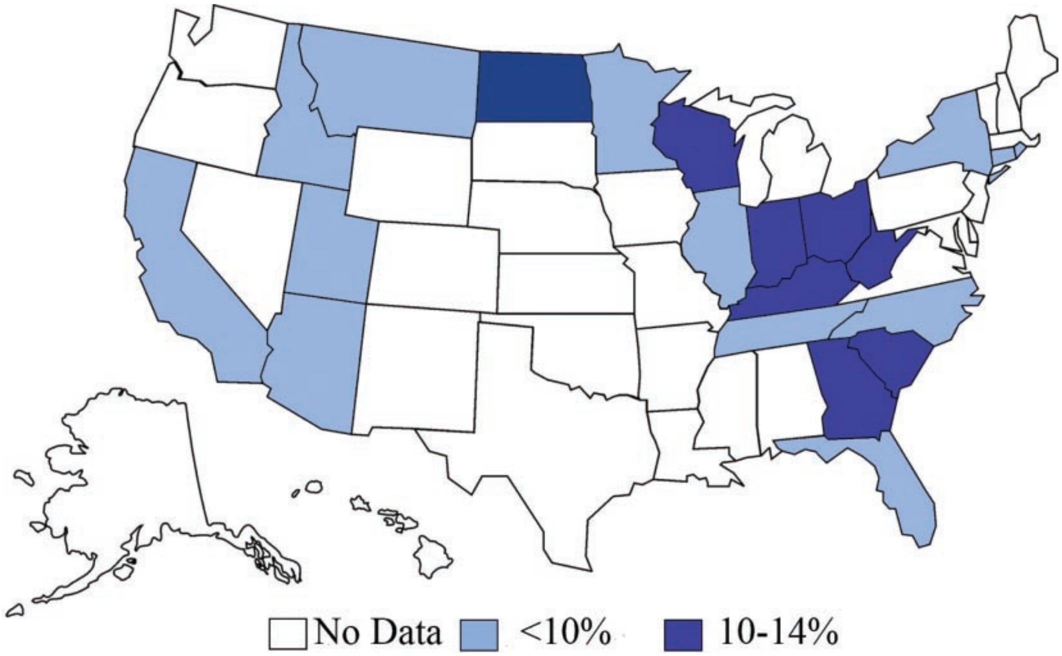

Figure 4. US adult obesity rates in 1985. Adapted from CDC (2008). Color version available in the online PDF.

of 2008: feed, energy, and fertilizer. Collectively, the markets for the 3 "F's," feed, fuel, and fertilizer, produced a scenario in which input costs to commodity producers reached unprecedented heights. All 3 factors were linked through their common relationship to energy. Global demand, speculators, and the diversion of more than a quarter of US corn to ethanol production created a rapid escalation in corn commodity prices (Figure 7). For example, between 2002 and 2008, US ethanol production quadrupled from 7.9 to 34.1 billion liters (2.1 to 9 billion gallons) (Figure 8; RFA, 2009). The Energy Independence and Security Act of 2007 required the use of 136.3 billion liters (36 billion gallons) of renewable fuels in the United States by 2022. Projections suggest that within a decade, 35% of the nation's corn will be used to produce ethanol (USDA, 2009). That potential alone will exert significant upward pressure on corn prices. As recently as December 2005, corn had been selling below $1.90 a bushel. In July 2008, a scant 31 mo later, corn had nearly tripled in value.

Similarly, global petroleum prices recorded tremendous increases in 2008 (Hamilton, 2009). From the late

