ONE

HOMO IMBIBENS

I Drink, Therefore I Am

ASTRONOMERS PROBING OUR GALAXY WITH powerful radio waves have discovered that alcohol does not exist only on the Earth. Massive clouds of methanol, ethanol, and vinyl ethanol—measuring billions of kilometers across—have been located in interstellar space and surrounding new star systems. One cloud, denoted Sagittarius B2N, is located near the center of the Milky Way, some 26,000 light-years or 150 quadrillion miles away from the Earth. While the distant location ensures that humans will not be exploiting extraterrestrial ethanol any time soon, the magnitude of this phenomenon has excited speculation about how the complex carbon molecules of life on Earth were first formed.

Scientists hypothesize that the vinyl ethanol molecules in particular, with their more chemically reactive double bonds, might have been held in place on interstellar dust particles. As in making a vinyl plastic, one vinyl ethanol molecule would couple to another, gradually building up ever more complex organic compounds that are the stuff of life. Dust particles, with their loads of these new carbon polymers, might have been transported through the universe in the icy heads of comets. At high velocities, the ice would melt, releasing the dust to seed a planet like Earth with a kind of organic soup, out of which primitive life forms emerged. It is a gigantic leap from the formation of ethanol to the evolution of the intricate biochemical machinery of the simplest bacteria, not to mention the human organism. But as we peer into the night sky, we might ask why there is an alcoholic haze at the center of our galaxy, and what role alcohol played in jump-starting and sustaining life on our planet.

CREATING A FERMENT

If alcohol permeates our galaxy and universe, it should come as no surprise that sugar fermentation (or glycolysis) is thought to be the earliest form of energy production used by life on Earth. Some four billion years ago, primitive single-celled microbes are hypothesized to have dined on simple sugars in the primordial soup and excreted ethanol and carbon dioxide. A kind of carbonated alcoholic beverage would thus have been available right from the beginning.

Today, two species of single-celled yeasts (*Saccharomyces cerevisiae* and *S. bayanus*), encompassing a large group of wild and domesticated strains, carry on in this grand tradition and serve as the workhorses that produce the alcohol in fermented beverages around the world. Although hardly primitive—they have most of the same specialized organelles as multicellular plants and animals, including a central nucleus which contains the chromosomal DNA—these yeast thrive in oxygen-free environments, such as we imagine existed on Earth when life began.

If we accept this scenario, then the alcohol generated by these first organisms must have been wafting across the planet for millennia. It and other short-chained carbon compounds eventually came to signal the presence of a convenient, high-energy sugar resource. The pungent, enticing aroma of alcohol announced to later sugar-loving animals of the world, ranging from fruit flies to elephants, where the banquet was to be found. When fruit-bearing trees appeared around 100 million years ago (mya), during the Cretaceous period, they offered an abundance of both sugar and alcohol. The sweet liquid that oozes out of ruptured, ripened fruit provides the ideal combination of water and nutrients that allows yeast to multiply and convert the sugar into alcohol.

Animals became superbly adept at exploiting the sugary cocktail of fruit trees, which in turn benefited from the animals' dispersal of their seed. The close symbiosis between a tree and the animals that pollinate its flowers, eat its fruit, and carry out a host of other mutually advantageous functions is astonishing. Take the fig tree, with some eight hundred species spread throughout the world. These trees do not bloom in the conventional sense: instead, they have male and female inflorescences that are tightly encased in a succulent-tasting sac called the syconium, and they cannot be pollinated directly because they flower at different times on the same tree. A species of wasp unique to each fig species must carry out this task. The female adult wasp bores through the tip of the syconium, ruining her wings and eventually dying. She lives long enough, however, to deposit her eggs and transfer the pollen from another tree to the female flowers. When the wasp eggs hatch, the wingless male, trapped within the syconium and eventually dying there, impregnates the female and chomps an opening with his powerful jaws for her to escape with another load of eggs. Sustained by sucking alcoholic nectar through her long, strawlike proboscis from the deep corollas of the fig flowers, she goes on to pollinate another fig tree.

While the fig wasps carry on with their secret sex life, air flowing into the hole created by the escaping female causes the syconium to ripen into the fig "fruit." The yeast goes to work and generates the alcoholic fragrances that alert animals to the potential feast. As many as one hundred thousand figs on a large tree can be devoured by birds, bats, monkeys, pigs, and even dragonflies and geckos in a feeding frenzy.

The fig tree illustrates the intricacy and specificity of the web of life. Other plant sugars, such as evergreen saps and flower nectars, have their own stories to tell. A much sought-after and luscious honey in Turkey, for example, is made from pine honeydew. This is a sugar-rich secretion produced by a scale insect, *Marchalina hellenica,* which lives in cracks in the bark of the red pine tree (*Pinus brutia*) and feeds exclusively on the resinous sap. Bees collect the honeydew, and with a specific enzyme, invertase, break down its sugar (sucrose) into simpler glucose and fructose. The final product, honey, is the most concentrated simple sugar source in nature, with the specific plant species from which it derives, red pine in this instance, contributing special flavors and aromas.

Entomologists have exploited insects' taste for fermented beverages by smearing the substances on the bases of trees in order to capture them. Charles Darwin employed a similar tactic: when he set out a bowl of beer at night, a tribe of African baboons were lured in and were easily gathered up as specimens the next morning in their inebriated state. Intemperate slugs—mollusks lacking shells—are less fortunate, as they self-indulgently drown in beer traps. In one carefully constructed set of experiments, it was shown that common fruit flies (*Drosophila melanogaster*) lay their eggs where there are intense odors of ethanol and acetaldehyde, another by-product of alcohol metabolism. The fermenting fruit guarantees that their larvae will be well-fed with sugar and high-protein yeast, as well as alcohol, for which they have highly efficient energy pathways.

Nature's hidden rationale and complex ecological interplay centered on sugar and alcohol resources can have a seriocomic side. Elephants, which consume fifty thousand calories a day, sometimes overindulge in their consumption of fermenting fruit. They can perhaps be excused, as they work hard for their pleasure: they have to remember where to find the trees and travel many miles to reach them at the time of ripening. Unfortunately, they also have a weakness for the human-produced equivalent. In 1985, about 150 elephants forced their way into a moonshine operation in West Bengal, ate all the sweet mash, and then rampaged across the country, trampling five people to death and knocking down seven concrete buildings. This episode highlights problem drinking in higher mammals, including humans.

Birds are also known to gorge themselves on fermenting fruit. Cedar waxwings feasting on hawthorn fruit have suffered ethanol poisoning and even death. Robins fall off their perches. Maturing fruits concentrate sugar, flavor and aroma compounds, and colorants that announce to birds and mammals that they are ripe for eating. As the fruit passes its prime, however, it becomes the target of a host of microorganisms, including yeasts and bacteria, that can threaten the plants. Ominously, the plants defend themselves by generating poisonous compounds. The manufactured plant toxins, including alkaloids and terpenoids, inhibit the growth of virulent microorganisms, as well as fending off noxious insects. A placid-looking apple orchard or idyllic vineyard may not look like a battleground, but a host of creatures are vying for supremacy and defining the balance of power through chemical compounds.

Sometimes, one creature unwittingly steps on a chemical landmine intended for another. If alcohol is dangerous when consumed in excess, plant toxins can be lethal. In one well-documented incident near Walnut Creek, California, thousands of robins and cedar waxwings apparently found the scarlet, mildly sweet berries of holly (*Ilex* spp.) and firethorn bush (*Pyracantha*) too good to pass up. Over a three-week period, the birds overdosed on the berries and their toxins and began crashing into cars and windows. Autopsies revealed that their gullets were bursting with the fruit. (By contrast, the normal, demure courtship behavior of cedar waxwings involves passing a single berry back and forth between the male and female until the gift is finally accepted and the pair copulate.)

