IV-31 Unintended Consequences

With more choices we loose certainty, but gain realism of unintended consequences and additional limitations.

Often noble experiments and good ideas turn out to be failures in public practice. If science is about extracting generalization from the particulars, delivering science to customers (technology in the market place) is a transition from goals and desires to the particulars in different contexts of reality. Rather than relying on the grandiose, art and politics of technology relies on incremental changes that provide market feed back. Our ability to deal with such a mix goes right to the heart of how to make meaningful choices including the choice of no-choice both as an individual and as a society.

Paradoxically selection criteria for choices also reduce the number of choices. For example as we select from the natural diversity more and more species go into extinction. The same happens to ideas and cultures. Also choice of violence and other forms of extreme behaviors to resolve conflict eliminates virtually all other options. Choice of having a car eliminates the choice of public transport. At a deeper level the distinction between the multi-culture versus monoculture follows from a difference between the sociologically imposed choices versus the individual preferences. Unintended consequences of some well-intentioned choices as part of innovation diffusion are outlined below.

Genetically modified organisms. Evolutionary experience is that sex is good, if it maximizes diversity. Passive genetic engineering with natural and low-tech methods has been used for millennia

for domestication and selective breeding of plants and animals. Thus we have selected strains of animals that do well in their niche environments. In recent years selection pressures have accelerated with the population and consumption demands. Even before the GMO runoff there were fertilizer and toxic agrochemical runoffs from the energy intensive practices. Society is still trying to come to grips with such short term runoffs. For the long term we hardly know what else is there in such Pandora's boxes. At the moment we do not even have ability to ask suitable questions, let alone device solutions against such encroachments.

The term genetically modified organism (GMO) is reserved for those organisms in which the genetic material has been tinkered by human whim of certain perceived advantages. The laboratory technology of gene transfer is orderly: Genes are inserted in the genome of plant tissue literally by shooting beads coated with the DNA of the new genes, or by infecting the host tissue with a pathogenic *Agrobacterium* containing swapped genes. The fist technique seems to work well with grasses and the second with plants with broad-leafs. In both cases, besides the desired gene, the inserted DNA also includes a gene that offers antibiotic resistance. The last capability is necessary to get rid of all the genetic material that is not modified. In such screens the freaks of the genetic stability are also discarded by trial and error.

GMOs encroach on traditional practices. Rather than consideration of food and nutritional value, GMO seeds are chosen for the needs of industry that require uniformity of the product. GMO farming becomes a recipe for another economic noose around the neck of the farmer. Seeds for every crop are sold to the farmers because the GMO seeds often loose their viability in few generations. Beyond the loss of diversity and variety, long term consequences of GMO mixing with natural

germplast are hardly understood. One of the most direct effects of this technology is that in less than a decade GMOs have spread beyond control. In eighteen common crop seeds in USA the GMO content has been found to be 0.05 to 1% in 2003. The modified genes from GMO crops in open fields are beginning to show up in the heritage organisms, such as the traditional corn crops in the far off regions of Mexico. Constraints of traditional organic farming require a deeper understanding of all the factors and forces that balance the ecosystem at the microscopic level. Is the terminator gene inserted in GMO on loose?

Unintended consequences of GMO diffusion

***Bt* gene in crops**: This insecticide gene from *Bacillus thurigensis* was transferred to larvae of monarch butterfly that feed on weeds that grow in the vicinity of the genetically modified crop.

Gene transfer across unrelated species is not uncommon. This is how agents of animal diseases (influenza, SARS, HIV, mad-cow) jump to humans.

Self-replicating biological pollution: Besides seeds, plant products are also used as feed, fertilizer and building materials. GMOs present the risk of exposing other organisms to self-replicating pollutants that do not dissipate with use.

Terminator genes have been introduced in some seed crops. At the very least, the collective shared experience with a crop can not be developed further in the form of a seed. Nature is stopped from experimenting through mutations that may adapt to the local environment.

Nefarious practices of the self-destruct genes included in GMO seeds prevent germination in the subsequent generations. It takes out the control and decision-making, as well as the possibility of the potential benefits that come from the practice and selection.

Lack of label is like an envelope with no return address, i.e. the producers are not willing to take responsibility for their product. This form of primordial deceit by the GMO producers and users raises issues about intellectual honesty.

