Ebook
6th Edition

Institute of PACKAGING PROFESSIONALS

Fundamentals of Packaging Technology

The definitive resource on packaging technology.

Reviewed and updated by leading experts and organizations across packaging disciplines.

The official text for IoPP's internationally recognized Certified Packaging Professional program.

Updates throughout.

Includes metric conversions!

Used by major universities and multinational consumer product companies as a packaging classroom text.

Comprehensive answer key for chapter review questions.

FUNDAMENTALS OF PACKAGING TECHNOLOGY

SIXTH EDITION

Institute of
PACKAGING
PROFESSIONALS

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Here's what I find fascinating about packaging: While some things seemingly stand still, certain other aspects of the industry display constant, often rapid, movement. That thought occurred to me after a seminar not too long ago, where the shape of a broken beverage bottle was shown on the screen. Only the bottle neck was intact, and no color, graphics or words accompanied it. Yet, 98% of those in attendance correctly identified the shape as the neck of a Coca-Cola bottle. The bottle's iconic silhouette has stood unchanged for more than 100 years.

A Coca-Cola Bottle Design Brief in 1915 foretold the design's success with a clearly stated objective: "A bottle so distinct that you would recognize it by feel in the dark or lying broken on the ground."

On the other hand, rapid change is evident elsewhere in the industry. Global market growth, sustainability, e-commerce, evolving consumer preferences and supply chain efficiency advances are among drivers profoundly impacting packaging today. Beyond that, we're wrapping our heads around how to bring circularity around packaging, further leverage the penetration of the Internet and smartphones, improve e-commerce efficiency, advance intelligent packaging and use "big data" effectively.

So, too, it goes for the packaging professional. Though many technical fundamentals around packaging generally don't change much, the factors that can influence materials development and selection, design considerations and more are impacted by overarching packaging trends, which do evolve. IoPP's *Fundamentals of Packaging Technology, Sixth Edition,* reflects this march forward well.

The focus of this new edition continues around the packaging basics. But we can't learn the fundamentals in a vacuum apart from the related, impactful factors that swirl around us. This new edition examines not only materials and technologies but also provides a solid, contemporary introduction on matters from sustainability to legal considerations to target audience understanding. This extra foundational knowledge is essential in the toolbox for developing the contemporary packaging professional.

IoPP once again thanks the many individuals and organizations listed in these acknowledgments who have generously given back to the packaging community with their time and expertise to make the update of this book possible. Special thanks go to our editor, Hallie Forcinio, for her eagle eye and coordinating the edits of dozens of subject matter experts. I also want to acknowledge the assistance of Brian Stepowany, CPPL, Fellow, for coordinating a group of IoPP Certified Packaging Professionals in reviewing and updating the study questions concluding each chapter, and the answer key in the back of the book. Finally, IoPP fondly remembers the late Walter Soroka, CPP. He wrote the first four editions of this book, and his contributions endure on many of these pages.

We're confident *Fundamentals of Packaging Technology, Sixth Edition,* will lay a solid foundation for your understanding of packaging and further your growth in a richly rewarding packaging career.

Jim George
Director of Education
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June 2022

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PERSPECTIVE ON PACKAGING 1

WHAT IS PACKAGING?

Packaging is best described as a coordinated system of preparing goods for transport, distribution, storage, sale and use. It is a complex, dynamic, scientific, artistic and controversial business function. In its most fundamental form, packaging contains, protects/preserves, transports and informs/sells. Packaging is a service function that cannot exist by itself; it needs a product. If there is no product, there is no need for a package.

Packaging functions range from technical to marketing-oriented:

Technical Functions		Marketing Functions	
contain	measure	communicate	promote
protect	dispense	display	sell
preserve	transport	inform	motivate
		connect	engage
		empower	persuade

Technical packaging professionals need science and engineering skills, while marketing professionals need artistic and motivational knowledge. Packaging managers need a basic understanding of both marketing and technical needs, mixed with good business sense. This unusual skill spread makes the packaging industry a unique career choice.

Packaging is not a recent phenomenon. It is an activity closely associated with the evolution of society and can be traced to human beginnings. The nature, degree and amount of packaging at any stage of a society's growth reflect the needs, cultural patterns, material availability and technology of that society. A study of packaging's changing roles and forms over the centuries is, in a very real sense, a study of the growth of civilization.

From an individual perspective, change seems to be that which has already happened, but society is changing daily—meeting new challenges, integrating new knowledge, accommodating new needs and rejecting systems proven to be unac-

Figure 1.1
Packaging of automotive products over the years; refillable glass bottle, metal can, spiral-wound fiber can and high-density polyethylene bottle.

ceptable. Inevitably, these changes are reflected in the way we package, deliver and consume goods.

Because the science of packaging is closely connected to everything we do as a society, it should come as no surprise that the packaging industry is always in a state of change. Entire sectors can become obsolete, or new industries can be generated by the discovery of a new material, process or need. For example, a whole new packaging sector was born with a single tragic tampering incident (the Tylenol episode of October 1982). Society suddenly required tamper-evident closure systems. Or consider the introduction of the aluminum beverage bottle in North America in 2001.

Until the 1950s, motor oil was delivered in bulk to service stations, which in turn measured it into 1-quart glass jars. (See Figure 1.1) The advantages of premeasured oil in metal cans swung the entire trade into metal cans. By the late 1960s, foil/fiber composite cans had replaced metal cans, and by the late 1970s, plastic bottles had replaced fiber cans.

Similarly, milk delivery went from glass bottles to today's variety of plain and aseptic paperboard cartons, plastic bottles and flexible bags, with each packaging method offering its own particular advantages.

How oil or milk will be delivered tomorrow is open to speculation. Packaging choices today typically reflect an increasing need for environmentally-acceptable packaging that will generate minimal waste. The relative costs of petrochemicals, wood pulp and metal will likely govern choices. And finally, the way we buy and consume oil or milk will have a significant impact. No option can be ignored.

PRIMITIVE PACKAGING

We don't know what the first package was, but we can certainly speculate. Primitive humans were nomadic hunters/gatherers; they lived off the land. Such an existence has severe limitations. It takes considerable land area to support the wild animals and vegetation needed to feed a single person. Social groupings were small, mostly restricted to extended family units.

These early humans would have been subject to the geographical migrations of animals and the seasonal availability of plant food. This meant that humans followed their food sources and quite often went hungry. Such an extreme nomadic existence does not encourage property accumulation beyond what can be carried on one's back.

Nonetheless, primitive people needed containment and carrying devices, and out of this need came the first "package." It was most likely a wrap of leaves, an animal skin, the shell of a nut or gourd or a naturally hollow piece of wood. Any belongings were carried from camp to camp, and evidence suggests that the role of fire-bearer and the "packaging" of fire carried a mystical significance.

Let's jump ahead to 5000 B.C., a time of some domesticated plants and animals. While the forage or hunt was still important, a reasonable food supply was available in a given vicinity. This evolutionary stage, which supported larger social groups, gave birth to small tribal villages. Storage and transport containers were needed for milk, honey, seed grains, nuts and dried meat. Villages with access to different resources traded with their neighbors, requiring transport containers.

Fabricated sacks, baskets and bags, made from materials of plant or animal origin, were added to the primitive packaging list. Wood boxes replaced hollow logs. Clay from a riverbank initially would have been shaped into shallow bowls and allowed to dry in the sun. This worked fine for dry products, but with wet products, the containers quickly reverted to mud. Some impatient Neolithic genius, probably trying to hurry the slow process of sun-drying, placed a clay bowl in a fire. Much to his or her pleasure, the fire-dried clay pots were more durable and held their shape when filled with water. Thus, the pottery and ceramic trade was born.

According to legend, Phoenician sailors, who used salt blocks to protect their fire from the wind on the sandy Mediterranean coast, discovered a hard inert substance in the fire's remains. By 2500 B.C., glass beads and figures were being made in Mesopotamia (today's Iraq). The earliest hollow glass objects appeared in Mesopotamia and Egypt around 1500 B.C.

Ancient Egyptian glass containers were core-formed. Hot strands of glass were wrapped around a core of clay and dung. (See Figure 1.2) Wavy patterns could be introduced by dragging a stick across the soft hot glass. Rolling the glass against a smooth surface flattened and smoothed the strand lines. When the glass was cool, the core was dug out of the container.

Along with metal, these glass containers were the ancient packaging materials. Many centuries would pass before modern materials such as paper and plastics expanded the packager's portfolio.

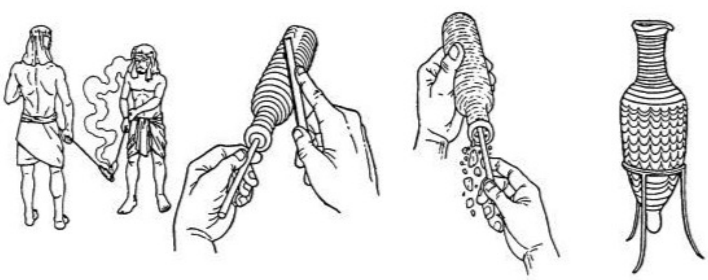

Figure 1.2
Forming a hollow glass vessel around a core. (Source: P. Copeland and H. Martin, *Story of Glass*, Dover Publications, New York.)

Figure 1.3
A portion of a Greek amphora handle dated 220–189 B.C. The stamped image shows a rose, indicating that the olive oil was pressed on the island of Rhodes. The symbol is encircled with the Greek words "in the tenure of Ariston, month of Hyakinthios." (Courtesy Royal Ontario Museum.)

While the printing arts and extensive packaging laws were still in the distant future, laws that affected packaging were being enacted as early as the Greek city-state period (about 250 B.C). For example, olive oil, at that time packaged in amphora (large clay jugs with elongated or pointed bottoms), was marked with a stamp identifying the city-state where it was produced, the time of pressing and the person responsible for it. (See Figure 1.3)

FROM ROME TO THE RENAISSANCE

As time went on, cities were established, trade flourished across the European and Asian continents, and conquering armies frequently sallied forth to plunder some other region's wealth. While the world witnessed many societal changes, the corresponding changes in packaging related mostly to the quality and quantity of existing packaging practices.

An important packaging event, attributed to the Romans in about 50 B.C., was the invention of the glass blowpipe. The blowpipe was a hollow metal rod on the end of which was placed a gob of molten glass. By blowing into the opposite end, the glassblower could inflate the gob into a hollow vessel in a variety of shapes and sizes. The glassblower could shape the vessel freehand by alternately blowing and shaping or blow the glass bubble into a cup mold with pre-existing decorations.

The blowpipe's invention brought glass out of noble households and temples. Roman glass beakers decorated with chariots and gladiator contests—apparently sold as souvenirs and mementos of such events—are reasonably common.

The origin of the first wooden barrel is not clear, but probably also had its start at this time, possibly in the Alpine regions of Europe. The barrel was destined to become one of the most common packaging forms for many centuries.

With the Roman Empire's collapse in about 450 A.D., Europe was reduced to minor city-states and squabbling kingdoms at best, and downright barbarity at worst. Many established arts and crafts were forgotten or became stagnant. The 600 years following the fall of Rome were so devoid of significant change that historians refer to them as the Dark Ages. Any progress came from the Far East and Arabic nations newly inspired by the Muslim faith.

As early symbolic markings on stones and mud tablets evolved into a more formal alphabet, there was a need for lighter, more portable media. The Egyptians produced one of the earlier forms of writing material by weaving together the split stalks of papyrus reeds. By pounding, pressing and drying the woven strips, they created a useful sheet material. Papyrus is not classed as being a true paper, but centuries later, the name "paper" was given to the Chinese invention made of matted plant fibers.

The earliest existing texts on papyrus date to about 500 B.C.

Ts'ai Lun (China) is credited with making the first true paper from the inner bark of mulberry trees about 105 A.D., although more recent archeology has found samples of paper made from hemp and ramie fiber in a tomb dated 140–87 B.C. When the Muslims sacked Samarkand in about 950, they brought three Chinese papermakers, and the secret, back to Spain. From there, the art of papermaking spread slowly throughout Europe.

Printing from woodcuts—the ancient parent of the printing process known as flexography—also originated in the Far East. The oldest existing printed objects are Japanese Buddhist charms dated to 768. The oldest existing book is the *Diamond Sutra*, found in Turkistan and printed in 868.

The European world awoke in about 1100. Neglected crafts were revitalized, learning and the arts were revived and trade increased. Gutenberg printed a Bible using a modified wine press and moveable type in 1455. By the 1500s, the great age of exploration was well underway.

Fundamental social structures had not changed significantly. Most of the population lived off the land, sometimes as freeholders, but more typically as serfs who owed their existence and part of everything they produced to a higher power. For the most part, they ate what they raised, found or caught. At this level, consumer needs were nonexistent.

Shops and stores where a person could buy goods did not exist as we know them. Although money as an exchange medium was available, much of the population never saw any. Manufacturing was strictly a custom business, and what we have called packages to this point were personally crafted, as were most goods. Packages, where they existed, were valuable utensils and were rarely disposable in the manner of a modern package.

Since there was no retail trade, concepts of marketing, advertising, price structures, and distribution were irrelevant. Population levels were not large enough to support mass production, even in the most limited sense.

THE INDUSTRIAL REVOLUTION

Encyclopedia Britannica describes the Industrial Revolution as "the change that transforms a people with peasant occupations and local markets into an industrial society with worldwide connections." This new type of society makes great use of machinery and manufactures goods on a large scale for general consumption.

The Industrial Revolution started in England in about 1700 and spread rapidly through Europe and North America. Some characteristics of this revolution included:

- Rural agricultural workers migrated into cities, where they were employed in factories.

- Inexpensive mass-produced goods became available to a large segment of the population; the consumer society was born.
- Factory workers needed commodities and food that were previously produced largely at home.
- Many shops and stores opened to sell to the newly evolving working class.
- By necessity, some industries were located in nonagricultural areas, requiring that all food be transported into the growing urban settings.

These changes increased the demand for barrels, boxes, kegs, baskets and bags to transport the new consumer commodities and to bring great quantities of food into the cities. The fledgling packaging industry itself had to mechanize to keep up with the growing demand. With large segments of the population living away from food production points, it became necessary to devise ways of preserving food beyond its natural biological life.