As with the West Bengal elephants, the California birds' drunken behavior was due to the excessive consumption of a mind-altering compound. Intriguingly, the compounds in holly berries—caffeine and theobromine—are the same ones humans enjoy today in coffee, tea, and chocolate. Native Americans in the woodlands of the north and the jungles of Amazonia also showed their appreciation for these substances: Spanish colonists observed that they brewed up a bitter but aromatic "black drink" by steeping toasted holly leaves in hot water.

A VERY PECULIAR YEAST

Just as a plant will defend its territory with a chemical arsenal, the invisible world of microorganisms engages in a similar struggle for supremacy and survival. A finely tuned enzymatic system and the production of alcohol are the weapons of choice for *S. cerevisiae,* the principal yeast used by humans in making alcoholic beverages. About the same time that fruit trees were proliferating around the globe, *S. cerevisiae* appears to have acquired an extra copy of its entire genome. Further rearrangements enabled it to proliferate in the absence of oxygen, and the alcohol it produced destroyed much of its competition. Other microorganisms, including many spoilage- and disease-causing yeasts and bacteria, simply cannot tolerate alcohol in concentrations above 5 percent, but *S. cerevisiae* survives in fermenting substances with more than twice this concentration of alcohol.

The yeast pays a cost for its success. In producing more alcohol, it forgoes making more of the compound adenosine triphosphate (ATP), which provides living organisms with the energy for essential biological processes. Pure aerobic metabolism yields thirty-six molecules of ATP from glucose. *S. cerevisiae* makes only two molecules of ATP in air, channeling the rest of the glucose into the production of alcohol to be deployed against its competitors.

S. cerevisiae's apparent loss later becomes its gain. Because of the doubling of its genome, each yeast cell develops two versions of the gene that controls the production of alcohol dehydrogenase (ADH). This enzyme converts acetaldehyde, an end product of glycolysis, into alcohol. One version of the enzyme (ADH1) reliably processes sugar into alcohol in an oxygen-free environment, whereas the other (ADH2) is activated only after most of the sugar has been consumed and oxygen levels start to rise again. For *S. cerevisiae,* this happens after many competing microbes have been destroyed. Then ADH2 springs into action, converting alcohol back into acetaldehyde and ultimately generating more ATP. Of course, other microorganisms, such as acetic acid–producing bacteria, which can tolerate high alcohol levels, wait in the wings. They are ready to turn any remaining alcohol into vinegar unless another hungry organism acts faster or is able, like a human, to improvise a way to preserve the alcohol.

It is still a mystery why varieties of *S. cerevisiae* live on the skins of certain fruits, especially grapes, or in honey, where they are able to tolerate high sugar levels. This yeast is not airborne but can take up residence in special microclimates, like the breweries around Brussels, with their lambic beers, or the rice-wine factories of Shaoxing in China (see chapter 2): both beverages are fermented without intentionally adding yeast. The yeast apparently lives in the rafters of the old buildings, from where it falls into the brew; when the rafters have been covered during renovations, brewers have been unable to start their fermentations. The yeast most likely was carried there by insects, especially bees and wasps, who inadvertently picked it up when they fed on the sweet juice oozing out of damaged fruit, and were drawn to the buildings by the aromas of the sweet worts and juices or musts.

ENTER *HOMO IMBIBENS:* MAN, THE DRINKER

Our world is awash in ethanol. In 2003, some 150 billion liters of beer, 27 billion liters of wine, and 2 billion liters of distilled spirits (mainly vodka) were produced worldwide. This amounts to about 8 billion liters of pure alcohol, representing about 20 percent of the world's total ethanol production of 40 billion liters. Now that alternative energy sources are a priority, fuel ethanol, made mainly from sugar cane and corn, accounts for the lion's share (70 percent in 2003, and more today). The industrial sector of chemicals and pharmaceuticals produces the remaining 10 percent. For the foreseeable future, the fuel sector will probably continue to expand, while the production of alcoholic beverages will show only modest gains to keep pace with the world's population. The world's total annual production of pure alcohol for beverages now exceeds 15 billion liters and is projected to reach 20 billion liters by 2012.

Fifteen billion liters of pure alcohol in naturally fermented and distilled beverages would provide every man, woman, and child on Earth with more than two liters a year. This estimate is likely too low, as illegal production is widespread and traditional home-brewed beverages, consumed globally in great quantities, are not included. Considering that most fermented beverages have an alcohol content of 5 to 10 percent and children generally do not imbibe, there is obviously plenty of alcohol to go around.

How has it come about that humans everywhere drink so much alcohol? Practically speaking, alcoholic beverages supply some of the water that we need to survive. Our bodies are two-thirds water, and the average adult needs to drink about two liters daily to stay hydrated and functioning. Untreated water supplies, however, can be infected with harmful microorganisms and parasites. Alcohol kills many of these pathogens, and humans must have recognized at an early date that those who drank alcohol were generally healthier than others.

Alcoholic beverages have other advantages. Alcohol spurs the appetite, and in liquid form, it also satiates feelings of hunger. The process of fermentation enhances the protein, vitamin, and nutritional content of the natural product, adds flavor and aroma, and contributes to preservation. Fermented foods and beverages cook faster because complex molecules have been broken down, saving time and fuel. Finally, as we have learned from numerous medical studies, moderate consumption of alcohol lowers cardiovascular and cancer risks. People consequently live longer and reproduce more. This was crucially important in antiquity, when life spans were generally short.

Drinking an alcoholic beverage, however, has meant much more to humankind than gains in physical health and longevity. To understand its broader biological and cultural dimensions, we must travel back to the period when *Homo imbibens* first walked the planet. By necessity, our tour guides are archaeologists, DNA researchers, and other detectives of the past, who have patiently excavated and studied the fragmentary remains of our ancestors and the genetic evidence encoded in our bodies today.

By examining the skeletal and dental evidence from early hominid fossils, dating from between about 4.5 to 2 mya, inferences can be drawn about how they lived and what foods they ate as they traversed the African jungle and savannah. Many of the fossils come from the Great Rift Valley of East Africa, including *Australopithecus afarensis,* best represented by the skeleton known as Lucy. Her forty-seven bones show that she could walk on two legs as well as climb trees. These traits would have served her and the rest of her "first family" well, enabling them to stretch tall and clamber through branches to reach sweet fruit.

The smaller molars and canines of early hominids (and the great apes), going as far back as *Proconsul* and other fossils around 24 mya, are also well adapted to consuming soft, fleshy foods like fruit. These dentitions are broadly comparable to those of modern apes, including gibbons, orangutans, and lowland gorillas, who get most of their calories from fruit. Chimpanzees, whose genome is the closest to our own, have a diet consisting of more than 90 percent plants, of which more than 75 percent is fruit. In other words, early hominids and their descendants have favored fresh fruit for millions of years.

If fruit was the food of choice at the beginning of the hominid odyssey, alcoholic beverages were probably not far behind. Especially in warm tropical climates, as the fruit matured, it would have fermented on the tree, bush, and vine. Fruits with broken skins, oozing liquid, would have been attacked by yeast and the sugars converted into alcohol. Such a fruit slurry can reach an alcohol content of 5 percent or more.

