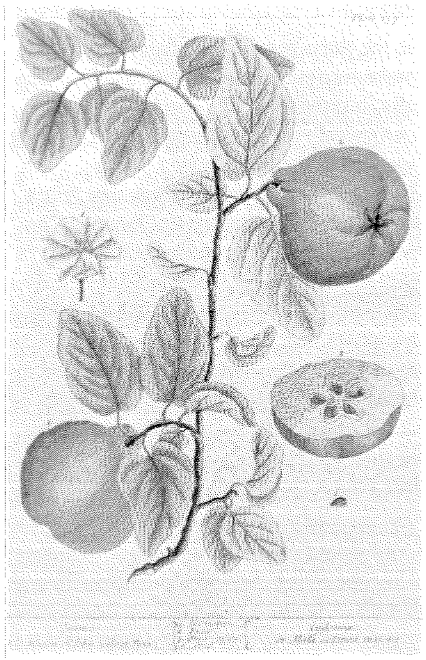
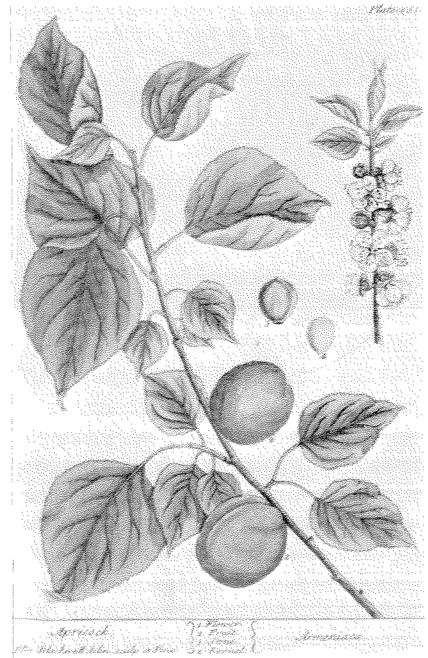
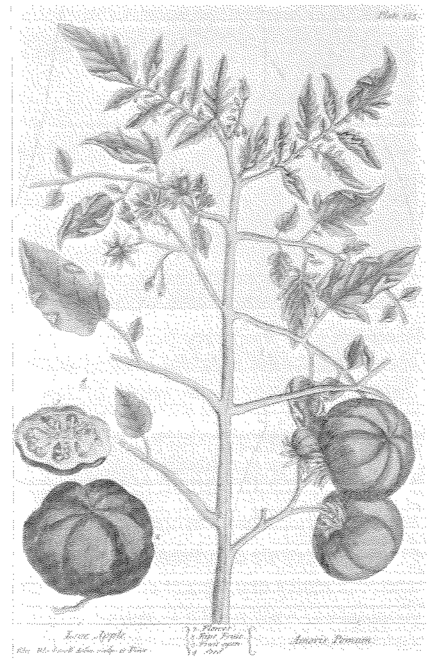




Ripeness Is All

by HAROLD McGEE

Like petrified wood or amber-preserved ants, linguistic fossils — clichés, dead metaphors, ancestral forms — can, if we listen to them, speak to us of conditions buried in the past and yet bearing on our present. Consider these specimens of all-too-common food metaphors. On one side: "That job is a real plum." "What a peach of a dress!" "Life is just a bowl of cherries." "She's the apple of her father's eye." And on the other: "That show was pure corn." "Your offer isn't worth a hill of beans." "Nuts!"

The difference is clear: Fruits convey praise, other plant products serve to disparage. Of course, this is too neat. Figs, raspberries, and the word *fruit* itself can all be used to express derision, while a carrot can mean a reward or inducement, though at the cost of turning its object into a quadruped. A lemon is perhaps the most obvious exception, but it proves the rule, as we shall see. Unlike vegetables or grain, meat or dairy products, fruit generally enjoys special status as an emblem of the ideal or the desirable.

The very fact that we distinguish between fruits and vegetables is noteworthy. As anatomical structures, green beans, corn, eggplants, peppers, and zucchini are the functional equivalents of grapes and peaches: They are all organs derived from the flower and surrounding the seeds. And to the botanist, they are all fruits. But in everyday usage we place many fruits with root, stem, and leaf foods and call them *vegetables*. This word has no anatomical reference and is based solely on culinary custom. Vegetables are usually eaten as a cooked accessory to the main course; fruit, usually raw, alone, and — at least since the Greeks — at meal's end. The special role of culinary fruit in our figures of speech is a reflection of its place at our table: the ultimate dish.