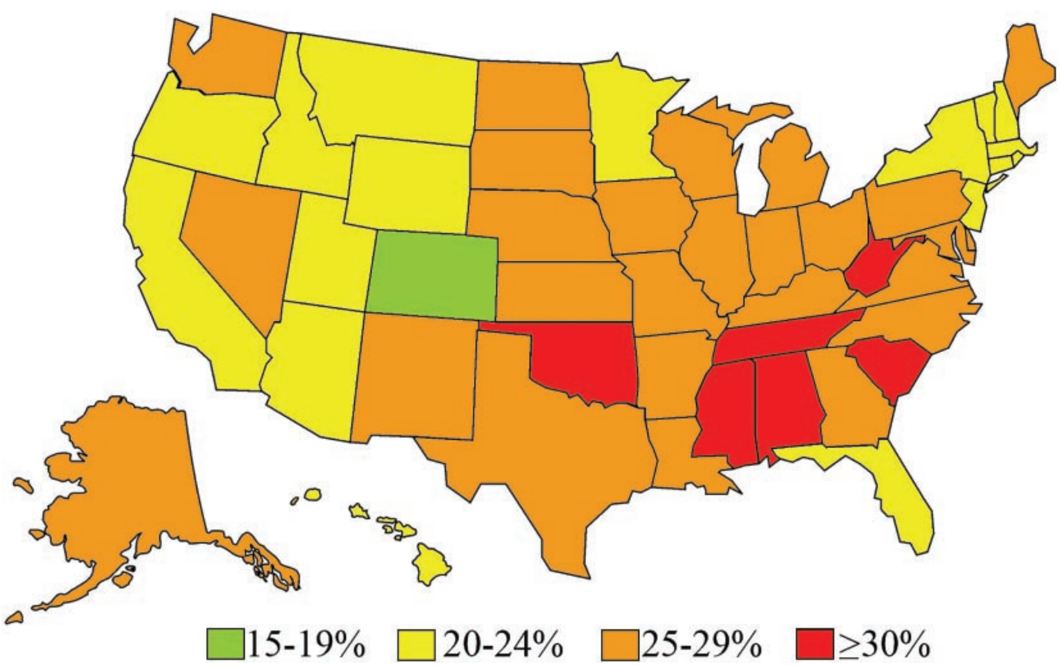

Figure 5. US adult obesity rates in 2008. Adapted from CDC (2008). Color version available in the online PDF.

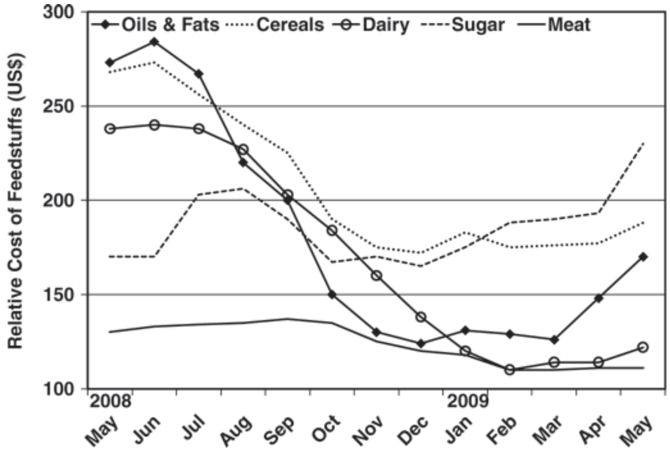

Figure 6. Contemporary trends in the relative costs of basic foodstuffs, 2002 to 2004 = 100. Data from FAO (2009).

1940s to the mid 1970s, a barrel of oil had stabilized around $20 a barrel (Figure 9). The decade that followed witnessed marked increases, with a peak in excess of $100 a barrel occurring during the first quarter of 1980. Six years later, oil prices had fallen to the $30 a barrel range and would remain so for much of the next 2 decades. In early 1999, oil prices had retreated to approximately $15 a barrel. However, by the spring of 2008, oil had risen to greater than a $130 a barrel. At one point in July 2008, the futures market recorded oil at nearly $150 a barrel.

Fertilizer prices tended to follow that of petroleum in 2008. Because much of our commercial fertilizers are produced from natural gas, their cost was directly linked to the cost of energy. Between 2000 and 2008, urea (45 to 46%), super phosphate (44 to 46%), and potassium chloride (60%) increased from $200, $233, and $165 a ton to $552, $800, and $561, respectively (Figure 10; USDA, 2008b).