THE EVOLUTION OF NEW PACKAGING ROLES

For most of recorded history, people lived in rural communities and were largely self-sufficient. Bulk packaging was the rule, with the barrel being the workhorse of the packaging industry. Flour, apples, biscuits, molasses, gunpowder, whiskey, nails and whale oil were transported in barrels. Packaging served primarily to contain and protect during transport. Individual packaging was of little importance until the Industrial Revolution spurred the growth of cities. The new industrial workers needed to be fed by a separate agricultural system and supported in most of their nonfood needs by the manufacturing skill of others.

City dwellers did not have a farm's storage facilities, and so quantities purchased tended to be small and trips to the shop more frequent. This was an open opportunity to create individual packages in the amounts that people preferred to purchase. In practice, it took many years for this to happen, and even today the transformation is evolving. In the second decade of the 21st century, we are seeing unprecedented stock-keeping unit (SKU) proliferation, as both consumers and retailers want products in packaging formats that reflect their preferences. The advent of technologies including online ordering and digital package printing are making both mass customization and one-to-one marketing possible through packaging.

Initially, shops simply adapted the bulk delivery system to consumer selling. The shopkeeper received apples and biscuits in barrels, cheese in large rounds and herbs or medicines in glass jars. He or she would measure and portion these items, often into a container provided by the purchaser. The shopkeeper sold mostly unfinished products.

Medicines, cosmetics, teas, liquors and other expensive products were the first prepackaged products, along with awkward items such as tacks or pins. The latter often were wrapped in paper, and the expression "a paper of pins" accurately described the product. In time, many products were sold in a "paper."

Products were sold generically. Cheese was cheese, oatmeal was oatmeal and lye soap was lye soap. Sometimes identifying marks were made with a blackening brush or with a hot branding iron on the barrel or cask to show origin or manufacturer. In

Figure 1.4
The Quaker personage as it appeared in 1896 and evolved through the years. In 2017, Quaker Oats slimmed down "Larry" in its logo, on the right, giving him a windswept, more energetic look. Such branding images have to change with time as perceptions and styles change.

time, certain brand marks became associated with quality products. As individual packaging began to develop, quality producers wished to identify their particular product as a guarantee of quality or composition. The brand mark was carried from the bulk package to unit packages or labels. It was an early form of product branding, as well as the origin of the term "brand name."

The first brand names were inevitably those of the maker. Yardley's (1770), Schweppes (1792), Perrier (1863), Smith Brothers (1866) and Colgate (1873) are a few of the personal names that have survived to this day.

Most packages that existed in the mid-1800s were for higher-cost goods, and the evolving printing and decorating arts were applied to these early "upscale" packages. Similarly, it was realized that the papers used to wrap products for sale were easily imprinted with a brand mark, with some message of instruction or with a description of the product's virtue. Many early decorations were based on works of art or national symbols. Labels were printed with ornate and elaborate scrolls, wreaths, allegorical figures or impossibly flawless and shapely ladies (some things are difficult to change!). These often were combined with typography in a dozen typestyles.

Early food can labels had to appeal to simple country folk, so pictures of pastoral life, barnyards and fruit on a branch were commonly used. Sometimes the label graphics had little to do with the contents, and sometimes the same graphic was used on unrelated products. Another popular practice was to display the gold medals won at one or another of the great national and international fairs held frequently at the time. Many early labels were so attractive that they were saved for decorative use.

A packaging milestone was set in 1877 when the American Cereal Company chose a symbol to represent or trademark its product. The Quaker personage represented purity, wholesomeness, honesty and integrity—values that by extension also applied to the product. (See Figure 1.4) It was perhaps one of the earliest forms of what designers refer to as the "persona," a description of the package or product as if it were a person.

After an intense advertising campaign, the company convinced a fair proportion of the population to ask for Quaker Oats rather than just oatmeal. The Quaker figure's success possibly inspired other companies to adopt fictitious persons to represent their products; among them were the former Aunt Jemima brand (1889, now known as Pearl Milling Company) and the Cream of Wheat smiling chef (1893).

Package decoration follows national art styles and trends. Between 1890 and about 1920, decoration followed the art nouveau style popular in that period. This was followed by a period of art deco graphics and designs.

The first plastic, based on cellulose, was made in 1856, but packaging applications were still a long way off. In 1907, phenol-formaldehyde plastic, later known as Bakelite, was discovered. Bakelite's major packaging application was for closures. A few years later, in 1911, a machine was built to manufacture continuous cellulosic film. DuPont chemists perfected the cellulose casting process in 1927 and called their product cellophane. Cellulose films dominated the clear film market until the advent of polyethylene and polypropylene. Bakelite was largely displaced by the newer thermoplastics in the 1960s.

In earlier days, craftspeople sold their own wares and were able to explain the available choices and how best to use a product. Over time, general merchandise stores selling a variety of products from different producers became the norm; but there was still a counter between the customer and the shopkeeper. (See Figure 1.5) In 1916, the Piggly Wiggly grocery store in Memphis, TN, started a whole new trend by introducing the self-serve concept. Now, the shopkeeper was not there to aid or influence the consumer's purchase. Stores with thousands of products were staffed by people who had little or no knowledge of the products and their applications. The consumer was face-to-face with the package, and the package's motivational and informational roles became critical:

- The package had to inform the purchaser.
- The package had to sell the product.

Package design and graphics were suddenly much more than a pretty picture, and a whole new profession, the package designer, was born. (Today, package design teams have become highly sophisticated to include experts in areas as diverse as ethnography, cultural anthropology and structural engineering to study the psychological as well as the physiological impacts of packaging on consumers.) The transformation from bulk packaging to individual packaging and from general stores to supermarkets continued, interrupted only briefly by the shortages of World War II.

PACKAGING IN THE LATE 20TH CENTURY

The birthrate between 1946 and 1964 was so imposing that it earned its own name: the baby boom generation. Demographics, the study of population structure and trends, was universally realized to be an important factor in designing products and packages.

Fast-food outlets made their appearance in the 1950s and created a demand for new kinds of packaging. The consumer met disposable single-serve packaging for the first time, while the fast-food outlets demanded the bulk delivery of ready-to-cook food portions in their own special type of packaging. Later, two other factors joined the fast-food outlet boom to influence packaging: increased levels of public health care and a rapidly growing trend toward eating out rather than at home.

Figure 1.5
A typical store in the middle 1900s. A general store such as this likely stocked well under a thousand product choices. Compare that to a modern discount chain superstore, including a full-service supermarket, which carries more than 140,000 stock-keeping units.

Today, this huge market is a sector unto itself and is sometimes called the HRI (hospital, restaurant and institutional) market.

The 1950s also saw the growth of convenience and prepared-food packages, such as cake mixes, TV dinners, boil-in-bag foods and gravy preparations. A rapidly growing technology added petroleum-derived plastics to the package designer's selection of packaging materials.

Coming-of-age baby boomers were the largest identifiable population segment in the late 1960s, and this was reflected in a major youth orientation in packaging and products. Sexual morality shifted significantly in the 1960s to allow more suggestive and provocative messages. In the 1960s, this was mostly confined to "cheesecake," images of scantily clad women aimed at selling products to men. Its counterpart, "beefcake," did not become common until the more liberated 1980s. Today, the practice continues despite protests that such tactics are inappropriate methods of promoting goods.

Consumerism and a concern for the environment became important factors at this time for those who watched for future trends.

The 1970s and early 1980s—the years of Generation X—brought numerous changes, many of them legislated. Child-resistant closures were mandated for some products. Tamper-evident closures were brought in for others. Labeling laws required the listing of ingredients. International agreements were signed to phase out the use of ozone-depleting chlorofluorocarbons. Standards for the acceptance of new packaging materials were raised.

Microwave ovens became a common household feature, and a significant effort went into devising products and packaging specifically for the microwave. A new health awareness meant not only changes in consuming habits and nutritional labeling but also opportunities for entire new food lines. Yogurt became the "in" food. Bottled water became big business.

In the last decades of the 20th century, millennials and the start of Gen Z came on the scene, and consumers witnessed rapid change. The population aged, and many social habits changed. Families became smaller. Single-person households became common. The domestic housewife became a relic of the past as both partners in a marriage sought professional careers and higher income levels. For the modern urban dweller, "convenient" and "fast" became the operative words in food products. Marketers recognized a whole subclass of people who know only how to boil water or turn on the microwave. If it wasn't ready in five minutes, they didn't want it. If it required more than one dish, their interest waned.

PACKAGING EVOLVING FOR THE MODERN WORLD

Changing Needs and New Roles

The first decades of the 21st century have produced profound social changes as well as technical and commercial evolutions. The population has become more socially distanced; we are as likely to interact with friends and relatives on social media as in-person, many of us work from home at least some of the time and conduct meetings through online chat services. We multitask like never before. These and other developments in human social interaction and the "need for speed" and convenience to make it through our busy days have empowered consumers to rethink how they engage with commerce. The population has continued to age in many developed parts of the world, and with it, changes are needed in packaging to suit consumers with reduced eyesight, strength and finger dexterity. Finally, new dynamics in the supply chain, advancing smartphone capabilities and the impact of increased counterfeiting have created major challenges as well as opportunities for packaging.

In North American culture, men have become more involved in raising the family and maintaining the household; in some cases, men are staying at home or working from home at least part-time and taking on more household and child-raising responsibilities. Women make the bulk of the household purchase decisions, frequently even when they involve men's products. Inside the store, men's products, such as body washes, have emerged in aisles that were once the domain of women. In turn, products marketed and packaged to appeal to women have begun to appear in sections of the store that were once primarily of interest to men, such as auto aftermarket accessories. Conveniences such as packaged, ready-to-eat meals are purchased at the store on the way home from work as consumers attempt to build free time into their hectic day.

E-commerce has become a well-established way of purchasing products in many parts of the world, and the COVID-19 pandemic brought about changes in online shopping frequency and behavior that seem permanent. Today's online shopping world requires retailers and brands to reconsider how they connect meaningfully with socially distanced consumers. In the e-commerce world, the package that arrives at its destination via a delivery service company or in the mailbox often becomes the sole opportunity for retailers and brands to physically interact with consumers. Package design has taken on more critical importance in this channel to give consumers a memorable package "opening experience."

Supply chains are evolving faster and more dynamically than ever before and becoming more complex to ensure that package and product are compliant with regulations and delivered efficiently, economically and undamaged. These considerations take on heightened importance in delivering highly regulated dangerous goods such as lithium batteries, which power products from consumer electronics and tools to medical devices.

Packaging in the modern world also needs to be mindful of the increase in reverse logistics for products purchased through e-commerce. Approximately 25% of e-commerce purchases are returned—for consumer electronics, the frequency is about 50%. Returns must comply with the same hazmat rules as those for shipping items to consumers. A successful total packaging approach in this environment must consider a simple but effective means for returns management that satisfies consumers, mitigates risk, complies with regulations and is mindful of its environmental footprint. Careful attention to packaging considerations is a pillar of a well-rounded e-commerce value chain.

Elsewhere, the need to harness resources and reduce waste and contamination has created a powerful movement to reduce food waste and increase food security across complex global distribution systems and fragmented retail networks. Today's consumers are demanding more from all packaging stakeholders as well as answers to the ongoing matters of sustainability and packaging waste. One result has been the rapid growth of active and intelligent (smart) packaging.

Active packaging can be best described as acting directly on the product, while intelligent packaging relies on interaction with the consumer, shipper or retailer through an external device, such as a smartphone or reader. Today, both are commonly described as smart packaging.

Active packaging tends to be used to extend shelf life or protect perishable products from bacterial or microbial growth. This is achieved by additives and coatings on packaging materials or gas/moisture/air scavenging technologies. Intelligent packaging relies on Quick Response (QR) codes, radio frequency identification (RFID) and near-field communication tags, printed electronics or increasingly used artificial intelligence and vision systems to add unique product identifiers that enable tracking, authentication and consumer engagement.

Active and intelligent packaging can be combined to achieve particular effects and solutions. For example, a color-changing pigment (active) can be added to a scannable timing or temperature device (intelligent) to monitor the condition of a product through the supply chain and provide visual and electronic alerts.

One driver for smart packaging is that consumers no longer want exactly the same product as their neighbors, but they do want it "their way" while benefiting from product availability and lower pricing through scalable production. As the world has become more connected, it is easier for consumers to seek more information about the product they are buying, its provenance, the journey it has made and whether it is authentic. Likewise, the rapid growth of digital printing allows greater personalization of products to give consumers a greater sense of ownership.

From a packaging industry perspective, manufacturers can communicate directly to individual consumers in new ways, as well as receive valuable information about consumer habits. This, in turn, has spawned the development of software platforms to store, sift and interpret this data—it's become known as the "Internet of Things"—in packaging. Products can be given unique digital identities.

An understanding of the intersection of technology and e-commerce is essential for packaging professionals. As mentioned earlier, online shopping has accelerated significantly and fundamentally shifted the way consumers source and purchase products. This acceleration has provided opportunities for some areas of smart packaging, notably RFID devices for inventory and stock management. It has become critical to know where a particular stock item is in order to fulfill an online order from any available source. These devices also can act as in-store or warehouse security devices to stop shrinkage.

This new world presents significant new packaging challenges for both consumer product companies and retailers. Let's look at two factors (there are others). First, from a branding perspective, the product's image (and the brand colors) are not as impactful or clear on an Internet browser. How will you address that and the impact of your brand to ensure the packaged good your consumer viewed and purchased on your website matches what arrives on their doorstep? Second, shoppers today are increasingly likely to visit non-retailer sites such as Amazon.com, rather than go to a retailer's or brand owner's website, to shop and make their purchases. Leading-edge consumer packaged goods companies now regard non-retailer websites as a major sales channel, and they develop products and packaging suitable for that online environment.

One way to stay connected with the consumer is to have some form of device on the packaging, inviting them to make contact via their smartphone. Advances in QR coding and taggants mean these devices can offer a range of immersive features, from simple loyalty programs and special offers to an augmented reality experience.

