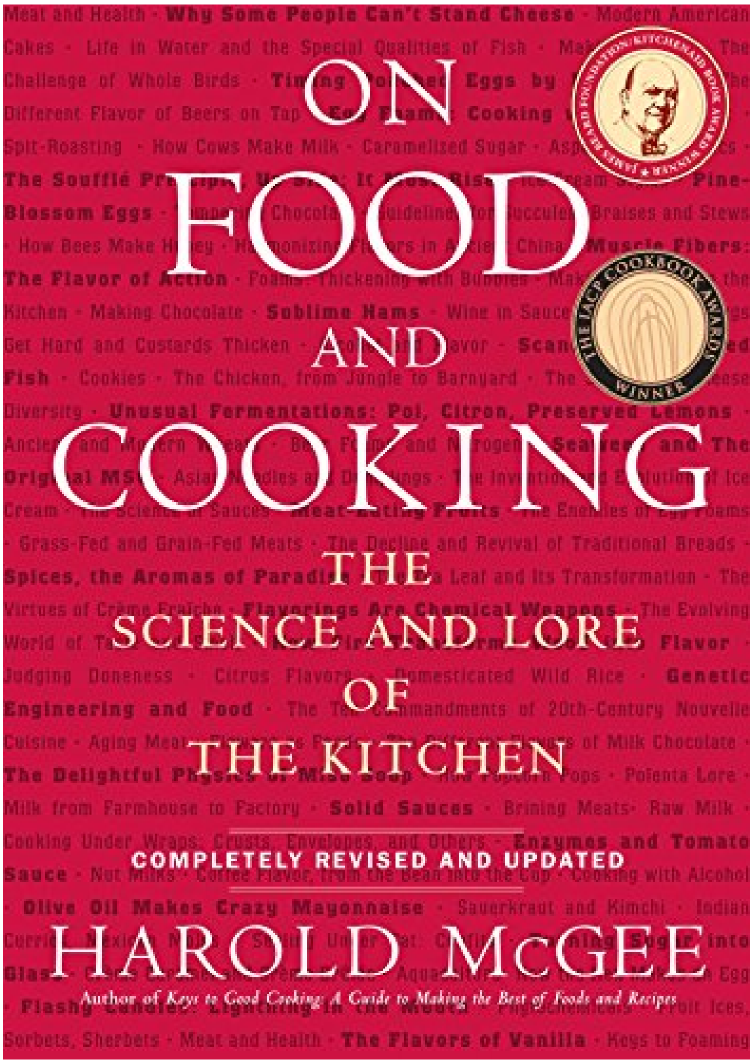
On Food and Cooking: The Science and Lore of the Kitchen (English Edition)



Par Harold McGee
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(Mobile book) On Food and Cooking: The Science and Lore of the Kitchen (English Edition)

Par Harold McGee : On Food and Cooking: The Science and Lore of the Kitchen (English Edition) before purchasing it in order to gage whether or not it would be worth my time, and all praised On Food and Cooking: The Science and Lore of the Kitchen (English Edition):

Description : Description du produitHarold McGee's On Food and Cooking is a kitchen classic. Hailed by Time magazine as "a minor masterpiece" when it first appeared in 1984, On Food and Cooking is the bible to which food lovers and professional chefs worldwide turn for an understanding of where our foods come from, what exactly they're made of, and how cooking transforms them into something new and delicious. Now, for its twentieth anniversary, Harold McGee has prepared a new, fully revised and updated edition of On Food and Cooking. He has rewritten the text almost completely, expanded it by two-thirds, and commissioned more than 100 new illustrations. As compulsively readable and engaging as ever, the new On Food and Cooking provides countless eye-opening insights into food, its preparation, and its enjoyment. On Food and Cooking pioneered the translation of technical food science into cook-friendly kitchen science and helped give birth to the inventive culinary movement known as "molecular gastronomy." Though other books have now been written about kitchen science, On Food and Cooking remains unmatched in the accuracy, clarity, and thoroughness of its explanations, and the intriguing way in which it blends science with the historical evolution of foods and cooking techniques. Among the major themes addressed throughout this new edition are: Traditional and modern methods of food production and their influences on food quality The great diversity of methods by which people in different places and times have prepared the same ingredients Tips for selecting the best ingredients and preparing them successfully The particular substances that give foods their flavors and that give us pleasure Our evolving knowledge of the health benefits and risks of foods On Food and Cooking is an invaluable and monumental compendium of basic information about ingredients, cooking methods, and the pleasures of eating. It will delight and fascinate anyone who has ever cooked, savored, or wondered about food.

Prsentation de l'diteurHarold McGee's On Food and Cooking is a kitchen classic. Hailed by Time magazine as "a minor masterpiece" when it first appeared in 1984, On Food and Cooking is the bible to which food lovers and professional chefs worldwide turn for an understanding of where our foods come from, what exactly they're made of, and how cooking transforms them into something new and delicious. Now, for its twentieth anniversary, Harold McGee has prepared a new, fully revised and updated edition of On Food and Cooking. He has rewritten the text almost completely, expanded it by two-thirds, and commissioned more than 100 new illustrations. As compulsively readable and engaging as ever, the new On Food and Cooking provides countless eye-opening insights into food, its preparation, and its enjoyment. On Food and Cooking pioneered the translation of technical food science into cook-friendly kitchen science and helped give birth to the inventive culinary movement known as "molecular gastronomy." Though other books have now been written about kitchen science, On Food and Cooking remains unmatched in the accuracy, clarity, and thoroughness of its explanations, and the intriguing way in which it blends science with the historical evolution of foods and cooking techniques. Among the major themes addressed throughout this new edition are: Traditional and modern methods of food production and their influences on food quality The great diversity of methods by which people in different places and times have prepared the same ingredients Tips for selecting the best ingredients and preparing them successfully The particular substances that give foods their flavors and that give us pleasure Our evolving knowledge of the health benefits and risks of foods On Food and Cooking is an invaluable and monumental compendium of basic information about ingredients, cooking methods, and the pleasures of eating. It will delight and fascinate anyone who has ever cooked, savored, or wondered about food.ExtraitIntroduction: Cooking and Science, 1984 and 2004This is the revised and expanded second edition of a book that I first published in 1984, twenty long years ago. In 1984, canola oil and the computer mouse and compact discs were all novelties. So was the idea of inviting cooks to explore the biological and chemical insides of foods. It was a time when a book like this really needed an introduction!Twenty years ago the worlds of science and cooking were neatly compartmentalized. There were the basic sciences, physics and chemistry and biology, delving deep into the nature of matter and life. There was food science, an applied science mainly concerned with understanding the materials and processes of industrial manufacturing. And there was the world of small-scale home and restaurant cooking, traditional crafts that had never attracted much scientific attention. Nor did they really need any. Cooks had been developing their own body of practical knowledge for thousands of years, and had plenty of reliable recipes to work with.I had been fascinated by chemistry and physics when I was growing up, experimented with electroplating and Tesla coils and telescopes, and went to Caltech planning to study astronomy. It wasn't until after I'd changed directions and moved on to English literature -- and had begun to cook -- that I first heard of food science. At dinner one evening in 1976 or 1977, a friend from New Orleans wondered aloud why dried beans were such a problematic food, why indulging in red beans and rice had to cost a few hours of sometimes embarrassing discomfort. Interesting question! A few days later, working in the library and needing a break from 19th-century poetry, I remembered it and the answer a biologist friend had dug up (indigestible sugars), thought I would browse in some food books, wandered over to that section, and found shelf after shelf of strange titles. Journal of Food Science. Poultry Science. Cereal Chemistry. I flipped through a few volumes, and among the mostly bewildering pages found hints of answers to other questions that had never occurred to me. Why do eggs solidify when we cook them? Why do fruits turn brown when we cut them? Why is bread dough bouncily alive, and why does bounciness make good bread? Which kinds of dried beans are the worst offenders, and how can a cook tame them? It was great fun to make and share these little discoveries, and I began to think that many people interested in food might enjoy them. Eventually I found time to immerse myself in food science and history and write On Food and Cooking: The

Science and Lore of the Kitchen.As I finished, I realized that cooks more serious than my friends and I might be skeptical about the relevance of cells and molecules to their craft. So I spent much of the introduction trying to bolster my case. I began by quoting an unlikely trio of authorities, Plato, Samuel Johnson, and Jean Anthelme Brillat-Savarin, all of whom suggested that cooking deserves detailed and serious study. I pointed out that a 19th-century German chemist still influences how many people think about cooking meat, and that around the turn of the 20th century, Fannie Farmer began her cookbook with what she called "condensed scientific knowledge" about ingredients. I noted a couple of errors in modern cookbooks by Madeleine Kamman and Julia Child, who were ahead of their time in taking chemistry seriously. And I proposed that science can make cooking more interesting by connecting it with the basic workings of the natural world.A lot has changed in twenty years! It turned out that On Food and Cooking was riding a rising wave of general interest in food, a wave that grew and grew, and knocked down the barriers between science and cooking, especially in the last decade. Science has found its way into the kitchen, and cooking into laboratories and factories.In 2004 food lovers can find the science of cooking just about everywhere. Magazines and newspaper food sections devote regular columns to it, and there are now a number of books that explore it, with Shirley Corriher's 1997 CookWise remaining unmatched in the way it integrates explanation and recipes. Today many writers go into the technical details of their subjects, especially such intricate things as pastry, chocolate, coffee, beer, and wine. Kitchen science has been the subject of television series aired in the United States, Canada, the United Kingdom, and France. And a number of food molecules and microbes have become familiar figures in the news, both good and bad. Anyone who follows the latest in health and nutrition knows about the benefits