FUNDING FOR THE NEW AGRICULTURE

Earlier, a reference was made to the agricultural economic storm of 2008 being characterized as the 3 “F’s”: feed, fuel, and fertilizer. When considering future funding for agricultural research, the 3 “P’s,” paradox, public policy, and private, are likely to be part of the conversation. In a sense, “paradox” is a good descriptor when we consider recent US agricultural policy and public attitudes about food production. Imagine trying

Table 2. Food and Agriculture Organization of the United Nations rice price index

Year	Index (2002 to 2004 = 100)
2004	118
2005	125
2006	137
2007	161
2008	295
July 2008	352
July 2009	252

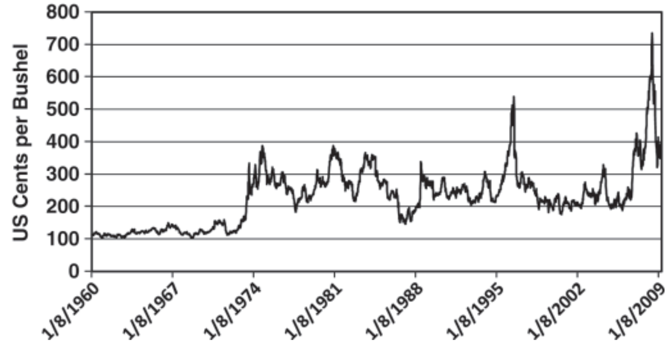

Figure 7. Corn-historic weekly average nearby futures prices. Data from Commodity Research Bureau, Historical Market Data, Nearby Weekly Corn Futures Data (N. E. Piggott, North Carolina State University, personal communication).

to convince members of Congress or the general public that a potential food crisis is emerging and that additional resources need to flow to agricultural research, when there is currently an abundant food supply. In the United States, it is difficult to engender public support when stomachs and grocery store shelves are full and we pay farmers to idle land and not grow certain crops.

Another factor that influences the limited support for the public funding of agricultural research is related to the demonization of large-scale agribusinesses. More than a decade ago, a popular press article entitled “Research support found to vary among species” examined the variation in funding among major food animals (Pardue, 1996). The article generated significant debate and evoked a letter to the editor suggesting that “. . . the industrialization and globalization of agriculture, with domination by a few multinational corporations, may have ended any historic public obligation to support some types of agricultural research” (Cheeke, 1996). Perceptions held by the public and those in government may assume that food, seed, animal health, and plant protection companies, with billions in annual sales, have sufficient resources for research and development and that agriculture no longer needs a public investment in research. That is tantamount to saying that

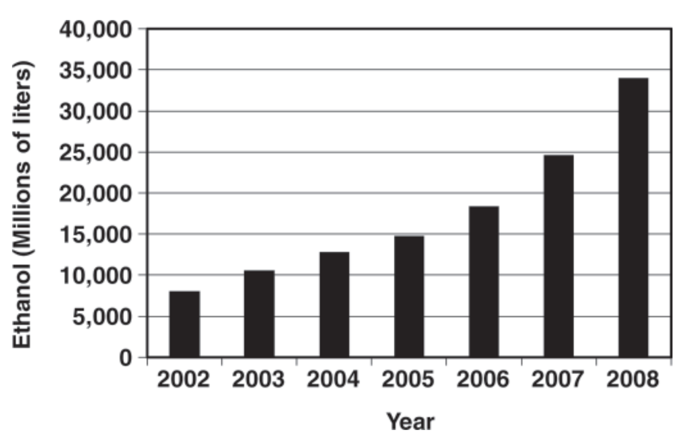

Figure 8. Historic US fuel ethanol production. Data from RFA (2009).

