Chapter 12

Future Developments and Technologies

Predicting the future is always a doubtful undertaking because it is always based on the extrapolation and interpretation of current and past events. It is appealing to create a wishful list of great technological leaps that will enhance our lives in some manner, but examining historical documents, books, or movies that predict their future (and our present) is always fertile ground for comedy. What is most useful is the critical examination of promising new technologies and their potential implications while keeping a sober eye on the realities of the larger scale of world trends and events. It is also useful to understand something about the way new technologies tend to be adopted in an accelerated technological world.

The Gartner Hype Cycle

Studying the world of "the latest thing," particularly in computers and consumer electronics, leads to the conclusion that many types of technology are initially over-promised and can take a good deal of time and effort to become part of the mainstream of whatever applications for which they are intended. The Gartner Hype Cycle, developed by Gartner Research, a consulting firm, illustrates this quite well, and may seem somewhat familiar to those who have bought the latest gadget only to find that the reality does not quite live up to the promise [1]. While this was developed in the overheated Web economies of the 1990s, its applications with appropriate time scaling can apply to nearly any new implementation of technology as it moves from promising discovery to commonplace implementation Figure 12.1.

Stages of the Gartner Hype Cycle

Technology Trigger

The first phase of a Hype Cycle is the *technology trigger* or breakthrough, product launch, or other event that generates significant press exposure and public interest.

Peak of Inflated Expectations

In the next phase, a frenzy of publicity typically generates over-enthusiasm and unrealistic expectations. There may be some successful applications of a technology, but there are typically more failures.

Food and Package Engineering, First Edition. Scott A. Morris.

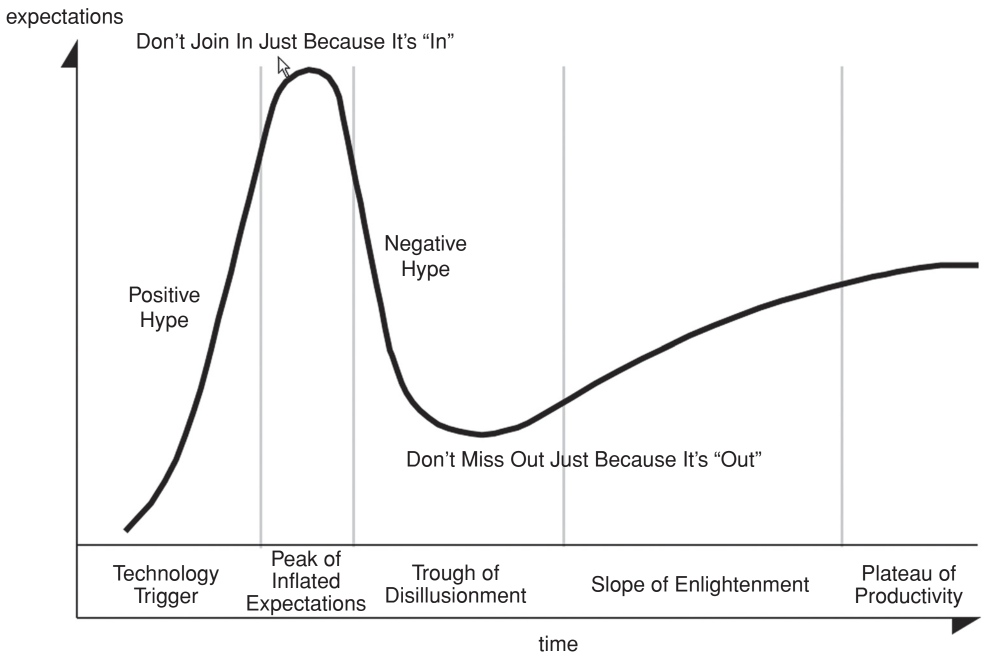

Figure 12.1. The Gartner Hype Cycle
Source: Gartner Inc. Used with Permission

Trough of Disillusionment

Technologies enter the *trough of disillusionment* because they fail to meet inflated expectations and quickly become unfashionable. Consequently, the press usually abandons the topic and the technology.