Visually oriented creatures that we are, we can imagine that the bright colors of the fermenting fruit, often red or yellow, would have attracted hominid interest. As our early ancestors approached the ripe fruit, other senses would have come into play. The intense aroma of alcohol from the fermenting fruit would have alerted them to the source of nourishment, and tasting it would have brought new and enticing sensations.

We cannot be sure how close to reality such a reconstruction is, since the ancient fossils tell us nothing about the easily degradable sensory-organ tissues. The taste and smell sensitivity of modern humans does not rate particularly high in the animal kingdom, despite the occasional super-taster among us. Early hominids might have had much more acute senses than ours, like the macaque, an Old World monkey, which has exquisite sensitivity to alcohol and other smells.

THE DRUNKEN MONKEY HYPOTHESIS

The biologist Robert Dudley has proposed that alcoholism among humans is rooted in the evolutionary history of primates. This thought-provoking hypothesis, dubbed the drunken monkey hypothesis, draws on the often fragmented and debatable pieces of the archaeological record and what is known about modern primate diets. If we grant that early hominids were primarily fruit eaters, at least up until about 1–2 mya, when they began consuming more tubers and animal fat and protein, then perhaps our early ancestors gained an advantage from imbibing moderate amounts of alcohol, whose benefits have been shown by recent medical research, and adapted biologically to it. On average, both abstainers and bingers have shorter, harsher life spans. The human liver is specially equipped to metabolize alcohol, with about 10 percent of its enzyme machinery, including alcohol dehydrogenase, devoted to generating energy from alcohol. Our organs of smell can pick up wafting alcoholic aromas, and our other senses detect the myriad compounds that permeate ripe fruit.

Among modern humans and other primates, the thirst for alcohol sometimes far exceeds any obvious nutritional or medical benefit (see plate 1). On the remote tropical island of Barro Colorado in Panama, Dudley reports, howler monkeys could not get enough of the ripe fruit of a palm (*Astrocaryum standleyanum*). You might think that monkeys would know better than to binge, in the same way that they avoid unsafe, even poisonous, plants in the natural world, but these monkeys gorged themselves on the bright orange fruit, ingesting the equivalent of about ten standard drinks, or two bottles of 12 percent wine, in twenty minutes. Obviously, there are diminishing returns to life and health if a monkey gets too drunk, misses a leap from one branch to another, and falls or is impaled by a sharp palm spine.

Malaysian tree shrews, who belong to a family dating back more than 55 mya that is believed to be ancestral to all living primates, have a similar penchant for fermented palm nectar. As documented by Frank Wiens and colleagues, they provide elegant testimony in support of Dudley's hypothesis. These small creatures, resembling flying squirrels, often lap up alcohol in excess of the cross-species benchmark for intoxication (1.4 grams pure alcohol per kilogram weight) over the course of a night. That equates to about nine glasses of wine for the average-sized human. Yet the shrews show no signs of intoxication as they make their way deftly through the sharp spines of the palm trees to one oozing flower bud after another. The inflorescences of the bertam palm (*Eugeissona tristis*) are like miniature fermenting vessels where nectar accumulates year-round. In the tropical climate, the resident yeast rapidly converts it to a frothy, strongly scented palm wine with an alcohol content as high as 3.8 percent. The symbiotic relationship between palm and shrew is remarkable: while the animal guzzles, it pollinates the plant. Humans may have lost some of the genetic machinery to metabolize alcohol as efficiently as the tree shrew, but they have emulated its behavior by fermenting the sugar-rich saps and nectars of numerous palm tree species in Africa (chapter 8) and elsewhere.

Ape behavior in the artificial environment of a laboratory cage is equally illuminating. According to Ronald Siegel, chimpanzees given unlimited access to alcohol—an "open bar"—will at first guzzle the equivalent of three or four bottles of wine. Males outdrink the smaller females and get intoxicated twice as often. Over time, their consumption falls into a more restrained pattern, but the chimpanzees still imbibe enough to stay permanently drunk. Such behavior has no apparent evolutionary benefit: intoxication seems to be an end in itself. By experimenting with a range of offerings at the bar, the researchers also noted that their chimpanzees generally favored sweet wines over dry and flavored vodka over pure alcohol.

Rats showed greater restraint than the chimpanzees under comparable experimental conditions. Outfitted with spacious underground quarters and a twenty-four-hour "bar," their drinking patterns assumed a regularity that many of us would immediately recognize. The colony avidly congregated around the drinking hole just before the main feeding time. The predinner cocktail, perhaps to whet the appetite, was followed several hours later by a nightcap before sleep. Every three to four days, the colony drank more than usual, as if they were partying.

DRIVEN BY DRINK

Early hominids and apes had a powerful incentive to overindulge in fermented fruits and other high-sugar resources, such as honey: these foods are only available in season. It might have been possible to store seeds or nuts in a dark, cool cave for a future repast, but tactics had not yet been devised to protect sweet, alcoholic delights from marauders and microorganisms. To tide themselves over the lean seasons, it made sense for our ancestors to eat and drink as much as they could when it could be had.

Gorging on energy-rich sugar and alcohol was an excellent solution for surviving in an often resource-poor and hostile environment. Extra calories could be converted to fat for future use, then gradually burned off in harsher times. For an early hominid, most of this energy was probably channeled into walking considerable distances in search of ripe fruit, nuts and other foods, hunting game, and evading predators. The hominid body, with its powerful leg muscles and generous gluteus maximus behind to balance forward thrust, can achieve relatively high running speeds of up to 48 kilometers an hour. Any overweight individuals were likely quickly weeded out by lions traveling at more than 120 kilometers an hour.

Drunkenness places individual organisms at greater risk of attack by a hostile species, as their reflexes and physical prowess are inhibited. Social animals, including birds and monkeys, have a distinct advantage when engaging in a bout of gluttony. As their muscular coordination and mental acuity decrease, their large numbers help ward off any party crasher in the neighborhood. Before lapsing into oblivion, these animals also usually send up a collective alarm or battle en masse against the intruder. A location safe from attack also facilitates binging, whether by default (if, for example, the inebriating substance is found at the top of a tall tree) or by design, if the fermented food and drink are carried to a mountaintop or into a cave before the festivities begin.

The reasons for alcohol consumption in the animal world are invisible to the observer. Specialists in animal behavior cannot read the "thoughts" of fruit flies or chimpanzees, let alone extinct hominids, to understand what might compel them to eat a batch of fermenting fruit. Although geneticists and neuroscientists have begun to elucidate the molecular mechanisms by which organisms sense, respond to, and metabolize alcohol, any comprehensive explanation of this phenomenon is still a long way off.

THE PALAEOLITHIC HYPOTHESIS

How far back in the mists of archaeological time have humans savored alcohol, and how has it shaped us as a biological species and contributed to our cultures? The drunken monkey hypothesis explores the biological side of the question. The Neolithic period, beginning around 8000 B.C. in the Near East and China (chapters 2 and 3), provides a rich trove of archaeological material to mine for answers to the cultural questions. Humans were then settling down into the first permanent settlements, and they left abundant traces of their architecture, jewelry, painted frescoes, and newly invented pottery filled with fermented beverages. For the Palaeolithic period, beginning hundreds of thousands of years earlier, we are on much shakier ground. Yet this is undoubtedly the time when humans first experimented with alcoholic beverages, as they relished their fermented fruit juices and came to apprehend their ecstasies and dangers.