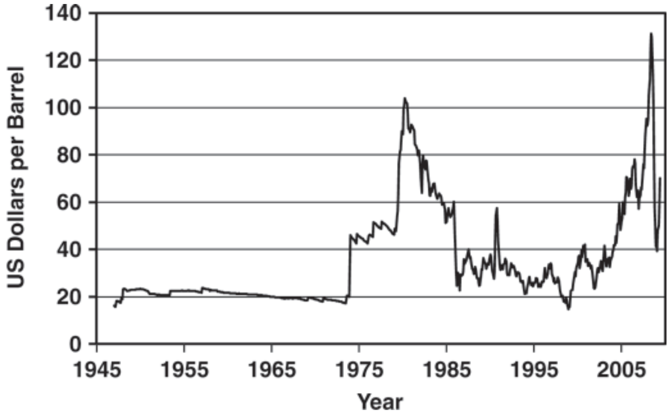

Figure 9. Inflation-adjusted price of crude oil (West Texas Intermediate, 2008 dollars). Data from Hamilton (2009).

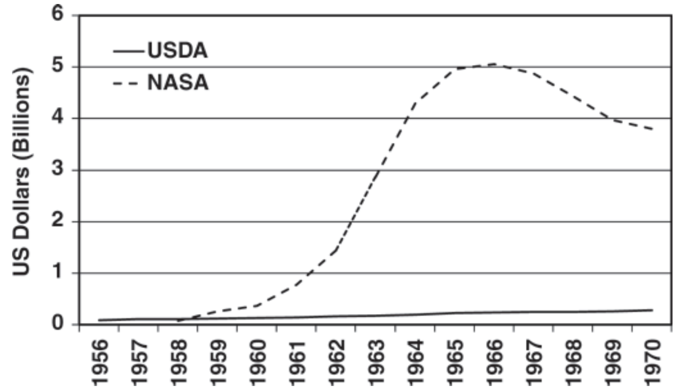

Figure 11. Comparative USDA and National Aeronautics and Space Administration (NASA) research funding trends. Data from NSF (1994).

Boeing or Lockheed Martin no longer needs aerospace engineering programs at public universities. Indeed, a greater percentage of research and development funding for agricultural research is coming from the private sector and this is not a recent trend. In an Economic Research Service report on agricultural research funding in the public and private sectors, private funding for agricultural research and development exceeded that from all public sources, state and federal, for the first time in 1980 (Day-Rubenstein, 2009). Whether or not the public ever had an "obligation" to support agricultural research is open to debate; however, policy makers need to engage in a vigorous discussion as to what is in the public's best interest. We would subscribe that the ability of a nation to feed itself is essential to its long-term stability and sovereignty.

Federal funding for research has frequently been driven by national security and public opinion. The Soviet Sputnik program of the late 1950s and early 1960s was a primary stimulus for the formation of the National Aeronautics and Space Administration in 1958 and triggered a massive ramping up of aerospace research funding. By the mid 1960s, National Aeronautics and Space Administration research funding exceeded that of the USDA by more than 20-fold (Figure 11; NSF, 1994). In more recent decades, funding for the National Institutes of Health (**NIH**) has grown precipitously and to a lesser extent, as has funding for the National Science Foundation (**NSF**) (Figure 12; NSF, 2009). In the early 1970s, federal investment in research for the NIH relative to USDA was approximately 3 to 1. Today that ratio has grown to greater than 12 to 1. Every constituent in a congressional district either knows of family members or friends that are afflicted with disease. It is relatively easy to gain support for funding when the potential outcomes are identifying cures or treatments of life-threatening conditions. The recent federal stimulus package is a clear example of this in which the NIH and NSF received \$10 and \$3 billion, respectively, whereas no research funds for agriculture were included.

For US agriculture, there is not a readily available crisis to create the public demand for increased research funding. To paraphrase a colleague concerning the public's apparent apathy toward supporting agricultural research: the problem agricultural research faces in America is that we have not had a "good" famine in quite some time (J. Brake, North Carolina State University, personal communication). Irrespective of a definable agricultural crisis, changes in how

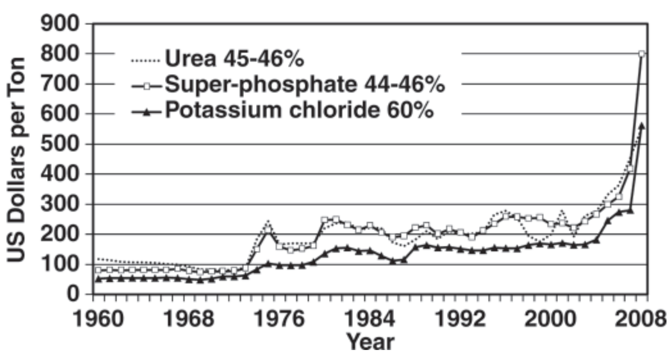

Figure 10. Historic US fertilizer costs. Data from USDA (2008b).