Slope of Enlightenment

Although the press may have stopped covering the technology, some businesses continue through the *slope* of enlightenment and experiment to understand the benefits and practical application of the technology.

Plateau of Productivity

A technology reaches the *plateau of productivity* as the benefits of it become widely demonstrated and accepted. The technology becomes increasingly stable and evolves in second and third generations. The final level of expectation of the plateau varies according to whether the technology is broadly applicable or benefits only a niche market.

Change and Chaos

Chaos theory is used to describe some types of systems whose values evolve with time. The chaotic aspect comes from the fact that with many of these systems, the exact position or state at a specific time cannot be predicted because minute, often unnoticed changes at the beginning can cause systems to diverge over time. Similarly, minute inputs into physical, social, and economic systems can cause them to deviate from a predicted path. Robert Lorentz, a meteorologist who studied predictive models (and who is responsible for the concept of the *butterfly effect**), found that weather models cannot predict weather accurately more than about a week in advance because of the enormous complexity of the systems and the unknown effects of small changes in initial conditions, as well as the rounding errors inherent in extensive computational modeling systems.

Although history is similarly prone to repeating itself in general terms, the specifics are nearly impossible to predict. Lorentz found that complex systems tended to center around general sets of values (termed "Lorentz Attractors") as their values varied. Thus, although the weather could not be predicted in exact terms, it could be generally said that for most non-polar locations on Earth, the temperature would range between $-50°C$ and $+55°C$, and rainfall would vary from none at all to something less than about 25 meters per year with most local conditions more closely bounded. Considering that the packaging and food processing industries are *laterally integrated*, drawing on and affecting nearly every aspect of society, the prediction of long-term directions will only yield a general set of boundaries among which the future might lie. The use of these concepts in addressing the issue of future technologies lies in the recognition that human endeavors have their own "attractor" metaphors; increased personal wealth, protection of health and safety, personal convenience, and the ability to enjoy one's life, among others. Although the specifics of these concepts vary among individuals and societies, they can point to ideals around which social systems will seek to evolve.

Coupling this concept with the idea of the Gartner hype cycle can provide some insight into the impetus driving the development and implementation of new technologies, and can give an idea of why some technologies are driven quickly through the cycle (or skip it all together) whereas others flounder or fail (or wait for a change in conditions to reappear for evaluation). Beyond this, it is useful to consider some of the broad-scale changes that may occur to influence the nature of food processing and packaging.

Economic Changes

As the industrial base of manufacturing shifts from a nationalistic to an international base, with the current powerhouses of manufacturing, China and India, offering a mix of low labor costs and improving technical infrastructure, the nature of packaging and processing of foods will change as well, although for the United States, the focus of food imports may be closer in Mexico and Central and South America. In 2005, the United States crossed the threshold of importing more food (by dollar value) than it produced internally [2]. This statistic is skewed by the nature of food imports, which tend to be of higher value to justify transportation costs. Nonetheless, the landscape of food manufacturing and packaging has inexorably shifted to an international model, following everything from electronics to automobiles.

With this change, comes a change in many of the factors that make up the food processing and packaging systems. The first of these is economics; because of the likely continuation of high energy costs, and therefore the relatively unfavorable economics of transporting low-value products long distances, it is unlikely that daily commodities such as milk will be processed and imported overseas except for specific, high-value consumer products. For other products that are intrinsically higher in value, such as confections and meat products, imported products are already flowing into the marketplace in increasing volumes, and this trend is likely to continue. The far-reaching consequences of this globalization have yet to be fully determined,

Table 12.1. Food Demand Increase in China in the Period 1999–2009

Product	Increase (%)
Milk	700
Olive Oil	600
Vegetable Oil (non-olive)	200
Poultry	60
Beef	30
Wheat	25

but problems with contaminated or counterfeited products, the spread of new parasites and pathogens, and the shifting infrastructure of supply and demand will all create new challenges with which both packaging and food processing will have to cope.