We can trace this underlying hierarchy even in the etymologies of the terms. A very early addition to the English language, the word *fruit* derives from the Latin *fructus,* the past participle of the verb *frui,* meaning to enjoy, to delight in, to have the use of. *Fructus* denoted enjoyment of or pleasure in something, a reward, or a useful product of any kind, but especially produce from the earth. The word was largely evaluative and implied desirability, as it has continued to do in English. Our word *vegetable,* on the other hand, is only about 300 years old. It derives from the Latin *vegere,* meaning to animate or enliven, and is relatively neutral (the Latin for vegetable, *holus,* came from the Greek for "green"). This etymological distinction and the figures of speech that parallel it vindicate the judgment of most children and probably not a few adults: Vegetables may be good for us, but it is fruit that tastes good.

What is it about fruit that gives it this privileged status? In essence, the single trait of sweetness, or a favorable balance between sweet and sour. Studies of newborn humans and other mammals indicate that of the four basic tastes, only sweetness is innately preferred. The plant parts we call fruits and treat as such generally have a much higher sugar content, and often more acid, than those we call and treat as vegetables. It is a rare vegetable that can match the 10 percent average sugar content of most temperate-zone fruits, to say nothing of the 20 to 60 percent characteristic of tropical fruits like the banana, date, or fig. It is on this count that the lemon is wanting and so has become a synonym for *dud*: Its 1 percent sugar content fails miserably to match its acidity.

There are other differences between culinary fruits and vegetables. Most vegetables are especially prized when young; let carrots, asparagus, or beans go too long, and they become tough, coarse, and dry. But most fruit can only be eaten just this side of rotten, at the very end of its development. The edible stage is often signaled by the sudden changes in color, flavor, and texture that constitute ripening. Other plant parts do not ripen, and this is why, unlike fruit, vegetables are usually cooked: Heat is needed to soften them and bring out their flavor.

Unexamined fruit is surely worth the eating. But once held at arm's length and interrogated, this commonplace object becomes more and more mysterious. What exactly is a fruit? Why does it differ so from the rest of the plant? What is going on as it ripens? Why does it ripen? Why does it, more than any other food, please us with its sweetness? Not all the answers are known, and each answer has its own set of exceptions. But a combination of cellular, chemical, and evolutionary perspectives can give us a fairly coherent picture of the nature of fruit.

First, what is a fruit? In botanical terms, it is a distinct organ that develops from the ovary and encloses the maturing seeds. Most fruits are simply the thickened ovary wall. Others incorporate nearby tissues as well. The apple, pear, fig, and strawberry, for example, are all composed principally of the "receptacle," or stem tip, in which the flower parts are embedded. The pineapple is a composite of many flowerlike structures and the central stalk. The fruit usually develops into three distinct layers: a protective skin, a seed coat, and an intermediate layer which in nuts and grains is thin and dry, but in the fleshy fruits is thick and succulent. Since the fruit does not support the plant structurally, like a root or stem, or nutritionally, like a root or leaf, it is composed primarily of storage cells, with a minimal complement of vascular and photosynthetic tissue.

The development of fruit can be divided into four distinct stages. The first is fertilization of the female ovule by male pollen, an event that initiates the production of growth-promoting hormones and leads to the expansion of the ovary wall. Some plants, called "parthenocarpic," can develop fruit without fertilization. Bananas, seedless grapes, and navel oranges are the most common genetic carriers of this trait, but many other plants can be tricked into setting fruit without seed by abnormal temperatures during flowering, or by such chemical manipulations as the application of growth hormones.

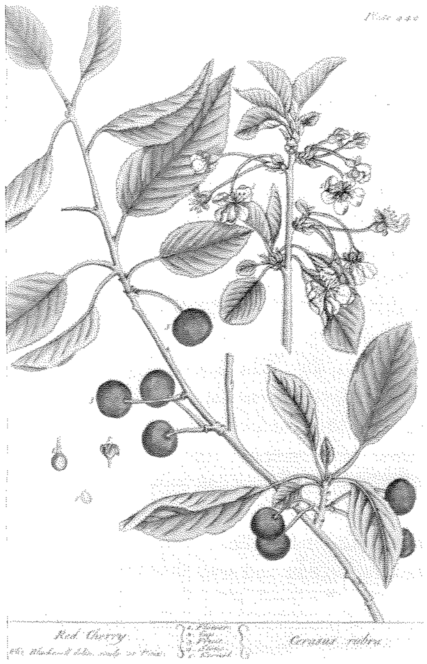
The second stage of fruit development is the multiplication of cells in the ovary wall. This phase is surprisingly short. In apples, cell division is over a month after flowering, though it takes about four months for the fruit to mature. And in the tomato, cell division is virtually complete at the moment of fertilization. An exception is the avocado (a vegetable to us, but with sugar added, a fruit in Brazil), whose cells continue to divide until it ripens.

