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Sandra Steingraber selling organic tomatoes in 1970

The Ecology of Pizza
(Or Why Organic Food is a Bargain)
Sandra Steingraber, Ph.D.

Pizza is a food I associate with happiness. It fueled all my childhood birthday parties and sleepovers. It was notably present the first time a boy put his arm around me, an event I regarded as miraculous. (At age 13, I wore thick glasses, size ten shoes, and stood at least a half-foot taller than my would-be suitor. The restaurant was darkly lit.) My worldly, cigar-smoking uncle, who was also our family dentist, ceremoniously took my sister and me out for pizza after visits to his office. And pizza was one of three dinner items that my father cooked-chili and spaghetti being the other two. Any night that Dad volunteered to be chef was bound to end well.

In college, pizza was a recurring motif in my first serious love affair. Brian--linebacker, poet, and eldest of four brothers--taught me the fine art of rolling up a pizza slice and eating it like sushi. This was much more efficient, he pointed out. The night he left his fraternity and moved in with me--setting in motion a small scandal I fully intended to enjoy--we ordered pizza. I recall the two of us hunched over the cardboard box, wordlessly chewing, his history of world literature piled on top of my organic chemistry books. (I wore contact lenses. He was six foot three.)

Nearly two decades later, pizza figured largely into my entrance to motherhood. "Morning sickness" is far too mild a term to describe the state of my misery during the first few months of pregnancy. "Gastronomic civil war" would be more accurate. The mere thought of food was revolting, but only food-and lots of it-had the power to quell the revulsion. How food looked, how it was served, how precisely hot or cold it was, all factored into whether or not I could successfully swallow it.

Except for pizza. Pizza I could eat hot or cold, night or day, alone or in the company of others. I knew by heart exactly what time each of the local pizza parlors opened in the morning, when they closed, and how fast they delivered. My husband Jeff (who, at five foot ten, is exactly my height) offered to make me pizza from scratch. A sculptor, he enjoys working with dough because it reminds him of plaster. However, I could not bear the smell of the raw ingredients. Furthermore, I couldn't wait for it. We coined the phrase "emergency pizza." Once, coming home from a biology conference, I ate half a large cheese pizza on the side of the highway. I wondered what I would say if a state trooper found me there behind the steering wheel, flasher lights blinking away, hands and face bloody with tomato sauce. When I learned that tomatoes are the single food most strongly favored by nauseated pregnant women, I felt somewhat less freakish.

Both my children, the almost five-year-old as well as the almost two-year-old, now identify pizza as their favorite entrée. I'd like to believe that some kind of prenatal memory accounts for this. But fully 70 percent of U.S. schoolchildren make the same claim.1 Presumably, not all of them were birthed by women as wolfish about pizza during their pregnancies as I had been.

Now that I can re-enter my kitchen without fear that the simple act of opening the refrigerator will send me, hand over mouth, racing for the bathroom, I occasionally make pizza for them. But when I am tired, or working late, or just dreading the pile of dishes that follows any home-cooked meal, I entertain a fantasy that I first dreamed up while in the first trimester of my first pregnancy: the fantasy of the organic pizzeria.

The Economic Sense of Organic Food

I have been involved with organic food ever since my dad handed me a cash box and stationed me behind a card table at the end of the driveway, next to a giant sign that read ORGANIC TOMATOES 25 CENTS A POUND. According to the photo in our family album, the year was 1970. I would have been ten.

The marketing plan worked. People stopped to ask what in the world organic meant. I then explained, with smarty-pants authority, that it was a way of growing food that does not use any artificial pesticides or fertilizers but instead relies on healthy soil and biological controls to keep weeds, bugs, and diseases away.2 Next, I offered commentary on the use of lady bugs to control aphids, the art of compost-making, and the importance of mulch. At this point, most of my customers had already slapped their quarters on the table and were loading vegetables into their backseats. I do remember one man listening to the whole speech and then asking, "Oh, yeah? And how do I know they're really organic?" My little sister had the answer to that one: "Because our dad says so!"

Our father taught business and consumer education at the local high school; he used Rachel Carson's Silent Spring as a textbook. The tomatoes were from his own garden; my sister and I got to keep the proceeds.

Since then, organic foods have penetrated both the marketplace and the consciousness of U.S. consumers in ways that would have amazed my father. Sales of organic food have increased one-hundred fold since 1980 and are predicted to hit $20 billion by 2005. With an average annual growth rate of 20 percent per year for the last decade, organic food production is now the fastest growing sector of U.S. agriculture.3 With the USDA's organic certification program now in place, buyers no longer have to rely on the personal reassurances of the grower to guarantee chemical-free methods of production. Says a recent issue of American Banker magazine in a clear message to lending institutions, "Organic farming is establishing itself as the bright spot in an otherwise bleak picture of U.S. agriculture."4