The evidence from Palaeolithic archaeology is scant, and it is easy to overinterpret and read modern notions into this fragmented past. Archaeologists once thought that early humans were meat eaters on a grand order because their encampments were littered with animal bones. Then it dawned on someone that the remains of any fruits or vegetables simply had not survived, and that the abundance of bones, which were infinitely better preserved, indicated only that meat constituted some portion, possibly minor, of the early human diet.

Figure 1.

In *Ancient Wine* I outlined a plausible scenario, which I refer to as the Palaeolithic hypothesis, explaining how Palaeolithic humans might have discovered how to make grape wine. In brief, this hypothesis posits that at some point in early human prehistory, a creature not so different from ourselves—with an eye for brightly colored fruit, a taste for sugar and alcohol, and a brain attuned to alcohol's psychotropic effects (see chapter 9)—would have moved beyond the unconscious craving of a slug or a drunken monkey for fermented fruit to the much more conscious, intentional production and consumption of a fermented beverage.

In an upland climate where the wild Eurasian grape (*Vitis vinifera* ssp. *sylvestris*) has thrived for millions of years, such as eastern Turkey or the Caucasus, we might imagine early humans moving through a luxuriant river bottom. Using roughly hollowed-out wooden containers, gourds, or bags made of leather or woven grasses, they gather up the ripe grapes and carry them back to a nearby cave or temporary shelter. Depending on their ripeness, the skins of some grapes at the bottom of the containers are crushed, rupture, and exude their juice. If the grapes are left in their containers, this juice will begin to froth or even violently bubble up. Owing to natural yeast on the skins, it gradually ferments into a low-alcohol wine—a kind of Stone Age Beaujolais Nouveau.

Eventually, the turbulence subsides, and one of the more daring members of the human clan takes a tentative taste of the concoction. He reports that the final product is noticeably smoother, warmer, and more varied in taste than the starting mass of grapes. The liquid is aromatic and full of flavor. It goes down easily and leaves a lingering sense of tranquility. It frees the mind of the dangers that lurk all around. Feeling happy and carefree, this individual invites the others to partake. Soon everyone's mood is elevated, leading to animated exchanges. Perhaps some people sing and dance. As the day turns into night and the humans keep imbibing, their behavior gets out of hand. Some members of the clan become belligerent, others engage in wild sex, others simply pass out from intoxication.

Once having discovered how to make such a beverage, early humans would likely have returned year after year to the wild grapevines, harvesting the fruit at the peak of ripeness and even devising ways to process it—perhaps stomping the grapes with their feet or encouraging better anaerobic fermentation of the juice and pulp by covering the primitive container with a lid. The actual domestication of the Eurasian grapevine, according to the so-called Noah hypothesis (see chapter 3), as well as the development of a reliable method of preventing the wine from turning swiftly to vinegar (acetic acid), was still far in the future. A tree resin with antioxidant effects might have been discovered accidentally early on, but it would only have delayed the inevitable by a few days. The wiser course was to gorge on the delectable beverage before it went bad.

Similar experiences with alcoholic beverages must have been played out many times, in different places, by our human forebears. Grapes are only one of many fermenting fruits. In sub-Saharan Africa, the heartland of modern humanity (*Homo sapiens*), from where we spread out to populate

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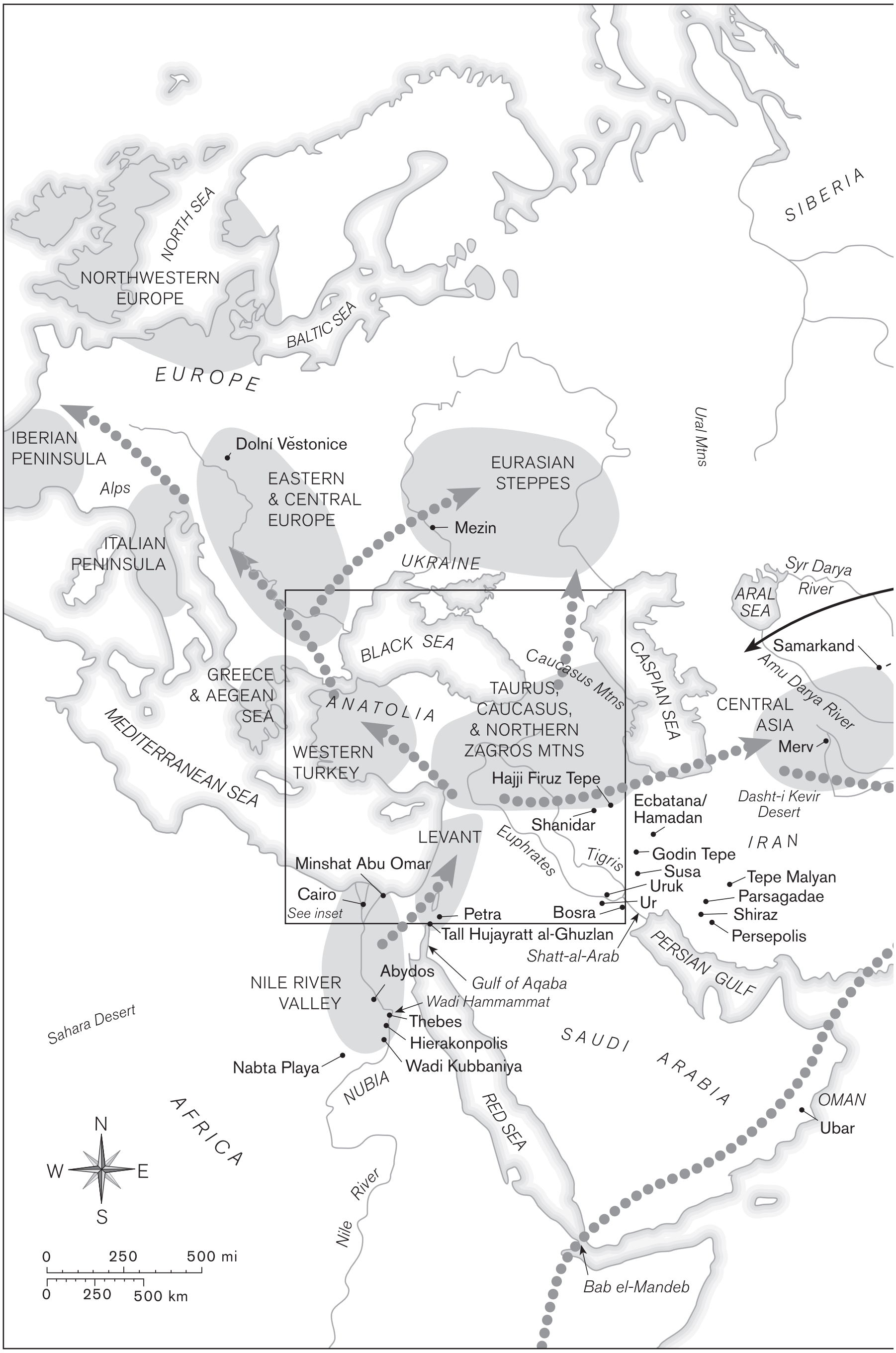
Map 1 *(overleaf)*. Spread of fermented-beverage experimentation across Eurasia. Fermented beverages were made as early as 100,000 B.P., when humans came "out of Africa" on their way to populating the Earth. Depending upon locally available and introduced domesticated plants, fermented beverages were produced from honey, barley, wheat, grape, date, and many other grains and fruits (e.g., cranberries in northwestern Europe). The earliest beverages were mixed "grogs," probably with added herbs, tree resins, and other "medicinal" ingredients (e.g., ephedra on the Eurasian steppes).