of antioxidants and phytoestrogens, the hazards of trans fatty acids, acrylamide, E. coli bacteria, and mad cow disease.Professional cooks have also come to appreciate the value of the scientific approach to their craft. In the first few years after On Food and Cooking appeared, many young cooks told me of their frustration in trying to find out why dishes were prepared a certain way, or why ingredients behave as they do. To their traditionally trained chefs and teachers, understanding food was less important than mastering the tried and true techniques for preparing it. Today it's clearer that curiosity and understanding make their own contribution to mastery. A number of culinary schools now offer "experimental" courses that investigate the whys of cooking and encourage critical thinking. And several highly regarded chefs, most famously Ferran Adri in Spain and Heston Blumenthal in England, experiment with industrial and laboratory tools -- gelling agents from seaweeds and bacteria, non-sweet sugars, aroma extracts, pressurized gases, liquid nitrogen -- to bring new forms of pleasure to the table.As science has gradually percolated into the world of cooking, cooking has been drawn into academic and industrial science. One effective and charming force behind this movement was Nicholas Kurti, a physicist and food lover at the University of Oxford, who lamented in 1969: "I think it is a sad reflection on our civilization that while we can and do measure the temperature in the atmosphere of Venus, we do not know what goes on inside our souffls." In 1992, at the age of 84, Nicholas nudged civilization along by organizing an International Workshop on Molecular and Physical Gastronomy at Erice, Sicily, where for the first time professional cooks, basic scientists from universities, and food scientists from industry worked together to advance gastronomy, the making and appreciation of foods of the highest quality.The Erice meeting continues, renamed the "International Workshop on Molecular Gastronomy 'N. Kurti' " in memory of its founder. And over the last decade its focus, the understanding of culinary excellence, has taken on new economic significance. The modern industrial drive to maximize efficiency and minimize costs generally lowered the quality and distinctiveness of food products: they taste much the same, and not very good. Improvements in quality can now mean a competitive advantage; and cooks have always been the world's experts in the applied science of deliciousness. Today, the French National Institute of Agricultural Research sponsors a group in Molecular Gastronomy at the Collge de France (its leader, Herv This, directs the Erice workshop); chemist Thorvald Pedersen is the inaugural Professor of Molecular Gastronomy at Denmark's Royal Veterinary and Agricultural University; and in the United States, the rapidly growing membership of the Research Chefs Association specializes in bringing the chef's skills and standards to the food industry.So in 2004 there's no longer any need to explain the premise of this book. Instead, there's more for the book itself to explain! Twenty years ago, there wasn't much demand for information about extra-virgin olive oil or balsamic vinegar, farmed salmon or grass-fed beef, cappuccino or white tea, Sichuan pepper or Mexican mole, sake or well-tempered chocolate. Today there's interest in all these and much more. And so this second edition of On Food and Cooking is substantially longer than the first. I've expanded the text by two thirds in order to cover a broader range of ingredients and preparations, and to explore them in greater depth. To make room for new information about foods, I've dropped the separate chapters on human physiology, nutrition, and additives. Of the few sections that survive in similar form from the first edition, practically all have been rewritten to reflect fresh information, or my own fresh understanding.This edition gives new emphasis to two particular aspects of food. The first is the diversity of ingredients and the ways in which they're prepared. These days the easy movement of products and people makes it possible for us to taste foods from all over the world. And traveling back in time through old cookbooks can turn up forgotten but intriguing ideas. I've tried throughout to give at least a brief indication of the range of possibilities offered by foods themselves and by different national traditions.The other new emphasis is on the flavors of foods, and sometimes on the particular molecules that create flavor. Flavors are something like chemical chords, composite sensations built up from notes provided by different molecules, some of which are found in many foods. I give the chemical names of flavor molecules when I think that being specific can help us notice flavor relationships and echoes. The names may seem strange and intimidating at first, but they're just names and they'll become more familiar. Of course people have made and enjoyed well seasoned dishes for thousands of years with no knowledge of molecules. But a dash of flavor chemistry can help us make fuller use of our senses of taste and smell, and experience more -- and find more pleasure -- in what we cook and eat.Now a few words about the scientific approach to food and cooking and the organization of this book. Like everything on earth, foods are mixtures of different chemicals, and the qualities that we aim to influence in the kitchen -- taste, aroma, texture, color, nutritiousness -- are all manifestations of chemical properties. Nearly two hundred years ago, the eminent gastronome Jean Anthelme Brillat-Savarin lectured his cook on this point, tongue partly in cheek, in The Physiology of Taste:You are a little opinionated, and I have had some trouble in making you understand that the phenomena which take place in your laboratory are nothing other than the execution of the eternal laws of nature, and that certain things which you do without thinking, and only because you have seen others do them, derive nonetheless from the highest scientific principles.The great virtue of the cook's time-tested, thought-less recipes is that they free us from the distraction of having to guess or experiment or analyze as we prepare a meal. On the other hand, the great virtue of thought and analysis is that they free us from the necessity of following recipes, and help us deal with the unexpected, including the inspiration to try something new. Thoughtful cooking means paying attention to what our senses tell us as we prepare it, connecting that information with past experience and with an understanding of what's happening to the food's inner substance, and adjusting the preparation accordingly.To understand what's happening within a food as we cook it, we need to be familiar with the world of invisibly small molecules and their reactions with each other. That idea may seem daunting. There are a hundred-plus chemical elements, many more combinations of those elements into molecules, and several different forces that rule their behavior. But scientists always simplify reality in order to understand it, and we can do the same. Foods are mostly built out of just four kinds of molecules -- water, proteins, carbohydrates, and fats. And their behavior can be pretty well described with a few simple principles. If you know that heat is a manifestation of the movements of molecules, and that sufficiently energetic collisions disrupt the structures of molecules and eventually break them apart, then you're very close to understanding why heat solidifies eggs and makes foods tastier.Most readers today have at least a vague idea of proteins and fats, molecules and energy, and a vague idea is enough to follow most of the explanations in the first 13 chapters, which cover common foods and ways of preparing them. Chapters 14 and 15 then describe in some detail the molecules and basic chemical processes involved in all cooking; and the Appendix gives a brief refresher course in the basic vocabulary of science. You can refer to these final sections occasionally, to clarify the meaning of pH or protein coagulation as you're reading about cheese or meat or bread, or else read through them on their own to get a general introduction to the science of cooking.Finally, a request. In this book I've sifted through and synthesized a great deal of information, and have tried hard to double-check both facts and my interpretations of them. I'm greatly indebted to the many scientists, historians, linguists, culinary professionals, and food lovers on whose learning I've been able to draw. I will also appreciate the help of readers who notice errors that I've made and missed, and who let me know so that I can correct them. My thanks in advance.As I finish this revision and think about the endless work of correcting and perfecting, my mind returns to the first Erice workshop and a saying shared by Jean-Pierre Philippe, a chef from Les Mesnuls, near Versailles. The subject of the moment was egg foams. Chef Philippe told us that he had thought he knew everything there was to know about meringues, until one day a phone call distracted him and he left his mixer running