The economic statistics for Europe are even more jaw-dropping. Consider Italy. There, organic fruit and vegetable sales more than doubled between 1998 and 2000. During those same two years, the amount of Italian acreage under organic cultivation jumped by 25 percent. Given the high demand in Europe and elsewhere, the Food and Agriculture Organization of the United Nations now officially recommends organic farming to developing nations as a means to increase export earnings and decrease domestic hunger.5

Meanwhile, biological investigations of organic farming practices have helped dispel some commonly held misconceptions about it. One is that organic farms are, however charming, unproductive. Let's be clear: organic farming is not an exercise in nostalgia. Yields on contemporary organic farms are far higher than they were on farms of the 1950s before pesticides became universally available.6 Moreover, according to a Swiss study that was twenty-one years in the making, organic farms are capable of producing yields nearly on par with those of conventional farms while burning up considerably less energy and natural resources to do so. They also leave soils healthier for future generations. The authors of this study found that soils under organic cultivation have more fungi to help plants take in water, more microbes to help plants absorb nutrients, and more earthworms to assist in making those nutrients available in the first place. Published in 2002, the study is considered the most comprehensive study to date that compares conventional and organic farming systems.7

Another myth is that organic farms are overrun by insects. Again, the data show otherwise. A recent survey of commercial tomato farms in California, for example, found no increase in pests on farms where pesticides had been withdrawn. Indeed, organic farms had about the same numbers of plant-eating bugs as did the conventional farms. What organic farms did have in greater abundance were insects that ate the plant-eating bugs. These so-called natural enemies--of which my father's precious ladybugs are one--apparently took the place of insecticides in controlling pest outbreaks, as levels of pest damage in conventional and organic tomatoes were virtually identical. Expressing surprise, the authors concluded, "At least for tomato in the Sacramento Valley, commercial production using organic management techniques is both practical and beneficial."8

A third belief, widely held among consumers, is that organic food is considerably more expensive than conventionally grown food. This is not a misperception. This is pretty much the truth. At the cash register, you pay premium prices for organic food. And, given that organic farmers enjoy comparable yields while using fewer natural resources, why should that be? The answer to this simple question turns out to be fairly complicated. Here is the short version.

In some cases, organic prices are higher because of retail mark-ups. Organic farms are often smaller, more local, or more seasonal. Supermarkets have to purchase their goods from more suppliers who provide less predictable quantities. This takes more work. By contrast, conventional growers can keep prices low by sheer volume. As organic farming becomes ever more popular, supplies should become less variable and retail prices more competitive.9

In some cases, organic food provides higher profit margins for those who produce it.10 This is almost certainly the case for dairy farmers in upstate New York, which is where I live now. In June 2003, farmers producing conventional milk received $11 for every hundred pounds. This was the lowest price in thirty years. Organic milk fetched $20. Not surprisingly, the dairy farmers I know who have switched to organic all say they earn more money now. Similarly, organic dairies in California net 60 percent more income than conventional dairies.11 Increased farm income is, of course, not a bad thing. It provides jobs, prevents bankruptcies and foreclosures, and strengthens the social fabric of rural communities.

But the principal reason that organic food costs more than conventional food is that organic food costs more to produce. By and large, organic farming relies more on labor and less on chemicals, and, in the United States, the former costs more than the latter.12

Except that pesticides are not as cheap as they appear. And here lies the reason why organic food is actually a bargain. The price of organic food reflects, more or less, the full costs of making it. The price of chemically grown food does not. Among the costs not incorporated into the bar codes that beep their way through the check-out lane: fertilizer-contaminated groundwater, insecticide-contaminated fish, herbicide-contaminated rain, dead honeybees, poisoned wildlife, deformed frogs, eroded soil, toxic algal blooms, ozone depletion, and antibiotic resistance. These are what economists call "externalities"-the costs of an activity that are borne by others. The bad thing about externalities is that they lead to market outcomes that are costly to society even though privately profitable.13

The almost universal presence of farm chemicals in U.S. rivers and streams is a classic example. The 130 different pesticides found in groundwater are another.14 Farmers do not intend to harm our drinking water by using it as a receptacle for their topsoil, fertilizers, and weed killers. But, because property rights to the environment are not defined, farmers are not required to include in their expense sheets the economic consequences of erosion, leaching, and drift.15 Instead, the cost of filtering silt and poison out of tap water is passed along to the water utilities. And then ultimately to anyone who pays a water bill.
What do all the externalities of conventionally grown food add up to? What is the final price tag? The answer to this simple question turns out to be more than $10 billion a year.

This is the sum tallied by Cornell University professor David Pimentel in a monumental paper first published in 1992 and recently updated.16 In it, Pimentel reports that U.S. farmers spend about $10 billion on pesticides each year to protect about $40 billion of food crops. For them, this investment is generally profitable. However, as revealed by Pimentel's accounting, the external costs of this pesticide use amounts to another $10 billion. This is the price tag passed along to society at large. Included in Pimentel's exhaustive inventory are costs of lost work caused by poisonings of farm workers, medical treatments for pesticide-induced cancers, and the maintenance of complex regulatory systems to monitor pesticide residues in everything from applesauce to lake sediments.