Most of the increase in size we notice during fruit maturation is the expansion of a fixed number of storage cells. In this third stage, growth can be astonishing. Melons at their peak put on better than five cubic inches a day. Pumpkins average 12 ounces, with some daily gains of 20 ounces. Most of this expansion is due to the accumulation of water-based sap in cell vacuoles. Storage cells in mature fruit are among the largest in the plant kingdom, in the watermelon reaching up to 350,000 times their original size, or about a millimeter in diameter. Actually, we should speak of nightly gains in size. Fruit grows faster — as much as 25 times faster — during the night than during the day, and some will even shrink when the sun is up. Daytime temperatures and humidity cause large losses of water from the rest of the plant, so less can be spared for storage in the fruit. In fact, fruit may act as a reservoir for the plant, supplying water during the day and storing it at night.

What is happening as the cells enlarge? Water and minerals from the roots and sugars newly synthesized in the leaves are translocated to the fruit, where they are put to various uses. As each cell expands, its surface area increases, and new cell wall material, which takes the form of cellulose fibers embedded in a cementlike layer of pectic substances, must be laid down. Sugar provides energy for the cell's metabolism, and excess supplies are stored in the vacuole as sugar or organic acids, or are converted into the more compact, less reactive starch granules (the avocado forms oil rather than starch). So-called secondary compounds, among them poisonous alkaloids and astringent tannins, are synthesized in order to deter infection or predation. And the many enzymes, hormones, and other intermediate molecules necessary to run these processes are continually replenished.

The gradual work of cell enlargement proceeds for weeks, even months, and compared with what goes on in the rest of the plant, it is not very remarkable. But the fourth stage of fruit development, ripening, is unique. It is a sudden, rapid, and drastic change in the life of the fruit that merges into its death and decay. While cell expansion will stop if the fruit is cut off from the plant, mature fruit will go ahead and ripen as if by remote control, and at times even faster than fruit left on the plant. (The anomalous avocado will not ripen *until* it has been picked — the tree appears to supply some inhibiting substance — with the result that storing avocados means leaving them in the orchards.)

Ripening consists of several simul-



taneous events. Skin color changes, usually from green to something else. Starch and acid contents decrease, and sugar increases. Cell walls weaken. Secondary compounds disappear. A characteristically fruity odor develops. Translated to the consumer's perspective: Fruit becomes sweeter, softer, safer, tastier, and gives us a visual advertisement of the fact.

What brings on these changes? The single largest cause is the action of many different enzymes, which break down complex molecules into simpler ones. Color shift, for example, is due primarily to the destruction of chlorophyll, together with some synthesis of other pigments. The membrane surrounding the chloroplast is weakened and permits an enzyme called chlorophyllase to reach and destroy the green pigment, which is normally so intense that it masks the presence of others that invariably accompany it.

Enzymes also convert starch into sugar and so make the fruit more palatable. An extreme example is the banana, which goes from a 25 percent starch, 1 percent sugar ratio to 20 percent sugar, 1 percent starch after ripening (the missing 5 percent is used to provide energy for the cell's metabolism). Several common fruits, however, do not store starch, and this fact has practical significance. Their final sugar content will depend on the time they spend attached to the sugar-supplying leaves. Melons, citrus fruits, and pineapples will not get any sweeter once they are picked; in these cases, we are left at the mercy of the growers.

Even these fruits will, however, improve in texture after picking. Fruit softens because pectic enzymes convert the cell wall cement into more soluble forms, which then dissolve away and weaken the entire network. For reasons that are not entirely understood, this change is so extensive in tree-ripened pears that they become unpleasantly mealy; pears turn out best if they are picked prematurely.

All secondary compounds do not follow this trend of enzyme degradation. Alkaloids do, but tannins bind to each other to form unreactive polymers. And fruity odors are a complex combination of the many volatile compounds that result from the general breakdown of storage tissue.

It was long thought that ripening is in fact nothing more than the progressive breakdown of cellular structure, which results in the mixing of reactive compounds normally segregated from one another, and so in eventual chemical chaos. Today, however, ripening is seen as the final, carefully programmed stage of fruit development, a directed process that involves the synthesis of new materials rather than mere destruction. The key piece of evidence for this view is the role of the gas ethylene.