In recent years, smart packaging developments have accelerated significantly, and new devices and applications continue to arrive on the market. Many brands have seen the value of direct consumer engagement, either as entertainment or as a means of delivering important messages to consumers, such as Coca-Cola's and Tetra Pak's use of connected packs to inform consumers about their sustainability goals and how to dispose of the packs safely for recycling. Other smart packaging technologies that can have multiple effects include thermochromic and photochromic inks. These are popular with beverage brands to indicate when a product is at the correct serving temperature or to provide an exciting visual effect in the dark or under ultraviolet light. They also can indicate that a can or pouch has received the proper sterilization temperature. Likewise, organic light-emitting diodes are being used to create dramatic visual effects, particularly in high-end spirits and cosmetics.

Because online shoppers often don't see the physical packaged product before making their purchase (unless they browse at a traditional store beforehand and then complete their purchase online), the first time they do see their product is when it is delivered. At this point, packaging plays a more crucial role than ever in meeting consumer expectations. If the product arrives damaged or ruined because of packaging that was inadequate for its warehousing and distribution environments, and if the experience of opening the package isn't satisfying, then the consumer might not purchase the product again.

But the intrinsic value of smart packaging is that it can fulfill far more important functions than its entertainment value. Time/temperature indicators are becoming more prevalent, giving a visual alert that a critical product—whether food, pharmaceuticals or even electronics—has exceeded its safe-temperature limit during transport or storage, and for how long. Some treated films that can detect and/or inhibit the presence of bacteria growth within a package are in development. There is particular interest in nano-technologies in this role. Other on-pack drivers, such as e-inks, can automatically and remotely change the expiration date on perishable foods or deliver important usage messages.

Blockchain is increasingly seen as a major boost to food security and is accessed via QR codes. Medical compliance also is an area of primary potential for connected packaging. These devices can be visual, aural or connected to a smart device, both for the patient and medical provider, to show if the regime is being adhered to or even if the medicine is running low and needs replenishment.

Here is an example of how one smart packaging device operates: In its simplest form, the QR Code, a 2-D matrix barcode, is an optical, machine-readable "label" attached to packages or printed directly on the package that records information related to the product inside the package. (Other barcodes are 1-D and limited in the amount of data they can hold.) (See Figure 1.6) Consumers can scan a QR code with a smartphone camera that includes a QR reader to access information. Additionally, the QR code can act as an authentication device for protecting easily counterfeited pharmaceuticals.

A standard QR code is composed of black dots arranged in a square grid on a white background. Encoded information consists of standardized types of data—numeric, alphanumeric, byte/binary. With advances in digital printing technology, QR codes now can contain much more embedded data than previously possible.

As smart packaging accelerates its development, the ability to connect smart packaging with consumers' mobile devices can profoundly influence and affect how packaging is regarded. Some challenges, such as the cost of components, scalable production, performance and issues of recycling components containing metal, are being addressed. Even though these and other challenges remain, consumers continue to become more aware of the potential unleashed for packaging via their smartphones. Consumers want to know more about the products they are buying, and consumer packaged goods companies see smart packaging as an increasingly effective option for marketing products, as well as offering authentication, security, traceability and direct consumer engagement.

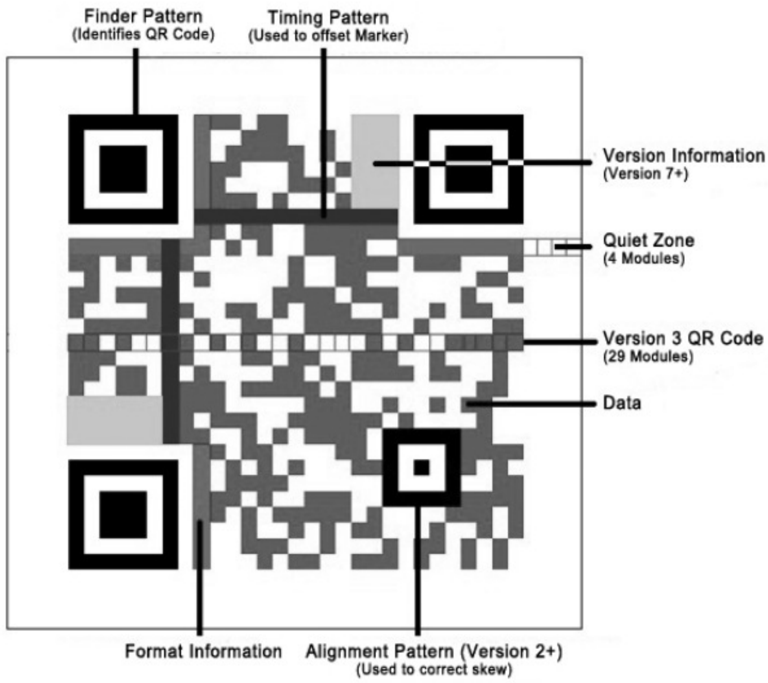

Figure 1.6
Anatomy of a Quick Response code.

Marketing and Production Dynamics: A New World

A host of changing and emerging marketing dynamics is reshaping consumer purchasing experiences in the 21st century. Their impacts on packaging are, in turn, having implications for production processes. Following are three of the major marketing-related forces:

1. **New-age and more connected consumer lifestyles.** Packaging long has been treated as a necessary function, but it also is becoming a strategy that supports business objectives, which are scrambling to keep pace with marketplace preferences—moving targets in their own right. The fundamental marketplace drivers behind this evolution in packaging are:

   - Successful brands deliver relevant differentiation. "The brand is a promise delivered"—this commonly accepted and quoted definition of a brand is increasingly presented in the context of packaging as advertising. For some consumer products, a well-designed package often *is* the product. It is the first impression and a crucial element of the consumer user experience. In other words, package design creates a reason to believe the brand promise and performance expectations, and therefore must deliver on that promise. Package look and feel, form and function, and emotional engagement are all leveraged to deliver brand relevance and differentiation.
   - Consumers have more product information and peer reviews than ever at their fingertips, and therefore are extremely savvy about the products they purchase. Besides a quality product, they are demanding products that reflect their lifestyles. For example, sugar is considered a commodity when packed in paper sacks. But it also is packed in rigid plastic tubs, zippered pouches, plastic reclosable tubs and small sachets. To meet various consumer/user needs, different packaging formats deliver entirely different product perceptions than the traditional paper sack. For more premium items, brand owners can engage their own online communities and exchange information with consumers having similar interests. They can engage them on a website (for example, Kleenex's e-commerce site that enables consumers to personalize tissue cartons for any occasion), on social media websites or by means such as texting to their smartphones.
   - The nature of shopper engagement has changed. Traditional brick-and-mortar retailers are fighting for survival as online businesses such as Amazon, (general online marketplace), TigerDirect (consumer electronics) and Etsy (vintage items, craft supplies) take away market share by offering consumers the convenience of ordering products from their desktop, with none of the limitations that may be associated with shelf space in a store (although supply chain issues can affect them, too). Amazon, in particular, is known for disrupting well-established industries using technological innovation and mass scale.
   - Machine technology and process management are advancing to make possible the package design modifications that product manufacturers and retailers need to engage shoppers. As a result, retailers also are more easily able to function in their own right as brand owners, with private-label products (also called private-brand products) that compete against national brands. In many categories, retailers are delivering two or more private-brand product tiers:

- Low cost, good enough value and quality.
- Undifferentiated—the same as the national brand.
- High cost, high personal value; premium.

Private label is discussed in further detail elsewhere in this chapter.

2. **Maturing and emerging retail channels.** Some retail channels have evolved while new ones have emerged. An example of the former is the discount store, which has evolved to include a full-service supermarket to provide the convenience of one-stop shopping in a superstore. As a result, traditional supermarkets' share of total grocery sales has been declining. Dollar stores compete with discount stores. Club stores and convenience stores offer still other shopper experiences. More recently, Amazon has begun opening Amazon Fresh, an online and physical grocery store. This concept offers same-day delivery and pickup in select locations for Amazon Prime members. Customers who shop in-store can place their orders ahead and save time or take advantage of technology options for skipping the checkout function.

   Each of these retail channels often demands its own packaging formats. Consider salad dressing, for example. The packaging unit could be a single bottle or a two-pack in a discount store or a four-pack at a club store. For dollar stores and institutional customers, salad dressing could be presented as a special single-pouch size. Some retailers welcome point-of-purchase displays while others prohibit them. Competing retailers may each specify their own display pallet configurations. Online merchants may have still other packaging formats that take shipping and handling into consideration.

   In summary, different package formats often are needed to satisfy not only each channel but also individual retailers within each channel. Sometimes a specific store in a retailer's chain wants to respond to current local or regional consumer needs with special limited-edition packaging.

3. **Shorter product life cycles.** E-commerce is making it possible for product manufacturers, and retailers functioning as product manufacturers (through their store brands), to engage in one-on-one conversations with their customers and to understand more about who purchases their products (and why) than ever before. Technologies that are newer to packaging, such as digital printing, are making it possible for consumer product companies to leverage packaging in executing marketing strategies that build very personal relationships between products and customers. Such approaches include regional product adaptations, with packaging to match (mass customization) and enabling consumers to create their own "product" (one-to-one marketing) by choosing a product formulation and then creating or specifying their on-label graphics and text preferences. Packaging plays an essential role in supporting these "just-for-me" product marketing strategies. For many of today's consumer products, the notion of one product, one package is history.

   These are among the marketing-side factors creating product proliferation that was unimaginable a few years ago. Consumer product companies offer a range of packaging formats in which some easily changeable features (graphics, words) are updated often to sustain consumer interest in their brands.

   Marketing dynamics is one side of the 21st-century packaging landscape. At the same time, the expanse of packaging formats and the changes in messaging on package labels are challenging production lines and package development teams to modify packaging not only rapidly but efficiently. The forces of product proliferation and packaging production processes are converging at a time when many manufacturing plants are looking for ways to simplify production, reduce costs and meet compressing time-to-shelf schedules.

Packaging teams that can simplify operational complexity, seamlessly add external service providers such as contract packagers into the mix and also satisfy consumer and retailer packaging preferences will succeed in the contemporary world of packaging. As you go through this book, whether you are a package designer or engineer, or perform some other packaging-related function, you will be well-served if you think of yourself as being part of a team. Each member of the team brings something different to the table to help develop packaging that meets today's complex challenges. Understand the objectives of colleagues who work upstream and downstream of you, and what they need to know from you as they perform their functions in helping to develop packaging that supports business objectives.

Success will be difficult to achieve if individuals work independently of the team—an occurrence that, unfortunately, still exists far too often in package development. For example, package structure might not work hand-in-hand with graphic design if structural designers don't understand and empathize with the work that graphic designers do, and if materials properties and capabilities aren't thoroughly investigated. Even if package structure and graphics work seamlessly, the project may go back to the drawing board—at the cost of a lot of time and expense—because the design process didn't include the insights and suggestions of engineers and line operations experts. So, although the package looks great, it isn't functional on a packaging line. If asked earlier during package development, the engineering and operations experts could have explained such essential factors as to why the proposed new container design won't orient properly on the packaging line.

Maturity of Private Label

IRI Group estimates that, in the United States (U.S.), shoppers spend $1 of every $5 on private-label brands. In Europe, private label's reach is far greater; overall, 53% of consumer good purchases are private-label products. Another influential aspect of modern packaging is reflected in the exploding multitude of products that stores are putting on their shelves, under their own brand names and control, to compete with nationally known brands. Various corners of the packaging industry also refer to private label as private brands and own brands.

Private-label products for years were offered as the "low-price alternative," products that often were inferior in quality to national brands and presented in generic-looking packages or in packages using decorative effects such as labels that sometimes came close to copying the predominant on-pack color and general appearance of the category-leading national brand. Though private-label products saw steady market growth for many years based mostly on price, more recently, retailers' marketing approaches—and packaging's place in them—have matured. As a result, many private-label products today have evolved into brands—with good-quality and high-quality products in original package designs—that appeal to new segments of consumers who view their product selections as an expression of lifestyle.

The business of private label has become highly sophisticated, and numerous surveys find that consumers now more typically believe private-label products are as good as, and in many cases better than or different from, national brands. The maturity of private label today is apparent on multiple levels:

- Sometimes, a retailer offers two or more different products in the same category. One product may be the low-cost offering while another operates at the high end of the quality and price spectrum. Each product competes for different types of consumers, in packaging appropriate for each product's positioning within the category.
- Other private-label products offer the best price-to-performance ratio. They build consumer loyalty by providing the best overall value. Interbrand defines these products as "value innovators," which offer either the lowest price and equal quality or equal price and higher quality, compared to national brands.
- In some cases, a store will offer an exclusive private-label product with a high price point but that also delivers special personal value or premium product quality. Such products aren't available anywhere else, so they help position the retailer as a destination. An example is a supermarket's custom-flavor salsa or jam spread in packaging that connotes a high-quality, exclusive product.

Private label is creating many new product choices for consumers. On the other hand, as mentioned previously, increased choice is making packaging a more complex task to do well. The challenge is magnified for private-label brands. Consider laundry detergent. For a national brand, packaging choices may need to be made for a small number of SKUs—several carton sizes for powdered detergent, a few sizes of bottles for liquids, and perhaps a flexible-film pouch and maybe a laundry pen.

What if a private-label brand offered a competing selection of laundry detergent products? It, too, faces these same packaging challenges. Such is the case with Target's Up & Up brand. (See Figure 1.7) But in addition to laundry detergent, Up & Up products can be found across any Target store—from over-the-counter medications

Figure 1.7
Target considers many packaging challenges for its Up & Up brand spanning approximately 1,200 products around the store.

to baby diapers to household cleaners—approximately 1,200 products and thousands of SKUs spanning more than 40 product categories in numerous packaging formats. For Target, packaging decisions concerning Up & Up are far more complex and horizontal in scope than for the national laundry detergent brand, which views packaging much more vertically and is typically confined to a single section or aisle of the store.

Packaging and the Modern Industrial Society

The importance of packaging to modern industrial society is most evident when we examine the food-packaging sector. Food is organic, having an animal or plant source. One characteristic of organic matter is that, by and large, it has a limited natural biological life. A cut of meat, left alone, might be unfit for human consumption by the next day. Some animal protein products, such as certain seafood, can deteriorate within hours.