So, only half of the total costs of using pesticides to grow conventional food are included in the price of the food itself.
Pimentel acknowledges that many public health costs were not incorporated in his calculations and that the real figure may be even higher. Indeed, when I pored through his many pages of tables and charts ("honeybee and pollination losses: $334 million/year"), I could think of several other externalities, familiar to me from the research that I do, that do not appear in his analysis. Many of these have to do with the ability of pesticides to affect pregnancy.

A recent study of Canadian farm families, for example, finds that exposure to certain weed killers raises the risk for miscarriages. A new study from Missouri reports on a link between pesticides and low sperm quality in men. (The likely route of exposure is drinking water.) Another finds that women exposed in the womb to the now-banned pesticide DDT have more difficulty becoming pregnant. Another reports on the apparent association between DDT and premature birth. Another on its continuing presence in human

amniotic fluid. In California, Minnesota, and Iowa, studies show living near pesticide-sprayed fields raises the risk of certain birth defects. Meanwhile, in Washington State, organophosphate insecticides used in agricultural fields turn up in the house dust of nearby homes and in the urine of the young children who inhabit them.17

Preterm birth is a leading cause of disability, and life-long disabilities are expensive. Organophosphate exposure is linked to a number of neurological problems that are expensive to address. Infertility treatments are expensive. Surgical repair of birth defects is expensive. So are pregnancy losses, although, having endured two miscarriages myself, I wouldn't know where to begin to assign a monetary cost to them.

Pizza: A Natural History

This brings us back to pizza, that food beloved of children and pregnant women. Had I lived in Eugene, Oregon when I was pregnant, I could indeed have dined in an organic pizzeria. There are two such establishments in Eugene.18 At one, a slice of cheese pizza sells for $2.00. At the other, $2.50. (Delivery available by bicycle or electric vehicle.) Here in Ithaca, the gourmet pizza parlor downtown--not organic but conveniently located across from the public library--offers a slice for $1.50.

As this hardly seems a fair comparison, given geographic differences and the variable size of a pizza slice, I decided to conduct a more controlled experiment. I made two pizzas from scratch, using the same recipe. The first was assembled from conventionally grown ingredients purchased at a local supermarket, the second from organically grown ones purchased at a local cooperative grocery. I then estimated the cost of the ingredients I actually used, based on the price I paid per unit amount.
The results, along with the recipe-whose origins I cannot account for, as it appears in my recipe box as scribbled notes on a sticky, yellowed index card-are detailed in the accompanying box. I feel compelled to add here that, while my children have reasonably adventurous palates, they prefer their pizzas plain. So, for that matter, do I. Everyone in this household is, nonetheless, favorably disposed to garlic.

Now let's take a closer look at the agricultural origins of each ingredient, conventional and organic.

Wheat flour: Triticum vulgare

Archeologists say that bread first appeared in the human diet at about 8000 BC, which makes wheat about as old as goats. What distinguishes domesticated wheat from wild grasses are tight husks. Indeed, they are so tight that wheat cannot scatter its seeds without human assistance. (Thus, threshing.) What distinguishes wheat from other domesticated grains is the abundant presence of the protein gluten. Gluten traps carbon dioxide bubbles released from live yeast, allowing bread dough to rise. The milled flour of no other grain can do this.

Farmers and cooks have different ways of describing wheat. Farmers talk about winter wheat and spring wheat. Winter wheat is planted in the fall, overwinters in the field, and then is harvested the following summer. Spring wheat is planted in the spring and harvested in the fall. Farmers also talk about hard wheat and soft wheat. Hardness refers to the amount of gluten in the grain. Hard wheats are grown in drier areas, soft wheats where it is humid.

Bakers, on the other hand, refer to bread flours and pastry flours. Bread flour is milled from hard wheat because it contains plenty of stretchy gluten. Pastry flour is milled from soft, low-gluten wheat, which allows for crumbliness. And all-purpose flour is a mixture of the two. (Durum wheat is a hard spring wheat used for pasta-making. It holds up well when boiled. However, try making bread with it and you will pull out of the oven something akin to a patio floor.)

Wheat flour is the single most consumed food in the United States. On average, it makes up seven percent of the daily diet. For preschool children, it's more than 15 percent.19 Not surprisingly, then, wheat takes up more acreage than any other crop. It therefore accounts for a big chunk of agricultural pesticide use. According to the United States Department of Agriculture, U.S. growers spray more than 10 million pounds of pesticides on wheat fields each year.20

Pesticides have allowed wheat fields to grow to gargantuan sizes. Twenty thousand acre farms are not unheard of. (My grandfather raised six children on 160 acres, a sizeable spread at the time.) And gargantuan sizes guarantee that pesticides will continue to be used. Even though an acre of wheat can now be harvested and threshed in six minutes flat, supersized fields mean that some crops are located a long way-as much 100 miles-from the barnyard. The cost of moving equipment through these far-flung fields is high. Therefore, big farming operations, by necessity, plant only single crops rather than many different ones in rotation. Vast tracts of land growing only one variety of one kind of crop allow pest populations to expand to equally vast proportions-at which point only

chemical poisons can keep them in check.21 Ecologically speaking, size matters.

