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American Indian Contributions To Science and Technology

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AMERICAN INDIAN CONTRIBUTIONS TO SCIENCE AND TECHNOLOGY

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INTRODUCTION

This Essay is principally concerned with the discoveries, innovations, technical practices and contributions of American Indian science. American Indians are not often given credit for having a scientific culture; indeed, numerous popular books, texts and other outsider accounts of American Indian cultures have depicted Indians as invariably superstitious, ignorant and helpless in the face of the powers of Nature.

Such an inaccurate picture has sometimes been used to justify a belief that American Indians are something less than fully human and thus not entitled to full human rights worthy of respect by all. It is important for teachers to have an understanding of the characteristics of American Indian scientific thought and accomplishments so that their students may be taught to appreciate the true stature of Indian people as one of the Four Colors of the Medicine Wheel of humanity.

We should begin by indicating something about the traditional frame of reference used by American Indians as they conducted their investigations of the world and decided which uses of their discoveries were appropriate. (In philosophy, the concept of a frame of reference combines the concepts of epistemology - 'ways of knowing' - and axiology - 'ways of valuing'.)

American Indians and Alaskan Natives (the term refers collectively to the Inuit ('Eskimo'), Aleut and American Indian peoples of Alaska) have long been careful observers of reality from a vantage point of great intimacy with Nature. From what they have learned over centuries of observation, empirical experiments, technical discoveries and continuous questing for visions to show the appropriate relationship of humans to those truths, American Indians have produced a distinctive body of scientific knowledge.

American Indian scientific and technical knowledge is profoundly imbued with a great sense of ethical responsibility. It marries knowledge and wisdom (knowing what can be done and what is appropriate to do) to produce a holistic sense of virtue (limiting oneself to doing the appropriate thing). This sense of virtue in making choices about how to apply knowledge has persisted to a great extent even after 500 years of continuing contact with a different system of beliefs and understandings about the world.

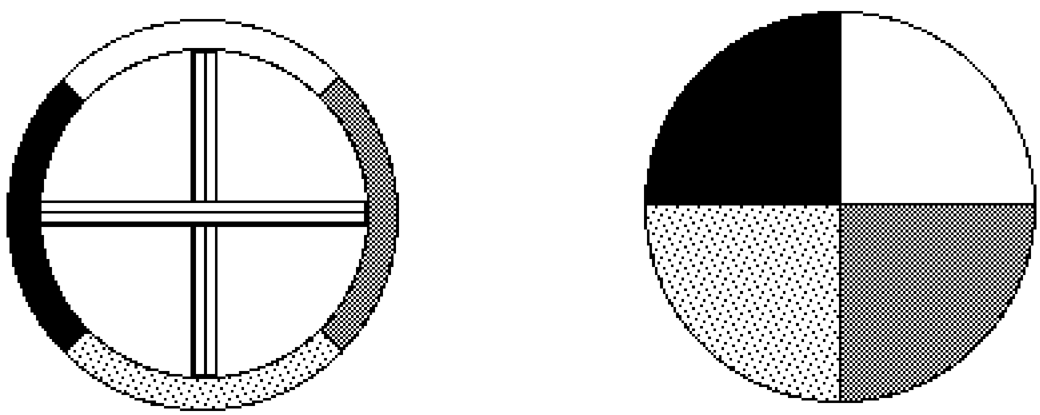
The system of beliefs brought to the Americas by Europeans was similarly drawn from observation, experiment and reflection upon the nature of reality, but it differed (and still does in some ways) from Indian views in several important respects. Many of the developments of the modern European-American system of scientific thought took place after Contact between American Indian and European cultures. However, the basic features of both systems were in place at the time Europeans and American Indians learned that the world had a larger physical and cultural dimension than either had experienced prior to Contact.

The generalized distinctions between the European-American and American Indian scientific worldviews are briefly compared in the table below.

Traditional American Indian Scientific Worldview	Traditional European Scientific Worldview
Circularity of spacetime as a unified quality of reality	Linearity of both space and time as separate qualities of reality
Unified view of material and spiritual reality; organic worldview	Dichotomous view of material and spiritual aspects of reality; mechanistic worldview
Synthesis the predominant cognitive process; holism the predominant scientific paradigm	Analysis the predominant cognitive process; reductionism the predominant scientific paradigm
Humans seen as equals to all the other beings in reality	Humans seen as a distinct and superior type of being as compared to others

American Indians today use many symbols to express the fundamentals of their worldviews. The different symbols result from the enormous diversity that exists between the hundreds of Indian cultures and languages and between environments separated by hundreds and thousands of miles across two great continents. Differences also arise from the degrees to which traditional worldviews have survived among Indian cultures subjected to a variety of destructive and assimilative pressures over the past 500 years.

Space does not permit an exhaustive survey here of the major traditional Indian worldviews. However, it is appropriate to offer one illustration. A symbol that is widely used and to which many references exist in the literature on Indian cultures is introduced below. Consider the Medicine Wheel.



Key

Color	Direction	Some Interpretive Meanings
White	North	Winter, purification, preparation, healing, midnight
Red	East	Spring, illumination, wisdom, insight, dawn
Yellow	South	Summer, growth, trust, fullness, midday
Black	West	Autumn, self-knowledge, power, mystery, evening

This symbol is used by many tribes, particularly on the Great Plains of North America. It is well-known elsewhere in various forms. The illustration of the Medicine Wheel given here presents two variants in the form of a hoop and of a disc. There are numerous variations in the choice, orientation, positioning and interpretation of the symbolic colors, so the representation here is not intended to be definitive or exhaustive.

The four colors and their orientation to the cardinal (or semicardinal, as shown in the disc) directions, sometimes called the Four Quarters, represent many things in addition to the meanings suggested above. Among these other meanings is that the colors represent the four major races of humankind. The Medicine Wheel is also often thought of as relating to two other directions and their associated colors: below stands the green of Mother Earth and above the blue of the heavens and the surrounding spirit of the Great Mystery.

The circular form of the Medicine Wheel shows the relationship of all things in a unity of perfect form. It exemplifies the cyclic or circular nature of all relationships and interactions. It symbolizes unified spacetime when conceived as representing the four ordinary dimensional qualities of reality. Some tribal traditions also ascribe various interpretive meanings to the axes of the hoop form or the axial divisions of the disc form. All individual beings are thought to be specially related to one or more of the colors and directions of the Medicine Wheel. More than one such relation is possible because of the transformations that any being goes through in the course of existence.

In essence, the Medicine Wheel is considered to be a representation of the being, form and processes of the entire universe and all of its individual member beings. It is thus a symbol of enormous depth and subtlety, capable of being understood in many ways and illuminating many relationships.[1]

In its scope and implications about the nature of matter and transformation, this symbol might be thought of as an American Indian analog to Einstein's famous statement $E = mc^2$. Pervasive as a symbol, the Medicine Wheel appears in many works of Indian art, is a theme or motif in Indian literature and forms the basis of many settlement and urban plans in Indian communities. Its orienting and symbolic functions are incorporated in many ceremonial activities. It guides the shape and functions of a number of American Indian scientific sites, as can be seen at the Medicine Wheel National Historic Landmark (a ceremonial location and astronomical observatory) between the towns of Lovell and Sheridan in Wyoming.

The foregoing discussion of a single American Indian symbol is intended to suggest that traditional native thought is far from being unsophisticated as some authors have asserted. In fact, it demonstrates that Indian scientific thought incorporates systematic theory, is based on the interpretation of empirical observations and is highly attuned to the discovery and understanding of relationships in Nature. This traditional focus, combined with a body of indigenous technical procedures, makes American Indian thought a distinctive part of the human scientific tradition.

American Indian science has long embodied an epistemology and axiology that is becoming more familiar to many modern scientists.[2] This orientation addresses the nature of man as an integral part of reality. American Indian science cannot conceive of man as a detached, ‘objective’ observer whose presence and impacts on reality can be minimized or eliminated by intellectual abstractions or experimental controls. One modern European-American who came to this same realization was Werner Heisenberg, a pioneer in 20th century high-energy physics. His quantum mechanical Uncertainty Principle includes the corollary that the observer is an integral and influential part of any experimental system.

This brief introduction to some of the premises and intellectual framework of American Indian scientific thought can be completed with the mention of one further contrast with the predominant pre-20th century traditions of European-American science. This contrast was noted by Vine Deloria, Jr., a noted Lakota historian, lawyer and philosopher. In a recent article in *Winds of Change*, the journal of the American Indian Science and Engineering Society, Deloria raised a number of issues about contemporary attitudes toward traditional American Indian science. One of Deloria's points in particular seems worthy of reflection; science teachers might find his final question (rhetorically asked by 'the old people') worth infusing into their instruction and their students' investigations:

> Modern science tends to use two kinds of questions to examine the world: 1) how does it work? and 2) what use is it? and these questions are natural for a people who think the world is constructed to serve their purposes. The old people might have used these two questions in their effort to understand the world but it is certain that they always asked an additional question: what does it mean?[3]

AGRICULTURAL SCIENCE AND TECHNOLOGY

An Overview of Indian Agricultural Contributions

Archaeology has established that agriculture arose independently in the Americas at about the same time as it began in the Eastern Hemisphere approximately 9,000 to 10,000 years ago.[4] A sense of the relative contributions of generations of American Indian farmers to the world comes from noting that over 300 cultivated American Indian food products have been documented as providing sixty percent of the varieties of agricultural foods now grown worldwide. These plants, most of them domesticated and hybridized by American Indian farmers, account for approximately two-thirds of the weight of plant foods produced in the world.[5]

American Indian-developed plants which are now grown as crucial staple crops in various parts of the world include dozens of varieties of potato, 300 types of maize ('Indian corn'), sunflowers, peanuts, all but two of the world's varieties of beans, cassava (also known as 'manioc', a root rich in carbohydrates and the source of tapioca), sweet potatoes, and amaranth (a grain from Mexico). There is also a single species of yam native to the Americas (*Dioscorea villosa*) which had mainly medicinal uses. It is little used for food, the African and Asian yams being preferred for that purpose around the world.

Other valuable American Indian food crops include tomatoes, many hundreds of varieties of squashes, pineapple, papaya, passion fruit, cashews, pecans, and a whole host of other nuts. Cranberries and many other varieties of berry fruits, celery, chocolate, avocados, quinoa (a grain from the Andes Mountains), jojoba seeds (for oil and meal), and Ojibwe ‘wild rice’ (a cultivated plant, despite the name, and one which can grow in northern wetlands, unlike Asian rice) are all native American Indian foods. Chicle, the original basis of chewing gum, was discovered and developed for that use by the Maya or their ancestors.

Chilies and sweet peppers in incredible variety have spread from the Americas around the world as a favorite condiment. The chilies are also valued in folk medicine as an effective treatment for intestinal gas and to improve blood circulation in small capillaries. American Indians introduced the rest of the world to turkeys, catfish, crayfish and maple syrup. The Peruvian Inca alone introduced more than 80 types of major food crops, more than were known in all of Europe at the time of Contact.[6]

Over the past 500 years, these American Indian foods have transformed the cuisines of Europe, India, Africa and Southeast Asia in particular.[7]

Many nations are now dependent upon American Indian foods. Jack Weatherford, an anthropologist, argues that Russia in particular improved her international position in the 18th and 19th centuries in part due to the nutritional support for her people derived from potatoes and sunflowers, in which Russia has led the world in production in recent centuries.[8] Sunflowers are prized there as an important source of vegetable fats and proteins. Maize, as a fodder crop, made possible a great expansion of European dairy, beef and pork production during the 18th through 20th centuries. It supported a near doubling of the populations of Italy and Spain in the 18th century alone.[9] Africa adopted the peanut, cassava, beans, and corn as the staples which support its booming population.[10] Many Asians came to rely on sweet potatoes and amaranth, and millions of Asian farmers also extensively plant American Indian peanuts, corn, beans, and chilies.[11] It should come as no surprise that the modern American nations continue to derive the bulk of their nutrition and much of the income of their agricultural economies from the production of American Indian food plants.