SIBERIA
NORTH SEA
NORTHWESTERN EUROPE
BALTIC SEA
EUROPE
Ural Mtns
IBERIAN PENINSULA
Dolní Věstonice
EASTERN & CENTRAL EUROPE
EURASIAN STEPPES
Alps
Mezin
ITALIAN PENINSULA
UKRAINE
Syr Darya River
ARAL SEA
BLACK SEA
Caucasus Mtns
CASPIAN SEA
Samarkand
Amu Darya River
GREECE & AEGEAN SEA
TAURUS, CAUCASUS, & NORTHERN ZAGROS MTNS
CENTRAL ASIA
ANATOLIA
MEDITERRANEAN SEA
WESTERN TURKEY
Merv
Hajji Firuz Tepe
Dasht-i Kevir Desert
Ecbatana/ Hamadan
Shanidar
LEVANT
Euphrates
Tigris
IRAN
Godin Tepe
Minshat Abu Omar
Susa
Tepe Malyan
Uruk
Cairo
See inset
Parsagadae
Ur
Petra
Bosra
Shiraz
Tall Hujayratt al-Ghuzlan
Persepolis
Shatt-al-Arab
PERSIAN GULF
Abydos
Gulf of Aqaba
NILE RIVER VALLEY
Wadi Hammammat
Sahara Desert
Thebes
Hierakonpolis
SAUDI ARABIA
Nabta Playa
Wadi Kubbaniya
NUBIA
RED SEA
OMAN
Ubar
AFRICA
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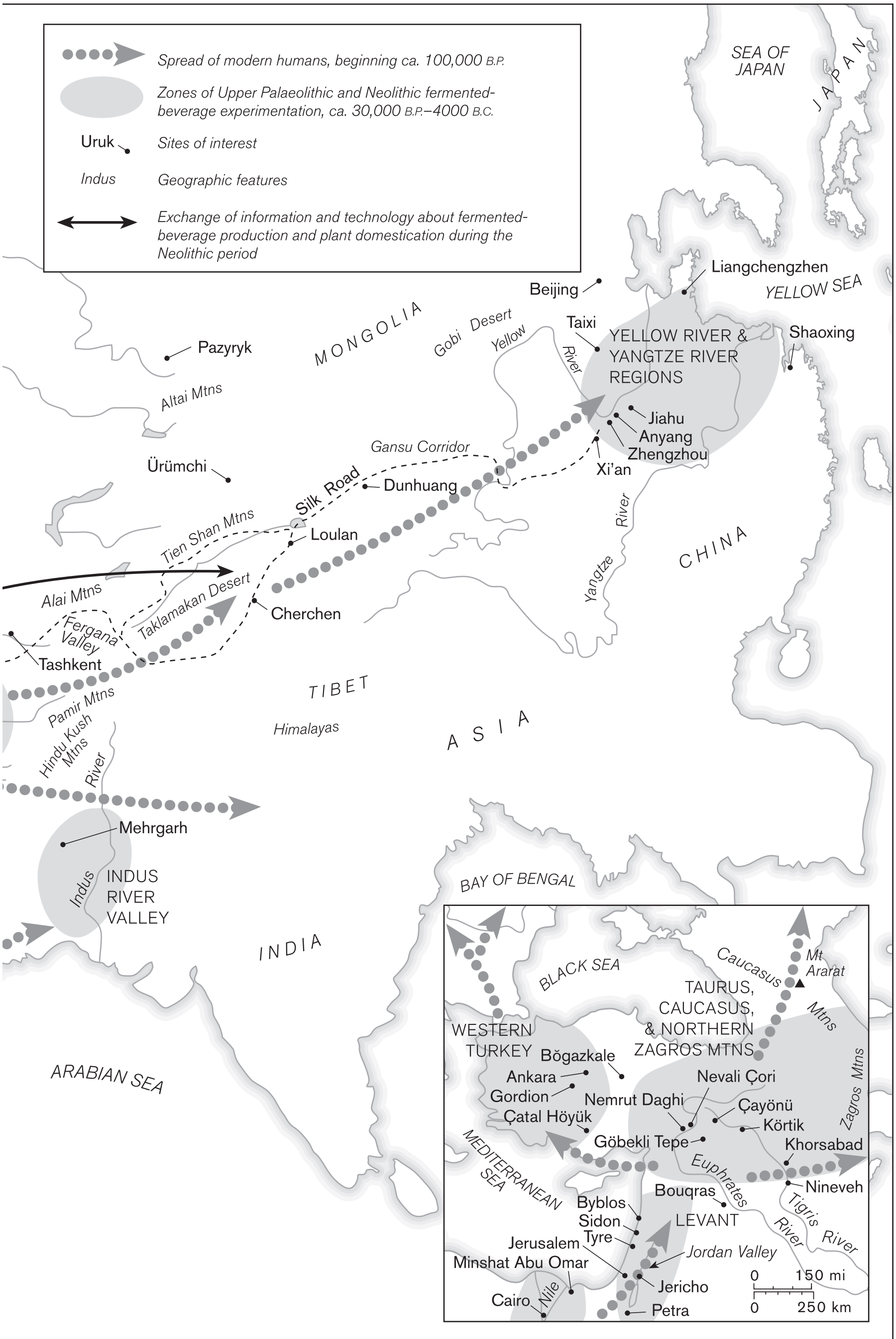
250
500 km
Bab el-Mandeb


Spread of modern humans, beginning ca. 100,000 B.P.
Zones of Upper Palaeolithic and Neolithic fermented-beverage experimentation, ca. 30,000 B.P.–4000 B.C.
Uruk
Sites of interest
Indus
Geographic features
Exchange of information and technology about fermented-beverage production and plant domestication during the Neolithic period
SEA OF JAPAN
JAPAN
Liangchengzhen
Beijing
YELLOW SEA
Taixi
YELLOW RIVER & YANGTZE RIVER REGIONS
Shaoxing
Pazyryk
MONGOLIA
Gobi Desert
Yellow River
Altai Mtns
Jiahu
Anyang
Zhengzhou
Xi'an
Gansu Corridor
Ürümchi
Silk Road
Dunhuang
Tien Shan Mtns
Loulan
Yangtze River
CHINA
Alai Mtns
Taklamakan Desert
Cherchen
Fergana Valley
Tashkent
TIBET
Pamir Mtns
Hindu Kush Mtns
Himalayas
ASIA
River
Mehrgarh
Indus
INDUS RIVER VALLEY
BAY OF BENGAL
INDIA
ARABIAN SEA
BLACK SEA
Caucasus Mtns
Mt Ararat
TAURUS, CAUCASUS, & NORTHERN ZAGROS MTNS
WESTERN TURKEY
Bŏgazkale
Ankara
Gordion
Nemrut Daghi
Nevali Çori
Çayönü
Körtik
Zagros Mtns
Çatal Höyük
Göbekli Tepe
Khorsabad
MEDITERRANEAN SEA
Euphrates River
Nineveh
Tigris River
Bouqras
Byblos
Sidon
Tyre
LEVANT
Jerusalem
Jordan Valley
Minshat Abu Omar
Jericho
Nile
Cairo
Petra
0 150 mi
0 250 km

the rest of the world about one hundred thousand years ago, the first fermented beverage might have been made from figs, baobab fruit, or sweet gourds. Honey, composed of 60 to 80 percent simple sugars (fructose and glucose) by weight, would have been highly sought after as an ingredient. Bees in temperate climates have been churning out honey since at least the Cretaceous period, and many animals, including humans, have risked the stings of angry bees to steal the sweet honey from their hives.