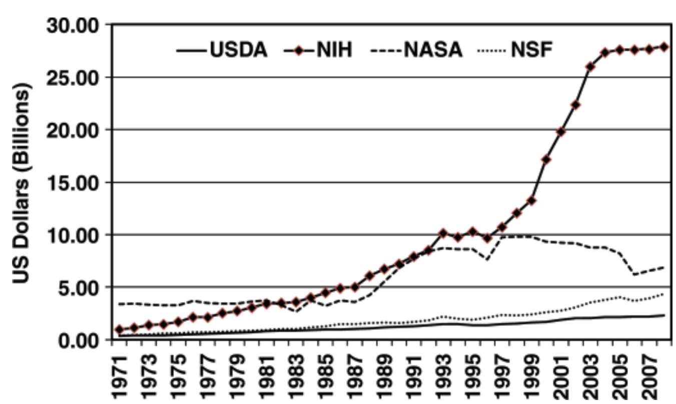

Figure 12. Federal funds (outlays) for research and development by agency. NIH = National Institutes of Health; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation. Data from NSF (2009). Color version available in the online PDF.

the United States approaches research are underway. In 2004, William Danforth led a USDA taskforce to make recommendations to Congress on the creation of a new research model in agriculture (Danforth, 2006). The end result of the taskforce's efforts was the formation of the National Institute of Food and Agriculture (**NIFA**) in 2008, replacing the Cooperative State Research, Education, and Extension Service. Described as transformative, NIFA may follow the model of its better funded and better known sister agencies of the NIH and NSF and focus a greater percentage of its resources in the competitive grants arena. Those agencies allocate nearly 90% of their research dollars via a competitive peer-reviewed process, whereas less than 10% of USDA funding is awarded in that manner. Through its competitive grants program, the Agriculture and Food Research Initiative, NIFA has a mechanism to bring about that transformation. Recently appointed NIFA director Roger N. Beachy hopes that the Agriculture and Food Research Initiative will eventually be allocated $700 million from Congress for competitive grants (Buchen, 2009). What effect this shift in funding will have on the traditional Hatch Act formula funds remains to be seen.

Historically, US agricultural research has had as its foundation formula funds and special grants or earmarks. The result has been the lowest food costs in the developed world. By many metrics, it has been incredibly successful. Conversely, US medical research has followed the peer-reviewed competitive grants model. As a result, remarkable advancements in health care and disease prevention and treatment have occurred. However, the US health system is one of the most costly in the developed world. With funding rates frequently in the low teens for NIH, many promising proposals go unfunded. Formula funds have allowed a wider array of projects to be pursued. Many would, however, suggest that it is not the most efficient model.

If change is difficult and US agricultural research has been profoundly successful, why suggest a new funding model? The answer may be found in perspectives expressed by those in the business world. In the early 1990s, the best-selling book on management titled *If it Ain't Broke...Break It!* challenged conventional wisdom and suggested that companies must change and anticipate shifts in the business environment (Kriegel and Patler, 1991). Similarly, the futurist Joel Barker, who popularized the concept of paradigm shifts, points out that change must occur because the factors that influence profit and loss are not static. Similarly, agriculture will be faced with dynamic shifts in climate change, access to water, energy, and fertilizer, population growth, and geopolitical stability. As Barker has popularized, change does not guarantee success, only the failure to adapt most assuredly leads to failure. With 6.7 billion humans on the planet today and billions more projected in the coming decades, failure is not an option for US agriculture.

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