One herbicide commonly used to kill weeds in wheat fields is 2,4-D. Increasing evidence links this chemical to non-Hodgkin's lymphoma, an often fatal cancer.

Farmers who use 2,4-D have higher rates of lymphoma than the general population, and their risk rises with the number of acres sprayed. Within the United States, the death rate from non-Hodgkin's lymphoma is highest in the wheat-growing region of the Great Plains.22 This herbicide may also be linked with birth defects. In Minnesota, Montana, North Dakota, and South Dakota, counties that grow a lot of spring and durum wheat show significantly higher rates of birth defects than counties where less wheat is grown. And within these wheat-growing counties, infants who were conceived in April, May, or June (the time of planting and herbicide application) show higher rates of malformations than children whose conceptions fall during other months of the calendar year.23

Large farms are also leaky farms. Nutrient delivery is a bigger problem in bigger fields. The nitrogen from fertilizers that wash into creeks and streams eventually ends up in the ocean where it contributes to algal blooms and dead zones.24 And this is how our flour-buying choices affect the health of the fish at sea.

Organic farms that grow wheat, by contrast, tend to be smaller-and they usually grow other crops as well. This simple combination of modest size plus diversity provides the farmer an entire armory of potential tricks with which to outwit pests. Lewis Grant, for example, farms 2,500 acres in northern Colorado. He has not used pesticides since 1985, and his wheat yields are consistently within the top 10 percent of yields in the state. Crop rotation, he claims, is the answer to 90 percent of his problems. He only plants his wheat in fields where wheat has not grown for the previous five to six years. During the off-years, he grows some combination of millet, sunflowers, lettuce, spinach, broccoli, beans, and hay. This constantly shifting vegetative landscape keeps disease and pest populations from exploding out of control. In addition, at the corners of his fields he plants insectories-beds of particular kinds of plants that serve as habitats for predatory insects. These species then return the favor by dining on any pest insects that do manage to establish a toehold in his fields. For fertilizer, Grant uses both cow manure and green manure (which is not really manure at all but a plowed-under cover crop like hairy vetch or rye). Soil analysis shows that his fields have tripled their organic matter since he started farming 30 years ago. Healthy soil makes healthy plants: when the Russian wheat aphid arrived ten years ago and devastated wheat crops throughout the area, wheat yields on his organic farms were not affected. 25
Cost of conventional flour: $.44. Cost of organic flour: $.77.

Olive oil: Olea europa
Argument surrounds the origin of the olive tree, with many nations wishing to claim it as their own. Most scholars locate its birthplace in what is now Iraq and Iran, where the discovery of ancient stone presses and mortars suggests that olive oil has been manufactured in the region since at least 5000 BC. From here, the Phoenicians, good mariners that they were, probably spread its cultivation throughout the Mediterranean. Along the way, the olive became, variously, a symbol of peace (Noah's dove brings back an olive sprig from an otherwise ruined world), wisdom (Athena's gift of an olive tree prompts the citizenry of Athens to name the city for her), and victory (Olympic athletes are crowned with olive wreaths).26

Certainly, few would argue that Western civilization has a more revered tree than the olive. Its oil defines the very concept of anointing. References to the olive abound in the sacred texts of Judaism, Christianity, and Islam. And its branches, leaves, flowers, and fruit appear in paintings and drawings throughout the ages. The Impressionists were particularly enamored of olive groves and, to my thinking, capture better than anyone their otherworldly nature.27 Olive trunks twist and writhe from the rocky ground, and yet offer serene and restful silhouettes. Olive branches grow in full sun and yet, with their gray bark and silvery leaves, seem eternally bathed in moonlight.

Ripe olives are 15-40 percent oil. At least a dozen pounds of them are required to make a quart of virgin oil in a process of simple squeezing that has not really changed much over the years. But more is concentrated than just the juice of the fruit. When organophosphate insecticides are used to control the olive fruit's nemesis, the olive fly, trace residues can remain on the olives. Because insecticides are lipid-soluble, they often find their way into the oil within. When olives are pressed, the concentrations of these residues can increase in the finished product by a factor of three to seven. Thorough washing of olives prior to pressing can sometimes lower residues, but the insecticide-laced wastewater from the mill then poses an environmental threat.28

Paco Nunez de Prado is a Spanish olive grower, a profession that men in his family have held for seven generations. He oversees

100,000 olive trees on four different farms as well as an olive oil mill and bottling plant. And he does it all organically. To control olive flies, he uses bait infused with sexual attractants. The males are trapped; the females, he supposes, "die of loneliness." And because they are not contaminated with pesticides, he can mix together olive residue left over after pressing with pruned leaves and branches and make organic fertilizer that is recycled back into his orchards.29
Cost of conventional olive oil: $1.44. Cost of organic olive oil: $2.35.