Flaw in the premise and the argument: It has been argued that the potatoes containing the Bt gene are safe because potatoes are not known to be harmful, and that the Bt gene product is not known to be harmful to humans. Here a lack of substantial evidence one way or the other is being substituted for safety.

Asexual reproduction appears to have some advantages, especially for biotechnology. However, it does not make up for the advantage that after a few generations the sexual modes of reproduction are able to take care of the accumulated genetic defects.

Property rights: GMOs have been claimed on the germ-plasm and genes stolen from traditional crops from the world over.

Uncertainty about the future consequences prevails at virtually all the levels of agricultural biotechnology - ranging from the use of chemicals (fertilizers, insecticides, weed killers) to the seed varieties. A major concern is about the accumulated effects. Unintended consequences of accumulated DDT ingested through the food chain affected the egg-shell of birds that were not directly exposed. Used in increasing strength these insecticides selected for resistant insects and mosquitoes. Overuse of antibiotics in the animal farms and hospitals have triggered selection of the antibiotic-resistant microorganisms.

As for the experience with GMO, consider the case of NewLeaf potato. This GMO is based on Russet variety preferred for the appearance of the fries. Not only nutrition is not a concern for such a selection, their taste has to be spiked with animal

extracts and garnished further with salt and ketchup. The Russet variety is far more prone to diseases. Monoculture of NewLeaf potato requires a large variety of chemicals along with a heavy dose of fertilizer. In fact, about half the price of the produce is used up for such treatments.

Global Warming. Svante Arrhenius in 1896 published a study showing that a doubling of the carbon dioxide levels in the atmosphere would lead to 4 to 5^{o}C (8-10F) warming of the earth's atmosphere. This is virtually half of what has already happened in a century. As a result ice-sheets in the Arctic Ocean are thinning and the glaciers are receding, heat-loving animals and plants are migrating a little closer to the poles. Weather seems to be more freakish than usual and the El Ninos cycle has shrunk from every seven to four years. For the first time in the recorded history tornadoes have appears along the coast of Brazil.

It is virtually certain that a large part of the global warming is the result of industrialization. The natural cycles of temperature change are part of long term geological history of the planet. Without any credible evidence of its own the oil and other interests continue to attack the credibility of the independent results and conclusions. Increased level of atmospheric greenhouse gases, such as carbondioxide formed from the use of fossil fuels like petroleum and coal, that trap heat in the lower atmosphere is something recent. Systematic measurements of carbondioxide levels began in 1950. Based on this data concerns were raised in 1970s about the green-house effect. This attracted worldwide attention. Netherlands started measures to reduce the carbondioxide levels. In spite of a US Congressional hearing in 1989 the warning signs have not translated into action. U. S. produces about 30% of all such emissions on the planet. Only in 2008 the US administrations has grudgingly yielded to the idea of

an international negotiation about reducing levels of such emissions.

Even if we stop using the fossil fuels that are the source of virtually all the new carbon dioxide in the atmosphere, by some estimates the global warming will probably continue for almost a century before the natural corrective processes kick in. In effect, considerable buffering capacity of nature is responsible for slow equilibration - in both the directions.

Ozone-hole. Depletion of the ozone layer is a related story with a happier ending because several decades ago the worldwide action was taken to reduce the rate of depletion of the ozone layer in the stratosphere of the upper atmosphere. This thin layer, at a height of few miles, acts as a filter for ultraviolet radiation from Sun. The radiation is mutagenic and causes increased risk in the incidence of skin cancer. Did this happen because people with lighter skin do not have natural protection from the sunlight?

In late 1950s Rowland and Molina showed that the chlorine derivatives of the small organic compounds reaching the upper atmosphere are degraded by sunlight. A degradation product, chlorine free radical, starts a chain reaction in which millions of ozone molecules are converted to oxygen molecules by a single chlorine radical. Not only the science was compelling, but it suggested that the chlorofluorohydrocarbons (CFC) were the culprit. In the preceding thirty years CFCs had been widely used as the chemically inert refrigerants and propellants for the spray cans of lubricants, furniture polish, antiperspirants and perfume. At first sight cheap, nontoxic and inert CFCs were reasonable alternatives to the toxic ammonia that was used as refrigerant before.