American Indian Agricultural Technology

Traditional American Indian agricultural techniques employed a sophisticated knowledge of the characteristics and interactions of soil, rain, and plants. Most agricultural Indians in North America and Central America relied upon polyculture (the growing of several species of plants together) in a small-field system called a milpa.[12] The milpa system is a low-impact means of interacting with the earth to produce crops. It is based upon the creation of small mounds into which a mixture of plants is seeded. Milpa planting avoids the types of soil disruption caused by linear plowing and greatly reduces rain runoff erosion compared to plowing techniques. Milpa techniques were taught to and quickly adopted by European immigrant farmers in the Eastern woodlands. There, they also have the advantage of allowing a good crop without the extra labor of digging out tree roots from cleared land.

When a milpa is planted in the traditional 'three sisters' of corn, beans and squash, with other native plants such as marigolds nearby, a number of synergistic effects occur. Corn provides shade for delicate beans and a stalk on which the vines of squash and beans can grow. The squash provides extensive ground cover, reducing weed habitat and weeding, and simultaneously shielding the soil from rain erosion while capturing a maximum of available rainfall. Beans fix nitrogen in the soil through their roots, and so improve fertility without use of artificial chemicals. Weatherford cites studies by Gliessman and by Chacon and Gliessman which show that the traditional Indian milpa technique as used in modern Mexico provides a corn yield as much as 50 percent greater than the common European-American plowing and monoculture cropping technique.[13]

Many of the plants associated with the milpas, thought of as 'weeds' by some people until just recently, were planted because they were natural generators of chemical compounds which discouraged insect herbivores. Dr. Weatherford has written that recent studies have also found that the plants in the 'three sisters' combination themselves attract predatory insects which help defend them against herbivores.[14]

Many European-American farmers continued using the milpa mound system they had adopted from the Indians up until the 1930s; many gardeners still use it. It is generally accepted that the predominance of mechanized plowing techniques and crop monoculture in large-scale agriculture since that time have resulted in serious problems. Among these are soil erosion, soil depletion and a need to rely on artificial insecticides to control herbivorous insects whose populations boom when favored by a monoculture of food plants.[15]

Another traditional American Indian agricultural practice which differed from European techniques at the time of Contact was the selective planting, rather than sowing, of seeds (and cuttings from root crops like potatoes and manioc).[16] European farmers traditionally sowed their fields by taking random handfuls of wheat, rye, barley or other seeds from a sack and strewing them upon the ground. When these seeds matured and exchanged pollen with similar plants (mostly from the same field or those nearby), the result was a limited range of self-hybridized grain types with little human control over genetic qualities.

Indians, who had to plant corn kernels individually due to the nature of the seed and the growing habits of the adult plants, learned that persistent selection of seeds for particular qualities enabled them to control the characteristics and diversity of their crops. (However, they did not develop a genetic theory to explain the basis of this diversity and control.) Having empirically mastered intentional selection in developing corn, American Indian farmers soon applied this technique to other plant species.

The result was a profusion of varieties of such staple crops as corn, chilies, beans and squashes. Indians also eventually learned how to conduct controlled pollination of plants in order to combine parent characteristics in desired ways. They thus became early masters of plant hybridization long before the 19th century botanical researchers Gregor Mendel and Luther Burbank demonstrated to the rest of the world the technique (and Mendel offered his now-famous genetic theory to explain this means) of producing plants with new, useful qualities.

In the Caribbean and much of South America, agriculture was and is practiced on a technical basis different from the milpa system used in the north. The conuco system (the word is from the Arawak language) is adapted to the year-long growing season of the tropics, were farmers can plant and harvest throughout the year instead of on a seasonal basis. Conuco agriculture is a form of slash-and-burn or swidden field agriculture.[17] It emphasizes the propagation of plants through cuttings and roots rather than through seeding the soil. Some of the plants long grown in this way have lost the ability to produce viable seeds or any seeds at all. Robert Carneiro has shown that conuco agriculture based principally on manioc cultivation is capable of producing very high yields of calories per acre and per unit of cultivation time.[18]

As did the empirical technique of selecting and planting maize seeds in the north, the selection and rooting of cuttings gave the Indian plant breeders of the south great control over the genetic qualities of crops. Jack Weatherford states

> Without question the Indians were the world's greatest plant breeders, and their knowledge rested largely on the techniques they used for planting seeds and cuttings rather than broadcasting the seeds. From this firm and practical base of plant manipulation the modern sciences of genetics and plant breeding have developed. Without the treasure of diversity created by the trial-and-error methods of early Indian farmers, modern science would have lacked the resources from which to start. The limited agricultural background of the Old World would have been far too meager and would have required centuries more of research before science reached its present level.[19]

Yet another form of agricultural technology created by Indians was the chinampas system of cultivation practiced in the Valley of Mexico. A chinampa is an artificial island built up of cut reeds overlain with lake bottom mud and anchored with willows planted around its perimeter. Believed to have been invented in the Classic Era city of Teotihuacan nearly two thousand years ago, chinampas agriculture flourished in the post-Classic cities on and around the Lake of the Moon in the Valley of Mexico, particularly Xochimilco and the Aztec capitol of Tenochtitlan.[20] Chinampas agriculture has also been practiced in the Andes at Lake Titicaca by the Uru people, although it is not known whether the Andean technique was developed independently or was brought south from Mexico.[21]

Planting and cultivation was done by hand in the chinampas. There, too, a profusion of plant varieties was developed in extraordinarily rich microenvironments which combined aspects of land agriculture with hydroponics. Flowers as well as produce were important components of chinampas agriculture; Professor Michael Coe notes that the Spanish descriptions of Tenochtitlan record marvels of gardening and floral display.[22]

American Indians also demonstrated to the world the value and uses of fertilizers in agronomy, the science of soil management. Incan guano (nitrogen-rich seabird droppings) and the fish fertilizers used by Indians in both North and South America rejuvenated the depleted soils of Europe in the 18th and 19th centuries. These natural fertilizers and their effects pointed the way for western science to later develop artificial fertilizers.[23] Today, the guano deposits so carefully managed by the Inca are largely gone due to overexploitation, but fish meal fertilizers are still a major Indian contribution to contemporary world agriculture.

Based on his observations of the site, Dr. Weatherford has developed an interesting hypothesis about the nature and one possible function of the mysterious Inca center of Machu Picchu. He believes that what we know about Incan culture makes it highly unlikely that some of the functions commonly assigned to Machu Picchu were carried out there, such as astronomical or religious observances, or its use as a place of refuge for Inca nobles and their gold. (He is disputed in some of this by other scholars.)

He notes that Machu Picchu is a small center, barely larger than a village, yet is endowed with a complex, extraordinarily durable stone architecture. It is surrounded by an extensive terrace system that is curiously unsuited to large-scale production of any one particular foodstuff. The terraces are often very small and were constructed with great difficulty far above the Urubamba River. They required an extensive irrigation canal system to support crops grown on them. However, the enormous variation in elevation and sun orientation of the many terraces creates a highly ramified system of ecological niches.

These facts suggest to Weatherford the possibility that Machu Picchu was built as an Incan state agricultural research station. He believes it served the same function as some other places in the Andes where plant experimentation was conducted. However, he argues that Machu Picchu was more focused on intensive agricultural experimentation than were most of these other sites.[24] Max Schmidt, a Paraguayan of German ancestry and a long-time student of South American cultures, reached a similar conclusion about the Peruvian site of Ollantaytambo in his last scientific journal article on South American Indian agricultural practices.[25]

Impacts of American Indian Agricultural Technology on Other Cultures

According to the anthropologist Jack Weatherford and the historian Fernand Braudel, European life was revolutionized by a combination of American Indian agricultural products with other technical and social innovations (some of these were also of American origin) during the centuries following Contact. These changes so fundamentally altered the long-established economy in Europe as to usher in the modern era of industrialization.[26]

Weatherford devotes a substantial portion of his book **Indian Givers: How the Indians of the Americas Transformed the World** to the changes wrought around the world by the establishment of regular contact between the hemispheres. His thesis echoes an understanding developed in various ways by the Taoist philosophers of China, the 19th century German philosopher Georg Hegel, and the 20th century practitioners of statistics. The interaction of multiple causes produces new, synthetic, often synergistic effects that sometimes far overshadow the effects that can be attributed to the original causes operating in isolation. In his argument on this point, Weatherford asserts that

> Had Europe and America not come together through Columbus or some other connection, the industrial revolution would never have happened in the way that we know it...once the two great civilizations of the Old World and the Americas collided, technological progress exploded, making a true revolution in the mode of production...[27]

The first impetus for the agricultural portion of the change was a foodstuff, the potato.[28] This Andean root crop profoundly reduced the traditional European dependence on cereal grains and caused many water-powered grinding mills to become idle throughout the continent in the course of the 16th through 18th centuries.[29]

The potato is capable of producing some 78 percent more calories per acre than any grain. Having been bred in the cold Andes Mountains, it was able to succeed in northern Europe where grain could not always be grown. As it spread in cultivation during the 17th through 19th centuries due to political foresight and stern measures for its introduction on the part of northern monarchs like Peter the Great of Russia, the potato reduced the incidence and severity of famine and made possible a level of population which shifted military, economic, and political power from southern to northern Europe.[30]

The next revolutionary crop was American Indian long-staple cotton, *Gossypium hirsutum* and *Gossypium barbodense,* which made a spun thread far stronger and more durable than the Eastern Hemisphere's short-fibered Asiatic and Egyptian cottons. Pure cotton cloth was little known in Europe prior to the 16th century, mostly as rare and delicate imports from India. The short-fibered cotton known in Europe was suitable mostly for use as padding or as woof threads on flax warp threads, as in the material fustian. Most ordinary Europeans wore woven wool clothing and leather before the mid-18th century; only the wealthy could afford finer fabrics such as silk or linen.[31]

The industrial revolution in Europe really got underway when the European supply of American Indian cotton fiber (imported directly from America or from transplanted crops in India and Egypt) outstripped the processing capacity of their traditional spinning and weaving cottage industry. Prior to the introduction of long-staple cotton, the European spinners and weavers, predominantly women working by hand, had been coping with low-volume wool production for centuries. Afterward, hand power was no longer sufficient to the task of utilizing the vast quantities of the newly available cotton fibers. European inventors turned to the idle (due to the potato) waterwheels of the former grist mills for power to operate first spinning wheels and then looms on a large scale.

The period of invention of the mechanized technology for turning cotton bolls into cloth extended into the late 18th and early 19th centuries, by which time cotton cloth became the most significant single item of the English export trade. The expansion of textile factory work led to the increasing transformation of the peasantry into an industrial working class in much of western Europe.[32]

Weatherford elaborates on this transformation, citing Prince Peter Kropotkin's 19th century economic analysis of the shift from the earlier European small-scale craft tradition to a centralized industrial mode of production. He notes that Kropotkin failed to identify where the new mode originated. Weatherford argues that the creation of an industrial working class in European culture was a development imported from the mines and sugar plantations of America. There, for the first time in the world, Indian and African slave labor had been organized on a large scale in combination with capital in the form of mechanized production technology.[33]

The remaining American Indian agricultural product to affect the early phase of the industrialization of European and European-American culture, according to Weatherford, was actually not a single product, but rather an entire American Indian technology principally derived from a botanical base. This was dyestuffs, mostly from a variety of American barks and woods, but also from certain insects.

One of these was *Dactylopius coccus*, a scale insect found on one species of cactus cultivated in Mexico, which yields the brilliant red dye cochineal. Cochineal had been available in Europe from related Oriental scale insects prior to the Turkish conquest of Constantinople in 1453. It became scarce and high-priced in Europe after the Turkish merchants began to raise prices on goods imported by sea and overland routes from India, Africa and China.[34] Cochineal became the second most valuable American colonial export to Europe after silver in the mid-to-late 16th century. It was the dye used for the uniforms from which the British Army took its nickname, 'redcoats'.[35]

Other Indian dyestuffs produced hundreds of stable colors previously unavailable to Europeans; Weatherford says that the Inca alone provided 109 hues. The dyes found uses far beyond cloth production (although they greatly stimulated demand for the new cotton cloth). American Indian dyes were applied in Europe to window staining, food coloring, ink making and leather preparation.[36] In the 19th and 20th centuries, the chemical industries of the European-Americans would be greatly developed in an attempt to find artificial or synthetic substitutes for Indian dyes, some of which became scarce as their American Indian producers were killed or the environments of the native plants were excessively disrupted.