The natural shelf life of plant-based food depends on the species and plant part involved. Pulpy fruit portions tend to have a short life span, while seed parts, which in nature have to survive at least until the next growing season, have a longer life. Stalks and leaves separated from the living plant are usually short-lived.

In addition to having a limited natural shelf life, most food is geographically and seasonally specific. Thus, potatoes and apples are grown in a few North American geographical regions and harvested during a short maturation period. In a world without packaging, we would need to live at a point of harvest to enjoy these products, and our enjoyment of them would be restricted to the natural biological life span of each.

It is by proper storage, packaging and transport techniques that we can deliver fresh potatoes and apples, or the products derived from them, throughout the year and throughout the country. Potatoes—whole, canned, powdered, flaked, chipped, frozen and instant—are available anytime, anywhere. Global trade brings fresh lettuce, tomatoes and tropical fruit to those in colder climes throughout their winter. This ability gives a society great freedom and mobility. Unlike less-developed societies, we are no longer restricted in our choice of where to live, since we are no longer tied to the food-producing ability of an area. Food production becomes more specialized and efficient with the growth of packaging. Crops and animal husbandry are moved to where their production is most economical, without regard to the proximity of a market. Most important, we are free of the natural cycles of feast and famine that are typical of societies dependent on natural regional food-producing cycles.

Central processing allows value recovery from food that would normally be wasted. By-products of the processed-food industry form the basis of other sub-industries. (See Figure 1.8) Chicken feathers are high in protein and, when properly milled and treated, can be fed back to the next generation of chickens. Vegetable waste is fed to cattle or pigs. Bagasse, the waste cane from sugar pressing, is a source of fiber for papermaking or can be used as the base feedstock for making ethanol fuel stock.

The economical manufacture of durable goods also depends on good packaging. A product's cost is directly related to production volume. A facility building 10,000 bicycles per year for local sale could not make bicycles as cheaply as a 3-million-unit-a-year plant intended to capture the national market. Both would fail in competition against a 100-million-unit, world-market facility. But for a national or international

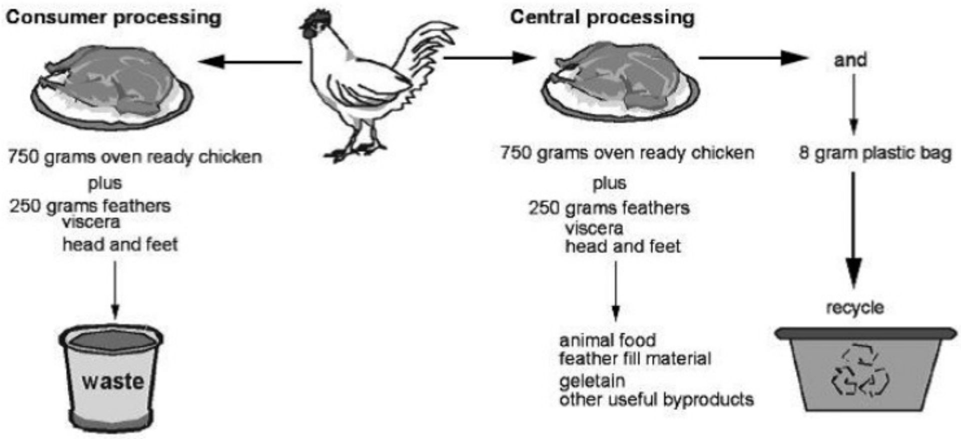

Figure 1.8
By-products collected with central processing can be converted into useful materials.

bicycle producer to succeed, it must find a way to deliver the product to a market, which may be half a world away. Again, sound packaging, in this case, distribution packaging, is key.

Some industries could not exist without an international market. For example, Canada is a manufacturer of irradiation equipment, but the Canadian market (which could account perhaps for one unit every several years) could not possibly support such a manufacturing capability. However, by selling to the world, a manufacturing facility becomes viable. In addition to needing packaging for the irradiation machinery and instrumentation, the sale of irradiation equipment requires the safe packaging and transport of radioactive isotopes, a separate challenge in itself.

A Global View of Packaging

While we often recognize the egg as nature's perfect package, the first man-made package, as mentioned earlier, was quite possibly an animal skin or a stone vessel fashioned in some way to hold water. Its importance cannot be overlooked. In fact, the importance of this invention may be second only to the wheel.

These seemingly simple tools increased mobility among ancient humans. They could explore greater distances from their water source because they could carry water with them. They were safer, too. When thirst struck as the sun went down, or in the middle of the night, they no longer had to go down to the stream, where hungry animals were lurking. Today, packaging still provides similar, if more sophisticated, conveniences for the consumer.

Packaging today is a global business. This means packaging must be adaptive. The only factors separating one culture from another are, primarily, languages and customs. Packaging does all the same things for every society—preserve, protect, contain and so on. How different cultures apply the tenets of packaging is what puts us in different places in terms of complexity, product safety, supply chain factors, source reduction and sustainability.

In North America, packaging is not just protective but also a silent salesperson. In sub-Saharan Africa, packaging simply may be a small bag of clean water needed to quench someone's thirst. Not fancy, but effective. This example shows the importance of the concept of "fit for purpose," and it highlights the need for adaptability in package design and materials development.

Sustainability plays an important role in today's and tomorrow's approach to package development and design. Early in the 21st century, it was generally true that most sustainability initiatives in the packaging sector were more about cost reduction than about an interest in the social importance of building a more sustainable civilization. But that is changing, with increasing momentum, with the growing consumer focus on environmentalism. Many consumers are looking to reduce their total carbon footprint in all aspects of their life, and they are pushing companies associated with the packaging industry to do their part as well. As a result, companies are developing packaging concepts rooted in more sustainable materials and techniques.

In fact, it is easy to argue that packaging engineers, scientists and chemists do a very good job when trying to address the criteria needed to satisfy the principles of a more sustainable society. The real challenge is to convince cultures around the world to treat packaging, especially used packaging, properly. There is a need to educate the general public about how to practice proper reuse and recycling of used packaging.

By all accounts, the business of packaging is growing rapidly. Currently, packaging is a more than $900 billion business worldwide, with expectations of an industry of more than $1 trillion in 2025.

Two significant factors are driving this growth. First and foremost, general population growth, particularly in developing nations, is rapid. According to the United Nations (UN), the world population in 2021 was 7.8 billion people. The UN estimates that by 2050, the world population will be 9.7 billion people, an increase of 59%. Nine countries—India, Nigeria, Pakistan, the Democratic Republic of the Congo, Ethiopia, the United Republic of Tanzania, Indonesia, Egypt and the U.S.—will account for more than half of the projected global population growth in the coming decades. The population of sub-Saharan Africa is expected to double. Meanwhile, the global fertility rate is projected to decline further, and the world's population is aging, with the age group of 65 and older growing the fastest. The need for properly packaged foods, beverages and pharmaceuticals, in packaging older people can carry, open and close, will grow in lock-step with these population changes.

Secondly, and almost as important, the growth of the middle class in these regions will drive the need for packaging for more and more consumer-packaged goods at an even faster rate. Packaging is becoming a good business investment and an excellent career choice that will be a self-sustaining growth sector for decades to come.

This textbook will help educate the reader about how to meet the exploding demand for better packaging. And it will educate capable packaging professionals who will serve society well.

In conclusion, why should Mexico's packaging professionals care about what is going on in the packaging community in Sri Lanka? Why should U.S. packaging professionals concern themselves about what is going on in packaging in sub-Saharan Africa? Why should packaging professionals in Brazil be interested in packaging education in India? Simply put, the opportunity to learn from people with totally different perspectives enriches all civilizations.

Packaging is a unique tool, common to every culture on Earth. As such, it is essential for a better quality of life. It doesn't matter if the packaging professional is

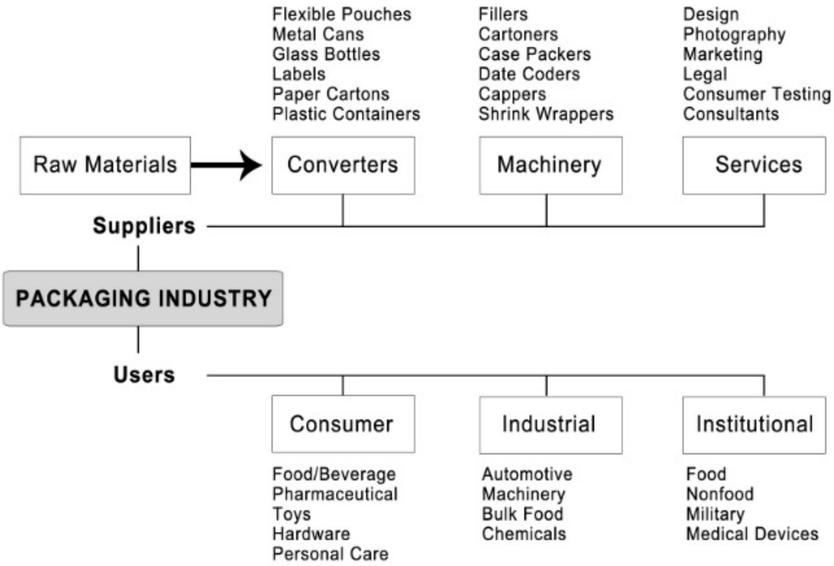

Figure 1.9
The packaging industry can be divided into those that use packaging for their products and those that supply it to these users.

working in México, Sri Lanka, the U.S., or in Ghana, or Brazil, or India. Packaging is a common denominator for all people, everywhere.

THE MODERN PACKAGING INDUSTRY

Drawing clear-cut boundaries around the packaging industry is difficult. Obviously, those manufacturing the physical package (cans, bottles, wraps) are part of the packaging industry. Their function is to take various raw materials and convert them (hence, the general classification of this part of the industry as “converters”) into useful packaging materials or packages. Viewed from this perspective, packaging becomes a materials application science.

In many instances, the company forming the physical package also prints or decorates it. Thus, part of the printing industry and all its attendant suppliers are viewed as part of the packaging industry.

Many user-sector companies, the firms that package products, also are regarded as part of the packaging industry. Package users can be divided into many categories, and each of these can be further subdivided. Each subsector has its own package design requirements. (See Figure 1.9)

The supplier sector, manufacturers of machines for the user sector and the suppliers of ancillary services, such as marketing, consumer testing and graphic design, are also important sectors of the packaging industry.

Serving these industry sectors are a large number of professional societies and trade associations. Some are broad-based general-interest organizations that cover the entire gamut of packaging concerns. Prominent among these is the Institute of Packaging Professionals (IoPP). Associations are more specialized in their packaging focus. Examples are PMMI, the Association for Packaging and Processing Technologies; the Flexible Packaging Association; the Paperboard Packaging Council; the Glass Packaging Institute; the Society of Plastics Engineers; and the Active & Intelligent Packaging Industry Association. The World Packaging Organisation coordinates many international packaging activities. The International Organization for Standardization develops and publishes international standards affecting packaging.

Some associations are not specific to packaging, but their activities are important to the packaging industry. ASTM International and the Technical Association of the Pulp and Paper Industry, for example, supply many material- and package-testing procedures. The International Safe Transit Association is concerned with loss prevention and the safe transit of goods. The decisions of various retailing associations can also greatly impact packaging.

The industry is served by a variety of trade journals, books, packaging-centric websites and blogs and online packaging group discussion sites. IoPP is among the organizations providing social media connections for packaging professionals, with a PackChat online discussion forum for members at www.iopp.org and peer-to-peer connections on LinkedIn, Twitter and Facebook. Beyond these resources, trade shows, conferences, seminars and online educational programs address all aspects of the packaging industry.

Lastly, today's packaging industry is highly regulated. Various aspects of packaging are governed by authorities ranging from federal to local, and it is not always clear which authority has jurisdiction over a particular issue. Ensuring that all legal requirements are met can be especially challenging.

Sustainability and the Environment

A discussion of packaging today means eventually turning to related environmental issues, a vital topic covered extensively in Chapter 5, Environmental and Sustainability Issues. Packaging waste is far less than the typical consumer imagines. In fact, residential waste is much less than half of what is in a typical landfill.

The greater part of what goes into a landfill is construction and demolition, commercial and industrial waste.

The measure of what exactly is going into landfills and what is being recycled or otherwise diverted is a significant problem. Individual waste management jurisdictions have various ways of measuring the waste stream and do not necessarily even agree on what should be measured.

One point of argument is whether waste should be measured by weight or volume. Residential waste removal trucks pick up at the curb by volume. The waste is delivered to the landfill site by weight, but when it is compacted and buried, it again occupies volume. This weight-volume issue is sometimes used to support a company's or an environmental association's platform. The U.S. Environmental Protection Agency (EPA) today reports Municipal Solid Waste (MSW) data by weight rather than volume.

In considering the breakdown of residential waste shown in Table 1.1, one could observe that it would be possible to recycle or compost almost the entire list. This

Table 1.1
Generation, recycling, combustion, energy recovery and landfilling of selected materials in municipal solid waste (in millions of tons and percent of generation of each material). These are national averages; local proportions can vary significantly. (Source: EPA.)

Material	Weight Generated	Weight Recycled	Weight Landfilled	% Recycled	% Combusted	% Landfilled
Paperboard*	67.39	45.97	17.22	68.2%	6.2%	25.6%
Glass	12.25	3.06	7.55	25.0%	13.4%	61.6%
Metals	25.60	8.72	13.93	34.1%	11.5%	54.4%
Plastics	35.68	3.09	26.97	8.7%	15.8%	75.5%
Wood	18.09	3.10	12.15	17.1%	15.7%	67.2%
Other misc.	4.56	0.97	2.93	21.3%	14.4%	64.3%
Food waste	63.13	—	35.28	—	11.9%	55.9%
Yard waste	35.40	—	10.53	—	7.3%	29.7%
Total MSW	**292.36**	**69.09**	**146.12**	**23.6%**	**11.8%**	**50.0%**

****Paper and paperboard***

is true if costs are not considered. It also is important to note that the ranges of residential versus commercial waste are wide in different locations around the U.S.