for half an hour. Thanks to the excellent result and to other surprises throughout his career, he said, Je sais, je sais que je sais jamais: "I know, I know that I never know." Food is an infinitely rich subject, and there's always something about it to understand better, something new to discover, a fresh source of interest, ideas, and delight.Copyright 1984, 2004 by Harold McGeeFrom Chapter 1: Milk and Dairy ProductsWhat better subject for the first chapter than the food with which we all begin our lives? Humans are mammals, a word that means "creatures of the breast," and the first food that any mammal tastes is milk. Milk is food for the beginning eater, a gulpable essence distilled by the mother from her own more variable and challenging diet. When our ancestors took up dairying, they adopted the cow, the ewe, and the goat as surrogate mothers. These creatures accomplish the miracle of turning meadow and straw into buckets of human nourishment. And their milk turned out to be an elemental fluid rich in possibility, just a step or two away from luxurious cream, fragrant golden butter, and a multitude of flavorful foods concocted by friendly microbes.No wonder that milk captured the imaginations of many cultures. The ancient Indo-Europeans were cattle herders who moved out from the Caucasian steppes to settle vast areas of Eurasia around 3000 BCE; and milk and butter are prominent in the creation myths of their descendents, from India to Scandinavia. Peoples of the Mediterranean and Middle East relied on the oil of their olive tree rather than butter, but milk and cheese still figure in the Old Testament as symbols of abundance and creation.The modern imagination holds a very different view of milk! Mass production turned it and its products from precious, marvelous resources into ordinary commodities, and medical science stigmatized them for their fat content. Fortunately a more balanced view of dietary fat is developing; and traditional versions of dairy foods survive. It's still possible to savor the remarkable foods that millennia of human ingenuity have teased from milk. A sip of milk itself or a scoop of ice cream can be a Proustian draft of youth's innocence and energy and possibility, while a morsel of fine cheese is a rich meditation on maturity, the fulfillment of possibility, the way of all flesh.Mammals and Milk: The Evolution of MilkHow and why did such a thing as milk ever come to be? It came along with warm-bloodedness, hair, and skin glands, all of which distinguish mammals from reptiles. Milk may have begun around 300 million years ago as a protective and nourishing skin secretion for hatchlings being incubated on their mother's skin, as is true for the platypus today. Once it evolved, milk contributed to the success of the mammalian family. It gives newborn animals the advantage of ideally formulated food from the mother even after birth, and therefore the opportunity to continue their physical development outside the womb. The human species has taken full advantage of this opportunity: we are completely helpless for months after birth, while our brains finish growing to a size that would be difficult to accommodate in the womb and birth canal. In this sense, milk helped make possible the evolution of our large brain, and so helped make us the unusual animals we are.The Rise of the RuminantsAll mammals produce milk for their young, but only a closely related handful have been exploited by humans. Cattle, water buffalo, sheep, goats, camels, yaks: these suppliers of plenty were created by a scarcity of food. Around 30 million years ago, the earth's warm, moist climate became seasonally arid. This shift favored plants that could grow quickly and produce seeds to survive the dry period, and caused a great expansion of grasslands, which in the dry seasons became a sea of desiccated, fibrous stalks and leaves. So began the gradual decline of the horses and the expansion of the deer family, the ruminants, which evolved the ability to survive on dry grass. Cattle, sheep, goats, and their relatives are all ruminants.The key to the rise of the ruminants is their highly specialized, multichamber stomach, which accounts for a fifth of their body weight and houses trillions of fiber-digesting microbes, most of them in the first chamber, or rumen. Their unique plumbing, together with the habit of regurgitating and rechewing partly digested food, allows ruminants to extract nourishment from high-fiber, poor-quality plant material. Ruminants produce milk copiously on feed that is otherwise useless to humans and that can be stockpiled as straw or silage. Without them there would be no dairying.Dairy Animals of the WorldOnly a small handful of animal species contributes significantly to the world's milk supply.The Cow, European and Indian The immediate ancestor of Bos taurus, the common dairy cow, was Bos primigenius, the long-horned wild aurochs. This massive animal, standing 6 ft/180 cm at the shoulder and with horns 6.5 in/17 cm in diameter, roamed Asia, Europe, and North Africa in the form of two overlapping races: a humpless European-African form, and a humped central Asian form, the zebu. The European race was domesticated in the Middle East around 8000 BCE, the heat- and parasite-tolerant zebu in south-central Asia around the same time, and an African variant of the European race in the Sahara, probably somewhat later.In its principal homeland, central and south India, the zebu has been valued as much for its muscle power as its milk, and remains rangy and long-horned. The European dairy cow has been highly selected for milk production at least since 3000 BCE, when confinement to stalls in urban Mesopotamia and poor winter feed led to a reduction in body and horn size. To this day, the prized dairy breeds -- Jerseys, Guernseys, Brown Swiss, Holsteins -- are short-horned cattle that put their energy into making milk rather than muscle and bone. The modern zebu is not as copious a producer as the European breeds, but its milk is 25% richer in butterfat.The Buffalo The water buffalo is relatively unfamiliar in the West but the most important bovine in tropical Asia. Bubalus bubalis was domesticated as a draft animal in Mesopotamia around 3000 BCE, then taken to the Indus civilizations of present-day Pakistan, and eventually through India and China. This tropical animal is sensitive to heat (it wallows in water to cool down), so it proved adaptable to milder climates. The Arabs brought buffalo to the Middle East around 700 CE, and in the Middle Ages they were introduced throughout Europe. The most notable vestige of that introduction is a population approaching 100,000 in the Campagna region south of Rome, which supplies the milk for true mozzarella cheese, mozzarella di bufala. Buffalo milk is much richer than cow's milk, so mozzarella and Indian milk dishes are very different when the traditional buffalo milk is replaced with cow's milk.The Yak The third important dairy bovine is the yak, Bos grunniens. This long-haired, bushy-tailed cousin of the common cow is beautifully adapted to the thin, cold, dry air and sparse vegetation of the Tibetan plateau and mountains of central Asia. It was domesticated around the same time as lowland cattle. Yak milk is substantially richer in fat and protein than cow milk. Tibetans in particular make elaborate use of yak butter and various fermented products.The Goat The goat and sheep belong to the "ovicaprid" branch of the ruminant family, smaller animals that are especially at home in mountainous country. The goat, Capra hircus, comes from a denizen of the mountains and semidesert regions of central Asia, and was probably the first animal after the dog to be domesticated, between 8000 and 9000 BCE in present-day Iran and Iraq. It is the hardiest of the Eurasian dairy animals, and will browse just about any sort of vegetation, including woody scrub. Its omnivorous nature, small size, and good yield of distinctively flavored milk -- the highest of any dairy animal for its body weight -- have made it a versatile milk and meat animal in marginal agricultural areas.The Sheep The sheep, Ovis aries, was domesticated in the same region and period as its close cousin the goat, and came to be valued and bred for meat, milk, wool, and fat. Sheep were originally grazers on grassy foothills and are somewhat more fastidious than goats, but less so than cattle. Sheep's milk is as rich as the buffalo's in fat, and even richer in protein; it has long been valued in the Eastern Mediterranean for making yogurt and feta cheese, and elsewhere in Europe for such cheeses as Roquefort and pecorino.The Camel The camel family is fairly far removed from both the bovids and ovicaprids, and may have developed the habit of rumination independently during its early evolution in North America. Camels are well adapted to arid climates, and were domesticated around 2500 BCE in central Asia, primarily as pack animals. Their milk, which is roughly comparable to cow's milk, is collected in many countries, and in northeast Africa is a staple food.The Origins of DairyingWhen and why did humans extend our biological heritage as milk drinkers to