Dr. Weatherford has identified two other American Indian botanical products that had profound effects on the development of industrialization in America and the world during the 19th century.

The first was sisal fiber, taken by the Indians from a species of agave in the desert Southwest and Mexico. The great length and strength of sisal fibers made possible the making of strong cord and rope of superior uniformity compared to cordage made of other fibers. Sisal cord enabled the newly developed mechanical harvesters of grain and hay to automate the baling process successfully.[37] However, its production on large plantations in the Yucatán and elsewhere around the Caribbean instituted a new era of large-scale serfdom for many of the surviving descendants of the Maya and tribes such as the exiled Yaqui from northern Mexico.

The second American Indian product was rubber, which had a profound impact on worldwide technological and social development once the Indian technique of vulcanization was accidentally reproduced by Charles Goodyear in 1839. Europeans had actually known of vulcanized rubber since Columbus first saw it used as a ball for sports. However, they remained largely ignorant of this material's possibilities, regarding it as a curiosity.

The inventive Indians of South America and Central America had used vulcanized rubber for over a thousand years to make such modern products as waterproof rainwear, rubber-soled shoes, playing balls, water bottles and a predecessor of the bungee cord, a type of rubber rope.[38] Europeans and European-Americans eventually duplicated these uses of rubber and added new ones, such as the pneumatic tire invented by John Dunlop. Another use of rubber developed in the late 19th century was as electrical insulation for wires, which enabled Benjamin Franklin's discovery of electricity to be put into practical use for something more than lightning rods.[39] The modern version of the American Indian bungee cord proved useful in early aircraft suspensions, continues to be a boon to modern motorcyclists as a means of securing cargo and enables contemporary thrill-seekers to practice a sport known as bungee jumping.

American Indian Food Processing Technology

American Indian farmers in the Andes Mountains were the developers of the technique of freeze-drying to preserve foods. They learned how to use the desiccating effects of alternating freezing mountain temperatures at night with dry, sunny days at high elevations where atmospheric pressure is substantially lower than near sea level. After freezing overnight, vegetables and meat would sublimate (evaporate directly from the frozen to the gaseous state) much of their moisture rather than simply thaw out.

The Andean farmers put these observed phenomena to use drying chunks of potatoes into small, light, foamy lumps which were easy to transport in bulk over the extensive Incan road system. These freeze-dried potatoes stored without decay for five or six years, and reconstituted well when soaked in water.[40] Freeze-drying was also used on other vegetables and a similar technique was used to preserve meat, in which form the Quechuan-speaking Inca referred to it as charqui, from which the English word 'jerky' is derived.

Indians also contributed to the world-wide store of techniques for the storing and grinding of grains. By adding the preparatory step of drying corn to stabilize its moisture content, they found a means to inhibit rot of both seeds and ground meal during storage. This technique was applied to a wide variety of foodstuffs and became a basic food technology of Indian America.[41] Other foods preserved by preparatory drying include the famous and highly nutritious pemmican, a mixture of dried and ground berries, seeds, nuts, meats, and fats. Pemmican was and is prepared using an enormous variety of basic ingredients by many tribes from the Arctic southward nearly to Mexico. Indian processing of chocolate from cacao seeds also uses drying and grinding techniques, supplemented by precisely controlled roasting in between the drying and grinding steps.[42]

American Indian Animal Husbandry

Compared to the Eastern Hemisphere, the Americas had relatively few large animals which survived the Late Pleistocene extinctions. Of these large animals, only the camelid llamas and alpacas of the Andes were domesticated as beasts of burden and for wool, milk, and meat. The related vicuñas, though prized for their wool, were not domesticated until the 20th century.[43] Smaller animals which were domesticated by various Indian groups in both North and South America included the dog, Muscovy ducks, and turkeys. South American Indians also domesticated the ostrich-like rhea for feathers, leather and meat, and also raised the guinea pig, which was and is used for food much as rabbits are elsewhere.[44]

Dogs served many Great Plains tribes of North America as beasts of burden before the reintroduction of horses to the Americas. They were commonly hitched to what came to be called (by the French) a travois, which was two poles lashed together in an elongated X or V shape, with a platform for cargo on the longer, trailing part of the X and the short, forward part serving to anchor a girdle around the dog's midsection.

The dog would follow its mistress as she walked with her band to new hunting and camping areas. Its load was mostly supported on the butt ends of the travois which scraped along on the ground. The travois technique was adapted to horses after they became available, and the similarity of function may have prompted at least one people, the Lakota ('Sioux'), to give the horse a name, šunka wakan, which means 'holy dog'.[45]

The turkey was the only American Indian domesticated animal which was commonly adopted for food by the Europeans. Dr. Michael Coe frequently mentions the cultivation of turkeys in his book **Mexico**. David Noble provides evidence of the value Indians placed on the domesticated turkey for food and feathers by showing that many Southwestern desert pueblos had extensive systems of stone pens built for keeping these birds.[46]

Domestication is not the only option in human interaction with animals, however. The relationships between humans and 'wild' game can be managed in a number of ways which increase their availability to hunters and fishermen. Many Indian groups have developed very sophisticated understandings of animal lifeways which allow the relationship between man and animals to be more 'rewarding' (in the many senses of that word, including the mutual sense) than simple searches for scattered game. This is true of nearly all hunting and gathering cultures.

The value of this kind of knowledge should not be unfavorably compared to that of animal domestication for a powerful reason. Animal resources (fish, game and medicinally useful species, not to mention the many interdependent species relationships that support abundance and diversity in the environment) can be available to a people in a relatively stable fashion over very long periods of time only when such deep knowledge of animal behavior and natural environmental factors guides subtle manipulation and exploitation so as not to disrupt the long-term carrying capacity of a given land or river. The decline of salmon fishing in the Pacific Northwest over the past 100 years should amply demonstrate this truth.

Animal husbandry, on the other hand, carries demonstrated risks of overgrazing, soil damage due to concentration of hoof impacts, water contamination, unbalanced predator-prey relationships, and the spread of disease among large, concentrated populations of genetically-similar stock. Combinations of these factors have caused some areas of the world to become desert (as in the conversion of parts of the Sahel into desert Sahara in Africa) or to otherwise deteriorate in their ability to support animal life, and this in just a few generations.

A few examples of North American Indian techniques for managing the relationship between man and animals may serve to illustrate some reasons why Indians resorted to animal domestication in a limited manner during traditional times.

In many areas of the continent, Indians practiced periodic controlled burning of the forest floor and the creation of clearings by the practice of girdling trees to kill them. This benefited those species of plants and animals which require more open ground for grazing than an untouched forest provides. Among the animals which become more plentiful under this type of forest management are deer and elk, woodland rabbits, many seed-eating birds, and even bears, which benefit from the increased production of berry bushes which often occurs in burned-over areas.

Certain species of useful, shade-intolerant trees, such as Douglas firs, propagate much better in burned-over forests than otherwise. Oaks also produce more plentiful crops of acorns when rival trees and shrubs are kept out of the oak groves by periodic burnings.[47]

In the buffalo country in pre-horse days, a number of tribes including the Blackfeet developed a managed hunting technique based upon psychological characteristics of the animals in a herd. Buffalo tend to run for open ground and avoid trying to run through or over anything that appears to be a solid barrier.

These characteristics made it possible for the Blackfeet and others to guide a herd into natural draws or bottlenecks on the terrain by constructing brush or rock fences. At the base of the draw might be a cliff or a constructed corral, called a piskin, into which a herd could be frightened by hunters or their wives and children jumping up from hiding, yelling and waving blankets or skins once the animals had gone by along the draw or fence.

If things went well for the hunters and the buffalo ‘gave’ themselves to the people, the animals would rush along the wings of the fence into the piskin or over the cliff, unable to turn around because of their own group momentum and their reluctance to attempt to break through a fence or line of hunters. Once in the piskin or fallen over the 'jump' of a cliff, the animals could be killed by other hunters waiting with spears.[48] A similar technique using brush corrals and bound-brush human effigies was sometimes used by several bands living in the Canadian Sub-Arctic when they hunted caribou.

A developed knowledge of the psychology and spirituality of buffalo carried the Blackfeet and some other tribes even further in sophisticated animal management. It was noticed that some buffalo would come toward a hunter who waved a blanket, bird wing or skin; this form of 'calling' the buffalo could sometimes be used more successfully than attempting to drive a herd into a piskin or jump.[49]

An ultimate development of this technique came as a few Indians acquired strong personal spiritual connections to the buffalo. This might occur as a result of finding a small stone shaped like a buffalo, or through dreaming, or in a trance during the Sun Dance.[50] Some of these buffalo callers gained the power to attract buffalo through a sacred song given to them.[51] The power of this song was in the nature of an agreement between the man and the animals which brought humans the buffalos' gifts of food, clothing, and shelter in exchange for appropriate respect and treatment on all occasions. Among the Cheyenne, a similar calling technique was used by some spiritually powerful people to hunt the normally shy and fleet pronghorn antelope.[52]

Fishing techniques among American Indians also show the influence of a sophisticated adaptive understanding of the fishes' lives and environment. Particularly in the Northwest Coastal region of North America, but also in the regions of New England and the mid-Atlantic coast, the Caribbean, the lakes of the Valley of Mexico and the Andes, and along the Pacific coast of South America, fishing was the economic mainstay of many tribes. It remains so for some.

In the Northwest, techniques for taking the most important aquatic life, such as whales and seals, salmon, halibut, shellfish, sea urchins, herring, and oolachan (or 'eulachon', a small, littoral fish rich in oils, used as a condiment for many dishes and also dried for use as candles) made use of what the Indians had learned of the environments and ways of life preferred by each species.

For example, Pacific salmon, as a group of species which return to the freshwater streams of their birth to spawn each new generation, were not hunted in the open ocean at great expense of time and equipment as they are now by modern trawlers. Instead, the characteristics of these fish were relied upon and the tribes awaited the annual return of the salmon to the rivers, where the catch could be most economically made using fish weirs, dip nets, and spears, all techniques allowing good escapement and minimizing the risk of overfishing the resource.[53] In the Amazon River drainage of South America, some tribes have learned to fish the often muddy waters of streams and flooded areas by using a plant drug called barbasco. This causes the fish to become immobile and float to the surface for a time, where they may be more easily found and harvested by canoe.[54]

After Europeans arrived in the Americas, Indians adopted several of the domesticated animals brought from the Eastern Hemisphere.

The return of the horse (of course, of course) quickly revolutionized the traditional ways of life and transport in many parts of North and South America. In turn, some tribes became not only expert users of horses but also became renowned as horse breeders. The Palouse and Nimipu ('Nez Percé') of the Plateau country, for example, created the beautiful and strong Appaloosa breed from Arabian stocks traded and captured from the Shoshone. Their neighbors the Cayuse developed a breed of fast, tough ponies that bear the tribal name.[55]

Many tribes in the grasslands of Venezuela, Argentina, Uruguay, Paraguay and

Chile similarly became expert horse riders and breeders, giving rise to the gaucho culture (mentioned further below in the discussion on beef ranching). Similarly, some tribes and numerous Indian individuals in Mexico participated in the development of the vaquero techniques and traditions which influenced the later Anglo-American cowboy culture.

These Indians learned the techniques of selective breeding and applied them to maintaining the quality of Eastern Hemisphere breeds of horses as well as to adapting Eurasian stocks to American conditions and needs. As horse culture spread throughout the Americas in the 17th and 18th centuries, the knowledge of stock breeding and management similarly was passed from tribe to tribe and between assimilated Indians and those still independent.

As horse culture developed in the Americas, mules and donkeys became better established than horses in the mountainous mining regions of the West and in Mexico and Peru, but they generally remained more popular among European-Americans than among Indians.