Roger Morse, a longtime friend of my family and formerly professor of apiculture at Cornell University, often argued that honey must have been the basis for the world's earliest alcoholic beverage. Imagine a cavity in a dead tree that bees have filled with wax and honey. One day the tree falls to the ground, and the cavity is exposed to a soaking rain. Once the store of honey is diluted to 30 percent honey and 70 percent water, yeasts specially adapted to survive high sugar contents will start the fermentation and produce mead. Along comes our hominid ancestor, who has been watching this hive for a long time. She goes straight to the cavity, has a taste, and if not a selfish sort, calls in her companions to enjoy the alcohol-laced libation.

Many such scenarios can be imagined. Although all are inherently plausible, based on what we know about human societies, the biology of the modern human brain, and personal experience, the main problem with the Palaeolithic hypothesis is that it is unprovable. No containers have yet been recovered from the Palaeolithic period, not even one made from stone. Objects made of wood, grass, leather, and gourds have disintegrated and disappeared. The only real prospect for chemically detecting a fermented beverage from this period is to try to extract what might have been absorbed into a crevice of a rock near a Palaeolithic encampment where the beverage might have been prepared.

Nevertheless, some enticing hints in the archaeological record suggest that the Palaeolithic hypothesis may not be far off the mark. For example, some of the earliest artistic representations of our species depict bare-breasted, large-hipped females, often referred to as Venuses because of their obvious associations with sexuality and childbearing. One particularly provocative Venus (see plate 2) was chiseled into a cliff at Laussel in the Dordogne region of France around twenty thousand years before the present (B.P.), not far from the famous cave of Lascaux, which teems with Palaeolithic frescoes. With one hand on her pregnant belly, the long-haired beauty holds up an object that resembles a drinking horn. Other identifications of this object are possible, including a musical instrument (but then why is the narrow end of the horn pointed away from her mouth?) or a lunar symbol denoting the female (but you could just as easily infer that a bison horn is a sign of complementary maleness or hunting prowess).

A drinking-horn identification is in keeping with the much later predilection of Celtic princes in this region to show off their drinking prowess with magnificent horns. The setting of this Venus in an open-air rock shelter, overlooking a broad valley, would have been ideal for bringing together a large group to enjoy and celebrate life with an alcoholic beverage, perhaps made from wild berries growing nearby (the famous wine-growing area of Bordeaux is only one hundred kilometers away) or a cache of honey. Further accentuating her sexuality and the fecundity of nature, the figure's breasts and belly were strikingly painted with red ocher. In later art, fermented beverages—including wine made from grapes and New World chocolate drinks—were often shown in red and symbolized blood, the fluid of life.

Even if the Laussel Venus is drinking from rather than blowing on her horn, it seems possible that early hominids or humans might have made music while they enjoyed their alcoholic beverage. In a cavern at Geissenklösterle in southern Germany, some fifteen thousand years earlier than Laussel, archaeologists discovered three fragmentary flutes with at least three holes, fashioned from a woolly mammoth's ivory tusk and the wing bones of whooper swans. The holes were beveled, suggesting that the instruments were played, like a modern flute, by blowing across one of the holes with variable lip pressure or embouchure, rather than blowing directly through one end. A range of tones, perhaps even octaves, could have been achieved by fingering, that is, closing off one or more of the holes while blowing.

In China around 7000 B.C., Neolithic people made a very similar instrument from a specific bone of the red-crowned crane (see chapter 2). The choice of the crane and swan bones, although separated by thirty thousand years, might have been quite deliberate, as these birds are known for their intricate mating dances, replete with bows, leaps, wing extensions, and ringing musical notes. The cacophony of hoots and calls can last all night, like a drunken fraternity party.

The high, dramatic flight of these birds over the countryside, especially when large flocks of them moved through during their spring and fall migrations, would also have captured the imagination of early humans. I can remember excavating in Jordan when someone cried out, "Storks!" Their white bodies, accented by black wings, stood out against the blue sky and made us marvel at the world they must inhabit.

The Geissenklösterle flutes do not stand alone. Ten thousand years later, humans were blowing on nearly an orchestra of flutes or pipes at the cave of Isturitz in the foothills of the French Pyrenees. Twenty examples, made from vulture wing bones, have thus far been recovered from what is considered to be the greatest accumulation of art at any site in Ice Age Europe. Four holes had been drilled into each flute, with one pair of holes clearly separated from the other. Because the vulture mating ritual is not very vocal, it might have been the high, languorous, circling flight of a male and female, bonded for life, that impressed early humans.

ENTERING DREAMLAND

Soaring bird flight is a long way from the stupendous art in the prehistoric caves of France and northern Spain. Yet if the skies represented a world beyond the reach of early humans, the bowels of the Earth must have been equally mysterious. Using only the light from animal-fat lamps, the Stone Age artists scaled walls and reached into remote crevices to create a wonderland of black- and red-pigmented animals, mostly bison, lions, mammoths, and other large animals of the hunt, so realistically rendered that they seem to leap out of the stone.

I experienced some of the excitement and awe of this underground world when my wife and I were led by a French guide through the narrow, snaking passageways of Font de Gaume, close to Les Eysies. Stooping down to make our way along, we felt as if we were traveling back in time to the first attempts of humanity to understand the world. As the dim light of our guide's flashlight picked out incised and painted bison, deer, and wolves in the glowering night of the cave, we came away amazed at the skill of the artists in representing the animals of the lush Dordogne Valley.

The naturalistic scenes are accompanied by geometric and figurative motifs—dots, hoofprints, hatched circles and squares, chevrons, and swirling circles—in red ocher. In the cave of Cougnac are the remains of a pile of ocher, apparently used to outline hands by stenciling or to transfer the pigment directly by smearing hands with it and pressing them against the wall.

What was going on in these Ice Age grottoes? They can hardly have been ordinary dwellings, as more convenient, warmer shelters existed closer to the surface. A possible answer can be gleaned from the anthropomorphic faces and figures that occasionally appear in the caves. Heads of humans are shown with horned headdresses or flowing, animal-like manes.

Faces appear to erupt into laughter, and erect penises reach out into the night.

The most wondrous example of anthropomorphizing art was brought to light inside the cave of Les Trois Frères, in an expansive underground chamber called the Sanctuary, which dates from close to the end of the Ice Age, about 13,000 B.P. The Palaeolithic artist had to wriggle out onto a narrow ledge four meters above the floor of the cave to accomplish this masterpiece. The result was a stunning, strange composite of human and animal, nearly a meter tall. A bearded, owl-like face is surmounted by the multipronged antlers of a stag. With paws like those of a rabbit or feline stretched out in front and a horse's tail trailing behind, the figure appears to be stamping out some kind of dance, jumping from one foot to the other. While the lower part of the body is distinctly human, even the exposed genitalia, everything else about the figure boggles the mind. Placed at the highest point in the large artistic composition, the creature appears to oversee the profusion of life below, including stampeding wild animals and even a nocturnal owl, and to reassure us that all is well as "it" stares down at us.

The names used to describe the enigmatic figure in the Trois Frères grotto—Sorcerer, Horned God, and Animal Master—point to the most obvious interpretation. In the jungles of Amazonia, the deserts of southern Africa and Australia, and the frozen tundra of the north, humans have historically assembled into groups dominated by a central religious figure, the shaman or an equivalent. Western observers, with a modern scientific, desacralized perspective, tend to dismiss such individuals as charlatans, witch doctors, or medicine men. But at the dawning of the human race, they would have been the ones who first attempted to understand the forces of nature and the mind.