Tomato: Lycopersicon esculentum
First domesticated in Mexico, the tomato is the only ingredient of pizza native to the Americas. When Cortez conquered Mexico City in 1519, he sent its seeds to Europe where it was initially grown for the beauty of its fruit but not widely eaten except by a few bold Spaniards and Italians. In contrast to the reverence bestowed upon the olive, tomato fruits were viewed with a certain suspicion. (Its Latin name means "wolf peach.") The tomato was reintroduced back to America in the 18th century and, according to legend, brought to the dinner table by Thomas Jefferson.30

The tomato is the delicate Victorian heroine of the horticultural world. With back of wrist pressed to brow of head, she is forever in need of revival by smelling salts. Tomatoes are vulnerable to no less than fourteen fungal diseases (with names that end with words like blight, rot, wilt, or canker) and an equally impressive number of insect pests, some of which inject disease-causing viruses or deposit secretions that attract mold.

The tomato's fragile yellow flowers require insect pollinators to set fruit, a service happily performed by bumblebees. A darkened tip around the flower's stigma indicates fertilization. Commercial varieties can self-pollinate but will not do so if the air is too cool or too still. Thus, one can find in any good agricultural library, step-by-step, full-color manuals on the art of performing tomato reproduction. This involves hand-held vibrating devices, which are applied to open flowers several times a day. A light touch is required, as too much mechanical stimulation can lead to scarring. Enough said.

Commercial field tomatoes come in two basic types that scarcely resemble each other--nor does either have much in common with the backyard garden tomato. Type one are processed tomatoes, which are those destined for canneries. Processed tomatoes are produced on tomato vines that are determinant in growth. This means they all set fruit and ripen at the same time (in contrast to the garden tomato that putters along indeterminately all summer, flowering and fruiting, flowering and fruiting). Processed tomatoes are harvested by machine and picked ripe. Those who produce them are usually under contract to those who turn them into paste or ketchup. Processed tomatoes are valued at about 3 cents a pound. Most come from California. Type two are fresh-market tomatoes. These are harvested by hand and picked green. They are sold on the open market, valued at 25 to 35 cents a pound, and most of them come from Florida.31

Let's take a closer look at fresh-market tomatoes. Many commercial tomato farms in Florida rely on an all-purpose fumigant called methyl bromide to sterilize the soil before planting. This chemical kills everything its vapors touch--insects, weeds, fungus, earthworms, disease pathogens. Happily, methyl bromide leaves little residue on the tomatoes themselves.

But this would be the only reassuring thing you could say about it. Methyl bromide is highly toxic to those who apply it. Colorless, odorless, and instantly absorbed through the lungs, it is responsible for at least 1,000 documented pesticide poisonings in the United States--many involving farm workers and many fatal. At higher doses, it causes seizures, vomiting, tremors, slurred speech, and pulmonary edema. At lower doses, it is a cumulative neurological poison.32 A recent study of more than 55,000 U.S. farmers found that methyl bromide is associated with prostate cancer--those farmers with the heaviest exposures tripled their risk.33

Just as distressing is the destructive effect that methyl bromide has on the ozone layer. Methyl bromide is a more powerful destroyer of ozone than chlorofluorocarbon coolants and aerosols. Consequently, it is slated for worldwide abolition by the Montreal Protocol on Substances that Deplete the Ozone Layer, an international treaty to which the United States and 182 other nations are signatories. For identical reasons, it also is scheduled for abolition under the Clean Air Act. By 2005, methyl bromide is to exist no more within the United States. (Developing nations have a more lenient schedule for phase-out.)

The Florida Fruit and Vegetable Association (FFVA), however, has challenged the ban. In a petition to the U.S. government, the group has asked for a "critical use exemption" that would allow the production and continued use of methyl bromide after the agreed-upon deadline. Acknowledging that "those who depend on methyl bromide for their livelihoods are in a corner," FFVA argues that no economically feasible alternatives exist for the production of tomatoes, strawberries, and a handful of other crops.34 In February

2003, the U.S. government forwarded the case of the Florida tomatoes growers and their co-petitioners to the Ozone Secretariat of the United Nations. At this writing, the U.N. has not yet reached a decision.35

And this is how our tomato-buying habits can subsidize an industry desperately lobbying for the right to use a chemical known to destroy that part of the atmosphere that protects us from sunburn and skin cancer. As a mother who struggles mightily to limit the sun exposure of my children, I would like the pizza sauce I feed them to be in line with my efforts to keep their hats on at the beach.

In the search for ozone-friendly tomatoes, one could do no better than to consult the writings of Charles Wilbur, an Alabama tomato grower and holder of the Guinness Book of World Records for Biggest Tomato Yield on a Single Tomato Plant. (That would be 342 pounds of tomatoes.) Wilbur is an organic grower. His secret, he says, is mulch. Also birds. Wilbur builds birdhouses around his fields and provides birdseed in the winter. The birds, in turn, eat the hornworms on his tomatoes. He uses cardboard collars to keep cutworms off the stalks and plants Austrian peas around this fields to collect aphids. "I can testify," says Wilbur, "that by and large the university professors will not listen. My methods compete with synthetic fertilizers and there is way too much money tied up in the chemical companies for America to change unless we have to."36
Cost of conventional tomato paste: $.50. Cost of organic tomato paste: $.99.
Cost of conventional fresh tomatoes: $1.20. Cost of organic fresh tomatoes: $.69.