Of the bovine species brought to the Western Hemisphere by the immigrants from Europe, goats and sheep became favorite domestic animals of some tribes in the American Southwest, most notably the Navajo. This Athabaskan people were recent migrants into the Southwest from northwestern Canada. Once in the Southwest, they established a mixed agricultural-hunting economy. After the Spaniards introduced sheep into the region in the 1600s, the Navajo became predominantly pastoralists. The raising of sheep and goats remains a mainstay of the modern traditional Navajo economy, despite several disastrous attempts beginning in the 1930s by the U.S. Government to enforce livestock reduction programs (see the Social Sciences Essay).

Elsewhere, the introduction of beef cattle has met with a variety of American Indian responses. On the American Great Plains, most tribes did not at first favor beef, preferring buffalo as a food and materials resource until the destruction of the herds in the 1870s-1880s. Some tribes took to ranching beef on their reservations, but the U.S. and the Canadian governments often interfered as part of their policies of trying to acculturate Indians as farmers.

These policies were driven by a combination of ethnocentric and religious assumptions about the role and sequence of farming in 'the march of civilization'. However, these notions ran contrary to the actual historical development of certain tribes of the western margins of the Northeast Woodlands and the river valleys of the Great Plains. While these cultures traditionally lived by a mixture of farming and hunting, they had reduced their dependence on agriculture with the coming of the horse in the 17th and 18th centuries.

Despite the destruction of their hunting economy by European-Americans in the 19th century, most were reluctant to return to farming as a way of life. On the Great Plains reservations where many tribes were forcibly resettled, farming on the European-American model seldom succeeded, given the conditions of soil and climate and Indian unfamiliarity with American farming tools when these were provided. Many of these tribes preferred to adopt cattle ranching as an alternative to buffalo hunting or farming.[56]

A small number of these U.S. tribes were provided stock in 1879 and succeeded in ranching for a few years. However, difficulties over range rights and mutual cattle theft by both Indians and immigrants soon led American citizens to demand that the Bureau of Indian Affairs curtail Indian ranching. Breeding stock supplies to the tribes, never large, were reduced. Then a severe winter in 1886-87 killed most cattle on the northern Great Plains. Despite the consequent elimination or reduction of stock, many Indians continued to raise small herds or to work for American ranchers as cattle hands.[57] Out of this experience came a tradition of Indian participation in the rodeos, competitive displays of ranching skills that became popular in the 20th century in most of the American and Canadian West. While this may come as a surprise, many American Indians have also been cowboys for a long time!

In South America, the introduction of beef ranching didn't have to compete for Indian favor with buffalo. There, Indian adoption of the combination of horse culture and ranch work for European landowners came sooner than in North America. A notable result was the development of a mestizo (mixed-blood) and Indian social class of professional cowboys known as gauchos in grassland areas such as Argentina and Venezuela.[58]

Like their Indian and mestizo counterparts in the U.S., Mexico and Canada, the gauchos became factors in the economic development of their countries. They too developed a colorful, romantic tradition of songs, clothing, language and public performances of their skills. Their ranching activities also altered the native environments in both subtle and overt ways. Beef ranching changed soil conditions and favored types of plants that survived grazing and the pounding of hooves. Changes in the animal populations living on the lands were another consequence of the economic practices of the gauchos. These Indian and mixed-blood cowboys also had social effects on the development of South America which went beyond their environmental and economic impacts. They were a powerful military factor on both sides in the wars of liberation that were fought by Bolivar and San Martín against Spanish viceroys in the early 19th century.

ASTRONOMY

The systematic study of the positions and motions of the sun, major planets and certain important stars and constellations was of great importance to many American Indian cultures. The evidence of the effort put into astronomy by some Indian civilizations remains in several forms.

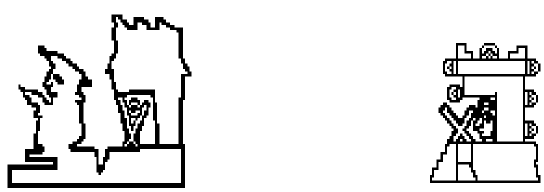
Building designs and urban plan alignments survive that clearly suggest observatory functions. A few locations preserve stones that have been set in circular Medicine Wheel patterns that have or had astronomic alignments; these lithic observatories gave some peoples the ability to determine and predict cyclic events in the heavens. Other cultures identified places from which to observe the alignment of natural landmarks with important celestial occurrences. Finally, many surviving Indian calendars give evidence of generations of patient astronomical observations to determine the periodic nature of many celestial phenomena. The calendars traced the relation of these phenomena to changes in the seasons and sometimes the events of public and private life.

The surviving oral traditions of many American Indian cultures identify the religious, agricultural and social significance of the observed behavior of various astral bodies. The calendars and astronomical tables contained in several of the remaining Mesoamerican writings (some of these are discussed in the Language Arts Essay) provide especially powerful evidence of the intensity and seriousness with which American Indian astronomers in those cultures pursued knowledge of the heavens. Other testimony to the seriousness of Indian scientific study of the heavens remains in the form of buildings, lithic monuments and astronomical instruments used in the past and sometimes even today.

Observatories, Medicine Wheels and Instruments

Astronomers, archaeologists and architects have devoted a great deal of work in this century to the task of identifying astronomical observatory sites and techniques used by American Indian cultures. Observatory sites and buildings were developed by many of the Mesoamerican cultures, and these are perhaps the most widely known and best understood. But the civilizations of Mexico and Central America were not the only ones in the Americas to leave evidence of an interest in astronomy. In the northwestern corner of the Great Plains, many stone symbols known as 'Medicine Wheels' were laid out on the land; some of these appear to have astronomical uses.

From Mesoamerican literary sources that have survived the Conquest, we also have illustrations of an astronomical instrument, the so-called 'crossed sticks' that appears to have been used to determine ascensions of stars and planets above the local horizons from fixed locations in temple observatories. Two of these illustrations, from the Mixtec sources known as the Codex Selden and the Codex Bodley, are rendered below.



Two Mixtec symbols from the Codex Selden (left) and Codex Bodley
showing a "crossed stick" astronomical instrument in use at two differ
The temple on the right is architecturally adorned with "eye" symbols
the identity of this building as an observatory. Drawn after an illustrat
(ed.) **Native American Astronomy**

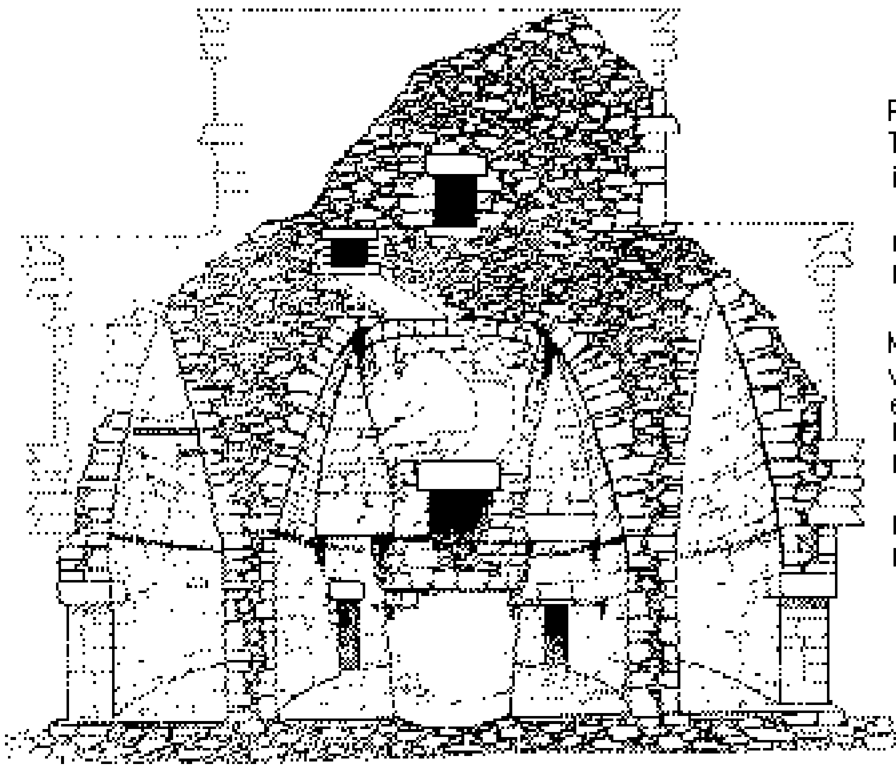
We lack clear documentary records from nearly all of the American Indian cultures about their astronomy. Also, expert survivors (when there are any) are frequently unwilling to share their astronomical knowledge outside of their tribal group because of its religious significance. To begin to understand what some of our ancestors might have done to study and interpret the heavens, we can turn to archaeologists, ethnologists and archeoastronomers, those modern scientists who interpret the buildings, artifacts and written records remaining from earlier times.

These specialists have applied contemporary observations, geometry and computer modeling of the positions of objects in the ancient skies to many American Indian buildings and stone sites in an effort to discover what past (and sometimes present) use as reliable observatories these structures can reveal. They have studied and tried to translate and interpret the surviving texts and collected American Indian oral traditions on astronomy. Much of their work has focused on buildings and writings by the Mesoamerican cultures of Mexico and Central America.

The Toltec-Mayan structure at Chichén Itzá known as the Caracol is the best understood example of an American Indian building used as an observatory. The Caracol is pictured on the following page.

It is thought that the windows of the Caracol were positioned to allow exacting observation of the setting and rising of the planet Venus, the celestial embodiment of the god Quetzalcóatl. Astronomical tables appearing in the Dresden Codex (predicting the precise moments of the disappearance and reappearance of this portentous being) are known to have been developed at Chichén Itzá. Anthony Aveni, a leading American archeoastronomer, believes that observations from the Caracol and other similar towers nearby probably helped the Toltec and Maya astronomers refine their predictive tables to an impressive degree.[59]

Archeoastronomers similarly suspect that the sighting-tube chamber in ‘Structure P’ at the ancient center of Zapotec culture, Monte Albán, functioned as a solar observatory.[60]



Remains of the Caracol at the Toltec-Maya city of Chichén Itzá in the Yucatán. The phantom outlines indicate archeologists' reconstruction of the original form of the building.

Modern astronomers believe the windows in the upper story enabled the Mayan astronomers to make precise observations of the settings and risings of the planet Venus. The data shaped the Mayan calendars which were the basis of the predictions that guided the life of their culture.

after drawing in Kopper, **The Smithsonian Book of North American Indians**

Aside from individual Mesoamerican buildings that show evidence of use as observatories, archeologists have noted that many groupings of buildings, plazas, stelae (inscribed stone monuments in the form of an obelisk) and natural objects on the horizon suggest their deliberate alignment to enable astronomical observations by American Indian astronomers of earlier times. Examples noted by various scientists include the 'Group E' buildings at Uaxactun in the upland Petén region of the Yucatán peninsula. The arrangement enabled observers to note the solstices and equinoxes, and apparently was reproduced in about a dozen other towns within about 100 miles of Uaxactun.[61] 'Building J' at Monte Albán similarly has alignments with key points on other nearby structures that point to the spot where hundreds of years ago the star Capella arose on the morning of the equinoxes.[62]

The civilizations of Mesoamerica were not the only American Indian peoples to create and use observatory sites, as mentioned above.

In the Canadian provinces of Alberta and Saskatchewan and the states of Montana, North Dakota and Wyoming are some 50 or so known circles laid out on the ground with stones. The construction of some dates back to just two hundred years ago. The oldest American Indian stone circle known, near Majorville in Alberta, was constructed around 2500 B.C. or about the time of the early Egyptian pyramids and the beginnings of Stonehenge in England.[63] Often called Medicine Wheels, these circles usually are emphasized at certain points with cairns of stone, containing anywhere from a few stones to piles of up to 100 tons of rock.[64] Most wheels include radial 'spokes' made of lines of stone, with anywhere from one to 28 spokes. Some have no spokes, only cairns. Astronomers believe a few of these circles had observatory functions, but after investigations most are thought to be ceremonial sites without astronomical utility.