Environmentalists will maintain that recycling is an issue of the environment, not of economics. This is quite true. However, money expended to recycle a material represents an investment in energy, water and other resources. When the resource investment to recover a material exceeds the value of the material recovered, then the harm to the environment is greater, not less. The process of recycling cannot ignore market economics.

Many consumers are acutely aware of the impacts of waste on the environment, and certainly, sustainability and environment considerations have converged with all the additional packaging created for e-commerce to create a perfect storm in which convenience and single-use packaging hang in the balance against the need to protect our planet for future generations. However, the total environmental impact often is not fully considered when discussing packaging's place in our world. It is important for the packaging professional to talk to all the players who are involved in circularity and to understand all the impacts of packaging decisions to identify the best long-term solutions in what's become known as the "circular economy." For example, corrugated recycles well, but paper requires greater water use than other forms of packaging. Flexible packaging requires less water use in manufacturing but has end-of-use management issues as it struggles to harmonize with the U.S. recycling system and take better advantage of its reuse potential.

Going forward, consumers are looking to product manufacturers, and their supplier networks, for leadership around the packaging of their products to reduce their environmental footprint. They want to feel good about the products they buy. Within that context, the job of the packaging professional is to consider the contents of the package and their end-use situations. This includes the use of sustainable materials in package design and development to provide environmental, social and economic benefits while protecting the environment over the life cycle of a package.

REVIEW QUESTIONS

1. Define "packaging."
2. Although packaging has existed from primitive times, the Industrial Revolution is generally considered as the time when modern packaging was born. What changes at that time lend validity to this statement?
3. What is the origin of the term "branding"?
4. Although there were earlier brand markings, the Quaker Oats brand mark set a new precedent in 1877. What was it?
5. The Quaker personage was one of the earliest uses of the imaginary person. How many other fictitious persons can you think of who were invented to represent a product or company?
6. As shops changed from specialized proprietor-owned outlets to today's large department stores, packaging needed to assume different roles. What were they?
7. What significant social trends and changes affected the way goods were packaged in the decades between 1970 and the 2000s?
8. How have social and technological changes in the 21st century impacted packaging?
9. What are QR codes and how are they used?
10. Packaging plays a vital role in modern society. Explain the significance of that role for: a) food products and b) mass-manufactured durable goods.
11. Why is food loss so high in less-developed countries?
12. Why is the United Nations so interested in packaging?
13. What are two significant factors attributed to the growth of the packaging industry?
14. What are the two major divisions within the packaging industry? Name two subcategories in each major division.
15. How have private-label brands evolved to compete with national brands of products?
16. What are the three major marketing-related forces?

Assignment

Benchmarking is used to compare the effectiveness of a practice with a peer group. For example: How many grams of packaging are needed to hold one liter of drinking water? It is a way of identifying the best practice.

Choose a category with at least five competitors, and determine who has the best practice for that category. Note that the quantity of product contained affects the amount of material that will be used. Some suggested categories are:

motor oil	household vinegar	shampoo	laundry detergent
bottled water	jam	spaghetti	

PACKAGING FUNCTIONS

2

CONTENTS

PACKAGING FUNCTIONS

2

INTRODUCTION

In Chapter 1, Perspective on Packaging, the functions of a package were given as:

- Contain.
- Protect/Preserve.
- Transport.
- Inform/Purchasing Decision.
- End-of-Life.

When discussing packaging functions, keep in mind the different packaging levels:

Primary package	The first wrap or containment of the product that directly holds the product for sale.
Secondary package	A wrap or containment of the primary package.
Distribution or tertiary package (shipper)	A wrap or containment whose prime purpose is to protect the product during distribution and to provide for efficient handling.
Unit load	A group of distribution packages assembled into a single unit for the purpose of mechanical handling, storage and shipping.

Figure 2.1 illustrates some of these levels. In addition, packages are often defined by their intended destination:

Consumer package	A package that will ultimately reach the consumer as a unit of sale from a merchandising outlet.

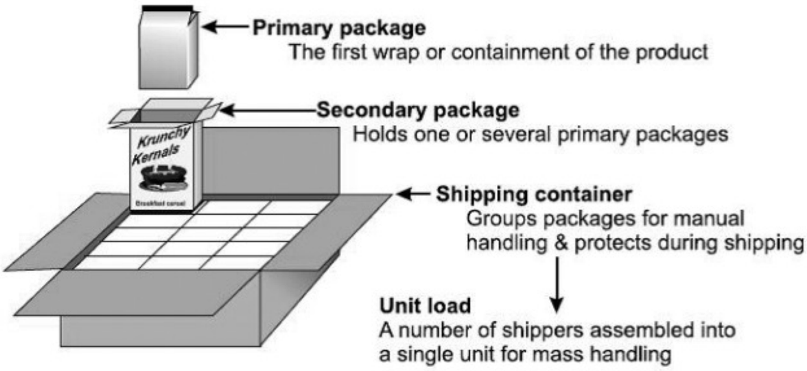

Figure 2.1
Packaging can have many levels. All levels must work together.

Industrial package A package for delivering goods from manufacturer to manufacturer. Industrial packaging usually, but not always, contains goods or materials for further processing. Typically, the inform/sell function plays a less significant role in industrial packaging.

The basic packaging functions have different levels of importance depending on the particular packaging level and intended destination. It is common for several packaging levels to contribute to a single function and for one level of packaging to contribute to several functions.

The primary package for bag-in-box breakfast cereal is the inner undecorated bag. Its main function is to contain and preserve the product, and to a lesser extent, protect it. The secondary package, a paperboard carton, provides physical protection, informs the consumer and motivates the purchase decision. Twelve cartons are packed into a corrugated shipping container to protect the product and facilitate manual handling and warehousing. The information printed on the corrugated shipper primarily identifies the product for distribution purposes. Finally, corrugated shippers are assembled into a unit load, whose primary purpose is to facilitate mechanical handling during transport and distribution.

In some instances, a package will be required to assume all the functions. The primary package for a power tool may be strong enough to protect the product and withstand the rigors of shipping. This single package may feature all the necessary information to inform and motivate the consumer.

THE CONTAIN FUNCTION

The first step in preparing a package design is to consider the nature of the product and the kind of packaging needed to contain the product. These considerations include:

- The product's physical form:

mobile fluid	viscous fluid	solid/fluid mixture
gas/fluid mixture	granular material	paste
free-flowing powder	non-free-flowing powder	solid unit
discrete items	multicomponent mix	

- The product's nature:

corrosive	corrodible	flammable
volatile	perishable	fragile
aseptic	toxic	abrasive
odorous	subject to odor transfer	easily marked
sticky	hygroscopic	under pressure
irregular in shape	temperature-sensitive	shelf-stable

- The product's use:

microwavable	dual-ovenable	portable
single-serve	multipack	reusable
foodservice	boutique	child-resistant
elder-friendly	multi-serve	

Throughout this chapter, the characteristics of various packaging materials will be explained, as well as how their qualities influence effective containment packaging design.

THE PROTECT/PRESERVE FUNCTION

In the context of this chapter, "protect" refers to the prevention of physical damage and pilferage, while "preserve" refers to stopping or inhibiting chemical and biological changes.

To provide physical protection, specifics on what will cause loss of value (damage) must be known. Specifics mean knowing not only the general condition but also a quantified measure of the level at which unacceptable damage starts to occur. (See Table 2.1)

Details of providing suitable product protection appear in Chapter 18, Shock, Vibration and Compression; and to a lesser degree in Chapter 16, Corrugated Fiberboard; Chapter 17, Distribution Packaging; and Chapter 21, Applied Packaging.

Table 2.1
Examples of protective packaging problems and solutions.

Condition	Quantification or Design Requirement
Vibration	Determine resonant frequencies
Mechanical shock	Determine fragility factor (drop height)
Abrasion	Eliminate or isolate relative movement
Deformation	Determine safe compressive load
Temperature	Determine critical values
Relative humidity	Determine critical values
Water	Design liquid barrier
Tampering	Design protective systems

Table 2.2
Typical preservation packaging problems and solutions.

Condition	Quantification or Design Requirement
Oxygen	Determine required barrier level
Carbon dioxide	Determine required barrier level
Other volatiles	Determine nature and barrier level
Light	Design opaque package
Spoilage	Determine nature/chemistry
Incompatibility	Determine nature
Biological deterioration	Determine nature
Deterioration over time	Determine required shelf life

The preservation function as defined above most often refers to the extension of food shelf life beyond the product's natural life, the achievement of commercial sterility in food products or the maintenance of the sterility and efficacy of medical products. Like the protective function, the preservation function needs to be defined and quantified. (See Table 2.2)

THE FOOD PRESERVATION FUNCTION

The Nature of Food

Food is derived from animal or vegetable sources. Its organic nature makes it an unstable commodity in its natural form. Left unprotected, foodstuffs can deteriorate rapidly, sometimes becoming unfit for human consumption within hours. Various means are used to increase the natural shelf life of foods, thus reducing dependence on season and location. To understand how the natural life of foodstuffs is prolonged, it is necessary to understand how food products deteriorate. Food spoilage can occur by three means: internal biological deterioration, external biological deterioration and abiotic deterioration.

Internal biological deterioration describes biological functions that continue even though the food has been harvested. Fruits continue to ripen and vegetables continue to respire. Fresh meat exhibits many of the processes associated with living tissue. For example, myoglobin, which gives meat its red color, continues to interact with atmospheric oxygen.

In some instances, internal biological factors are used to advantage. Fruit, for example, is often picked green or in a firm state; final ripening is a controlled process allowed to take place on the way to the market. Beyond a certain point, however, all biological activity will lead to spoilage and loss of product.

External biological deterioration refers to the action of microorganisms. What is food to us is also food to a host of other organisms. Molds, bacteria and yeasts are present in most foods. Often, they are harmless and even beneficial. In other instances, they can be deadly.

Abiotic deterioration describes changes that are chemical or physical in nature and not dependent on a biological agent. Atmospheric oxygen will chemically react with (oxidize) many substances. For example, vitamin C is no longer a useful nutrient once oxidized; oxidized oils and fats taste rancid.

What is generally described as "taste" more correctly refers only to the sweet, sour, salty, bitter and umami sensations that we detect with the taste sensors located on our tongue. Other mouth sensations are texture or mouthfeel, temperature and chemical burning such as the effect of pepper.

We are also capable of detecting complex volatile substances, variously known as essential oils or sensory active agents. We detect essential oils when minute quantities, in gaseous form, pass over sensors located in our nasal passages. Our sense of smell is highly developed, and we are capable of differentiating thousands of smells or aromas compared to the four tastes we detect in our mouths.

What we perceive as a food product's flavor is a combination of what we detect with our sense of taste combined with what we detect with our sense of smell. Because essential oils are volatile, they are easily lost through evaporation or oxidation. Preservation of essential oils retains the food's full flavor at retail.

Volatiles from outside the package can permeate a packaging material. Many food products are virtual blotters for any stray volatiles in the atmosphere. Absorption of even part-per-million quantities of undesirable volatiles can impart unpleasant odors and off-flavors. Contamination from improperly dried or cured inks and adhesives are common sources of this problem.

The above discussion addresses the importance of controlling the gain or loss of essential oils in food products. Similarly, it is equally important to retain essential oils in many nonfood products where scent is an important attribute. Perfumes, colognes and room fresheners are blends of pure essential oils. Most health and beauty aids such as cosmetics, soaps, shampoos and toothpastes also contain essential oils.

Water vapor is similar to an essential oil in that it readily permeates many packaging materials. Moisture loss or gain can be a deteriorating factor, depending on the nature of the food. A snack food loses quality as it gains moisture while a cake loses quality as it loses moisture.

Temperature can promote undesirable changes that are abiotic. The most common of these are the irreversible changes encountered when some fruits are frozen. The formation of ice crystals punctures the fruit's fragile cell walls, and the fruit loses its desirable character. Thermal abuse also may result in the separation of ingredients, melting/deformation and changes in crystallized structures, which may alter the bioavailability of the ingredient.

Meat Products

Meats are an ideal medium for microorganisms because they contain all the necessary nutrients to sustain growth. In addition to biological action, fatty tissue is susceptible to oxidation, and the entire mass can lose water.

Reduced temperature retards microorganism activity and slows evaporation and chemical reactions such as those associated with oxidation. At 0°C (32°F) and 85%

relative humidity (R.H.), beef carcasses keep for about 21 days. Pork and lamb keep for about 14 days. Beef retail cuts on open display at 5°C (41°F) keep for one or two days. Proper packaging and storage of retail cuts can increase this fresh life to 10 days.

An important marketing factor with red meat is the bright red color associated with freshness. This color results from different oxidation states of myoglobin. Fresh-cut beef tends toward a purplish red color that comes from a slightly oxygen-deficient state. Exposure to controlled amounts of oxygen produces the bright cherry red of oxymyoglobin so desired by the consumer in North America. (Consumers in most other countries do not have an aversion to beef that is not bright red.)

In fact, neither state is wrong. Since North American consumers prefer the bright red appearance, packagers use plastic films that allow the correct amount of oxygen into the package to maintain a bright red appearance.

Fish

The preservation of fresh fish is difficult because:

- Psychrophilic bacteria may be present.
- Many fish oils are unsaturated and oxidize easily.
- Typical fish proteins are not as stable as red meat proteins.

Chilling does not affect the activity of psychrophilic bacteria to the extent it does mesophilic types, so the "keeping quality" of fresh fish is limited. Frozen fish is typically kept at much lower temperatures (–30° C/–22° F) than other frozen foods to ensure the control of psychrophilic bacteria.

Produce

Harvested fruits and vegetables continue to respire and mature. Furthermore, they contain large amounts of water and will wither if water loss is excessive. No two fruits or vegetables are alike, and the rate at which biological and abiotic changes occur varies with the species. For example, peas, green beans and leafy vegetables have high respiration rates compared with those of apples, oranges and pears. Potatoes, turnips and pumpkins respire slowly and are easy to store. Moisture loss is more rapid with lettuce than with a turnip because of the large surface area.

Most fruits have an optimum ripening temperature, usually about 20°C (68°F), and a threshold temperature that will prohibit ripening. Few fruits will ripen below 5°C (41°F). As a rule of thumb, a temperature drop of 10°C (18°F) typically increases shelf life by a factor of three (as long as freezing is avoided). Freezing damages the cell structure of many produce items, and breakdown is very rapid after thawing.