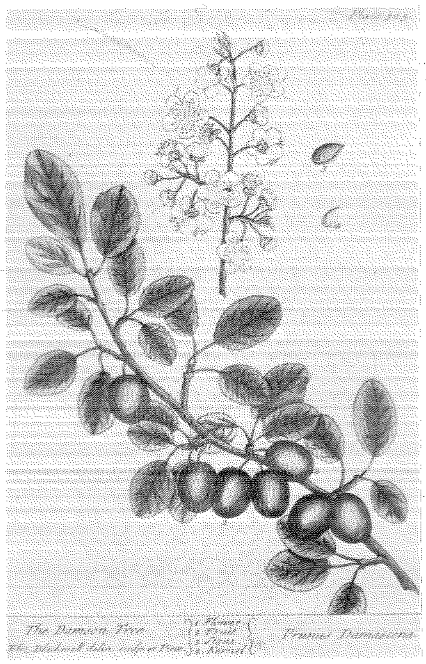
In the Caribbean islands, around 1910, it was reported that bananas stored near some oranges had ripened earlier than others. In 1912, California citrus growers noticed that green fruit kept near a kerosene stove changed color faster than the rest. What secret ripening agent did fruit and stoves have in common? The answer came two decades later: ethylene, a simple hydrocarbon gas ($H_2C = CH_2$) which, when applied to mature but unripe fruit, triggers ripening. More recently, it has been determined that the fruit itself produces ethylene in advance of ripening, an event called "autostimulation." Ethylene is not merely a byproduct of cell disorganization, then, but a specific hormone that initiates this process in an organized way.

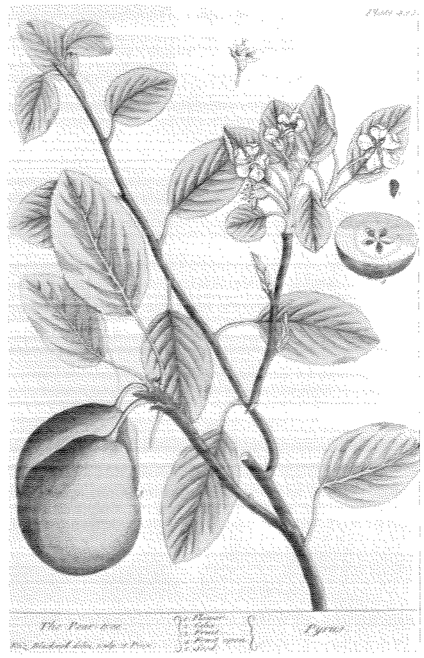
This knowledge has found widespread commercial application. Bananas, tomatoes, and other fruit are shipped hard and unripe to reduce the damage caused by picking, packing, and transport, and then are gassed on arrival. Oranges are treated simply to improve their color; their flavor and texture do not change. But the control of ripening is hardly an invention of the supermarket era. In the fourth century B.C., Theophrastus, a student of Aristotle's and author of the first known botanical treatise, wrote of the Egyptian fig: "It will not mature fully unless it is cut and anointed with oil. . . . For the excess juice is drawn off by the wound, and the oil, like the sun, warms the open fruit and accelerates its maturation." This practice of "oleification" for the purpose of ripening figs about a week early continued well into this century in the Mediterranean region. Research in the Yale laboratory of Bruce B. Stowe (Caltech BS '50) has shown that long-chain fatty acids in the oil, given the compact name "oleanimins" by the investigators, stimulate the fruit to produce the ripening hormone ethylene. Today, most growers say that the gain of a few days is not worth the trouble and that treated figs are not as tasty as the untreated — a familiar remark about supermarket produce.

Exactly how ethylene works is not known. It probably increases the permeability of cell membranes, and triggers the synthesis of enzymes that are immediately responsible for the series of changes that constitutes ripening. It is known that once ethylene reaches a certain concentration in the fruit, the cells suddenly begin to respire — to use oxygen and produce carbon dioxide — from two to five times more rapidly than before. This respiration rate is a sign of furious biochemical activity. The cells are not simply dying away and disintegrating, but are living a last, intense phase of life. As it ripens, the fruit actively prepares for its end, organizing itself into a feast for eye and palate.

That may explain what fruit is and what ripening is. But why such an elaborate ritual of passage for something that is in the process of falling apart? Here we must shift perspective drastically.