Among the Medicine Wheels thought to be observatories are the Big Horn Medicine Wheel near Sheridan, Wyoming, the Fort Smith Medicine Wheel on the Crow Reservation in Montana, and the Moose Mountain Medicine Wheel in Saskatchewan.[65] Solar physicist John Eddy has stated that more than half of the more numerous Canadian Medicine Wheels have tolerably close alignments (within 2°) of cairns or radial spokes indicating the position of the rising sun on the summer solstice.[66]

The Big Horn Medicine Wheel and the similar, but much larger, Moose Mountain Medicine Wheel appear by measurements to offer the clearest evidence of early Great Plains Indian observatories. Cairns of stone on some of their radial lines and at the center of the circle mark key points which, when used as points on a sight line, give an accurate determination even today of the summer solstice and, with less accuracy, the ancient heliacal rising points on the horizon for the stars Aldebaran, Rigel and Sirius.[67]

Similarly, some of the 16th century Wichita villages in Kansas include earth mounds, dugout basins and stones formed into circles that appear to provide sight lines for the determining of the winter solstice. Some of these circles may have been a part of the organized structure of the early Wichita villages.[68]

The Anasazi of the Southwest appear to have used natural site alignments to determine the date of the winter solstice in at least two places near their great cultural center at Chaco Canyon in New Mexico during the 12th century.[69] Alignments of windows, doorways and niches in the walls of two of the six great kivas in the Canyon also suggest their use in observing the solstices. These are Casa Rinconada and the Great Kiva A at Pueblo Bonito.[70] Casa Rinconada also apparently records the geometries of solstice observations with a line traced through two wall niches and a nearby mesa edge, although the kiva roof, once completed, prevented the use of the line for ongoing observations. Perhaps this line served to astronomically align the construction of the kiva. Great Kiva A also suggests several similar geometrical alignments that may have had an astronomical basis.

Astronomers are examining the possible use of Anasazi towers at Hovenweep National Monument in Utah to determine whether they could have served as observatories. Williamson, Fisher and O'Flynn have noted from observations that the Hovenweep towers, and possibly other Anasazi towers elsewhere, may have functioned as stellar observatories as well as solar or lunar observation sites.[71]

The Kogi of Colombia build pole-and-thatch temples of a rounded conical form, with the height equal to the diameter of the base of the structure. The top of the temple has a hole that is ordinarily covered by a piece of pottery. Inside, four ceremonial hearths are arranged on nearly semicardinal lines (northwest to southeast, and northeast to southwest).

At the precise points where first light from the morning sun on the solstices strikes the floor (southwest corner in the summer, northwest corner in the winter) are two of the hearths, while the other two are located at the spots to the northeast and southeast where the light of summer and winter solstices respectively last fall through the hole. Since the Kogi live at about 10° North latitude, the points for the hearths do not fall exactly on the semicardinal points, but their method of temple construction brings them fairly close at this latitude. This Kogi temple pattern of light and hearths is referred to as 'weaving the sun' and has ritual significance in Kogi culture, where weaving is a metaphor for the structure of life and the cosmos.[72]

Among the Inca domains in Peru, Ecuador and Chile, a system of hundreds of shrines called huacas was widely distributed throughout the Tawatinsuyú or lands of the empire. These huacas had many levels of significance; they could serve as local points of worship and ritual, were important politically or might mark reference points on the highway system. Of relevance here, some were integrated into the Inca calendric system.

One anthropologist has learned that certain huacas called sucanca were also used as observational points in Incan astronomy.[73] He notes that the Inca calendar recognized and interrelated synodical months (lunar months of 29 or 30 days), solar months of 30 or more days, sidereal months ($27^1/_3$ days between conjunctions of two stars) and months with 23, 24 or 26 days. The system of lunar, sidereal and solar months required some form of astronomical observation to precisely time and interrelate into the complex Inca calendar.[74] Positional sightings using the sucanca as observatory markers apparently met these needs of the Incan astronomers.

ENGINEERING

Hydraulics

Hydraulic techniques for the collection, transport and management of water as a resource for agricultural and urban use were well developed by pre-Contact American Indians in three separate regions of the Americas. In the American Southwest, the Hohokam culture centered on the Gila River and San Juan River near modern Phoenix built extensive irrigation systems that are thought to have inspired imitation by a number of neighboring cultures. In Mesoamerica, various groups developed agricultural and urban water systems that display a high degree of ingenuity and technical skill in adapting to local conditions and needs. The Peruvian peoples of pre-Inca and Inca times also mastered agricultural and urban water supply problems in the mountainous river valleys and highland centers of their cultures.

Archaeological evidence suggests that the development of technical skill in building and controlling water supply systems developed in these three regions around 300 B.C.[75] Some scientists believe that coastal valley farmers in Peru may have begun developing irrigation systems as much as 500 years earlier, although the evidence remaining is largely circumstantial.[76]

Because of a lack of surviving records, we do not know for certain how the technical knowledge for the construction of canals, pipelines, aqueducts, dams, reservoirs and check valves was maintained and passed along from generation to generation in these cultures. It is likely that the knowledge of controllable canal grades and the canal construction materials and techniques needed for these gravity-fed systems was the province of master technicians who passed the information on orally. It is thought that the Hohokam especially relied on skilled technicians who handed down their hydraulic knowledge.

It seems possible that the Mesoamerican engineers of the Nahuatl-speaking cultures of the Valley of Mexico, the Zapotec of the Oaxaca region, and the Maya of the Yucatán-Guatemala areas may have recorded technical information about their water systems in their written languages. So far, we know only of a few descriptive images from wall paintings and lack more specialized texts on native hydraulic engineering.[77] Similarly, any Inca or pre-Inca records (assuming some were made) about the engineering of the canal systems in Peru failed to survive the destruction of the coded quipu string libraries of the Inca state. Thus, nearly all of what we know of the engineering of pre-Contact American Indian water systems comes from the archaeological record.

Contemporary Indian hydraulic engineering still uses some of the techniques of the past in the case of some small irrigation systems in Peru and in the American Southwest. It also uses the modern techniques adapted from European-American engineers, as can be seen in the fully modern, tribally built and operated hydroelectric dam on the Warm Springs Reservation in Oregon or in the municipal water and liquid waste systems operated by many tribal communities on many reservations throughout the United States. The fish hatchery systems that numerous tribes have established in the West can also be thought of as part of contemporary Indian hydraulic engineering (as well as part of modern tribal wildlife management).

Hohokam Irrigation and Water Systems

The Hohokam peoples, thought to be the ancestors of the present-day Pima and Tono O'Odham ('Papago') tribes, established themselves on the Gila River near modern Phoenix sometime around 300 B.C. Many archaeologists believe them to have been migrants from Mexico. Hohokam culture, divided between desert and river groups, went through several phases of development before dissolving sometime around 1400 A.D. Their cultural center was a rambling village of about one square kilometer, the remains of which are now called Snaketown, south of Phoenix. It and more than 20 other significant villages have been identified in the Gila, Salt, Santa Cruz, and Verde River basins in Arizona.

The riparian Hohokam began to build systems of irrigation canals shortly after they established their village sites. These were usually unlined earthen canals cut by hand tools, the soil being removed by the basket load. By the time the culture reached its high point between about 1000 to 1400 A.D., the Hohokam farmers were able to settle considerable distances away from the rivers due to the extent and complexity of the canal systems. According to the text of a recent technical advertisement which appeared in the journal of the American Indian Science and Engineering Society, one of the Hohokam systems was able to supply the irrigation needs of over 14,000 acres of cropland.[78] Some examples follow to give a sense of the hydraulic engineering accomplishments of the Hohokam people.

The main canal serving Snaketown was four to five feet in depth and about eight feet in width. The two canals providing water to the village and fields at what archaeologists call Pueblo Grande, also near Phoenix, range from ten to fourteen feet in depth and twenty to thirty-three feet in width. One of these canals was uncharacteristically lined with clay to prevent water loss into a layer of gravel through which the canal was cut. One village, called Los Muertos by Frank Cushing, the Smithsonian Institution scientist who excavated it in the 1880s, was supplied by canal with water from the Salt River over six miles away. The 14th-century Hohokam trading center now called Casa Grande, midway between Phoenix and Tucson, was served by a canal sixteen miles in length.

The canal system within any given river drainage often served several Hohokam villages, leading scholars to suppose that close cooperation and planning took place among village leaders to coordinate use and movement of the water through the system.[79] As is mentioned in the Art Essay, the Hohokam canals were valved by the use of closely-woven mats that were moved in and out of place on gateway frames at the junctions of the feeder canals and the irrigation ditches.

Pre-Incan and Incan Irrigation and Water Systems

Sometime in the era between 800 B.C. and 300 B.C., the Chavín culture on the coast of Peru began to expand inland, moving from earlier river mouth settlements into the mountainous river valleys. The Chavín farmers began to terrace the valley slopes to raise maize, greatly expanding the agricultural base of their economy. The eroded remains of these terraces have not retained clear evidence of irrigation, but scholars suspect that the terrace fields required irrigation to be productive.

One large terraced Chavín site, that of the Casma Valley on Peru's central coast, is thought by anthropologist Alfred Kidder to imply the early presence of irrigation systems since, in Kidder's analysis, the population known to have lived at the site "could hardly have been supported without irrigation on a fairly large scale."[80]

Later, between 300 B.C. and 200 A.D., other valleys such as the Virú and Chicama on the north coast show some surviving signs of canal irrigation of the terraces.[81] By 200 A.D., clear archaeological evidence shows that the Mochica and Nazca cultures of the Peruvian coast were making extensive use of canal irrigation and fertilizers on their terrace farms. Kidder believes that these civilizations were using their river valleys to their full agricultural potential.[82] The limited supplies of irrigation water had become a primary constraint on the further expansion of these cultures. Kidder also states that the artistic records of the Mochica and Nazca show that state militarism developed at this time. A program of conquest of others' agricultural land and water supplies apparently became the only way to support further growth in the populations of these vigorous cultures.[83]

The final technological innovations of Andean irrigation and civic water systems were developed around the time of the last preeminent pre-Conquest Peruvian cultures, those of the Chimú and Inca. Irrigation systems were linked between river valleys by long systems of canals and, where necessary, aqueducts. This linkage was made possible by the growth of 'kingdoms' capable of uniting and controlling whole regions rather than just specific locales.[84]

The Inca in particular elevated hydraulic engineering to great heights just prior to the arrival of the Spanish in 1532 A.D. Under Inca Roca, the first lord of Upper Cuzco, they built extensive systems of flood control dams and used heavy masonry levees to channel the rivers supplying water to the agricultural terraces and to the fields below their capitol of Cuzco.

Streams and springs that supplied drinking water to the capitol were similarly managed. The Inca deepened natural pools and cut artificial ones to heighten the aesthetic qualities of the streams, along which the royalty and nobility built villas. The engineers led these water sources into huge masonry reservoirs from which underground pipelines or open masonry trenches supplied both private and public fountains and ritual bathing pools, each identified with its own huaca or 'distinctive spirit'.[85]

In the Intihuasi or fortress of Sacsahuaman which overlooked Cuzco, the Inca engineers reached the high point of their technical sophistication. They created a system of underground piped, pressurized water for use in the apartments of the royal Inca. These royal apartments included extensive bath facilities.[86] While the available records do not indicate that any valve mechanisms for this pressurized water system have survived, it is technically likely that such valves were made. The Inca were masters of bronze casting and could readily have produced functional valves using this alloy, a material which is still widely used by plumbers for this purpose.

Mesoamerican Irrigation and Water Systems

As in the American Southwest and Peru, archaeological evidence places the inception of hydraulic engineering technology in Mexico and Central America at around 300 B.C. The Zapotec-speaking peoples of the Monte Albán culture in the Valley of Oaxaca in Mexico are known to have created artificial terraces on a hillside site called Hierve el Agua at that time. The irrigation canals the Zapotec cut to supply these farming terraces with water from nearby springs have been preserved by hard calcium deposits laid down by the mineral-rich waters of the springs.[87]

The urban center of Teotihuacan began to develop about two millennia ago. It reached substantial size by about 300 A.D. This city presents an interesting puzzle to archaeologists. It had a large population and is located in a relatively dry highland basin in the northeast part of the Valley of Mexico. These factors suggest that irrigation was needed if local agriculture were to yield sufficient produce to support the population, estimated at about 125,000 people in 600 A.D.[88] Interestingly, no physical remains of contemporaneous Indian irrigation systems have been found in the valley around the ancient city.