the cultural practice of drinking the milk of other animals? Archaeological evidence suggests that sheep and goats were domesticated in the grasslands and open forest of present-day Iran and Iraq between 8000 and 9000 BCE, a thousand years before the far larger, fiercer cattle. At first these animals would have been kept for meat and skins, but the discovery of milking was a significant advance. Dairy animals could produce the nutritional equivalent of a slaughtered meat animal or more each year for several years, and in manageable daily increments. Dairying is the most efficient means of obtaining nourishment from uncultivated land, and may have been especially important as farming communities spread outward from Southwest Asia.Small ruminants and then cattle were almost surely first milked into containers fashioned from skins or animal stomachs. The earliest hard evidence of dairying to date consists of clay sieves, which have been found in the settlements of the earliest northern European farmers, from around 5000 BCE. Rock drawings of milking scenes were made a thousand years later in the Sahara, and what appear to be the remains of cheese have been found in Egyptian tombs of 2300 BCE.Diverse TraditionsEarly shepherds would have discovered the major transformations of milk in their first containers. When milk is left to stand, fat-enriched cream naturally forms at the top, and if agitated, the cream becomes butter. The remaining milk naturally turns acid and curdles into thick yogurt, which draining separates into solid curd and liquid whey. Salting the fresh curd produces a simple, long-keeping cheese. As dairyers became more adept and harvested greater quantities of milk, they found new ways to concentrate and preserve its nourishment, and developed distinctive dairy products in the different climatic regions of the Old World.In arid southwest Asia, goat and sheep milk was lightly fermented into yogurt that could be kept for several days, sun-dried, or kept under oil; or curdled into cheese that could be eaten fresh or preserved by drying or brining. Lacking the settled life that makes it possible to brew beer from grain or wine from grapes, the nomadic Tartars even fermented mare's milk into lightly alcoholic koumiss, which Marco Polo described as having "the qualities and flavor of white wine." In the high country of Mongolia and Tibet, cow, camel, and yak milk was churned to butter for use as a high-energy staple food.In semitropical India, most zebu and buffalo milk was allowed to sour overnight into a yogurt, then churned to yield buttermilk and butter, which when clarified into ghee (p. 37) would keep for months. Some milk was repeatedly boiled to keep it sweet, and then preserved not with salt, but by the combination of sugar and long, dehydrating cooking (see box, p. 26).The Mediterranean world of Greece and Rome used economical olive oil rather than butter, but esteemed cheese. The Roman Pliny praised cheeses from distant provinces that are now parts of France and Switzerland. And indeed cheese making reached its zenith in continental and northern Europe, thanks to abundant pastureland ideal for cattle, and a temperate climate that allowed long, gradual fermentations.The one major region of the Old World not to embrace dairying was China, perhaps because Chinese agriculture began where the natural vegetation runs to often toxic relatives of wormwood and epazote rather than ruminant-friendly grasses. Even so, frequent contact with central Asian nomads introduced a variety of dairy products to China, whose elite long enjoyed yogurt, koumiss, butter, acid-set curds, and, around 1300 and thanks to the Mongols, even milk in their tea!Dairying was unknown in the New World. On his second voyage in 1493, Columbus brought sheep, goats, and the first of the Spanish longhorn cattle that would proliferate in Mexico and Texas.Milk in Europe and America: From Farmhouse to FactoryPreindustrial Europe In Europe, dairying took hold on land that supported abundant pasturage but was less suited to the cultivation of wheat and other grains: wet Dutch lowlands, the heavy soils of western France and its high, rocky central massif, the cool, moist British Isles and Scandinavia, alpine valleys in Switzerland and Austria. With time, livestock were selected for the climate and needs of different regions, and diversified into hundreds of distinctive local breeds (the rugged Brown Swiss cow for cheesemaking in the mountains, the diminutive Jersey and Guernsey for making butter in the Channel Islands). Summer milk was preserved in equally distinctive local cheeses. By medieval times, fame had come to French Roquefort and Brie, Swiss Appenzeller, and Italian Parmesan. In the Renaissance, the Low Countries were 0renowned for their butter and exported their productive Friesian cattle throughout Europe.Until industrial times, dairying was done on the farm, and in many countries mainly by women, who milked the animals in early morning and after noon and then worked for hours to churn butter or make cheese. Country people could enjoy good fresh milk, but in the cities, with confined cattle fed inadequately on spent brewers' grain, most people saw only watered-down, adulterated, contaminated milk hauled in open containers through the streets. Tainted milk was a major cause of child mortality in early Victorian times.Industrial and Scientific Innovations Beginning around 1830, industrialization transformed European and American dairying. The railroads made it possible to get fresh country milk to the cities, where rising urban populations and incomes fueled demand, and new laws regulated milk quality. Steam-powered farm machinery meant that cattle could be bred and raised for milk production alone, not for a compromise between milk and hauling, so milk production boomed, and more than ever was drunk fresh. With the invention of machines for milking, cream separation, and churning, dairying gradually moved out the hands of milkmaids and off the farms, which increasingly supplied milk to factories for mass production of cream, butter, and cheese.From the end of the 19th century, chemical and biological innovations have helped make dairy products at once more hygienic, more predictable, and more uniform. The great French chemist Louis Pasteur inspired two fundamental changes in dairy practice: pasteurization, the pathogen-killing heat treatment that bears his name; and the use of standard, purified microbial cultures to make cheeses and other fermented foods. Most traditional cattle breeds have been abandoned in favor of high-yielding black-and-white Friesian (Holstein) cows, which now account for 90% of all American dairy cattle and 85% of British. The cows are farmed in ever larger herds and fed an optimized diet that seldom includes fresh pasturage, so most modern milk lacks the color, flavor, and seasonal variation of preindustrial milk.Dairy Products Today Today dairying is split into several big businesses with nothing of the dairymaid left about them. Butter and cheese, once prized, delicate concentrates of milk's goodness, have become inexpensive, mass-produced, uninspiring commodities piling up in government warehouses. Manufacturers now remove much of what makes milk, cheese, ice cream, and butter distinctive and pleasurable: they remove milk fat, which suddenly became undesirable when medical scientists found that saturated milk fat tends to raise blood cholesterol levels and can contribute to heart disease. Happily the last few years have brought a correction in the view of saturated fat, a reaction to the juggernaut of mass production, and a resurgent interest in full-flavored dairy products crafted on a small scale from traditional breeds that graze seasonally on green pastures.Milk and HealthMilk has long been synonymous with wholesome, fundamental nutrition, and for good reason: unlike most of our foods, it is actually designed to be a food. As the sole sustaining food of the calf at the beginning of its life, it's a rich source of many essential body-building nutrients, particularly protein, sugars and fat, vitamin A, the B vitamins, and calcium.Over the last few decades, however, the idealized portrait of milk has become more shaded. We've learned that the balance of nutrients in cow's milk doesn't meet the needs of human infants, that most adult humans on the planet can't digest the milk sugar called lactose, that the best route to calcium balance may not be massive milk intake. These complications help remind us that milk was designed to be a food for the young and rapidly growing calf, not for the young or mature human.Milk NutrientsNearly all milks contain the same battery of nutrients, the relative proportions of which vary greatly from species to species. Generally, animals that grow rapidly are fed with milk high in protein and minerals. A calf doubles its weight at birth in 50 days, a human infant in 100; sure enough, cow's milk contains more than double the protein and minerals of mother's milk. Of the major nutrients, ruminant milk is seriously lacking only in iron and in vitamin C. Thanks to the rumen microbes, which convert the unsaturated fatty acids