The growth, maturation and ripening of a fruit or vegetable are controlled by various hormones and gases. Increasing the amount of carbon dioxide while reducing the amount of oxygen slows respiration rates. However, some oxygen always must be present to keep the fruit alive. These techniques are used in modified-atmosphere packaging (MAP).

Ethylene gas, produced by plant tissues, is associated with the ripening of many fruits, and its control is effectively used to retard or accelerate the ripening process.

Although particularly sensitive to the atmosphere around them, bananas can remain in a mature but green state for up to six months in atmospheres of 92% nitrogen, 5% oxygen, 3% carbon dioxide and no ethylene. The bananas will ripen normally when transferred to "ripening rooms" containing a few parts per million of ethylene.

As the above discussion illustrates, atmosphere and temperature control are key requirements for extending the shelf life of fresh produce. Packaging for these products must be tailored to the individual product's needs, and trade-offs are necessary. The ideal humidity for most produce is about 90%. At these levels, bacterial and fungal growth is greatly increased. Furthermore, sealed plastic bags are subject to condensation and wetting, which only aggravates the problem. The compromise for many produce items is a perforated or vented plastic wrap. It allows respiration while providing some containment and restraint to loss of moisture. Another option is a packaging film with a high gas-transmission rate.

Some recently developed films have an excellent moisture barrier and low oxygen barrier. One application is for precut salad bags. The high moisture barrier keeps bagged produce from drying out, while the good supply of oxygen allows the produce to respire naturally. The shelf life of precut salads packaged with this material is about 10 days.

Barrier Packaging

We have noted that the movement of gases into or out of a package can lead to undesirable changes in the product. An important factor in the preservation of products that contain gaseous or volatile components or that are susceptible to change through the action of such components is the ability to control the movement of these gases and volatiles. (See Figure 2.2)

Stopping or reducing gas permeation requires barrier packaging. This packaging construction either retains desirable gases and volatiles inside the package or prevents undesirable gases and volatiles from entering the package. Often, barrier packaging must address both conditions. Of the packaging materials available, only glass and metal provide absolute barriers to all gases and volatiles. However, despite superior barrier properties, glass and metal have disadvantages, which prompt packagers to seek plastic alternatives.

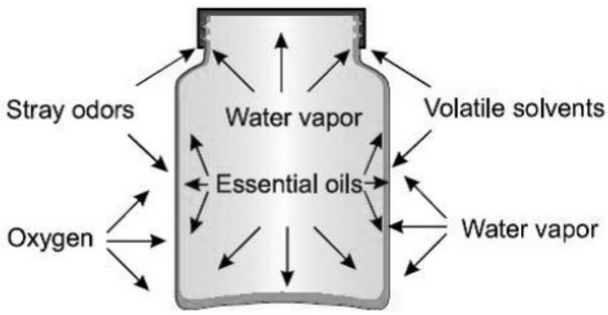

Figure 2.2
A barrier packaging material slows down or stops the movement of selected gaseous substances into or out of a package.

Unfortunately, all plastics have a measurable permeability. The actual permeability varies widely depending on the plastic selected and the nature of the permeant gas or volatile. It is important to understand both the nature of the permeant and the properties of the candidate plastic. The term “high-barrier” plastic is a relative, nonspecific term and should not be taken to mean “absolute” barrier. Furthermore, since any given plastic can be a good barrier to some gases and poor barrier to others, the term must be qualified by identifying the gas to which the statement applies. Barrier properties of specific plastics are discussed in Chapter 10, Polymer Chemistry for the Nonchemist; Chapter 12, Plastic Applications; and Chapter 15, Flexible Packaging Laminates.

Barrier packaging is not always desirable. Fresh produce, for example, continues to respire after harvesting and would shortly consume all the oxygen in an oxygen-barrier package. This condition would lead to reduced shelf life. Plastic bags for produce commonly have vent holes to enable a free exchange of atmospheric gases.

Microorganisms

A large part of food preservation depends on the control of microorganisms, which can be present in various forms. Bacteria or microbes are unicellular microscopic organisms that reproduce by splitting into two identical cells (binary fission). Bacteria grow exponentially and can divide as fast as every 20 minutes. Certain bacterial species can form spores that are extremely difficult to kill.

Molds or fungi are multicellular and unicellular organisms. Although plant-like, neither is capable of producing chlorophyll or carbohydrates. Instead, these organisms depend on outside sources for nutrients. Molds form filamentous branching growths called mycelia and reproduce by spores. Yeasts are similar organisms that reproduce by budding. The propagation and spread of molds and yeasts are typically slower than for bacteria because of the reproduction method.

Typical of any living entity, each microorganism type has a preferred environment in which to exist and propagate. Manipulating the four principal environmental factors that regulate microorganism growth—temperature, moisture, acidity (pH) and nutrient source—controls or eliminates microorganisms. Microorganisms are often classified by their preferred reproduction environment, the most important being the following:

Mesophilic	Prefer ambient conditions, 20–45°C (68–113°F)
Psychrophilic	Prefer cool conditions, 10–25°C (60–77°F)
Thermophilic	Tolerate heat; will propagate at 30–75°C (86–167°F)
Aerobic	Need oxygen to propagate
Anaerobic	Propagate only in the absence of oxygen

Some microorganisms act only on food. They or their by-products may change the nature of the food to either its benefit or detriment but do little harm when ingested. Pathogenic organisms, on the other hand, cause sickness or death. Pathogens fall into two classes:

Table 2.3
Toxin-producing microorganisms and the illnesses they cause.

Organism	Toxin-induced illness
Clostridium botulinum (bacterium)	Botulism
Claviceps purpurea (fungus)	Ergotism
Aspergillus flavus (fungus)	Aflatoxin poisoning

- Those that produce harmful toxins as by-products in the food they infest. Examples of toxin-producing organisms are shown in Table 2.3.
- Those that infest the food and then grow in the human gut and cause illness. Examples include Salmonella, Shigella dysenteriae, Staphylococcus aureus and Escherichia coli.

Extending Shelf Life

Six basic methods are used to extend the normal biological shelf life of food. The methods are used alone or in combination. They are:

- Reduced temperature.
- Thermal processing.
- Water reduction.
- Chemical preservation.
- Modified atmosphere.
- Irradiation.

Each method requires its own unique combination of packaging materials and technology.

Reducing Temperature and Freezing: Reducing temperatures below the ambient temperature has many beneficial effects that lead to longer shelf life. Doing so:

- Slows chemical activity.
- Slows loss of volatiles.
- Reduces or stops biological activity.

While chilling a food product increases its shelf life, actual freezing provides the greatest benefits. Bacteria and molds stop developing at about –8°C (–18°F), and by –18°C (0°F) chemical and microorganism activity stops for most practical purposes. Freezing kills some microorganisms, but not to the extent of commercial usefulness.

Ice crystal formation is greatest between 0 and –5°C (32 and 23°F). Ice crystals can pierce cell walls, destroying the texture of many fruits and vegetables. Rapid freezing minimizes this damage somewhat by reducing the size of the ice crystals.

Freezer conditions will cause ice to sublimate, and serious food dehydration, commonly known as freezer burn, will occur. Snug, good moisture-barrier packaging with a minimum of free air space will reduce freezer dehydration. Complete filling of the package is desirable because ice will sublimate inside the package, dehydrating the product and leaving ice pieces in the voids.

Frozen food package materials must remain flexible at freezer temperatures, provide a good moisture barrier and conform closely to the product. When paperboard is used as part of the package, it should be heavily coated to give protection against the inevitable moisture present in the freezing process. Wax was once commonly used in this coating process but has largely been supplanted by polyethylene.

Poultry packaging in high-barrier polyvinylidene chloride (Saran) bags is an example of an ideal freezer pack. Prepared birds are placed into bags and pass through a vacuum machine that draws the bag around the bird like a second skin. The tight barrier protects against water loss and freezer burn for extended periods and minimizes oxygen transmission that would oxidize fats and oils.

Thermal Processing

High temperatures will destroy microorganisms. The degree of treatment depends on the following:

- Nature of the microorganism to be destroyed.
- Acidity (pH) of the food.
- Physical nature of the food.
- Heat tolerance of the food.
- Container type and dimension.

In some instances, it is not necessary to kill all microorganisms. Pasteurization, a mild heat treatment of 60–70°C (40–158°F), kills most, but not all, microorganisms present. Pasteurization is used when:

- More severe heating would harm the product.
- Dangerous organisms are not very heat resistant (such as some yeasts).
- Surviving organisms can be controlled by other means.
- Surviving organisms do not pose a health threat.

"Hot filling" refers to product filling at temperatures up to 100°C (212°F). Hot filling is used to maintain sterility in products such as jams, syrups and juices.

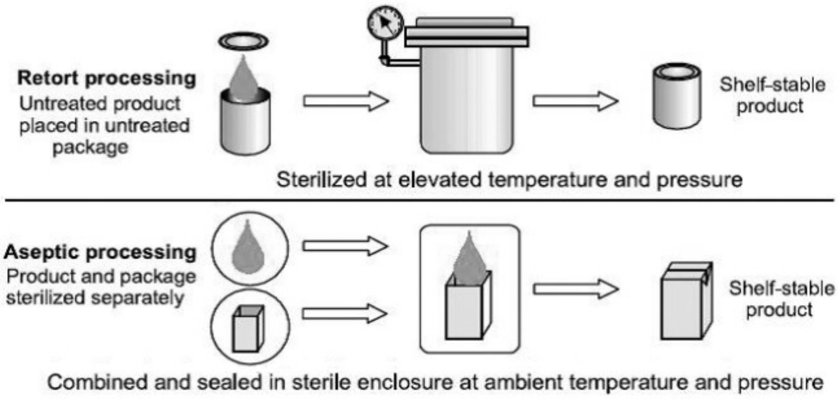

Figure 2.3
Conventional retort process (top) and aseptic filling process (bottom).

Some products can tolerate high temperatures, but only for a short time. Ultra-high-temperature (UHT) processing of milk and fruit juices uses temperatures in the range of 135–150°C (275–302°F), but for a few seconds or less. The high temperature is enough to kill most pathogens but the exposure period is not long enough for chemical reactions that would negatively impact flavor. UHT is the basis of most flexible aseptic drink packaging. The term "aseptic" as applied to packaging has come to refer to any system wherein the product and container are sterilized separately and then combined and sealed under aseptic conditions. (See Figure 2.3) Metal cans were sterilized and then filled with puddings, sauces and soups (the Dole process) in the 1940s. In the 1970s, aseptic packaging was adapted to institutional bag-in-box systems.

Sterilizing package and product separately eliminates the need for the elevated temperatures and pressures used in conventional canning methods. The less extreme sterilizing conditions allow aseptic packaging materials to have lower physical strengths and lower temperature tolerance. Commercial systems, such as Tetra Pak, Combibloc and Syntegon (formerly Bosch Packaging Technology), use hydrogen peroxide to sterilize simple paper, foil and polyethylene laminates, and then the formed package is filled with UHT-treated product.

Several aseptic systems use the heat of forming plastic as a "free" sterilant. Thermoformed plastic containers can be kept sterile until after they are filled and sealed. Sterile solutions are filled into blow-molded bottles at the molding machine as a guarantee of sterility.

Unlike aseptic packaging, normal canning maintains only nominal cleanliness in the food and the can. After the food is sealed in the can, it is subjected to temperatures high enough to kill pathogens and achieve commercial sterility. Temperatures of 110–130°C (230–265°F) are typical. The actual cook time depends on many factors, calculated in advance to ensure commercial sterility. One of the most important factors is the rate of heat penetration to the farthest and most insulated portion of the product, usually the container's geometric center.

Sealed cans are an oxygen-free environment. At pH levels above 4.5, conditions are conducive to the growth of Clostridium botulinum, a particularly dangerous anaerobic bacterium that produces heat-resistant spores. Generally, the less acidic the food, the longer the cook times needed to ensure the destruction of Clostridium botulinum. Foods with acidities high enough to prevent harmful pathogens from propagating can be heat-processed by immersion in boiling water.

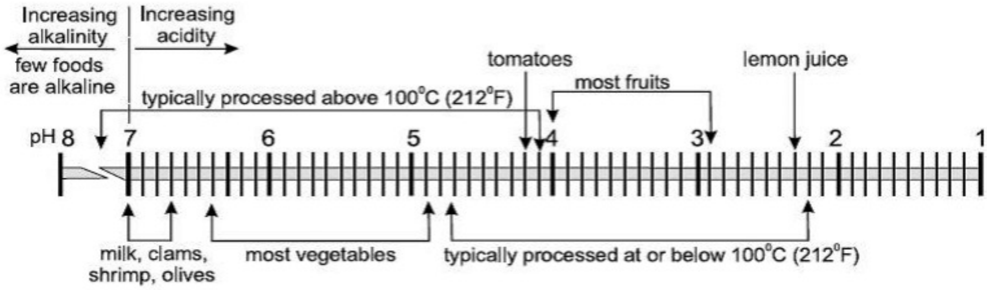

Figure 2.4
Food pH levels and typical processing temperatures.

Most canned-food processing takes place in large pressure cookers, or retorts, that raise temperatures considerably above the atmospheric boiling point. Keeping food at these temperatures for a long time results in overcooking and gives some foods their "canned" taste or texture. Canning is not successful for many foods because the cooking cycle would produce objectionable changes in taste or texture.

Cans are subjected to alternating positive and negative pressure effects as they are heated and cooled. They suffer mechanical abuse, too. The rigorous temperature and pressure conditions needed to achieve commercial sterility restricted retorting to rigid metal cans and glass jars for many years. As flexible materials became more heat-resistant and stronger, film-based constructions became feasible alternatives to rigid containers.

The retortable pouch is a laminate of polyethylene terephthalate, foil (for an oxygen barrier) and a heat-sealable polyolefin. Retortable pouch material is shipped in roll form, creating significant transport and storage savings. Since finished pouches can be as little as 12 mm (0.5 inch) thick, thermal processing time can be reduced, thus improving food texture and nutritional qualities. Pouches also offer positive implications for waste disposal.