The locus of the world economy will continue to shift, with an increased presence of developing countries in Asia and perhaps Africa – currently, capital-rich governments such as Kuwait and China are purchasing agricultural land from more fertile countries such as Cambodia and Congo. The long-term effects of this are unknown, but may result in significant changes in the way that multinational agribusiness interests interact with foreign competition.

This change will likely be accompanied by an irreversible increased demand for higher-quality foods, with leaps in production and prices, but also the expanded markets and broad range of infrastructure that may result in a diversity of technologies available for food processing and packaging. An extraordinary example of this is the increase in demand for certain foods by China in the period between 1999 and 2009 [3].

These increased demands will drive a concomitant demand for agricultural supplies, from water to fertilizer, and in competition with crops diverted to heavily subsidized (and therefore financially lucrative) fuels applications. This can only drive production and prices upward, perhaps providing capital for better production and packaging methods, or perhaps driving costs to minimum and requiring shortcuts that would be unacceptable today.

The world of packaging will continue to shift as well in response to economic changes and the diminished safety and environmental requirements for some types of manufacturing. Plastic film and bag imports have shifted to offshore facilities because of the high density (and therefore value) of the final product. Importing empty containers such as cans or bottles does not offer the same incentives as exporting whole manufacturing facilities to produce them locally because of the relatively high shipping costs to transport empty containers – a problem that has long motivated container manufacturers to locate operations close to food producers because it is more efficient to do the converting close to the filling operation.

The complex nature of these systems makes them extremely unpredictable. A shift in labor costs that can make processing in one part of the world more attractive can be canceled in an instant by a fluctuation in transportation costs or the availability of discretionary income to consumers in another part of the globe.

Information Technologies

The nature of information technology is changing so quickly that it may be impossible to track the specifics in a textbook, but several trends are likely to be pervasive over long periods as specific technologies appear and are refined.

Moore's Law was coined by journalist Carver Mead after an observation by Gordon E. Moore, co-founder of the Intel Corporation, that the number of transistors in a minimum-cost circuit doubles approximately every 24 months [4]. The practical implication of this is that computing power for a particular type of device (usually built for a specific market segment and price range) will double every two years, although this figure has been taken to be 18 months by the popular press.

There are several variations of this that may affect technologies in general and several specific applications in the packaging and food processing industry segments in the foreseeable future. The first of these is the divergence of Moore's Law into applications other than the central processing units of computer, and the second is the exponential growth of information sharing and connectivity between devices, and the unintended consequences of this growth.

The Divergence of Moore's Law

The popular take on Moore's law is that computing power doubles every two years, whereas the original observation was that the number of transistors (and by extraction, elementary electronic switching or storage devices contained in a circuit) doubles. This seemingly subtle difference has broader implications in that as processing power and speed grow, so do capacities of peripheral devices such those used for memory, imaging, and communication, all of which require similar elementary components.

Because packaging and food processing are very-high-volume, very-low-cost applications, as noted elsewhere in this book, the plummeting prices for all aspects of circuitry bring truly smart packaging closer to a broad scale of implementation. Similarly, the dropping cost of computational ability and peripheral capacities means that the cost of creating "smart" factories – those capable of self-optimization and flexible manufacturing – become closer to reality for smaller and smaller operations. Additionally, the ease of creating a flexible production operation – one that produces a range of products from a single installed base of equipment – increases markedly. The consequences of this can range from lower production costs to an increase in the number of devices that consumers can truly buy "made to order."

Connectivity

More and more machines are talking to one another at an increasing rate and with increasing sophistication. At this point in time, mobile phones are now sophisticated, networked computers in their own right and can link to any number of other devices. This has led to profound social changes as people in developed countries can connect more conveniently, but has also resulted in profound sociological changes as simple handheld phones become access points to both acquire and disseminate news, financial information, and transactions for people in developing countries and enable them make the leap directly from isolation to global conversation and trade [5].