of grass and grain into saturated fatty acids, the milk fat of ruminant animals is the most highly saturated of our common foods. Only coconut oil beats it. Saturated fat does raise blood cholesterol levels, and high blood cholesterol is associated with an increased risk of heart disease; but the other foods in a balanced diet can compensate for this disadvantage (p. 253).The box below shows the nutrient contents of both familiar and unfamiliar milks. These figures are only a rough guide, as the breakdown by breed indicates; there's also much variation from animal to animal, and in a given animal's milk as its lactation period progresses.Milk in Infancy and Childhood: Nutrition and AllergiesIn the middle of the 20th century, when nutrition was thought to be a simple matter of protein, calories, vitamins, and minerals, cow's milk seemed a good substitute for mother's milk: more than half of all six-month-olds in the United States drank it. Now that figure is down to less than 10%. Physicians now recommend that plain cow's milk not be fed to children younger than one year. One reason is that it provides too much protein, and not enough iron and highly unsaturated fats, for the human infant's needs. (Carefully prepared formula milks are better approximations of breast milk.) Another disadvantage to the early use of cow's milk is that it can trigger an allergy. The infant's digestive system is not fully formed, and can allow some food protein and protein fragments to pass directly into the blood. These foreign molecules then provoke a defensive response from the immune system, and that response is strengthened each time the infant eats. Somewhere between 1% and 10% of American infants suffer from an allergy to the abundant protein in cow's milk, whose symptoms may range from mild discomfort to intestinal damage to shock. Most children eventually grow out of milk allergy.Milk after Infancy: Dealing with LactoseIn the animal world, humans are exceptional for consuming milk of any kind after they have started eating solid food. And people who drink milk after infancy are the exception within the human species. The obstacle is the milk sugar lactose, which can't be absorbed and used by the body as is: it must first be broken down into its component sugars by digestive enzymes in the small intestine. The lactose-digesting enzyme, lactase, reaches its maximum levels in the human intestinal lining shortly after birth, and then slowly declines, with a steady minimum level commencing at between two and five years of age and continuing through adulthood.The logic of this trend is obvious: it's a waste of its resources for the body to produce an enzyme when it's no longer needed; and once most mammals are weaned, they never encounter lactose in their food again. But if an adult without much lactase activity does ingest a substantial amount of milk, then the lactose passes through the small intestine and reaches the large intestine, where bacteria metabolize it, and in the process produce carbon dioxide, hydrogen, and methane: all discomforting gases. Sugar also draws water from the intestinal walls, and this causes a bloated feeling or diarrhea.Low lactase activity and its symptoms are called lactose intolerance. It turns out that adult lactose intolerance is the rule rather than the exception: lactose-tolerant adults are a distinct minority on the planet. Several thousand years ago, peoples in northern Europe and a few other regions underwent a genetic change that allowed them to produce lactase throughout life, probably because milk was an exceptionally important resource in colder climates. About 98% of Scandinavians are lactose-tolerant, 90% of French and Germans, but only 40% of southern Europeans and North Africans, and 30% of African Americans.Coping with Lactose Intolerance Fortunately, lactose intolerance is not the same as milk intolerance. Lactase-less adults can consume about a cup/250 ml of milk per day without severe symptoms, and even more of other dairy products. Cheese contains little or no lactose (most of it is drawn off in the whey, and what little remains in the curd is fermented by bacteria and molds). The bacteria in yogurt generate lactose-digesting enzymes that remain active in the human small intestine and work for us there. And lactose-intolerant milk fans can now buy the lactose-digesting enzyme itself in liquid form (it's manufactured from a fungus, Aspergillus), and add a few drops to any dairy product just before they consume it.New Questions about MilkMilk has been especially valued for two nutritional characteristics: its richness in calcium, and both the quantity and quality of its protein. Recent research has raised some fascinating questions about each of these.Perplexity about Calcium and Osteoporosis Our bones are constructed from two primary materials: proteins, which form a kind of scaffolding, and calcium phosphate, which acts as a hard, mineralized, strengthening filler. Bone tissue is constantly being deconstructed and rebuilt throughout our adult lives, so healthy bones require adequate protein and calcium supplies from our diet. Many women in industrialized countries lose so much bone mass after menopause that they're at high risk for serious fractures. Dietary calcium clearly helps prevent this potentially dangerous loss, or osteoporosis. Milk and dairy products are the major source of calcium in dairying countries, and U.S. government panels have recommended that adults consume the equivalent of a quart (liter) of milk daily to prevent osteoporosis.This recommendation represents an extraordinary concentration of a single food, and an unnatural one -- remember that the ability to drink milk in adulthood, and the habit of doing so, is an aberration limited to people of northern European descent. A quart of milk supplies two-thirds of a day's recommended protein, and would displace from the diet other foods -- vegetables, fruits, grains, meats, and fish -- that provide their own important nutritional benefits. And there clearly must be other ways of maintaining healthy bones. Other countries, including China and Japan, suffer much lower fracture rates than the United States and milk-loving Scandinavia, despite the fact that their people drink little or no milk. So it seems prudent to investigate the many other factors that influence bone strength, especially those that slow the deconstruction process (see box, p. 15). The best answer is likely to be not a single large white bullet, but the familiar balanced diet and regular exercise.Milk Proteins Become Something More We used to think that one of the major proteins in milk, casein (p. 19), was mainly a nutritional reservoir of amino acids with which the infant builds its own body. But this protein now appears to be a complex, subtle orchestrator of the infant's metabolism. When it's digested, its long amino-acid chains are first broken down into smaller fragments, or peptides. It turns out that many hormones and drugs are also peptides, and a number of casein peptides do affect the body in hormone-like ways. One reduces breathing and heart rates, another triggers insulin release into the blood, and a third stimulates the scavenging activity of white blood cells. Do the peptides from cow's milk affect the metabolism of human children or adults in significant ways? We don't yet know.Milk Biology and ChemistryHow the Cow Makes MilkMilk is food for the newborn, and so dairy animals must give birth before they will produce significant quantities of milk. The mammary glands are activated by changes in the balance of hormones toward the end of pregnancy, and are stimulated to continue secreting milk by regular removal of milk from the gland. The optimum sequence for milk production is to breed the cow again 90 days after it calves, milk it for 10 months, and let it go dry for the two months before the next calving. In intensive operations, cows aren't allowed to waste energy on grazing in variable pastures; they're given hay or silage (whole corn or other plants, partly dried and then preserved by fermentation in airtight silos) in confined lots, and are milked only during their two or three most productive years. The combination of breeding and optimal feed formulation has led to per-animal yields of a hundred pounds or 15 gallons/58 liters per day, though the American average is about half that. Dairy breeds of sheep and goats give about one gallon per day.The first fluid secreted by the mammary gland is colostrum, a creamy, yellow solution of concentrated fat, vitamins, and proteins, especially immunoglobulins and antibodies. After a few days, when the colostrum flow has ceased and the milk is saleable, the calf is put on a diet of reconstituted and soy milks, and the cow is milked two or three times daily to keep the secretory cells working at full capacity.The Milk Factory The mammary gland is an astonishing biological factory, with many different cells and structures working together to create, store, and dispense milk. Some components of milk come directly from the cow's blood and collect in the udder. The principal nutrients, however -- fats, sugar, and proteins -- are