Garlic: Allium sativum
Garlic is a lily with origins in western Asia. Unlike the tomato, garlic has no sex life. No flowers. No bees. No fruits. No seeds. Domesticated garlic reproduces solely by cloning itself. And, like wheat, it needs the help of humans to do so. Specifically, garlic growers plant whole garlic cloves (about six inches deep), which then sprout leaves and roots and bud off more cloves, resulting nine months later in an underground bulb of 12-15 cloves that is about the size and shape of a doorknob. This is not, admittedly, a lot of bang for the buck. Consider that garlic farmers who save their own planting stock must hold back 10-12 percent of their harvest. The miserly assexuality of garlic is one reason for its high price.37

Gluttony, not lust, characterizes garlic. Insisting on lots of nutrients and water, garlic is what farmers call a heavy feeder. Such crops pose real problems for conventional growers because the soluble nitrogen the plants require can easily be swept away in the irrigation water. Garlic also dislikes growing alongside weeds and is prone to a number of fungal diseases. Conventional farmers address these problems with a battery of herbicides and fungicides whose trade names--Stomp, Prowl, Repulse, Roundup, Pondmaster, Sabre, Torch, Policar, Goal, Elite--sound more like designations for Special Operations forces than tools of farming. Two of them are highly toxic to fish. Another is toxic to clams, oysters, and aquatic plants. Another is known to kill birds. Two are potential human carcinogens, and two cause birth defects in rabbits. One rapidly breaks down into a chemical byproduct known to disrupt thyroid functioning. And one alters brain and spinal cord development in fetal animals.38
These are the chemicals we spray into our environment in order to bring to market a food that many people buy for its health benefits. Which are very real. All folkloric powers aside, garlic has been scientifically shown to lower blood pressure and cholesterol, stimulate the human immune system, and slow tumor growth. Frequent garlic consumption lowers the risk for colon cancer and may well do the same for breast cancer.39

Phil Foster is a commercial organic garlic grower near Hollister, California. A farmer since the mid-1970s, he originally farmed conventionally but shifted to organic methods after seeing the results on a neighboring organic farm. Foster's farm as been certified organic since 1989. Like Colorado wheat farmer Lewis Grant, Foster relies on crop rotation to fool pests and insectories to provide food and shelter to the pests' natural enemies. Sweet alyssum and cilantro flowers, for example, support populations of serphid flies, which in turn eat the larvae of plant-eating aphids. In fact, Foster likes to see some pest insects around because they keep the population of the beneficial bugs up. "We're not trying to have a sterile system here," he says.

On Foster's farm, the nutrients so greedily desired by garlic are provided by compost and cover crops like vetch, field peas, and barley. This is a more expensive way to deliver nitrogen to his crops, he admits. Commercial synthetic fertilizer would be cheaper. However, garlic grown on healthy, microbe-rich soil is prone to fewer diseases and requires less water. And while organic garlic grows a bit more slowly, it also seems to store better, he has observed. As for weed control, Foster uses plain, old-fashioned fire: he pulls behind his tractor a flame weeder to get a jump on unwanted vegetation that might compete with his crop.40
Cost of conventional garlic: $.12. Cost of organic garlic: $.07

Cheese: from the milk of Bos taurus
Women and dairy cows have two things in common. Our pregnancies last nine months, and our milk contains four percent butterfat.

There the similarities end. Newborn calves double their birth weight in about six weeks. It takes human babies a full half-year to do this. Accordingly, cow's milk contains three times more protein than human milk, and the ratio of proteins is different. Compared to human milk, cow's milk has twice the curds and one-third the whey. This is one good reason not to manufacture mozzarella out of breast milk.

Curds are the starting point of cheese-making. They're obtained by adding milk-curdling enzymes and acid-making microbes to liquid milk and then, once the curd coagulates into a big blob, draining off the whey. Of course, there are innumerable ways of doing this, and, depending on temperature, humidity, and kind of yeasts, molds, and enzymes used, the result can range from parmesan to brie. The fat concentrates along with the protein. At 56 percent fat, mozzarella is actually one of the leaner cheeses. According to historian Joan Thirsk, the making of cheese received a big boost from the plague. During a remarkable two years (1348-49), one third of the population of Europe died. Demand for food plummeted. At the same time, labor for cultivation became scarce. European farmers put more land in grass, and every poor family aspired to own a cow. Milk production increased. Techniques for cheese-making improved. An unexpected benefit emerged: turning arable land into meadow renewed its fertility. By the 16th century, there was no longer any reason to rotate fields into leas, but peasant farmers lobbied the nobility for the right to do it, arguing that this practice enabled the land to "regain heart."41 And so, cow pastures and cheese-making became enshrined in western agriculture.