Professor William Sanders has shown that the Teotihuacan farmers practiced terracing on hillsides to control erosion and has long argued that irrigation must have existed on the terraces. Irrigated gardens are shown in wall paintings at the Tepantitla palace in the city, so it is evident that the Teotihuacanos knew of hydraulic technology.[89]

Michael Coe, professor of archaeology at Yale University, has suggested that the city may have relied on other means for feeding its people. He notes that there is evidence that the Teotihuacanos practiced chinampas agriculture within the city itself.

Logically they must have had some means of supplying the plots with the water needed for this partly hydroponic type of agriculture. Coe alternatively points out that the city dominated an extensive trade and tribute network and may not have needed to rely much on local produce.[90]

In the core area of the Valley of Mexico, the numerous city-states that rose to prominence after the fall of Teotihuacan in the 8th century continued to practice chinampas agriculture. Chinampas plots were common in lakes Texcoco, Xaltocan, Zumpango and especially Chalco.

The Alcohua additionally created a system of canals and aqueducts from the mountains into their cities and to the terraced agricultural fields on the hills they farmed.[91] From the Alcohuan capitol of Texcoco, the famed 15th century poet-king Nezahualcoyotl engineered and directed the construction of this system. He assisted his Aztec allies in solving one of their water supply problems as well. He is credited with the creation of the ten-mile long dike in Lake Texcoco that held brackish flood waters away from the chinampas plots of the Aztec capitol of Tenochtitlan.[92]

However, the Aztec themselves were accomplished hydraulic engineers The eighth huey-tlatoani or Great Speaker of the Aztec, Ahuitzotl, constructed an aqueduct over eight miles in length to supply his capitol city with drinking water in the latter part of the 15th century.[93] A portion of this aqueduct is currently being uncovered in archaeological excavations in Mexico City, and has been shown to be a carefully-crafted, stone-lined structure. The twin island cities of the Aztec capitol (Tenochtitlan and Tlatelolco) were served by several such aqueducts, carried across the waters of Lake Texcoco on earthen dikes, as were the causeway roads that connected the cities to the mainland on the north, south, and west.[94]

In the southern part of Mesoamerica, the Maya people faced a variety of engineering challenges in obtaining and transporting water in the differing environments of their widespread cities and farming settlements. In the highland regions of Guatemala and in the Mexican state of Chiapas, terraced farming was practiced and irrigation may also have existed; the remaining physical evidence is inconclusive.[95]

In the lowlands of the Yucatán peninsula and neighboring coastal regions where the Maya settled, much of the land is underlain with an extensive, porous limestone layer that contains a huge underground aquifer. The rains quickly percolate down to this aquifer. As a result, surface water is scarce despite heavy tropical precipitation. Few rivers or streams exist in this region. However, numerous natural sinkholes, or cenotes, allow access to the underground water supplies, and the Maya sometimes enlarged these cenotes to provide easier access when required.

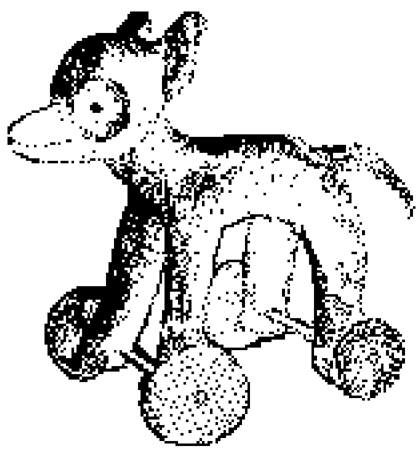
Elsewhere, they cut cisterns called chultuns into the rock under buildings and ceremonial plazas. The Maya engineers devised drainage systems from the buildings and courtyards to divert rain runoff into the chultuns to provide year-round water supplies in areas where cenotes did not exist, such as the Puuc region of the northwestern Yucatán.[96]

These chultuns were lined with plaster to prevent seepage and average about 7,500 gallons each in capacity. This is enough water to supply about 25 people year-round. Professor Sylvanus Morley, a noted researcher of Mayan civilization, reported that the chultun capacity available to some of the Yucatán towns in their artificial water systems could support between 2,000 and 6,000 people.[97]

Maya hydraulic engineers and architects also created elaborate systems for using water in some public buildings, temples, and palaces. Among their creations were steam baths using stone channels to deliver water to heated rocks which generated steam for these saunas.[98] At Palenque, a major city in what is now the Mexican state of Chiapas, the Maya engineers developed toilets with running water and supplied the city's water system by aqueduct.[99]

Transportation Systems

In the Western Hemisphere, large animals suited to domestication and use as draft animals had become extinct by the close of the last Ice Age. As a consequence, American Indians did not develop wheeled transport vehicles in the Americas, although the principle of the wheel was known to at least two American Indian cultures. Artists in Remojadas (northwest of Tres Zapotes in Veracruz) and Panuco (a Huasteca community further north on the Gulf Coast) put the wheel to use in children's toys.[100]



An example of one of the distinctive wheeled toys made in Mexico during the Classic Era, ca. 600 - 900 A.D. This one was formed in pottery, with working wheels, by the skilled artists of central Veracruz on the Gulf coast. Such wheeled toys were also crafted further north on the Gulf coast by the Huasteca at their cultural center of Panuco. These toys are the only known application of the principle of the wheel by American Indians. Drawn after a photograph in Coe, **Mexico.**

Although wheeled vehicles were absent from pre-Contact America, other modes of transport and extensive transportation systems were well-developed by American Indians.

Trails and Road Systems

The American continents were laced with a well-developed system of trails and even hard-surfaced roads in some areas. One of the longest trails ran along the eastern edge of the Rocky Mountains from far north in the Sub-Arctic regions of present-day Alberta to Mexico in the south, well over 3,000 miles.[101] The road system built by the Anasazi people among and outward from their Chaco Canyon complex of villages in the Four Corners area of the United States covers an area nearly equal to that of the nation of Ireland.[102] As adjuncts to this road system were mesa-top smoke and reflected-light signaling stations that could communicate a message over dozens of miles in very little time.

Among the North American Indian trails that later were used by European-American immigrants as roads and highways (some even into our own times) are those now called the Oregon Trail, the Central and Southern Overland Trails, the Cumberland Gap–Wilderness Road, the Natchez Trace, and the Santa Fe Trail.[103]

Describing the extent of the network of trading and traveling routes used by North American Indians, one historian has said

> …because so many modern roads were originally important Indian paths of transportation, one can get a sense of the intricate network of historical Indian trails crisscrossing the continent by looking at current road maps. And one can assume with near certainty, when taking a walk in any part of North America, that native peoples previously walked the same path.[104]

For some further information American Indian road and trail networks, see the information on trade routes in the section on Economics in the Social Sciences Essay. However, two of the technically remarkable road systems developed by American Indians are discussed in some detail below.

Inca Roads and Bridges

From the center of Cuzco, the capitol of the Inca Tawantinsuyu (literally, the ‘Four Corners’ or what European-Americans often call the ‘Inca Empire’), four remarkable roads radiated from the symbolic square called the Haucaypata, now known as the Plaza de Armas. These major roads of the Tawantinsuyu, were hard paved with fitted stone surfaces. They ran northwest to Ecuador (the Capac Ñan or 'Royal Road'), southeast to Bolivia (the Collasuyo Road), southwest to the coast and Chile (the Contisuyo Road) and to the northeast over the Andes linking with the trading routes of the Amazon Basin (the Antisuyo Road).[105]

These roads thus formed the semicardinal axes of a great Medicine Wheel. This arrangement showed that the Inca thought of Cuzco as an especially sacred place. Cuzco was the social, intellectual and spiritual center of their world and was among the greatest of their huacas or sacred beings. To the Inca, Cuzco was something more than just a capitol city.[106]

Parallel to the main northwest-southeast axis of the Inca highland roads, a western coastal road was also built. It was interconnected to the highland arterial by lateral roads through the major valleys. These two main parallel roads each ran for approximately 2,250 miles.[107] The total known length of the Incan road system is about 14,000 miles.[108]

In the mountainous regions, the Inca engineers cut road tunnels through granite prominences to avoid dangerously steep slopes.[109] To span major gorges, they built suspension bridges of ropes, some with up to 22,000 feet of handmade rope. They used the same basic construction techniques utilized in making modern steel suspension bridges. They also built solid bridges with stone piers and wooden decking to cross narrower gorges or built pulley-operated gondola bridges.[110] Inca engineers raised their roads over marshes or flood-prone areas on causeways that were built with culverts to pass water under the roads without undermining them.[111]

All along the network of roads there were garrisons, lookout posts, stations for the system of chasqui runners (official carriers of messages and royal delicacies), toll booths at the bridges, and huaca shrines at all spiritually important points. Taken as a system, the construction, maintenance and administration of the Inca roads must be considered one of the great feats of human engineering in the pre-industrial era, especially considering the incredibly demanding terrain of the Andean highlands.

Mayan Roads

While not as extensive or spectacular a system as the Inca roads, those of the Maya in the Yucatán are of considerable technical interest in a historical sense. This is because the Maya mastered and extensively used the relatively advanced technique of concrete surfacing for many of the major roads connecting important cities and ceremonial centers in the Yucatán. As is mentioned in the Art Essay, the Mayan engineers and architects also eventually learned how to use concrete as a building construction material.[112] They prepared their concrete according to procedures still used today, using crushed, powdered limestone mixed with gravel and sand fill and water.

Notable examples of their concrete roads are still found in a network centered on the Classic-era Yucatán center of Coba, established around 623 A.D. The Mayan road builders created their sacbeob (‘artificial roads’) from the center to outlying sites and villages by raising rubble-filled causeways from 2 to 8 feet above the surrounding ground, covering the sides with dressed stone blocks and the tops with their limestone cement. Widths at the road surface average about 15 feet and range from 12 to 32 feet.[113] Evidence shows that the sacbeob were planned and surveyed, running straight between cities for distances from less than one mile to as much as 62.3 miles, deviating in their course where necessary to connect to outlying towns and other sites. On one of these roads, archaeologists found a five-ton cylindrical stone road roller, used for packing the roadbed prior to paving, much as is still done in building concrete roads today.[114]

Land Transport Technology

In the northern parts of North America, where climatic conditions keep snow on the trails for long periods each year, American Indians invented a number of unique forms of aids to winter travel. Snowshoes are the best known and most distinctive of these Indian inventions, but several forms of toboggans and sledges (some pulled by dog teams) also originated among the Indians and Inuit of the north. These devices played important roles in Inuit and Sub-Arctic Indian trade and travel and also served in the international era of polar exploration in the 19th and 20th centuries. Snowshoes, toboggans and sledges are still in use today for their traditional purposes and have been adopted by non-natives for economic and recreational uses as well.

The dog- or horse-drawn travois frame for transporting heavy loads has already been mentioned above in connection with American Indian adaptations of horse culture.