assembled by the gland's secretory cells, and then released into the udder.A Living Fluid Milk's blank appearance belies its tremendous complexity and vitality. It's alive in the sense that, fresh from the udder, it contains living white blood cells, some mammary-gland cells, and various bacteria; and it teems with active enzymes, some floating free, some embedded in the membranes of the fat globules. Pasteurization (p. 22) greatly reduces this vitality; in fact residual enzyme activity is taken as a sign that the heat treatment was insufficient. Pasteurized milk contains very few living cells or active enzyme molecules, so it is more predictably free of bacteria that could cause food poisoning, and more stable; it develops off-flavors more slowly than raw milk. But the dynamism of raw milk is prized in traditional cheese making, where it contributes to the ripening process and deepens flavor.Milk owes its milky opalescence to microscopic fat globules and protein bundles, which are just large enough to deflect light rays as they pass through the liquid. Dissolved salts and milk sugar, vitamins, other proteins, and traces of many other compounds also swim in the water that accounts for the bulk of the fluid. The sugar, fat, and proteins are by far the most important components, and we'll look at them in detail in a moment.First a few words about the remaining components. Milk is slightly acidic, with a pH between 6.5 and 6.7, and both acidity and salt concentrations strongly affect the behavior of the proteins, as we'll see. The fat globules carry colorless vitamin A and its yellow-orange precursors the carotenes, which are found in green feed and give milk and undyed butter whatever color they have. Breeds differ in the amount of carotene they convert into vitamin A; Guernsey and Jersey cows convert little and give especially golden milk, while at the other extreme sheep, goats, and water buffalo process nearly all of their carotene, so their milk and butter are nutritious but white. Riboflavin, which has a greenish color, can sometimes be seen in skim milk or in the watery translucent whey that drains from the curdled proteins of yogurt.Milk Sugar: LactoseThe only carbohydrate found in any quantity in milk is also peculiar to milk (and a handful of plants), and so was named lactose, or "milk sugar." (Lac- is a prefix based on the Greek word for "milk"; we'll encounter it again in the names of milk proteins, acids, and bacteria.) Lactose is a composite of the two simple sugars glucose and galactose, which are joined together in the secretory cell of the mammary gland, and nowhere else in the animal body. It provides nearly half of the calories in human milk, and 40% in cow's milk, and gives milk its sweet taste.The uniqueness of lactose has two major practical consequences. First, we need a special enzyme to digest lactose; and many adults lack that enzyme and have to be careful about what dairy products they consume (p. 14). Second, most microbes take some time to make their own lactose-digesting enzyme before they can grow well in milk, but one group has enzymes at the ready and can get a head start on all the others. The bacteria known as Lactobacilli and Lactococci not only grow on lactose immediately, they also convert it into lactic acid ("milk acid"). They thus acidify the milk, and in so doing, make it less habitable by other microbes, including many that would make the milk unpalatable or cause disease. Lactose and the lactic-acid bacteria therefore turn milk sour, but help prevent it from spoiling, or becoming undrinkable.Lactose is one-fifth as sweet as table sugar, and only one-tenth as soluble in water (200 vs. 2,000 gm/l), so lactose crystals readily form in such products as condensed milk and ice cream and can give them a sandy texture.Milk FatMilk fat accounts for much of the body, nutritional value, and economic value of milk. The milk-fat globules carry the fat-soluble vitamins (A, D, E, K), and about half the calories of whole milk. The higher the fat content of milk, the more cream or butter can be made from it, and so the higher the price it will bring. Most cows secrete more fat in winter, due mainly to concentrated winter feed and the approaching end of their lactation period. Certain breeds, notably Guernseys and Jerseys from the Channel Islands between Britain and France, produce especially rich milk and large fat globules. Sheep and buffalo milks contain up to twice the butterfat of whole cow's milk (p. 13).The way the fat is packaged into globules accounts for much of milk's behavior in the kitchen. The membrane that surrounds each fat globule is made up of phospholipids (fatty acid emulsifiers, p. 802) and proteins, and plays two major roles. It separates the droplets of fat from each other and prevents them from pooling together into one large mass; and it protects the fat molecules from fat-digesting enzymes in the milk that would otherwise attack them and break them down into rancid-smelling and bitter fatty acids.Creaming When milk fresh from the udder is allowed to stand and cool for some hours, many of its fat globules rise and form a fat-rich layer at the top of the container. This phenomenon is called creaming, and for millennia it was the natural first step toward obtaining fat-enriched cream and butter from milk. In the 19th century, centrifuges were developed to concentrate the fat globules more rapidly and thoroughly, and homogenization was invented to prevent whole milk from separating in this way (p. 23). The globules rise because their fat is lighter than water, but they rise much faster than their buoyancy alone can account for. It turns out that a number of minor milk proteins attach themselves loosely to the fat globules and knit together clusters of about a million globules that have a stronger lift than single globules do. Heat denatures these proteins and prevents the globule clustering, so that the fat globules in unhomogenized but pasteurized milk rise more slowly into a shallower, less distinct layer. Because of their small globules and low clustering activity, the milks of goats, sheep, and water buffalo are very slow to separate.Milk Fat Globules Tolerate Heat...Interactions between fat globules and milk proteins are also responsible for the remarkable tolerance of milk and cream to heat. Milk and cream can be boiled and reduced for hours, until they're nearly dry, without breaching the globule membranes enough to release their fat. The globule membranes are robust to begin with, and it turns out that heating unfolds many of the milk proteins and makes them more prone to stick to the globule surface and to each other -- so the globule armor actually gets progressively thicker as heating proceeds. Without this stability to heat, it would be impossible to make many cream-enriched sauces and reduced-milk sauces and sweets....But Are Sensitive to Cold Freezing is a different story. It is fatal to the fat globule membrane. Cold milk fat and freezing water both form large, solid, jagged crystals that pierce, crush, and rend the thin veil of phospholipids and proteins around the globule, just a few molecules thick. If you freeze milk or cream and then thaw it, much of the membrane material ends up floating free in the liquid, and many of the fat globules get stuck to each other in grains of butter. Make the mistake of heating thawed milk or cream, and the butter grains melt into puddles of oil.Milk Proteins: Coagulation by Acid and EnzymesTwo Protein Classes: Curd and Whey There are dozens of different proteins floating around in milk. When it comes to cooking behavior, fortunately, we can reduce the protein population to two basic groups: Little Miss Muffet's curds and whey. The two groups are distinguished by their reaction to acids. The handful of curd proteins, the caseins, clump together in acid conditions and form a solid mass, or coagulate, while all the rest, the whey proteins, remain suspended in the liquid. It's the clumping nature of the caseins that makes possible most thickened milk products, from yogurt to cheese. The whey proteins play a more minor role; they influence the texture of casein curds, and stabilize the milk foams on specialty coffees. The caseins usually outweigh the whey proteins, as they do in cow's milk by 4 to 1.Both caseins and whey proteins are unusual among food proteins in being largely tolerant of heat. Where cooking coagulates the proteins in eggs and meat into solid masses, it does not coagulate the proteins in milk and cream -- unless the milk or cream has become acidic. Fresh milk and cream can be boiled down to a fraction of their volume without curdling.The Caseins The casein family includes four different kinds of proteins that gather together into microscopic family units called micelles. Each casein micelle contains a few thousand individual protein molecules, and measures about a ten-thousandth of a millimeter qlacross, about one-fiftieth the size of a fat globule. Around a tenth of the volume of milk is taken up by casein micelles. Much of the calcium in milk is in the micelles, where it acts as a kind of glue holding the protein molecules together. One portion