Despite these advantages, North Americans were slow to accept retort pouches. Initially, the primary interest came from the military. In recent years, Americans are increasingly receptive to retort pouches, particularly for processed foods like rice and tuna and in the foodservice industry where concerns about consumer safety and reduced storage space make pouches an attractive alternative to #10 cans. Retort pouch styles include flat and stand-up.

Figure 2.4 shows the pH level of several foods and food classes, along with the likely temperature processing ranges. Figure 2.5 shows the effect of temperature on molds, yeasts and bacteria.

Water Reduction: Drying is an old and well-established method of preserving food. The essential feature of drying is that the moisture content is reduced below that required for the support of microorganisms. An added advantage is less bulk and reduction of other chemical activity. Available moisture can be reduced by simple heat drying or, less obviously, by the addition of salt or sugar. Concentrated salt and sugar solutions tie up free water and make it unavailable to microorganisms. Jams and marmalades having high sugar contents do not require refrigeration for this reason.

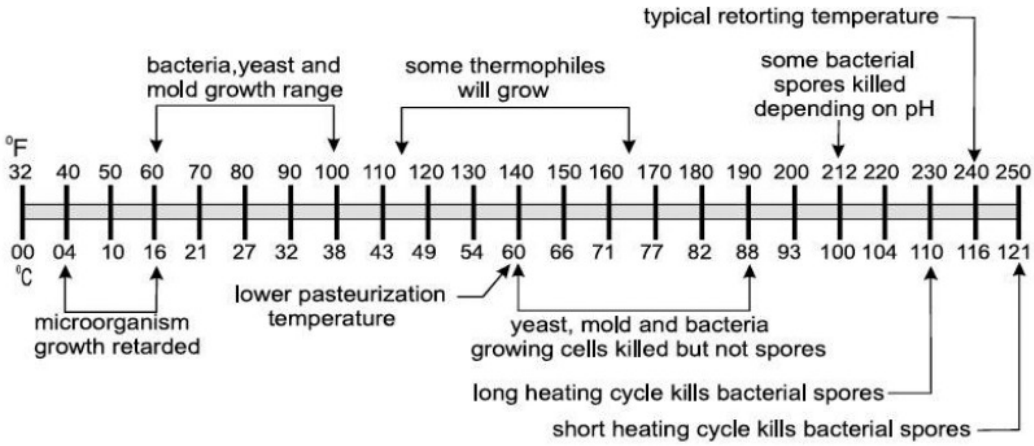

Figure 2.5
Temperature levels and the growth and destruction of microorganisms.

Figure 2.6
The equilibrium moisture content of a representative cereal product at three humidity levels.

In addition to managing moisture content as a method for controlling microorganisms, moisture control is important for keeping many foods at their most desirable moisture levels.

Most foods are hygroscopic and exist in a state of equilibrium with the relative humidity (R.H.) in the immediate atmosphere. If a food is sealed in a closed container, it will gain or lose moisture until equilibrium with the moisture content in the air space is reached. (See Figure 2.6)

Equilibrium relative humidity (ERH) is the atmospheric humidity condition under which the food will neither gain nor lose moisture to the air. This value is often expressed as A_W, the water activity, defined as:

$$A_W = \frac{\text{food vapor}}{\text{water vapor}}$$

A food with an A_W of 0.5 will be at equilibrium at an R.H. of 50%. Table 2.4 lists the moisture content and the desired ERH for some common foods. Sorption isotherms (a plot of food water content against ERH at a specific temperature) can be drawn to show the moisture content at any R.H. (See Figure 2.7)

Ambient R.H. ranges from very low to very high during a year, and a food's moisture content will change continuously as it adjusts to the current R.H. However, the best mouthfeel for many foods is at a specific moisture content.

Table 2.4
Representative moisture content and ranges.

Product	Typical Moisture	Percentage
Potato chips, instant coffee	3% or less	10–20%
Crackers, breakfast cereals	3–7%	0–30%
Cereal grains, nuts, dried fruit	7–20%	30–60%
Salt	75%	
Sugar	85%	

The curve in Figure 2.7 shows a snack food's moisture content across an R.H. range. Usually, the most enjoyable crispness, or mouthfeel, is when the snack food has a moisture content no higher than 5%. The curve shows that the snack will have a moisture content above 5% any time it is exposed to humidity above 28%. So, a properly designed package for this snack food would seal the snack in a water-vapor barrier material that keeps the snack at a humidity below 28% until the package is opened for consumption.

The A_W for sugar is 0.85, which explains why sugar rarely cakes. Salt is somewhat lower at 0.75, and it does take up moisture on the most humid days. Both would present problems at conditions of 90% humidity.

Knowledge of a food's ERH, or A_W provides a good indication of the package required by the food. Very low-ERH foods are hygroscopic and will draw available moisture from the air. These foods require a barrier package that prevents the entry of atmospheric moisture.

Dried foods such as potato chips and instant coffee require a moisture content of 3% or lower and an ERH of 10–20%. Since ambient relative humidity is rarely this low, these products tend to take up water. Such foods require packaging materials with high moisture-barrier properties. Potato chips are rich in oil (about 30%), so

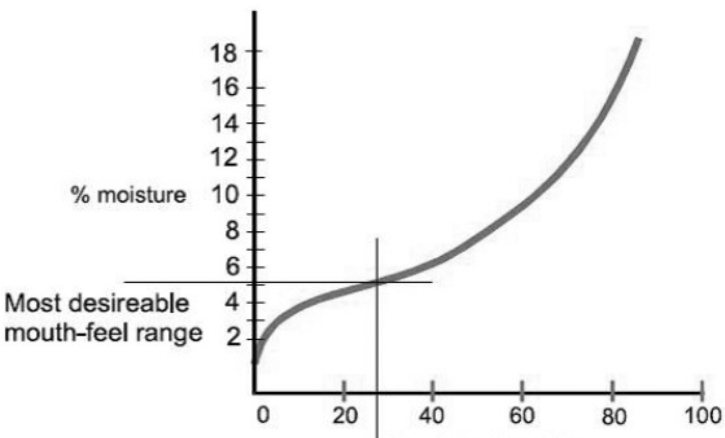

Figure 2.7
The moisture content of a representative snack food at various R.H. levels. The most desirable crispness, or mouthfeel, occurs when the food has 5% or lower moisture content.

they also need a high oxygen barrier. In-package desiccants and oxygen scavengers are sometimes used to increase the shelf life of very sensitive products.

Dried foods with ERH values of 20–30% have less stringent moisture-barrier requirements and are easier to package. Depending on the food, oxygen or other barriers also may be needed. Many crackers, biscuits and breakfast cereals fall into this category.

Foods with an ERH of 30–60% often can be stored for long periods with little or no barrier packaging since their ERH corresponds to typical atmospheric conditions. Cereal grains, nuts and dried fruits are in this group. Again, if the food has a high oil content, an oxygen barrier may be needed. Bacteriological activity is rarely a problem with low- or reduced-moisture foods since one of the essentials for bacterial growth has been removed.

High-ERH foods lose moisture under typical atmospheric conditions. At first thought, it may seem that effective packaging would include a good barrier to stop the loss of moisture; however, a cake with an ERH of 90% would soon establish a relative humidity of 90% inside a sealed package, creating ideal conditions for mold growth. The packaging challenge is to control moisture loss, retarding it as much as possible, but not to the extent that high humidity is established within the package.

Chemical Preservatives

Various natural and synthetic chemicals and antioxidants help extend the keeping quality of foods. Generally insufficient alone, they are used in conjunction with other preservation methods. Usage of most is strictly controlled by law, although requirements vary from country to country.

Chemical preservatives work in various ways. Some, such as lactic, acetic, propionic, sorbic and benzoic acids, produce acid environments. Others, such as alcohol, are specific bacteriostats. Carbon dioxide, found in beers and carbonated beverages, creates an acid environment and is also a bacteriostat. Smoking and curing meat and fish is partly a drying process and partly chemical preservation. Aliphatic and aromatic wood distillation products (many related to creosote) are acidic and have variable bacteriostatic effects. Varying amounts of salt pretreatment accompany most smoking.

Antioxidants and oxygen absorbers can reduce oxidation. Some oxygen absorbers have been used indirectly, contained in separate pouches within the sealed package. The absorber, usually a fine iron powder, scavenges any available oxygen still in the package. Oxygen absorbers also may be incorporated into the packaging material. Packaging with oxygen absorbers is considered active packaging.

MAP (Modified-Atmosphere Packaging)

Ambient air is about 20% oxygen and 80% nitrogen with traces of carbon dioxide and other gases. Altering these proportions alters product response. This is the basis of MAP. For example, one mode of degradation is removed if a product prone to oxidation is packaged in an atmosphere free of oxygen. MAP involves the introduction of a gas mixture other than air into a package; that mixture is then left to equilibrate or change according to the nature of the system.

Table 2.5
Typical modified atmospheres for selected food products.

Product	Oxygen	Carbon Dioxide	Nitrogen
Red meat	40%	20%	40%
White meats/cooked pasta	1%	50%	50%
Fish	20%	80%	—
Produce	5%	—	95%
Baked goods	1%	60%	39%

A related process, controlled-atmosphere storage, is used in storage and warehousing where the atmosphere is continuously monitored and adjusted to keep the atmospheric conditions constant. The process often is referred to as controlled atmosphere packaging, but since it is a warehousing technique, the term is not technically accurate.

Vacuum packaging is one type of MAP. It has the effect of eliminating some or all oxygen that might contribute to degradation. However, the method is not universally useful, since products such as fruits and vegetables have respiratory functions that must be allowed to continue. Another difficulty is that red meat will turn brown or purple without oxygen. Pressures created by the external atmosphere surrounding a vacuum-packaged product can physically crush delicate products or squeeze water out of moist products. Other types of MAP solve these problems.

Table 2.5 lists atmospheric combinations for some common food products. With few exceptions, MAP works with the atmospheric gases as follows.

Oxygen is biologically active, and for most products, is associated with respiration and oxidation. Oxygen is normally reduced to slow down the respiration rate of produce and reduce oxidation activity. Red meat is the single exception, where high oxygen levels are used to keep the bright red "bloom" associated with freshness. Some oxygen is required in situations where anaerobic bacteria may be present to reduce the possibilities of propagation.

With most other meats, baked goods, pastas and dairy products, oxygen is reduced to the absolute minimum consistent with not creating an oxygen-free atmosphere that would encourage the growth of anaerobic bacteria. Produce needs at least some oxygen to continue natural respiration.

Carbon dioxide in high concentrations is a natural bacteriostat. Levels of 20% and higher are used to create conditions unfavorable to most microorganisms. Carbon dioxide is highly soluble in water, creating a mild acid, and moist products can dissolve enough carbon dioxide to create a partial vacuum. In some instances, the resulting external pressure is undesirable.

Nitrogen, unlike the previous two gases, is biologically inert. Its solubility in water is negligible, and it is tasteless. Nitrogen is used as a "filler" gas or to displace oxygen.

Most packaging materials used in MAP for everything other than produce must have good gas-barrier properties to all three gases. This is true even if the package does not contain the gas. A package containing only carbon dioxide and nitrogen is a system where atmospheric oxygen is trying to penetrate the package and establish an equilibrium partial pressure. The integrity of all seals is of paramount importance.

The natural respiration of a fruit or a vegetable consumes oxygen and produces carbon dioxide and moisture. Ventilated or low-barrier packaging is needed to ensure a supply of oxygen and to rid the package of excess moisture.

MAP has increased natural shelf life by a factor ranging from two to 10. Cooked pasta, for example, will keep for up to 21 days in an atmosphere of 50% carbon dioxide and 50% nitrogen. The atmosphere used must be tailored specifically to the food item and the type of package being used.

Irradiation

Radiation is energy categorized by wavelength and includes radio waves, microwaves, infrared radiation, visible light, ultraviolet light and X-rays. These types of radiation increase in energy from radio to X-rays—the shorter the wavelength, the greater the energy. Given sufficient energy, waves can penetrate substances. With still more energy, they will interact with the molecules of the penetrated substance.

Short-wavelength radiations have enough energy to ionize molecules, mainly water. Ionization can disrupt complex molecules and lead to the death of living organisms. Enzymes, vitamins and other similar complex molecules also can be destroyed. Excessive exposure will produce enough chemical changes that the taste of food or the chemistry of an enclosing container will be altered.

Irradiation has been used to increase the keeping quality of various foods. Cobalt 60, a radioactive isotope, is the principal source of ionizing radiation (gamma rays). Since the cobalt source is radioactive, it must be shielded with about 1.8 meters of concrete and lowered into a pool of water when not in use. All safety precautions pertaining to radioactive hazards must be observed. It should be noted that while the energy source is radioactive, gamma rays cannot make other substances radioactive. Irradiation is a unique process in that it is carried out at ambient temperatures and can penetrate packaging materials or products. Gamma radiation can alter—to a detrimental effect—the properties of some polymers, such as polypropylene.

Low irradiation doses have been used to reduce microbial or insect populations. In addition, irradiation has been found to inhibit sprouting in onions and potatoes and delay the opening of mushroom caps. A common use is to reduce microbial loadings on such heat-sensitive items as herbs and spices. In addition to treating food, gamma rays can sterilize packaging materials. A significant proportion of hospital supplies are sterilized with gamma irradiation.

Not all packaging materials are sufficiently stable for higher levels of gamma treatment. Polystyrene and polyethylene can tolerate high exposures. Polyvinyl chloride discolors (browns) and with extended exposure may start to decompose and release chlorine. Glass is also prone to browning. Paperboard products lose mechanical strength and polypropylene becomes brittle.

In another application, light irradiation induces cross-linking in some polymers to yield tougher films, some of them with attractive heat-shrink properties.

Figure 2.8
The international food irradiation symbol (Radura).

Irradiation of consumable food is an issue that is not fully resolved, and the process is carefully controlled in most countries. Critics argue that irradiation causes chemical change and that we are unsure of the prolonged effects of consuming irradiated food. Proponents reply that normal heat processing also causes significant chemical changes in food whose details we are also unsure of, but that this has never been viewed as a problem. On this basis, food irradiation is prohibited in some countries and highly regulated in most. However, the use of irradiation to achieve sterility for medical devices, packaging materials and personal care products does not present a problem and is a useful technology.