Arguments abound about how many kingdoms of organisms there are on the planet, but plants and animals are assuredly two. Plants are generally "autotrophic," or self-nourished. Given a supply of water, minerals, oxygen, carbon dioxide, and sunlight, they can thrive, independent of other organisms. But animals are unable to synthesize from such primitive materials the complex proteins, carbohydrates, and other compounds necessary for life. They are "heterotrophic," or other-nourished, and depend on the ingestion of other organisms, plant or animal, to meet their needs for energy and building materials. And while land-dwelling autotrophs need access only to





the soil, atmosphere, and sun — sources which, once located, are rather reliable — the heterotroph must worry more about the availability of food, and will have a distinct advantage if it can control its access to prey. Hence the animal's unique combination of sensory organs, central information processor, and locomotive power, which empowers it to perceive its situation, choose an appropriate response, and act accordingly.

The plant, cradled at the constant breast of Mother Earth, seldom does without nourishment, and so has no need for eye or muscle or brain. But this versatile system does multiple duty for the animal, and in some areas of life plants have had to develop special strategies for which the animal has no need. Lacking the power of movement, plants defend themselves from predators with unpleasant or poisonous chemicals. The tannins and alkaloids in unripe fruit are two such chemical weapons. And pollen and flowers are structures designed to make use of mobile middlemen — the wind, insects, birds — in joining male and female in the process of reproduction. Then there is the subsequent task of seeing the next generation off to a good start. If a plant's seeds were to fall straight to the ground, then they would have to compete with each other and with their overshadowing progenitor for the limited resources of a small area. Most seedlings would die, and the population would grow very slowly, if at all. Successful plant species have tended to develop mechanisms for dispersing their seeds over as wide an area as possible. These mechanisms include seed appendages that catch the wind, containers that pop open and spray their contents in all directions, burrs that catch on passing fur . . . and structures that manage to hitch a ride *inside* passers-by.

Fruit is in essence a device of seed dispersal, the result of long coevolution between plants and animals. One needs food, the other a transportation service, and fruit is the compromise, the medium of exchange. Different animals have called for different inducements, and while we are a long way from being able to say exactly how particular fruit characteristics have evolved, some generalizations are possible. Reptiles are not generally climbers, and reptile fruits are usually borne near the ground or dropped at maturity. Birds are sensitive to color contrasts and can easily reach heights, and typical bird fruits are accordingly brightly colored and remain attached. Fruit bats are color-blind, attracted to their own odor, and have trouble negotiating leaves; their fruits are drab, smell musty, and hang exposed below the foliage. Mammals are generally color-blind, have a good sense of smell, and possess teeth; their fruits develop odors and can have tougher skins. Primates, relative latecomers to the mammal family, can climb and see colors and have invaded the birds' territory.

Of course, the plant will have gained nothing at all if its embryonic offspring do not survive the animal's attentions. Seeds can escape being consumed along with the fruit in several ways. They may be too large and hard to be eaten with the fleshy covering, or else small and numerous enough that some will be spilled during feeding and not be worth the trouble of searching after. They may remain distasteful, even poisonous: Apple, pear, peach, and citrus seed coats all contain cyanide compounds, though the fruits are perfectly edible. Or the seeds may be constructed so as to pass through the animal's digestive tract uninjured and finish their journey in a pile of fresh manure. In such cases the animal both transports and unwittingly nourishes the new generation of plants.

We can understand fruit's special place in our language and our cuisine as a consequence of the special roles it and we play in the plant's life. Unlike the rest of the plant, edible fruit is meant to be eaten, and this is why the complex of taste, odor, and texture is well matched to our animal predilections. And so it is that, in everyday language, fruit tends to suggest desirability. But fruit is meant to be eaten only when its seeds — its whole reason for being — are mature and viable. This is why ripening occurs: Vegetables can be eaten any time, and the earlier the tender-er, but we must wait for fruit to indicate that it is ready to engage our services.

In its conjunction of death and new life, of purposefulness and disintegration, ripeness too has metaphorical power. It is perhaps most sweepingly invoked by Shakespeare, toward the end of *King Lear*. Old, loyal, cruelly blinded Gloucester rests on the ground beneath a tree. He hears of Lear's defeat in battle, and, weary of life, wishes aloud for death: Like the tree's own fruit, "a man may rot even here." But he is as yet unreconciled with his devoted son Edgar, whom his other, treacherous son Edmund has successfully accused of planning parricide. For Gloucester to die now would be to leave his and his sons' lives incomplete, to escape the painful and joyous truth rather than accept it, not to know the good seed from the bad. Edgar, as yet unrecognized, tells his father as much in words that transcend the particulars of the play.

> Men must endure
> Their going hence, even as their
> coming hither:
> Ripeness is all. Come on.