of calcium binds individual protein molecules together into small clusters of 15 to 25. Another portion then helps pull several hundred of the clusters together to form the micelle (which is also held together by the water-avoiding hydrophobic portions of the proteins bonding to each other).Keeping Micelles Separate...One member of the casein family is especially influential in these gatherings. That is kappa-casein, which caps the micelles once they reach acertain size, prevents them from growing larger, and keeps them dispersed and separate. One end of the capping-casein molecule extends from the micelle out into the surrounding liquid, and forms a "hairy layer" with a negative electrical charge that repels other micelles....And Knitting Them Together in Curds The intricate structure of casein micelles can be disturbed in several ways that cause the micelles to flock together and the milk to curdle. One way is souring. Milk's normal pH is about 6.5, or just slightly acidic. If it gets acid enough to approach pH 5.5, the capping-casein's negative charge is neutralized, the micelles no longer repel each other, and they therefore gather in loose clusters. At the same acidity, the calcium glue that holds the micelles together dissolves, the micelles begin to fall apart, and their individual proteins scatter. Beginning around pH 4.7, the scattered casein proteins lose their negative charge, bond to each other again and form a continuous, fine network: and the milk solidifies, or curdles. This is what happens when milk gets old and sour, or when it's intentionally cultured with acid-producing bacteria to make yogurt or sour cream.Another way to cause the caseins to curdle is the basis of cheese making. Chymosin, a digestive enzyme from the stomach of a milk-fed calf, is exquisitely designed to give the casein micelles a haircut (p. 57). It clips off just the part of the capping-casein that extends into the surrounding liquid and shields the micelles from each other. Shorn of their hairy layer, the micelles all clump together -- without the milk being noticeably sour.The Whey Proteins Subtract the four caseins from the milk proteins, and the remainder, numbering in the dozens, are the whey proteins. Where the caseins are mainly nutritive, supplying amino acids and calcium for the calf, the whey proteins include defensive proteins, molecules that bind to and transport other nutrients, and enzymes. The most abundant one by far is lactoglobulin, whose biological function remains a mystery. It's a highly structured protein that is readily denatured by cooking. It unfolds at 172F/78C, when its sulfur atoms are exposed to the surrounding liquid and react with hydrogen ions to form hydrogen sulfide gas, whose powerful aroma contributes to the characteristic flavor of cooked milk (and many other animal foods).In boiling milk, unfolded lactoglobulin binds not to itself but to the capping-casein on the casein micelles, which remain separate; so denatured lactoglobulin doesn't coagulate. When denatured in acid conditions with relatively little casein around, as in cheese whey, lactoglobulin molecules do bind to each other and coagulate into little clots, which can be made into whey cheeses like true ricotta. Heat-denatured whey proteins are better than their native forms at stabilizing air bubbles in milk foams and ice crystals in ice creams; this is why milks and creams are usually cooked for these preparations (pp. 26, 43).Milk FlavorThe flavor of fresh milk is balanced and subtle. It's distinctly sweet from the lactose, slightly salty from its complement of minerals, and very slightly acid. Its mild, pleasant aroma is due in large measure to short-chain fatty acids (including butyric and capric acids), which help keep highly saturated milk fat fluid at body temperature, and which are small enough that they can evaporate into the air and reach our nose. Normally, free fatty acids give an undesirable, soapy flavor to foods. But in sparing quantities, the 4- to 12-carbon rumen fatty acids, branched versions of these, and acid-alcohol combinations called esters, provide milk with its fundamental blend of animal and fruity notes. The distinctive smells of goat and sheep milks are due to two particular branched 8-carbon fatty acids (4-ethyl-octanoic, 4-methyl-octanoic) that are absent in cow's milk. Buffalo milk, from which traditional mozzarella cheese is made, has a characteristic blend of modified fatty acids reminiscent of mushrooms and freshly cut grass, together with a barnyardy nitrogen compound (indole).The basic flavor of fresh milk is affected by the animals' feed. Dry hay and silage are relatively poor in fat and protein and produce a less complicated, mildly cheesy aroma, while lush pasturage provides raw material for sweet, raspberry-like notes (derivatives of unsaturated long-chain fatty acids), as well as barnyardy indoles.Flavors from Cooking Low-temperature pasteurization (p. 22) slightly modifies milk flavor by driving off some of the more delicate aromas, but stabilizes it by inactivating enzymes and bacteria, and adds slightly sulfury and green-leaf notes (dimethyl sulfide, hexanal). High-temperature pasteurization or brief cooking -- heating milk above 170F/76C -- generates traces of many flavorful substances, including those characteristic of vanilla, almonds, and cultured butter, as well as eggy hydrogen sulfide. Prolonged boiling encourages browning or Maillard reactions between lactose and milk proteins, and generates molecules that combine to give the flavor of butterscotch.The Development of Off-Flavors The flavor of good fresh milk can deteriorate in several different ways. Simple contact with oxygen or exposure to strong light will cause the oxidation of phospholipids in the globule membrane and a chain of reactions that slowly generate stale cardboard, metallic, fishy, paint-like aromas. If milk is kept long enough to sour, it also typically develops fruity, vinegary, malty, and more unpleasant notes.Exposure to sunlight or fluorescent lights also generates a distinctive cabbage-like, burnt odor, which appears to result from a reaction between the vitamin riboflavin and the sulfur-containing amino acid methionine. Clear glass and plastic containers and supermarket lighting cause this problem; opaque cartons prevent it.Unfermented Dairy ProductsFresh milk, cream, and butter may not be as prominent in European and American cooking as they once were, but they are still essential ingredients. Milk has bubbled up to new prominence atop the coffee craze of the 1980s and '90s.MilksMilk has become the most standardized of our basic foods. Once upon a time, people lucky enough to live near a farm could taste the pasture and the seasons in milk fresh from the cow. City life, mass production, and stricter notions of hygiene have now put that experience out of reach. Today nearly all of our milk comes from cows of one breed, the black-and-white Holstein, kept in sheds and fed year-round on a uniform diet. Large dairies pool the milk of hundreds, even thousands of cows, then pasteurize it to eliminate microbes and homogenize it to prevent the fat from separating. The result is processed milk of no particular animal or farm or season, and therefore of no particular character. Some small dairies persist in milking other breeds, allowing their herds out to pasture, pasteurizing mildly, and not homogenizing. Their milk can have a more distinctive flavor, a rare reminder of what milk used to taste like.Raw Milk Careful milking of healthy cows yields sound raw milk, which has its own fresh taste and physical behavior. But if it's contaminated by a diseased cow or careless handling -- the udder hangs right next to the tail -- this nutritious fluid soon teems with potentially dangerous microbes. The importance of strict hygiene in the dairy has been understood at least since the Middle Ages, but life far from the farms made contamination and even adulteration all too common in cities of the 18th and 19th centuries, where many children were killed by tuberculosis, undulant fever, and simple food poisoning contracted from tainted milk. In the 1820s, long before anyone knew about microbes, some books on domestic economy advocated boiling all milk before use. Early in the 20th century, national and local governments began to regulate the dairy industry and require that it heat milk to kill disease microbes.Today very few U.S. dairies sell raw milk. They must be certified by the state and inspected frequently, and the milk carries a warning label. Raw milk is also rare in Europe.Pasteurization and UHT Treatments In the 1860s, the French chemist Louis Pasteur studied the spoilage of wine and beer and developed a moderate heat treatment that preserved them while minimizing changes in their flavor. It took several decades for pasteurization to catch on in the dairy. Nowadays, in industrial-scale production, it's a practical necessity. Collecting and pooling milk from many different farms increases the risk that a given batch will be contaminated; and the plumbing and machinery required for the various stages of processing afford many more opportunities for contamination.