The reproductive preferences of the domestic cow create supply and demand challenges for any dairy, medieval or contemporary. Left to her own devices, a cow would get pregnant in the fall, give birth in the spring, and then reach her lactational peak some weeks later, when fresh green grass provides maximum nutrition for both her and her calf. If all the cows in the herd followed this pattern--and almost all mammals do naturally give birth in the spring--the dairy would produce an abundance of milk in midsummer and almost none in late winter when the cows are heavily pregnant. (Cows can be milked when they have calves because they produce more than is needed for their offspring. They are not milked during the last two months of their gestations.)

One of the big differences between conventional and organic dairies is the extent to which this reproductive and lactational cycle is manipulated. Hormones are permissible in conventional operations; their use is prohibited in organic ones. Undoubtedly, the most controversial use of hormones in the dairy industry involves the one called rBGH-recombinant bovine growth hormone.42 When injected under the skin, rBGH makes cows produce more milk. The protein hormone itself is manufactured by a technique of genetic engineering that involves inserting the cow's own growth hormone gene into bacteria, which then churn out pure rBGH in commercially plentiful quantities. The engineered hormone is just slightly different in its chemical structure than the cow's own naturally produced version of BGH, which is made in the pituitary gland. The Food and Drug Administration approved the use of rBGH for dairy cattle in 1993. It is illegal for use in Canada and the European Union.

The first question that many consumers have about rBGH is whether it ends up in the milk and cheese they buy in the store. The short answer is that it does, but this may not be the biggest concern. FDA scientists have concluded that drinking milk with slightly higher levels of rBGH should not affect human health, and they provide three reasons for their argument. One is that the amount of rBGH in milk products is insignificant in comparison to the amount of growth hormone produced by our own bodies. The second is that rBGH is only recognized as a hormone by the cells of cows, not the cells of human beings. And, third, as a protein, rBGH is completely digested in our stomachs.43

Of more concern are the indirect effects of rBGH on cows. Cows injected with rBGH need higher protein feed, more intensive veterinary care, and are more prone to mastitis, which can necessitate antibiotic use. They also produce slightly higher levels of a naturally occurring protein called insulin-dependent growth factor-1 (IGF-1). This, too, finds its way into the milk. There is troubling evidence to suggest that IGF-1 plays a role in cancer: women with naturally occurring levels of IGF-1 have a higher risk of breast cancer, and IGF-1 makes breast cancer cells growing in petri dishes grow faster.44

But IGF-1 is a protein. Any IGF-1 in milk should be broken apart by our digestive tracts. This is a reassuring supposition. As a biologist, I am nevertheless humbled by how easy it is to be wrong about hormones. Many smart researchers argued for years, on the basis of some fine-looking studies, that estrogen hormone therapy for menopausal women lowers the risk of stroke and dementia. We now know the opposite is true. My colleagues at Cornell University's Program on Breast Cancer and Environmental Risk Factors have taken a close look at the data on rBGH and breast cancer risk. They conclude, "Use of rBGH for dairy cattle has been in practice in the U.S. for only [ten] years. It is too early to study the breast cancer risk of women who drink milk and eat milk products from hormone-treated animals."45

They are right. Currently, we have no solid evidence to say that milk from hormonally altered cows is dangerous to health of women's breasts. But as a mother, I prefer to err on the side of caution. If the introduction of rBGH into the milk supply is an ongoing human experiment, I'd like to keep my daughter, as much as possible, in the control group.

Fay Benson operates an organic dairy farm not far from me in Groton, New York. As a conventional dairyman, he had accumulated enough debt that he "couldn't even afford to go out of business." But the last straw was rBGH. "I don't like pushing my cows. I like working with Nature instead of pushing against her." After three years of transition, Benson's operation became a certified organic dairy in 1997. It's been blossoming ever since, he says. His cows spend five months each year on pasture and the other seven in the barn (with daily walks outside) where they are fed organic grains and silage, most of which is produced on Benson's own 200 acres. Their manure is returned to the soil of these fields, where it builds organic matter.46

Benson's biggest initial worry was what he would do when his cows became sick, as antibiotics are not permitted on organic dairies. But rates of illness in his herd declined once he switched to organic practices. Benson has come to believe that organic cows are less stressed. And less-stressed cows are happier cows. And happier cows are healthier cows. And healthier cows make healthier milk. (I have no data to back up these claims except the authority of my own experience. As a breastfeeding mother, I have certainly noticed dramatic changes in the quality and quantity of my own milk when I am sick, overworked, or under stress. And so has my nursing son.) It's certainly true that organic cows last longer. Cows in conventional dairies typically produce milk for about 3.5 years before they are carted off.47 Cows on the organic dairies I'm familiar with are typically milked for 10-12 years.