As with many human problems, the lack of a common language (protocol) for information interchange becomes problematic from time to time, but the trend is clear and communications standards such as the previously mentioned IEC-61131-3 are adapted to cope with this. With an increase in connectivity, problems similar to the globalization of the food supply begin to appear. The most obvious of these are computer viruses and various bits of malware that can exploit the monoculture of the most common operating systems and can (and do) corrupt devices and whole networks with the result of a whole infrastructure based on their prevention being created.

Nonetheless, with decreasing device costs and an increase in the utilization of communication devices, the connectivity of packaging is going to become more and more likely. The most obvious examples of this are RFID devices that are being increasingly incorporated into products, packaging, and even luggage tags at airports. As the cost of producing these devices and the amount of memory available in each device increase, the amount of data transmitted (and, with the addition of simple sensors, collected) will grow enormously. Additionally, links using QR codes can directly link the consumer from packaged good to web and media experiences.

A simple change from IPv4 addressing (four clusters of three numbers, separated by periods that you might see as an Internet address) to IPv6 (six clusters) would raise the number of potential Internet addresses from 2^{32} to 2^{128}, effectively allowing each individual package and product to have its own Internet address for the foreseeable future, although there is a cost in translation time associated with this [6]. This change, similar to the change from simple three- or four-digit telephone numbers to the US standard seven digits (plus area code, if necessary) may offer a great deal more connection density and diversity among devices, objects, environments, and people.

The larger problem – one of a "common language" – may be more troublesome. Communication protocols are relatively standardized within a particular strata of devices (mobile phones, for example), but across product types this may be more difficult. Getting all types of RFID tags to "talk" to all types of cell phones may be more difficult because of different frequencies and different protocols. This tower of Babel may be a limiting factor in the intercommunication of devices and products, though this may not be a bad thing (imagine getting a computer virus in your mobile phone from a tube of toothpaste). The effects of biological engineering, sensor development, massive interconnection, and locative technologies are unlikely to be predictable but will be massively important in the science and engineering as well as economics and marketing of food and packaging products.

On a larger scale, global communication, computation ability, and accessibility can drive information technologies into unheard-of scales and the utilization of cheap, distributed systems that inevitably influence the nature of commerce, markets, and the way economies work. Certainly, the low-cost and high-speed nature of these will play directly into the economic niche within which processed foods and packaging work. Several very early changes such as the implementation of the Rural Free Delivery mail system in the United States and the use of UPC bar coding to speed checkout and inventorying practices have already been discussed in this book.

Engineering Biological Systems

The effects of recombinant DNA and related technologies has already produced a groundswell of promises but has fallen into the secondary phase of the Gartner cycle, one of slow growth and hard work. These have produced interesting and profitable projects such as the production of insulin and the incorporation of herbicide resistance into crops, which have already been marketed. Nonetheless, the potential for new organisms and biologically linked technologies is enormous. Bioplastics, aggressive biosterilants to accentuate or replace current preservation technologies, and other manipulations to provide not only new technologies and materials but entirely unheard-of types of foods and even manipulate the human digestive system may be forthcoming. More interesting is the downward spiral of cost and complexity for these kinds of development processes, mimicking the development of capable, low-cost electronics components that helped spur the Silicon Valley boom in computer design.

Thus, “garage biology” is underway as amateur developers begin to explore under the same set of circumstances that led to explosive developments in electronics several decades ago, with the substantial difference that we are not fundamentally electronic in nature and therefore not susceptible to being infected by a bad or malicious project (electrocution hazards notwithstanding) beyond a burned finger or a blown fuse.

Materials Sciences

Many materials development efforts have a very difficult time with the hype cycle; composite materials have taken years to find widespread implementation in aerospace manufacturing applications for instance, although this has been the result of manufacturing difficulties rather than a fundamental flaw in the materials themselves.