Even without any written or oral commentary to explain the activities carried out in the Stone Age grottoes, we can appreciate that those orchestrating the proceedings in the caves must have been the most sensitive artists, musicians, dreamers, and likely also the group's principal imbibers of fermented beverages. A woman like the Laussel Venus might have been responsible for making the magic potion that opened up the hidden resources of the human brain, healed disease, and assured a successful hunt. In traditional societies today, women generally take the lead in gathering the fruit, honey, and herbs for alcoholic drinks used to mark burials, deaths, rites of passage, auspicious natural events, and social gatherings; in the Palaeolithic period, perhaps such rituals marked the completion of another cave painting.

Figure 2. The "Sorcerer," the "Horned God," or the "Animal Master" in the so-called Sanctuary of Les Trois Frères grotto in the French Pyrenees, created near the end of the Ice Age, about thirteen thousand years ago. However we describe such shaman-like figures, they were likely the original artistic innovators of humankind, who probably served up the first fermented beverages to their societies. Adapted from drawing by Henri Breuil.

Other elements of a Stone Age ritual can be cautiously inferred from the artworks and their settings in dark caves. The early French explorers of the caves remarked on their extraordinary acoustic properties, especially the resounding echoes produced when they struck the stalagmites and stalactites with bones. A large group of people (their presence recorded for posterity by fingerprints on the walls) could have produced a symphony of sounds. The Sorcerer, wearing a bird-stag mask, might then have tramped out the rhythms of the music, whether choreographed or impromptu. She might dramatize the goings-on by holding up a special symbol, like the bird silhouette shown mounted on a pole next to what may be a bird-headed shaman on the wall of the cave at Lascaux.

Bones might also have been pounded together as musical accompaniment for Palaeolithic ritual. At Mezin on the western plains of Ukraine, a house was discovered that was made entirely of mammoth bones, dated to 20,000 B.P. The excavators argued that the ocher-adorned shoulders, skulls, and other bones of the mammoths that were massed together on the floor of the building, along with two ivory rattles, were percussion instruments. They put their theory into practice by forming a band, the Stone Age Orchestra, whose performance was well received but unlikely to have been as impressive as the music made by hammering sounds out on an "organ" of limestone formations inside a cave.

The red dots, swirling circles, and other designs interspersed with the wild-animal artwork in the caves have also been drawn into the argument for a Palaeolithic shamanistic cult. According to investigators such as David Lewis-Williams, the recurrent motifs represent entoptic phenomena, or optical illusions, of an altered human consciousness. The geometrical interplay of such visual images in our brains can be generated by sensory deprivation, extreme concentration, or repetitive activities like playing music and dancing. But the most direct route to an altered consciousness is a psychoactive drug, and of all the drugs available to early humans, alcohol was far and away the most readily available and best adapted to the human condition. Following its initial stimulatory effects, imbibers would have begun to see visual phenomena and struggled to understand their meaning, possibly culminating in full-scale hallucinations.

One might question the proposition that early humans found these mind-altering properties a compelling reason to consume alcohol. Yet, all of us, not only mystics, engender visual phenomena and hallucinatory experiences every night in our dreams, and nearly a third of our lives is spent in sleep. We can choose to ignore our dreams or pass them off as the detritus of our waking existence. On occasion, however, they rise up and shake us from sleep in terror. They can inspire us, too, and lead to serendipitous juxtapositions of images and ideas that elucidate the world's mysteries. For example, the chemist Friedrich August von Kekulé discovered the ring structure of benzene in a dream: he saw writhing snakes, one of which was biting its own tail and formed a ring. He went to sleep not knowing the answer and woke up with the solution.

The phantasmagoria of our dreams can be extremely fluid and evocative: we might imagine an animal transformed into a human, see ourselves from the outside as if acting in a play, or experience the sensations of flying or falling into an abyss. The Stone Age murals in their dark caverns thus have strong similarities to dream images that well up in our three-dimensional and often vividly colored fantasies in the dark of night. The deep silence of the grotto, intensified by the effects of an alcoholic beverage, might have nourished the imaginations of sensitive individuals, who then represented their inner and outer worlds in two-dimensional art. The shaman and the community could then act out the essential rituals that would guarantee their welfare in this life and the one to come.

The Palaeolithic cave paintings, like so many Sistine Chapels, must have been a monumental task in their day, especially when one considers that they were accomplished with extremely limited technology in pitch-black, nearly inaccessible locations. The motivations for devoting so much time and energy to otherworldly activities were probably similar to those of today. The needs of *Homo sapiens* include social rituals that bring the community together, artwork that symbolizes the workings of the mind and nature, and religious rituals that give human experience meaning and coherence. A fermented beverage or drug can enhance these experiences and stimulate innovative thought. To the people of the Palaeolithic, ceremonial observances, heightened by an alcoholic beverage and other techniques for achieving an altered consciousness, might have been viewed as assuring good health, placating the spirits of invisible ancestors and other spirits, warning of danger, and predicting the future.

SONG AND DANCE

We do not know when humans first became preoccupied with the universal concerns of "wine, women, and song"—to which I would add religion, language, dance, and art. There are faint glimmerings of a new kind of symbolic consciousness at around 100,000 B.P. in sub-Saharan Africa, about the same time that our species began its journeys around the globe. At Border Cave and Klasies River Mouth Cave in South Africa, powdered ocher and a perforated shell, presumably strung as a piece of jewelry, suggest that humans were now interested in making themselves attractive, whether to entice a mate, satisfy vanity, or invoke the help of ancestors or gods. One adolescent skeleton at Border Cave was covered in the pigment, a custom that our ancestors likely carried with them to Mount Carmel in Israel (at the caves of Skhul and Qafzeh) and throughout the Old World. Monkeys and apes may groom one another, but they are not known to engage in intentional beautification. If early humans could adopt the practice of personal adornment, then perhaps they were already using arbitrary sounds and gestures to communicate with one another. Certainly, by the time of the European cave paintings, the quantum leap in cognitive and symbolic ability of our species is on full display.

Early human inventiveness is further reflected in the stone-lined hearths that were used to contain and control fire at Mumbwa Cave in Zambia around 100,000 B.P. This knowledge stood our ancestors in good stead when they spread into the colder regions of the Earth. Intricate bone harpoons from Katanda in the Congo, and carefully wrought microliths—small, sharp flints for specialized use—at Klasies River Mouth Cave were fashioned at a somewhat later period.

Archaeology cannot, however, tell us how the brain was changing and adapting as humans entered new, challenging environments. Endocasts, or plaster casts of the inside of ancient hominid and human skulls, suggest that the human cortex was already distinctly modern by 100,000 B.P. Some researchers have discerned evidence of a region referred to in the modern human brain as Broca's area, the third convolution or gyrus of the inferior frontal lobe on the left side, which is essential for speech and some aspects of music making.