Pasteurization extends the shelf life of milk by killing pathogenic and spoilage microbes and by inactivating milk enzymes, especially the fat splitters, whose slow but steady activity can make it unpalatable. Pasteurized milk stored below 40F/5C should remain drinkable for 10 to 18 days.There are three basic methods for pasteurizing milk. The simplest is batch pasteurization, in which a fixed volume of milk, perhaps a few hundred gallons, is slowly agitated in a heated vat at a minimum of 145F/62C for 30 to 35 minutes. Industrial-scale operations use the high-temperature, short-time (HTST) method, in which milk is pumped continuously through a heat exchanger and held at a minimum of 162F/72C for 15 seconds. The batch process has a relatively mild effect on flavor, while the HTST method is hot enough to denature around 10% of the whey proteins and generate the strongly aromatic gas hydrogen sulfide (p. 87). Though this "cooked" flavor was considered a defect in the early days, U.S. consumers have come to expect it, and dairies now often intensify it by pasteurizing at well above the minimum temperature; 171F/77C is commonly used.The third method of pasteurizing milk is the ultra-high temperature (UHT) method, which involves heating milk at 265-300F/ 130-150C either instantaneously or for 1 to 3 seconds, and produces milk that, if packaged under strictly sterile conditions, can be stored for months without refrigeration. The longer UHT treatment imparts a cooked flavor and slightly brown color to milk; cream contains less lactose and protein, so its color and flavor are less affected.Sterilized milk has been heated at 230-250F/110-121C for 8 to 30 minutes; it is even darker and stronger in flavor, and keeps indefinitely at room temperature.Homogenization Left to itself, fresh whole milk naturally separates into two phases: fat globules clump together and rise to form the cream layer, leaving a fat-depleted phase below (p. 18). The treatment called homogenization was developed in France around 1900 to prevent creaming and keep the milk fat evenly -- homogeneously -- dispersed. It involves pumping hot milk at high pressure through very small nozzles, where the turbulence tears the fat globules apart into smaller ones; their average diameter falls from 4 micrometers to about 1. The sudden increase in globule numbers causes a proportional increase in their surface area, which the original globule membranes are insufficient to cover. The naked fat surface attracts casein particles, which stick and create an artificial coat (nearly a third of the milk's casein ends up on the globules). The casein particles both weigh the fat globules down and interfere with their usual clumping: and so the fat remains evenly dispersed in the milk. Milk is always pasteurized just before or simultaneously with homogenization to prevent its enzymes from attacking the momentarily unprotected fat globules and producing rancid flavors.Homogenization affects milk's flavor and appearance. Though it makes milk taste blander -- probably because flavor molecules get stuck to the new fat-globule surfaces -- it also makes it more resistant to developing most off-flavors. Homogenized milk feels creamier in the mouth thanks to its increased population (around sixty-fold) of fat globules, and it's whiter, because the carotenoid pigments in the fat are scattered into smaller and more numerous particles.Nutritional Alteration; Low-Fat Milks One nutritional alteration of milk is as old as dairying itself: skimming off the cream layer substantially reduces the fat content of the remaining milk. Today, low-fat milks are made more efficiently by centrifuging off some of the globules before homogenization. Whole milk is about 3.5% fat, low-fat milks usually 2% or 1%, and skim milks can range between 0.1 and 0.5%.More recent is the practice of supplementing milk with various substances. Nearly all milks are fortified with the fat-soluble vitamins A and D. Low-fat milks have a thin body and appearance and are usually filled out with dried milk proteins, which can lend them a slightly stale flavor. "Acidophilus" milk contains Lactobacillus acidophilus, a bacterium that metabolizes lactose to lactic acid and that can take up residence in the intestine (p. 47). More helpful to milk lovers who can't digest lactose is milk treated with the purified digestive enzyme lactase, which breaks lactose down into simple, absorbable sugars.Storage Milk is a highly perishable food. Even Grade A pasteurized milk contains millions of bacteria in every glassful, and will spoil quickly unless refrigerated. Freezing is a bad idea because it disrupts milk fat globules and protein particles, which clump and separate when thawed.Concentrated Milks A number of cultures have traditionally cooked milk down for long keeping and ease of transport. According to business legend, the American Gail Borden reinvented evaporated milk around 1853 after a rough transatlantic crossing that sickened the ship's cows. Borden added large amounts of sugar to keep his concentrated milk from spoiling. The idea of sterilizing unsweetened milk in the can came in 1884 from John Meyenberg, whose Swiss company merged with Nestl around the turn of the century. Dried milk didn't appear until around the turn of the 20th century. Today, concentrated milk products are valued because they keep for months and supply milk's characteristic contribution to the texture and flavor of baked goods and confectionery, but without milk's water.Condensed or evaporated milk is made by heating raw milk under reduced pressure (a partial vacuum), so that it boils between 110 and

140F/43-60C, until it has lost about half its water. The resulting creamy, mild-flavored liquid is homogenized, then canned and sterilized. The cooking and concentration of lactose and protein cause some browning, and this gives evaporated milk its characteristic tan color and note of caramel. Browning continues slowly during storage, and in old cans can produce a dark, acidic, tired-tasting fluid.For sweetened condensed milk, the milk is first concentrated by evaporation, and then table sugar is added to give a total sugar concentration of about 55%. Microbes can't grow at this osmotic pressure, so sterilization is unnecessary. The high concentration of sugars causes the milk's lactose to crystallize, and this is controlled by seeding the milk with preformed lactose crystals to keep the crystals small and inconspicuous on the tongue (large, sandy lactose crystals are sometimes encountered as a quality defect). Sweetened condensed milk has a milder, less "cooked" flavor than evaporated milk, a lighter color, and the consistency of a thick syrup.Powdered or dry milk is the result of taking evaporation to the extreme. Milk is pasteurized at a high temperature; then about 90% of its water is removed by vacuum evaporation, and the remaining 10% in a spray drier (the concentrated milk is misted into a chamber of hot air, where the milk droplets quickly dry into tiny particles of milk solids). Some milk is also freeze-dried. With most of its water removed, powdered milk is safe from microbial attack. Most powdered milk is made from low-fat milk because milk fat quickly goes rancid when exposed to concentrated milk salts and atmospheric oxygen, and because it tends to coat the particles of protein and makes subsequent remixing with water difficult. Powdered milk will keep for several months in dry, cool conditions.Cooking with Milk Much of the milk that we use in the kitchen disappears into a mixture -- a batter or dough, a custard mix or a pudding -- whose behavior is largely determined by the other ingredients. The milk serves primarily as a source of moisture, but also contributes flavor, body, sugar that encourages browning, and salts that encourage protein coagulation.When milk itself is a prominent ingredient -- in cream soups, sauces, and scalloped potatoes, or added to hot chocolate, coffee, and tea -- it most often calls attention to itself when its proteins coagulate. The skin that forms on the surface of scalded milk, soups, and sauces is a complex of casein, calcium, whey proteins, and trapped fat globules, and results from evaporation of water at the surface and the progressive concentration of proteins there. Skin formation can be minimized by covering the pan or whipping up some foam, both of which minimize evaporation. Meanwhile, at the bottom of the pan, the high, dehydrating temperature transmitted from the burner causes a similar concentration of proteins, which stick to the metal and eventually scorch. Wetting the pan with water before adding milk will reduce protein adhesion to the metal; a heavy, evenly conducting pan and a moderate flame help minimize scorching, and a double boiler will prevent it (though it's more trouble).Between the pan bottom and the surface, particles of other ingredients can cause curdling by providing surfaces to which the milk proteins can stick and clump together. And acid in the juices of all fruits and vegetables and in coffee, and astringent tannins in potatoes, coffee, and tea, make milk proteins especially sensitive to coagulation and curdling. Because bacteria slowly sour milk, old milk may be acidic enough to curdle instantly when added to hot coffee or tea. The best insurance against curdling is fresh milk and careful control of the burner.From Publishers WeeklyStarred . Before antioxidants, extra-virgin olive oil and supermarket sushi commanded public obsession, the first edition of this book swept readers and cooks into the everyday magic of the kitchen: it became an overnight classic. Now, 20 years later, McGee has taken his slightly outdated volume and turned it into a stunning masterpiece that combines science, linguistics, history, poetry and, of course, gastronomy. He dances from the spicy flavor of Hawaiian seaweed to the scientific method of creating no-stir peanut butter, quoting Chinese poet Shu Xi and biblical proverbs along the way. McGee's conversational stylerich with exclamation points and everyday examplesallows him to explain complex chemical reactions, like caramelization, without dumbing them down. His book will also be hailed as groundbreaking in its breakdown of taste and flavor. Though several cookbooks have begun to answer the questions of why certain foods go well together, McGee draws on recent agricultural research, neuroscience reviews and chemical publications to chart the different flavor chemicals in herbs and spices, fruits and vegetables. Odd synergies appear, like the creation of fruity esters in dry-cured hamthe same that occur naturally in melons! McGee also corrects the European bias of the first edition, moving beyond the Mediterranean to discuss the foods of Asia and Mexico. Almost every single page of this edition has been rewritten, but the book retains the same light touch as the original. McGee has successfully revised the bible of food scienceand produced a fascinating, charming text.