Benson is so enthusiastic about organic dairying that he is soon to take a position in Cornell's cooperative extension office that will allow him to share his knowledge with other farmers. For Les Miller, Benson's appointment cannot come soon enough. Miller farms three counties east of Ithaca where he manages a dairy herd of 100 cows. He began shifting toward chemical-free methods in the mid-1980s when he noticed that his soil contained fewer and fewer earthworms and his cows required increasing amounts of hormones to control their reproductive cycling. His farm has been certified organic since 1997. His biggest challenge is finding good sources of information for solving the veterinary problems that do come up. It is Miller's impression that far more research and development is directed toward promoting chemical and hormonal solutions rather than those consistent with an organic philosophy.48
Cost of conventional mozzarella: $.80. Cost of organic mozzarella: $1.98.

Final Thoughts
"If the public could only see the real price tag of the food we buy, purchasing decisions would be easy. Compared to industrial food, organic alternatives are the bargains of a lifetime."49

So says Andrew Kimbrell, the director of the Center for Food Safety. I agree with the second sentence wholeheartedly. Jeff and I do buy organic groceries for our family. By directing our food dollars toward organic farmers, we are helping to build healthy soils, sustain rural communities, defend the ozone layer, prevent cancer, and protect drinking water. That's a big impact without a big time commitment-we have to go shopping and cook dinner anyway. At the same time we're also protecting our children's health. Children who have organic diets have lower pesticide residues in their urine than children fed conventionally grown foods.50 And we know we are not passing along externalized costs of growing the food we eat to the next generation, of which our children are part.

I'm less certain about that first sentence. It's not always easy to make organic food fit into a household budget. While two of the ingredients for my organic pizza (fresh tomatoes and garlic) actually cost less than their conventional counterparts, the total cost was higher ($6.85 vs. $4.50; you may have completely different results if you do this in your kitchen, as prices for all these ingredients will vary). On the other hand, I did not actually pay $6.85 for the organic pizza ingredients. I actually paid $5.65.
That's because our food coop allows its members to work two hours a week for a 17.5 percent discount on groceries. Jeff's work shift is Saturday morning. While he stocks shelves, I do the shopping and the feed the kids at the deli. Afterwards, we both get to read the paper and drink (organic) coffee while the little ones play in the play area. Many items--oil, honey, rice, cereal--can be bought in bulk and packaged by the shopper in containers brought from home, which offers additional savings. As we are currently a single-income family, these cost-cutting options are important to us. In the summer months, we also shop at farmers' markets and buy a share in a small organic vegetable farm that is organized along the principles of community supported agriculture. For a fixed price paid to the farmer at the beginning of the growing season, we receive a weekly share of the harvest all the way through October.

Meanwhile, a coalition of human service agencies in upstate New York has just announced a program to make organic vegetables accessible to low-income residents. For $30 a month, participants receive a weekly bag of fresh organic produce. In exchange, they spend two days on a nearby organic farm, helping with chores and learning the art of growing food without pesticides.51

Can organic pizzerias be far behind?

Cheese and Tomato Pizza

Cost (in upstate New York, summer 2003. Prices in your area may differ.)

Ingredients	conventional	organic
1 cup warm water	--	--
1 tbsp. sugar	--	--
1 tbsp. yeast	--	--
1 tsp. salt	--	--
1/2 cup extra virgin olive oil	$1.44	$2.35
1 1/2 cups whole wheat flour	$0.22	$0.37
1 1/2 cups all-purpose flour	$0.22	$0.40
1 small can tomato paste	$0.50	$0.99
2 fresh tomatoes, chopped	$1.20	$0.69
3 cloves garlic, diced	$0.12	$0.07
1 cup mozzarella cheese, grated	$0.80	$1.98
Total cost per pizza:	**$4.50**	**$ 6.85**

Mix water, sugar, yeast, salt, oil, and a spoonful of the flour in a large bowl and let sit for 10 minutes. When bubbles appear, begin adding the rest of the flour. When the dough becomes stiff, turn it out onto a floured, flat surface. Knead until shiny, smooth, and no longer sticky. Place it back in the bowl. Cover and let rise until it doubles in bulk-about 1 hour. Meanwhile, grease a cookie sheet and preheat the oven to 475 F.

Ask a small child to punch the dough down. Roll it out and stretch it to fit in the cookie sheet. (Freeze any extra dough in a plastic bag.) Smear with tomato paste. Layer on tomatoes. Sprinkle with garlic and cheese. Bake for 10-15 minutes or until cheese bubbles and begins to brown.

(Serving suggestion: While pizza is cooling, call hungry children to table. Offer steamed broccoli spears and chunks of baked sweet potatoes. Encourage family members to make believe they are red-eyed locusts in search of green trees to eat. After broccoli disappears, announce that orange food makes you see farther. While children chew sweet potatoes and test their eyesight, slice pizza and serve.)

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Pizza Source Notes

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farmers who generously granted interviews: Fay Benson, Paco Nunez de Prado, Phil Foster, Lewis Grant, David Hardy, and Les Miller. I dedicate this essay to my father, Wilbur F. Steingraber.

Source Notes

1. Based on interviews with 600 school food service directors, nearly 70 percent of U.S. school children name pizza as their favorite entrée (American School Food Service Association, School Lunch Trends, 1999, http://www.asfs.org).

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