The acquisition of language processing and speech capabilities required a set of interdependent genetic, biological, and social changes. The upright posture on two legs led to the human larynx's being positioned lower in the throat, so that a wider range of sounds could be produced. The tongue acquired a larger supply of nerves, as shown by the larger size of the hypoglossal canal in fossil crania. The canals for the thoracic nerves, controlling the contraction of the diaphragm, were also noticeably enlarged, allowing better control of air flow and sound. New modules in the brain, like Broca's and Wernicke's areas, may have been integrated into or added on to existing brain centers, leading to the development of emotional responsiveness and consciousness. Broca's area, for instance, contains what are called mirror neurons, which, as the phrase implies, may record any action that we observe, and then call it up again, like a photograph, to imitate it. This facility could have been essential in coordinating the facial and tongue movements necessary for speech. The final step that might have tipped the scales toward language in humans could have been a minor change in the so-called FOXP2 gene. A mutation in this gene, which occurs widely in the animal world, resulted in the fine motor control of the tongue and lips that is essential for speech.

Language gave us the ability to articulate our ideas. Many of our thoughts are believed to lie below the level of consciousness, as "logical forms," in the terminology popularized by Noam Chomsky. By bringing these thoughts to the surface—by representing them in a sequence of arbitrary sounds that have been given meaning as words—they are secured in memory and consciousness.

Music, which shares many brain areas with language comprehension and production, might have been the harbinger of language. Like language, music is hierarchical, highly symbolic, and well adapted to our body forms. By changing the intonation, speed, and emphasis of specific sounds, we can communicate emotions. By tapping our feet or joining in a line dance, we can stir our bodies to action and share a sense of community with fellow humans. It's readily apparent today that music is much more than "auditory cheesecake," as the evolutionary biologist Stephen Pinker would have it. From the iPod earplugs sprouting from the heads of commuters to the constant banter about the latest rock star, music is ubiquitous in modern human culture. You might even say that sex, drugs, and rock-and-roll never had it so good.

If we think about how music affects us personally, we begin to see how central it is to our lives and how it might have become part of the cultural package of our forebears. By combining and ordering individual sounds along an arbitrarily defined tonal scale, early humans might have created the first kind of universal language. Although the significance of rhythmic tones is less precise than that of a language using words, it is in some ways more accessible: music made in one culture can be at least partly understood and appreciated by a person in another culture. As we listen to music, we are consciously and unconsciously trying to intuit its emotional significance, including where it is headed and what it means. As when we are trying to figure out where our lives are going or to predict the future, music arouses emotional centers of our primitive brain, the limbic system.

Emotion is as crucial to our survival as rational thought. Being happy, sad, afraid, incensed, or nauseated by some food or beverage, person, or circumstance spurs us to different courses of action, often without thinking. Excitement breeds perseverance—we must be on the right track!—but disappointment or frustration signals that we might be headed in the wrong direction and need to modify our approach or stop altogether. *Star Trek*'s Mr. Spock might have tried to ponder a problem from every angle, but a Palaeolithic hunter or modern homeowner must act more quickly. When a twig cracks in the savannah underbrush, or we hear footsteps close behind us on a dark, deserted street, our emotions mobilize our brains and bodies to evade a perceived danger. It could be a meaningless noise, but by comparing its sound and timbre to others in our memories, we might infer that a lion is ready to leap or a mugger is closing in.

Apes and chimpanzees, the species most similar to us biologically, are also attuned to music. Gibbons in Southeast Asian rain forests put on a musical show of the first order. In ten of the twelve species, a male and female gibbon pair, who mate for life, engage in a duet that seems intended both to defend their territory and to announce their union. The female's "great call," an intricate, rhythmic series of notes, can last between six and eight minutes. It ascends in tempo and pitch as it proceeds. Males do not sing during this monumental performance but follow the female's performance with a kind of recitative or coda. Males also have their own repertoires of shorter songs that round out the program.

We can hypothesize at length about the survival advantages of early human emotions, music, and symbolic systems. Of all the animals that we regularly observe, birds perhaps have the most to tell us about the origins and functions of music. As I woke up this morning, in a dense deciduous forest outside Philadelphia, I listened to the lilt and typewriterlike call of the wood thrushes, recently arrived from Central America. Another neotropical migrant, the black-throated blue warbler, gave out its piercing, ascending trill. The resident tufted titmice, not to be outdone, called insistently and monotonously, "Peter, Peter, Peter." Despite the din, each bird was somehow communicating with others of its own species by using its own kind of music.

My wife, Doris, who is a bird bander, once worked on a project recording the calls of individual prothonotary warblers in the wetlands of southern New Jersey. In this species, only the males sing during the breeding season. The goal was to see whether individual birds had unique songs. Recording the songs and analyzing their frequencies and timing showed that they do, even if the human ear is oblivious to many of the subtle variations. The young birds apparently take elements from the songs of their elders and improvise a distinctive vocabulary of notes and phrases that then becomes fixed for life. Having recorded the songs, my wife did not even have to use her binoculars to confirm that the same birds returned year after year to the same spot in New Jersey. It was a great delight one morning in April, after months of cold weather, to hear the highly distinctive double call of one bird (called Yellow-Yellow because he was banded with two yellow bands).

We cannot know what emotions birds are feeling as they sing. There is little doubt, however, that the main purpose of many of their songs is to attract a mate. When a female hears Yellow-Yellow calling, she can be sure that it is a male of her species. His special call and the brilliance of his yellow plumage are guarantees that he is carrying good genes and can compete with any rival in the neighborhood. The peacock's tail transmits a similar message: in what has been called runaway evolution, a seemingly excessive and burdensome excrescence has become the focus of the mating ritual and is elaborated into an ever more ornate appendage.

Nature is full of other amazing mating rituals based on timed body movements, or what we often call dance. The sexual foreplay of the silver-washed fritillary butterfly might be described as a ballet. While the female fritillary floats languorously through the air, her partner darts seductively all around her, making fleeting contact at specific points in the ritual. The two then land together, make a final check of their specific scents (pheromones), and mate. Seven distinct aerial maneuvers are required for a successful coupling.

A NEW SYNTHESIS

If the emotions and thoughts of early humans in sub-Saharan Africa were likely first conveyed by music and other art forms, then alcoholic beverages can be viewed as nourishing this new symbolic way of life. Indeed, these widely available beverages might well have served as a principal means—another kind of universal language—for accessing the subconscious recesses of the human brain. I have already observed that musical instruments were probably tools of the trade for shamanic figures. These early mystics might also have been the most avid imbibers of fermented beverages, which induced mind-altering visions and enabled them to perform their many other roles. They would have been the doctors who could prescribe the right herb for an ailment, the priests who invoked the ancestors and other unseen presences, and the overseers of the rituals that guaranteed the success and perpetuation of the community. Their Stone Age ceremonies might have been overtly sexual: the humans depicted in cave art, after our species came out of Africa, are invariably naked or have exaggeratedly large sexual organs (note that the human penis, when engorged, is longer and thicker than that of any other primate, both absolutely and relatively when compared by body size).

Perhaps most significant, the Palaeolithic shaman's mantle of office and power had to be passed on to a successor. Because musical and linguistic facility, and even sexual prowess and mystical capacities, often runs in families, the position of the shaman in Palaeolithic society might have been an inherited one. Conscious selection for special traits of musical and artistic ability, mystical absorption, and a capacity for alcoholic beverages would then have been reinforced over time and embedded in our genes.

This book proposes a new framework for interpreting our biocultural past, based on the latest archaeological and scientific findings. As will become increasingly clear in the following chapters as we travel around the world in search of fermented beverages, economic, utilitarian and environmental arguments, which are much in vogue, can only go so far in explaining who we are and how our species has arrived at where it is today. I contend instead that the driving forces in human development from the Palaeolithic period to the present have been the uniquely human traits of self-consciousness, innovation, the arts and religion, all of which can be heightened and encouraged by the consumption of an alcoholic beverage, with its profound effects on the human brain.