The lucrative market for new packaging materials, as well as the promise of the widespread benefits offered by potential changes, keeps both academic and industrial researchers actively pursuing new materials, surface treatments, and additives. Some of the possibilities for packaging materials to take a more proactive role both in preservation and perhaps even in processing steps (slow, intrinsic processing steps while in storage and transit replacing fast, energy-intensive ones in factories) offer some tantalizing possibilities.

Resource Scarcity

Given the unlikely probability of population growth reaching a plateau under anything but catastrophic circumstances, the Earth’s resources will be ever more hard-pressed, and we will have to move ever farther out on our technological limb to cope with these problems. With recycling growing in profitability, landfills may become the mine sites of the future as past waste is reclaimed and refined in preference to seeking dwindling supplies of difficult-to-obtain materials. The alternative is to pursue politically untenable manipulation of resource-rich countries, which has substantial historical precedent, and inevitable unpleasant consequences.

Changes in the Nature of Change

It has been postulated by genetic biochemists that humans, as a species, have uniquely evolved to be the one species that can directly manipulate its own genetic evolution rather than having it be a matter of chance [7]. Whether this is for better or worse cannot be predicted, but it is one of the certainties of the changeable nature of change itself. We do not know if, in a century, we will be dealing with the same humans among who we are currently living. A simple metabolic change – the ability to host intestinal flora capable of directly digesting cellulose, for instance – could have staggering global implications. In more mundane aspects of technological change, the intrinsic nature of science and engineering is to provide ever-changing tools and paradigms for design and analysis, guaranteeing changes in the way change occurs.

For example, the development of communications capabilities that enable a broadly interconnected population will allow many more people to consider creative solutions to a particular problem, at a cost of increased “noise” and the necessity of understanding group dynamics. Cheap computational analysis can lead to automated engineering and development, many of which are already in use, that can create and even analyze different designs using genetic, adaptive, or other evolutionary and optimization algorithms to provide startlingly unexpected results. All of this may be coupled to broadly distributed information and geolocation databases to provide unforeseen future technologies and benefits, as well as the inevitable problems and inequities. The future is certainly going to occur, but a utopia based solely on complete and static technical solutions to ever-changing social problems is as unlikely as past science fiction movies' flying cars.

Endnote

[*] The butterfly effect, popularized by Lorentz, states generally that the minute effect of a butterfly flapping its wings in China might result in an eventual hurricane in the United States, and refers to the enormous, compounded effects over time of subtle changes in starting conditions.

Additional Resources

1. "Understanding Hype Cycles." Gartner Research. http://www.gartner.com/pages/story.php.id.8795.s.8. jsp. Used with permission.
2. Jerardo, Albert (2004), "The U.S. Ag Trade Balance… More Than Just a Number." *Amber Waves* 2 (1). http://www.ers.usda.gov/amberwaves/February04/pdf/features_agtradebalance.pdf.
3. Carlo Ciani, Caini & Company, quoted in "Green Shoots." *The Economist* (March 19, 2009).
4. "Excerpts from a Conversation with Gordon Moore: Moore's Law." (2005), Intel Museum Archives. ftp://download.intel.com/museum/Moores_Law/Video-Transcripts/Excepts_A_Conversation_with_Gordon_Moore.pdf
5. Hesse, Brian (2007), "The Sky's the Limit – The Mobile Phone in Africa." Paper presented at the annual meeting of the International Studies Association 48th Annual Convention, Hilton Chicago, Chicago, IL, February 28. http://www.allacademic.com/meta/p180641_index.html
6. Edelman, Benjamin (2009), "Running Out of Numbers: Scarcity of IP Addresses and What To Do About It." Working Paper 09–091, Harvard Business School. http://hbswk.hbs.edu/item/6132.html
7. Dr. Morris, Allan J. (1992), Personal Communication.