The size of the ozone-hole over the southern hemisphere and the polar cap regions increased as these human-created gases

wafted to the upper atmosphere in ever increasing quantities. Its effect, an increase in the incidences of skin cancer was perceived to be immediate and imminent danger. Chemical companies tried to discredit the science and the observed facts. Thanks to the activism when the facts could not be ignored a tooth-less accord was reached in 1985. As the size of the ozone hole kept increasing the evidence was reconsidered in 1987 and the agreement in Montreal considerably reduced the use of CFCs. With these measures, the ozone-layer depletion has apparently peaked at the 2001 level. It is not clear if ozone is being replenished.

Rituals of innovation diffusion and room for activism. There is no substitute for good science. Often we can not predict outcomes of recent developments, much less convince others of their consequences. For example, many of the technologies inherent in the order created by Linnaeus taxonomy and by Mandelian rules of genetics are just now taking shape after more than a century. Ironically, often more certainty is perceived when distance from the cutting edge of science is maximized.

Natural phenomena may be certain and its technological use may be perceived legitimate. However elements of controversy evolve around certain potentially fallible aspects. The champions of a new-paradigm always have sustained optimism and an unshakable belief in the effectiveness of their means of technological salvation. When faced with counter-evidence, buzz of self-referential word-boxes replaces arguments. Such words include efficiency, value for the money, transparency and accountability of decision-making, empowerment of the practitioners, self-directed learning, multidisciplinary, consumer choices, job-loss. Such strategies are apparent in attempts to fight controls against tobacco, asbestos, solvents, drugs, public health measures, water-gate burglary, ploy of WMD to attack Iraq, and

the debacles of hiding and misrepresenting results of clinical trials of drugs pushed prematurely in the market. Here the goal is to create appearance of controversy until the profit is already maximized and the risks are socialized. The court settlements for such misdeeds ever reach 5% of the profit.

Beyond the fog of mis-information, cry from the interest groups for more evidence is a devise to buy time. Data collection, like exploring a poorly understood territory, plays an important role. There are mechanisms to reduce the uncertainty in poor data. Selectively filtered data from the interest groups can only create confusion. A better understanding of the relations, variables, constraints and hierarchy of a system, while getting feed-back from the results of prescription, is useful for charting a rational course of action based on models that have predictive value.

Need for activism: Clearly there is role for public, beyond the market forces, in the shaping of the technology for social use. The appeal for social activism gains momentum with major disasters. Such events are much more widespread than implicated by events in Bhopal, Chernobyl, Challenger, or Three-mile-Island. In such cases *the closure* refers to perceived legitimacy without admission or assignment of guilt. In science-based policies and projects the public perception of the electorate is a key element in evaluating the spell of science and technology on the society at large.

Disenchantment and intellectualization appears to have replaced the naïve optimism of early science. More information hastens demystification, which probably has little to do with scientific certitude. This is the area of attitudes and beliefs about science uncovered by polls. These are often used as guide for the political spins, pronouncements and leaks. Obviously, the public perception is based on a variety of complex factors skillfully

molded by the army of opinion-makers from the governments, press, industry, and other interest groups. Some of the problems may be amenable to standard non-expert study in terms of the existing laws or known scientific expertise. For example the epidemiological data for the health care needs and its relationship to smoking, exercise and dietary habits. Still other problems may border on the scientifically controversial or unknown where one can only render opinion based on what is known. There are unknown on both sides of decision-making about complex issues. Often what is known is not always relevant to decision making, and what is needed for the decision-making may not be known.

Decision-making is forward-looking anticipation for prediction, adaptation, and prevention of contingencies and emergencies. Public consumption of technologies requires framing the problem in terms of good science, cooperation and consultation. As for any complex system, with multiple variables and relations, there are no magic bullets, no quick-fixes, and no tool boxes. Art of listening to people for feed-back is part of the multi-faceted approach to institutionalize a change. It is to be tailored to specific purposes and fitted to particular circumstances. Agencies capable of building trust and credibility are likely to generate real change. Policy decisions for managing risk (warding off unfavorable or at least protection from its full impact) require elaborating details in a complex situation with varying degrees of technical difficulties. Since there is no formula for future, there is always room for judgment but not for prognostication that may have significant bias and lead to confusion.

Room for Doubt