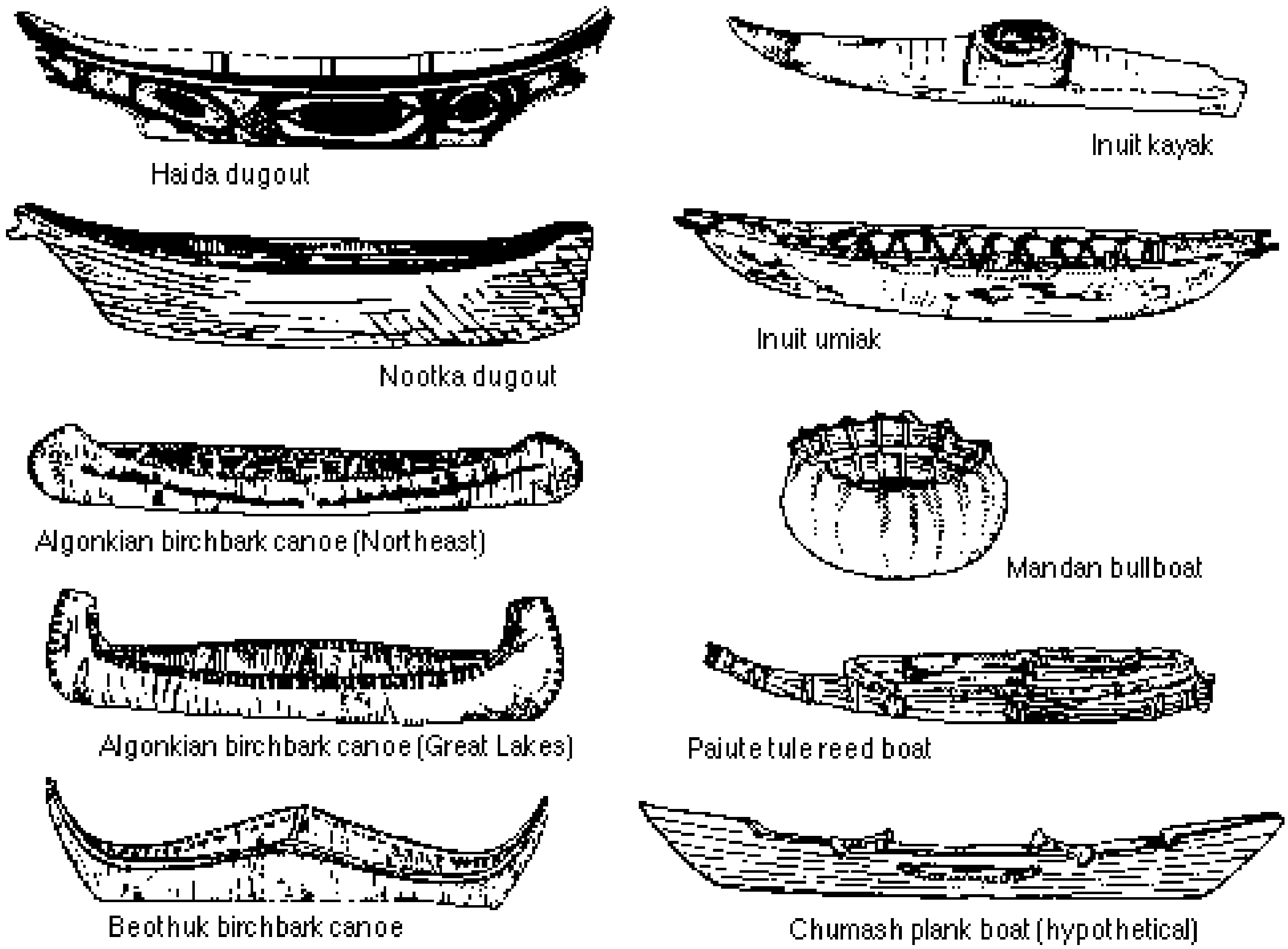
Two other American Indian contributions to land transportation should be mentioned here. These take the highly personal form of footwear. Both have had lasting (sorry about the pun) influence on the design of modern footwear. The moccasin used by American Indians in much of North America set a pattern for comfortably shaped, lightweight, flexible, and breathable uppers that has come to dominate the international market for shoes. The South American Indian rubber soled shoe, mentioned elsewhere in this Essay, similarly inspired a radical transformation of the materials and techniques of shoe sole making. The combination of these ideas and their elaboration by modern shoemakers has resulted in one of the most popular forms of footwear in the world today, the sneaker and its more expensive brother, the athletic shoe. Even more directly related is the modern boating shoe, which often explicitly takes on the form of a rubber-soled moccasin.

American Indian Navigation and Vessels

Coastal, riparian and lake-dwelling tribes on both American continents created a variety of types of boats. Some types are illustrated in the drawing on the following page. The ocean-going vessels were principally large log dugout canoes in many styles, but others included such ingenious vessels as the plank-hulled boats of the Chumash in California as well as the skin-covered kayaks and umiaks of the Inuit and their relatives, the Aleut.[115]

Inland waters were home to smaller, shallow-draft dugouts and several other kinds of boats as well. Bark-covered canoes were popular in the Northeast for their light weight and easy portability between lakes and rivers. Hide-covered, round-bottomed 'bullboats' were favored on the Missouri River. Most of these craft were driven by single-bladed paddles. In the lakes and marshes of places as distant from one another as California and highland Peru, a number of tribes built canoe-shaped craft of dried reeds lashed together and usually propelled by poling.

The Northeastern Woodlands birchbark canoe and the Inuit kayak, recreated in modern materials, have become immensely popular as models for contemporary recreational and sporting vessels around the world. Naval architects who create modern sailing yachts also frequently employ the forms of canoe bodies and especially the rounded 'canoe stern' in their contemporary designs, a tribute to the efficiency and sea-kindly manners of these American Indian designs.



Several varieties of North American Indian vessels, as drawn by Molly Braun in Waldman, **Atlas of the North American Indian.**

We have learned from studies of trade artifacts that there were extensive networks of coastal and trans-Caribbean trade carried out by the Arawak, Carib and the Putun Maya in large dugout canoes with as many as 25 paddlers.[116] These sealanes extended throughout the Greater and Lesser Antilles islands of the Caribbean and touched the coasts of northern South America and the southeastern United States.

The Putun Maya, in particular, were very active sea traders in the 9th and 10th centuries along the coasts of the Yucatán and what are now the Mexican states of Tabasco, Campeche and Veracruz.[117] From their center on Cozumel Island, the Putun Maya combined militarism, mass production and marketing techniques with their skill as mariners to become immensely influential in the power vacuum that resulted following the fall of the major Maya and Toltec centers in the period between 900 - 1156 A.D.[118] They are known to have established themselves in the Valley of Mexico and in the highland Maya regions. The Putun Maya are thought to have carried Toltec cultural elements (and perhaps some of the Toltec survivors, possibly including the exiled leader Quetzalcóatl Topiltzin himself) into the Maya homeland.[119]

On the western coast of South America and probably extending up to the shores of Mesoamerica, Ecuadorian traders carried on a similar linking function between the economies and cultures of the two regions. Some traits thought to be of Olmec origin appear on the northern coast of Peru as early as 1500-700 B.C., although it is not certain that they arrived by boat-borne coastal trade.[120]

Between 500 B.C. and 500 A.D., a culture known as the Bahía appeared on the Ecuadorian coast. They possessed considerable mastery of water craft and offshore travel, to judge from cultural remains found on islands 25 miles off the coast and along the coast as far as southern Peru. There is also evidence from pottery and masks that the Bahía culture had established extensive maritime contacts with Mexico, apparently by direct sailing in the open ocean and not through coastal voyaging.[121]

It is thought that later water-borne contacts from Ecuador introduced metallurgy skills into Mesoamerica through the Zapotec homeland of Oaxaca, probably around 800-900 A.D. [122] We know little about the craft used by the Ecuadorian navigators; the Mochica culture to the south is known to have used reed boats by around 200 A.D.[123]

On the southern California coast, the Chumash built a type of boat that was exceptional by American Indian norms. Formed of planks that were drilled to accept lashings of sinew or plant fibers, these boats were waterproofed by a coating of naturally-occurring asphalt. These vessels were capable of voyages between the mainland and the Chumash settlements on three of the Santa Barbara Channel Islands lying 25 miles and more off the coast.[124]

Further north, several styles of dugout canoes were carved by craftsmen on the Pacific coast from northern California to Alaska. It is recorded that some of these craft reached 60 feet in length.[125] Their craftsmanship was of a remarkably high standard. Hilary Stewart quotes the diary of Rev. Charles Moser, a missionary in the Haida country during the early 20th century, as saying:

> All the work is done without instruments to go by or measure; yet most of these Indian canoes are so true and so well shaped and proportioned that not even an expert could detect the least flaw or imperfection.[126]

Variations in the uses, styles and sizes favored by the tribes which produce them make most of these Northwest canoes distinctive. Some are small, relatively flat, 'shovel nosed' river canoes. Others are high-prowed, large, whaling canoes for use on the open seas. Others, with substantial beam and freeboard, were freighters; one example is known to have a displacement capacity of 5 tons.[127] Some of the variations and techniques of Northwest coast canoe manufacture are illustrated in Hilary Stewart's outstanding volume **Cedar**. Interested readers are strongly urged to consult this beautiful and informative work.

The Aleut of Alaska and their relatives, the Inuit of the circumpolar regions of Canada, Greenland, Alaska and Siberia, built extremely seaworthy vessels from waterproofed hides of marine mammals stitched tightly over bent and lashed driftwood frames. The decked and sealed kayak design was generally used by a single hunter, who would hunt seals and sea otter from the small vessel. The design enabled the craft to withstand an inadvertent or deliberate capsize (the so-called 'Eskimo roll') and right itself with the aid of the paddler's double-ended paddle. The larger, open umiak design was used to move a family from place to place, to hunt whales, or to engage in long distance freight trading – Inuit from Alaska regularly paddled umiaks across the Bering Sea to attend the great trade fairs of their Siberian relatives.[128]

In the Northeastern woodlands of what became the United States and Canada, American Indians formed extremely lightweight canoes out of birchbark. This thin, water-resistant material could be peeled from the trees in wide strips. These panels of bark were sewn to lashed wooden frames in a variety of shapes including the oft-depicted high-prowed, double-ender form. Overlapping ends of panels and stitch holes for the lashings were often sealed with a glue made of tree resins. The Beothuk people of Newfoundland and the neighboring coasts near the Gulf of St. Lawrence used birchbark canoes of a more seaworthy design to cross their more exposed Atlantic coastal waters (see illustrations above).

While somewhat prone to puncture damage, these Northeastern Woodlands canoes served well on the numerous portages between the rivers and lakes of the region. Together, these made up a great waterway network that supported an equally extensive trade network. The canoes could be readily repaired from the widely-available birch trees, so the light weight of this material more than offset its fragility.

The trade networks made possible by these canoes, as well as the Indians' knowledge of the routes, were later of inestimable value to the early European fur traders and explorers in the Northeast. The French particularly adopted the Indian techniques of travel quickly, although not without trepidation as the historian James Axtell has reported.[129]

Finally, Indians on the rivers of the Great Plains made occasional use of skin-covered bullboats (of a circular design similar to Welsh and Irish coracles) as a means to cross rivers too deep and broad to swim.[130]

Urban Design

In a statement on the urban component of contemporary Latin American culture, Michael Olien once offered the observation that urban development there “predates much of the urban development in Europe”.[131] This comment was probably not intended to overlook the European urbanization of classical times, which occurred at about the same time as the rise of urban centers in the Western Hemisphere. Rather, Olien noted a break in the development of the older centers and the long delay in creation of new urban centers throughout most of Europe during the several centuries following the collapse of the Roman Empire in the European west.