Labeling is another contentious issue. The irradiation symbol (see Figure 2.8) must be accompanied by a statement such as "treated by irradiation" or "irradiated." The term "ionizing energy" is being touted to replace the more dangerous sounding "irradiation." Some claim that the design of the irradiation symbol is misleading.

Canada has given product clearances for irradiation of potatoes, onions, wheat flour, spices and raw ground beef. The United States has given product clearance for potatoes, wheat flour, spices, fresh fruits and vegetables, pork, chicken, ground meats and dehydrated vegetables. Australia and New Zealand have approved irradiation for various fruits, vegetables, herbs and spices. Israel and the Netherlands have the broadest range of food irradiation clearances.

THE TRANSPORT FUNCTION

The transport function entails the effective movement of goods from the point of production to the point of final consumption. This involves various transport modes, handling techniques, environmental hazards and storage conditions. In addition to the general physical rigors of distribution, there are carrier rules that influence package design. Information required to design successful distribution packaging appears in Table 2.6.

Transportation and distribution generally are regarded as activities that are hazardous to the product being moved. In many instances, the stresses that the product will experience are greater than the durability of the unprotected product. In such instances, it will be necessary to design additional packaging to isolate or cushion the product from external forces.

In the case of dangerous goods, the package is designed to protect the environment where the goods are transported. Packaging for international transport of dangerous goods is regulated by the United Nations. This is covered in more detail in Chapter 17, Distribution Packaging.

Table 2.6
Typical transport, handling and storage information.

truck	rail	aircraft
cargo ship	storage duration	storage conditions
handling methods	unitizing methods	specific shipping unit
weight considerations	stock picking	dimension limits
carrier rules	environmentally controlled storage	orientation requirements
hazardous material labels		

Packaging contributes to the safe, economical and efficient storage of a product. Good package design takes into account the implications of transport and warehousing, not just for the distribution package and unitized load, but for every level of packaging.

Chapter 17, Distribution Packaging, describes how goods should be prepared for effective transport and warehousing.

THE INFORM/PURCHASE DECISION FUNCTION

The communication role of packaging is perhaps the most complex of the packaging functions to understand, measure and implement because of the many levels at which this communication must work. Laws and customs dictate certain messages, without much leeway in their presentation. Examples of such messages are:

- Specific name and description of the product.
- Quantity (weight, measure or numerical count) contained in the packaging.
- Identification and address of the seller/manufacturer (weight, measure or numerical count) contained in the packaging.
- Nutritional information.
- Dosage size, potential medicinal interactions.
- Scannable retail point-of-sale codes such as UPC/EAN, QR or DataMatrix.
- Font size requirements for warnings and other information.
- Linear codes such as SSCC on distribution or tertiary packaging and unit loads to ensure fast, accurate handling throughout the supply chain.

However, to promote the contained product effectively, a package must appeal to the potential customer at all levels. A good package creates a “persona,” or personality. If the designer has done an effective job, that persona will appeal to the targeted audience.

The targeted audience itself needs to be identified and studied. This is the realm of demographics and psychographics, which study user interactions including feel, texture and the package-opening experience.

The package itself communicates by many elements, such as:

- Selected material.
- Shape and size.
- Color.
- Predominant typography.
- Recognizable symbols or icons.
- Illustrations.

A brand of peanut butter aimed at family consumption might come in a plastic tub with a snap-on lid. The text may simply state that it is an economy peanut butter. The tub would have minimal or no illustrations. A gourmet peanut butter, on the other hand, would more likely come in a glass jar with an old-fashioned-looking screw-on closure. The label would have an upscale name in a carefully selected, classic font. Features such as embossing or gold stamping might further promote the gourmet persona. The whole package might be offered in a wooden box or wicker basket—similar products, two totally different packaging treatments and resulting personas.

All of the communication elements must be balanced and supportive of one another to produce a persona with appeal and instant recognition. All supporting material, such as promotions and advertisements, must agree with the image projected by the package.

First Moment of Truth: The now-legendary phrase was popularized by Procter & Gamble CEO A.G. Lafley, who in a 2002 letter to shareholders defined it as the moment "when consumers stand in front of a store shelf … and decide whether to buy a P&G brand or a competing product." The phrase has been widely interpreted both as an affirmation for the importance of in-store marketing and as an endorsement for the store as a viable brand-building medium. The key, therefore, is to win the first moment of truth, meaning, capture and keep the attention of the shopper at the point of purchase where a massive 70% of buying decisions are made. As such, it has become an oft-quoted battle cry among industry practitioners.

Second Moment of Truth: This moment is when the consumer first interacts with the product and package at home. P&G advocates that any marketer who can win on both First and Second Moments has a strong chance of gaining a loyal, long-term customer.

Zero Moment of Truth (ZMOT): This term, developed by Google, takes into account the influence of social media in making purchase decisions. At the ZMOT, the customer is making decisions based on feedback and online blogs, long before entering a store.

Developing the information and incorporating it into a package's surface design is the subject of Chapter 3, Brand Identity Strategy and Package Design.

Producing a well-balanced package persona requires an intimate familiarity with not just the structural qualities of packaging materials, but also the emotional qualities that they project. A thorough understanding of printing processes and decorating techniques used to create particular effects or decorate unusual surfaces is essential. These topics appear in Chapter 4, Package Printing and Decorating.

THE END-OF-LIFE OR CRADLE-TO-CRADLE FUNCTION

The end-of-life role of packaging comprises all the roles and functions of packaging and includes material reduction, reuse and recycling. Cradle-to-cradle is also referred to as C2C, and products can be certified as C2C model compliant. The term is fully explained by William McDonough, Michael Braungart and Stephen Hoye in their book, *Cradle to Cradle: Remaking the Way We Make Things*. The term was first coined in Europe in the 1980s and essentially embraces sustainability as a full life-cycle endeavor. More recently, focus has turned to the development of a circular economy, and packaging's role in it. This concept is discussed in detail in Chapter 5, Environmental and Sustainability Issues.

REVIEW QUESTIONS

1. Name the four principal functions of a package.
2. Define primary package, secondary package and distribution/tertiary package.
3. Containment is a primary packaging function. List 12 product characteristics that will affect your choice of material and package design.
4. What conditions or events might cause physical damage and loss of value for a package? Where are these conditions likely to be encountered?
5. In providing for the protect/preserve function, it is essential to know and quantify what factors?
6. Describe two biological spoilage mechanisms.
7. Give three examples of food-spoilage mechanisms that are not biological in nature.
8. In most food packaging, the goal is to eliminate or reduce oxygen levels. There are, however, three situations in which the presence of oxygen is desirable. What are they?
9. Microorganisms are controlled by manipulating four conditions. What are they?
10. What is an essential oil? Why is it necessary to preserve essential oils?
11. What specific protection must be given to extend the keeping quality of oily foods?
12. Why are some vegetables never found in a can?
13. What MAP gas can act as a bacteriostat?
14. Why aren't high water-activity foods packaged in high-barrier materials to prevent them from drying out?
15. Name the six ways of extending the natural shelf life of foods. For each method, briefly note the mechanisms by which the keeping quality of a food product is increased.
16. What gases are used in controlled-atmosphere packaging?
17. Why is it difficult to extend the shelf life of fresh fish?
18. What is meant by the term "barrier material"?
19. What is an essential difference between a mold and a bacteria?
20. What is a characteristic of microorganisms that are: mesophilic, psychrophilic, thermophilic, anaerobic and aerobic?
21. One anaerobic bacterium is of special concern to humans. What is it, why is it of such concern and in what packaging type is it most commonly found?
22. What is a pathogen?
23. What are the levels of food heat treatment, and where are they used?

24. What does the term "aseptic packaging" describe?
25. A cake will lose quality by drying out, yet we never put a cake into a high-moisture barrier package to extend shelf life. Why not?
26. A particular food has an A_W of 0.3. What does this mean, and what kind of package might this suggest to you?
27. What is one purpose behind vacuum packaging of cheese and prepared meat products?
28. What are the advantages of a retortable pouch?
29. What details are needed to provide good design information for creating distribution packages that will provide for efficient handling, transport and storage?
30. What is a unit load?
31. A package communicates in many ways besides the actual written text. Name six avenues of communication.
32. What is meant by the "persona" of a package?
33. What are the advantages of aseptic processing of food?
34. What two packaging materials offer absolute barrier properties?
35. List five means by which a package communicates its persona to the observer.
36. What does the First Moment of Truth describe?
37. Describe how the same product can be packaged differently and result in a different persona.

BRAND IDENTITY STRATEGY AND PACKAGE DESIGN 3

CONTENTS

Introduction

Packaging's technical and communication roles.

Demographics, Psychographics and Ethnography

Importance of having demographic and psychographic information, definition of psychographics, examples of psychographic population groups. Example of demographic/psychographic study of shopping habits. Package features that appeal to consumers, knowing the competition's targets, strengths and weaknesses. How ethnography studies buying decisions.

The Retail Environment

Offline shopping, online shopping, a sea of choices, the final confrontation is between consumer and package, how long you have to motivate a purchase decision, disruptive simplicity, merchandising methods. Changing loyalties, shopping habits, merchandising methods, virtual reality.

Fundamental Messages

The three messages: "What is this? What is it going to do for me? Who guarantees it?" Real and imagined points of difference, the importance of point-of-difference messages, examples of points of difference for modern shampoos. "All-new" and "old-fashioned" points of difference.

Equity and Brand Names

Definitions of equity and icons, leading brand names, fanciful and descriptive brand names.

Color

The first thing an observer sees, color and emotions, how color influences perception, universal rules for making color decisions, cultural associations.

Graphic Design Elements

Basic design elements, balance and unity, direction and dominance, typography.

Package Design and Marketing Studies

New product launches, qualitative vs. quantitative analysis, ethnography, wording study questions, selecting panelists, market and package evaluation methodology examples.

Packaging Design Best Practices

Simplicity, vintage packaging study, mock-ups, shopper profile, examine other product categories, future variations, innovatively breaking the rules, empathy, the power of humor, rooted in good design basics.

BRAND IDENTITY STRATEGY AND PACKAGE DESIGN

3

INTRODUCTION

The fundamental objective of any package design is to contain and help sell the product. But it also must be a visual manifestation of the brand and create long-term brand affinity between the consumer and the product.

A package design is composed of two components, structural and graphic:

- **The structural component** encompasses the features and characteristics that fulfill the package's technical and physical requirements: containment, protection/preservation, ease-of-use and the qualities that facilitate transport and distribution.

  But in addition to function, the most successful package structures become core mnemonics for the brand. Consider Listerine's distinctive and iconic bottle shape with its square shoulders. (See Figure 3.1) Coca-Cola only offers its contour glass bottle during special promotions, and yet this shape is undoubtedly one of the most recognized brand icons of our time.

Figure 3.1
Listerine's distinctive bottle shape makes it instantly recognizable on-shelf across a growing range of label variations.

Figure 3.2
Color as a graphic element can be a great brand identifier. Kellogg's brand color also acts as a unifier across all its products and ranges.

The best structures also go well beyond the functional benefits of consumer usability and become part of the brand experience. Witness the number of "unboxing" videos on the Internet. The role of packaging is not limited to the point-of-sale but extends through every stage of consumer engagement with the brand, and the product structure helps drive this engagement.

- **The graphic component** comprises the brand equities and product information that attract and engage consumers and motivate them to buy. Again, the best package graphics go well beyond this goal and become the single most influential articulation of the brand's identity and its most powerful asset across integrated campaigns and every type of media. A quick question: What color is Kellogg's? Kellogg's visual identity is so ingrained in our minds that its identity no longer needs the brand name to be among the most recognized and successful brands in its category. (See Figure 3.2) A great part of package graphics concerns surface decoration, although, as mentioned above, form, material and shape can be equally important.

Structural and graphic components should complement each other to produce a holistic and coherent image. The tactile "feel" of the package can be part of both the structure and the graphics. While this chapter is going to discuss the graphic design of packaging, the physical shape and the choice of material are important factors in creating a compelling and memorable brand experience in the mind of the consumer.

For example, a peanut butter positioned as a no-frills value product typically will come in a plastic container with minimum graphics. Most shoppers will subconsciously interpret these cues as an economical brand at the value end of the category. If the brand intends to price its peanut butter at a premium and sell it through boutiques as a gift item, a completely different design strategy would be needed. (See Figure 3.3)

The plastic container would be replaced by a glass jar with a metallic lid. The label would be printed with special colors on a tactile paper, with additional touches such as die-cut shapes and embossing. Images, illustrations and fonts would all be bespoke, specially crafted for the brand. The closure might have a gingham cloth held on with a ribbon or a paper seal across the closure that needs to be broken on the first opening. All of these elements would serve to increase the perceived value of the peanut butter and elevate the brand experience.

The packaging strategy should be aligned with the positioning of the brand and the price-point of the product. Consumers expect brands to be authentic and hon-

Figure 3.3
A basic packaging treatment for an economy grade of peanut butter and one for an upscale presentation of the same product.

est. Sophisticated graphics and misleading statements may motivate the first purchase, but if the product experience does not live up to the promise, the consumer is unlikely to buy it again.

A packaging graphic project starts with a clear definition of the brand promise, the unique experience that differentiates this product from any other. This brand promise addresses the questions:

- With what product and what does it offer?
- Who is the demographic/psychographic shopper and consumer?
- How will this succeed in the marketplace?
- What is the reason-to-believe, or what makes this special?
- How is this better than or different from the competition?
- In conjunction with what other activities?

The overall strategic plan is formalized in a design brief. The graphic designer must have the following information:

- A clear description of the goal.
- A schedule of the identified elements that must appear and can't be changed.
- A schedule of all legally required information.
- A clear positioning statement (who is going to buy this product and why).
- An identified unique selling proposition statement.
- A clear understanding of the market in which the product competes.
- A clear understanding of the competition's positioning.
- Graphic constraints and technical specifications related to printing.

This chapter provides an overview of the information and methods used to create packages that successfully communicate information to the potential buyer.