Only a very few cities in Europe had a population near or greater than 50,000 at the time of Contact with the Americas. About 10% of the European population is thought to have lived in the larger cities then. The cities and countryside were just beginning to rebound from the demographic decline that the ‘Little Ice Age’ and plagues of the 14th century had forced upon Europe.[132]

One result of this long hiatus in European urbanization was that the Spanish (who were among the most urban of European peoples in the 9th through 18th centuries[133]) were astonished at their first encounters with the major cities of Mesoamerica. As testimony, consider the words of the soldier/diarist Bernal Díaz del Castillo, who marched with Cortés into Tenochtitlan on the eighth of November 1519. Tenochtitlan, with its twin city of Tlatelolco, was the Aztec capitol and one of the newest of American Indian cities at that time. Díaz recorded the Spaniards’ reaction to the sight of such an urban setting:

> During the morning, we arrived at a broad causeway and continued our march towards Iztapalapa, and when we saw so many cities and villages built in the water and other great towns on dry land and that straight and

> level Causeway going towards Mexico, we were amazed and said that it was like the enchantments they tell of in the legend of Amadis, on account of the great towers and cues and buildings rising from the water, and all built of masonry. And some of our soldiers asked whether the things that we saw were not a dream.[134]

Yale archaeologist Michael Coe, in describing what the Aztec capitol was like in 1519, noted that the Spanish conquistadors who had been to Venice compared Tenochtitlan to that Italian city, each with a mixture of canals and streets to carry the traffic of a great urban center. At that time, Tenochtitlan encompassed 20 square miles and boasted a population estimated between 200,000 and 300,000 people, making it five times the size of contemporary London and one of the largest cities in the world.[135] When the first true American city, Teotihuacan, was at its peak of development one thousand years earlier, it was larger than contemporary imperial Rome.[136]

How was Tenochtitlan built? The Mexica (later known as 'Aztec') completed their migration into the Valley of Mexico in the early 14th century. They were granted the right to live on a pair of marshy islands by their local sponsor and overlord, Tezozomoc of the Tepanec kingdom of Atzacapotzalco, the most powerful state in the Valley at that time. The spot had been pointed out to the Aztec by their god Huitzilopochtli. They began their settlement by employing two techniques of urban development worked out by the creators of the city of Teotihuacan fourteen centuries earlier.

The first of these was the chinampas technique. The Aztec dredged lake-bottom mud and mixed it with reeds cut from the surrounding marshes. This mixture was used as landfill. The two small islands were rapidly expanded and anchored with willows planted around the peripheries. New, artificial islands could also be created by this technique in the shallows of the lake margins. Several soon were, with canals left between islands for access by canoes.

At first, the chinampas were used for agriculture to support the Aztec economy. As their acreage expanded and the Aztec also began to solve the political problems of living among more powerful neighbors who controlled access to wood and stone, they began to bring these more durable materials to their settlement. Hauled overland and barged on canoes, stone and wood came to serve as the foundations of their apartments, temples and pyramids.[137] This process greatly accelerated as the Aztec began independent military subjugation of their neighbors after 1428.

The second urban design technique borrowed by the Aztec from the heritage of Teotihuacan and the later Toltec capitol of Tula was the laying out of their twin cities of Tenochtitlan and Tlatelolco on a rectangular grid pattern. According to Dr. Coe, the Teotihuacanos were the first people in the Western Hemisphere known to have used this technique, employing it as early as 50 A.D. They gave a regular alignment of the grid to 15° 25´ east of true north, which Coe takes as evidence that the planners also possessed sophistication in surveying techniques.[138] The planners of the Aztec capitol followed this principle of grid design, adapted to a transportation network that mixed canals and streets, as has already been noted.

The first Spanish witnesses were amazed by Tenochtitlan partly because they came from a nation that had no large cities that evidenced such mastery of regularized design, as Michael Olien notes:

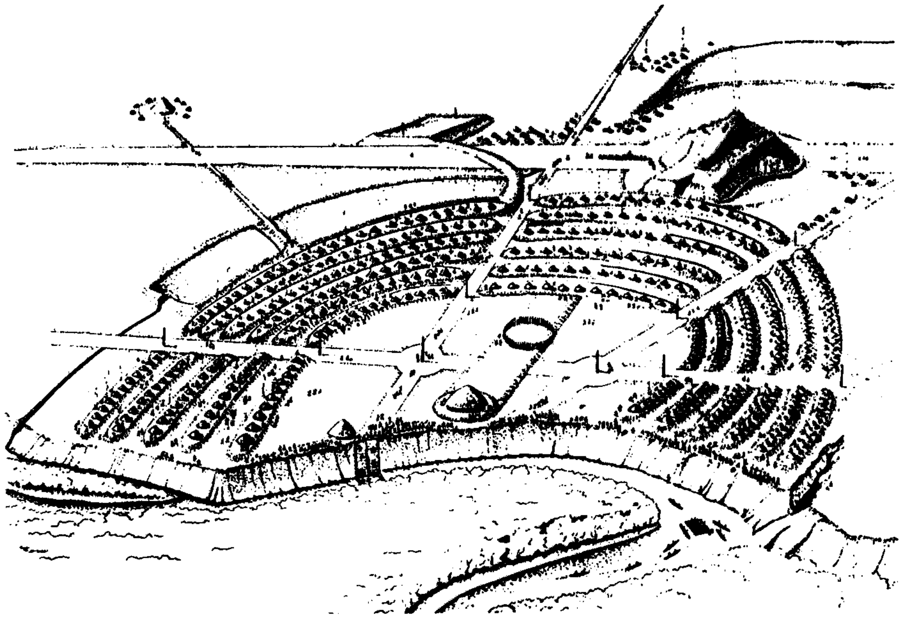
> The idea that a town should be established according to a preconceived plan was, therefore, foreign to the Spanish. Houses, streets, and alleys were built in a haphazard fashion in the fifteenth century Spanish community. The first New World Spanish settlements were established in a similar haphazard manner. In these early settlements on the Caribbean islands, little attention was given to the choice of sites, resources, or community plan.[139]

What the Spanish witnessed in the Western Hemisphere may well have prompted them to recover the urban planning knowledge of European antiquity, particularly that of the Roman architect Vetruvius, whose guidelines for city development became embodied in Spanish royal edicts for colonial building after 1550.[140]

Other American Indian cultures outside of Mesoamerica also made some use of the grid design urban plan and also regular alignments of buildings and temples. Notable examples were some of the Iroquois and Algonkin stockaded villages of the Northeast and some of the towns and ceremonial centers of the several 'mound-builder' Mississippian cultures of the Mississippi Valley and the Southeast. John White, governor of the failed English colony of Roanoke Island off the shore of modern North Carolina, made a well-known drawing of part of the main village of the Secotan people that shows some of these features as they existed in the late 1580s.[141]

Various American Indian cultures also used other regular planning forms in laying out their towns, villages and camps. One interesting example was that of the Archaic Era cultural center in northeast Louisiana now called Poverty Point. Poverty Point was a trade center which flourished between 1400 and 1100 B.C. It was one nucleus of a pre-agricultural civilization that arose in 3000 B.C. and extended its influence from the Gulf Coast to the conjunction of the Mississippi and Arkansas Rivers for two and a half millennia.

This town occupied an area of one square mile and was laid out on six concentric, semicircular mound terraces that became successively higher from the center outward. As illustrated on the following page, it had four avenues which radiated outward through the terraces from two points on either side of a central ceremonial plaza.[142]



Urban Plan of the Archaic Era trade center called Poverty Point in northeastern Louisiana. Homes are located on the six raised, semicircular terraces surrounding the central plaza. A temple mound arises outside the terraces to the right of center. The Mississippi and Arkansas Rivers meet in front of the town.

after an illustration in Kopper, **The Smithsonian Book of North American Indians**.

Another geometrical settlement form, the Medicine Wheel, is most familiar from its use by many tribes of the Great Plains in the horse era and today. Their transportable lodges or tipis are traditionally set up by the women (men may help raise the poles) in a circular form with an opening usually facing east. The circular arrangement has profound spiritual meaning and serves to harmonize the community with the surrounding forces of the cosmos, which are conceived as operating in circles. The gap to the east opens the circle of the people to the illuminating wisdom and physical light which dawns in that direction each day.

The organization of the Inca capitol of Cuzco was analogously divided into a sacred and symbolic Medicine Wheel (Four Quarters of the World) by the intersection of the major highways of the Empire at its central square. These highways, as noted earlier, were approximately oriented to the semicardinal Four Directions. This urban design formed the city of Cuzco as a huaca or spiritual being.[143]

Not always as regular in plan but indicative of some of the ways in which American Indian peoples adapt their communities to their surroundings are the towns of the Pueblo peoples of the American Southwest. Built by six major cultures in a number of distinctive styles over the past millennium, the distinctive ‘apartment house’ blocks of dozens of ruined and active communities are located in southern Utah and Colorado, eastern Arizona, and throughout New Mexico down into the State of Chihuahua in Mexico.

Examples of abandoned pueblos include the spectacular Anasazi sites of Mesa Verde, Colorado and the Chaco Canyon complex in New Mexico. The 800-room Pueblo Bonito is the largest and best known of the Chaco Canyon pueblos, but there are ten other major towns and an undetermined number of outliers in the Canyon.

Living communities of the modern Pueblo peoples who descended from the earlier Hohokam, Sinagua, Mogollon, Salado, and Anasazi cultures include the Hopi and Tewa towns on three prominences of Black Mesa in Arizona. Oraibi is the oldest continuously inhabited community in the United States; other Hopi and Tewa pueblos on Black Mesa are Shipaulovi, Shungopavi, Mishongnovi, Hano, Sichomovi, Walpi, Hotevilla, and Bakabi. There is the beautiful pueblo of Acoma – sometimes called ‘Sky City’ – and that of Zuni, both in New Mexico. The Tewa communities of the upper Rio Grande valley in New Mexico include the well-known San Ildefonso, Santa Clara, and San Juan Pueblos. There are other pueblos, ruined and living, too numerous to exhaustively list here.[144]

Each pueblo reveals something of the insights and techniques used by its founding people to create a distinctively appropriate human habitation in each particular locale.

Sun exposure, wind directions, water availability, thermal control, access and means of defense – the unique considerations and solutions found at each place can be discerned by thoughtful minds. Even good quality photographs or maps of the sites which appear in many sources can suggest much of how and why each came to have its distinctive character. The architecture and town plans of the pueblo communities are worthy of study and reflection for anyone interested understanding some traditional American Indian solutions for effective urban development.

MINING SCIENCE AND TECHNOLOGY

American Indians made use of a wide range of minerals for tools, building materials, and pigments. There were some cultures that made little use of stone, developing horn or bone implements instead, particularly in the earliest times about which we have any knowledge. However, it is generally true that most Indian cultures were fully expert in lithic (stone) technology. This technology included pebble and cobble tool making, surface mining and quarrying skills and, in certain parts of the Americas, metal mining knowledge.

In some places, American Indians also practiced the surface collection of petroleum for various uses. Jack Weatherford and other authors have recorded the contribution of American Indians to establishing uses for asphalt and other petroleum products. Their oil pits in Pennsylvania became the birthplace of the modern American oil industry.[145] There and elsewhere, surface seeps of petroleum were developed and exploited for medicinal purposes. In Pennsylvania alone, over 2,000 oil pits were dug by various tribes to promote the collection of petroleum.[146]

American Indians developed petroleum jelly from these sources by combining olefin-bearing hydrocarbons with methane (natural gas) to make a salve for treating burns and open wounds. After obtaining metal tools in trade from Europeans, some tribes used petroleum jelly as a lubricant and preservative, in contrast to the less effective animal fats employed as a grease by the Europeans.[147] As noted above in the section on Navigation and Vessels, the Chumash in California also developed the use of asphalt (the heaviest fraction of petroleum) as a waterproofing material for their plank-hulled boats. It is thought that some of this asphalt came from the famous tar pits at LaBrea ans well as from seeps near Santa Barbara.

Stone quarrying for building materials was practiced chiefly in Mexico and in the urban regions of South America. Basalts appear to have been the most commonly quarried building stone, to judge from the remaining Indian buildings and the materials salvaged from them by the Spanish to build colonial-era structures. These basalt building stones, sometimes of several tons each, were split by use of stone and wood wedges, drills and hammers, then shaped and dressed by hammering, pecking and grinding with other stone tools. In the north, some quarrying of stones used for art and ceremonial purposes (for example, catlinite for pipe bowls, and soapstone for pipes, lamps and small carvings) took place at the few locations where these relatively soft minerals could be reached by surface mining techniques.

In Mexico and the mountainous regions of South America were the primary American Indian cultures that developed metal mining skills. They principally mined for the copper and tin ores used to make bronze for tools and ornaments. It is thought that they and the copper-using cultures of Alaska and the upper Midwest obtained most of their ores by working stream (‘placer’) deposits. Laborious cutting into surface veins of ore in hard rock was usually resorted to only if placer deposits were inadequate or unavailable. Most gold, in the places where it was gathered by Indians at all, was obtained similarly.

After the Conquest, South American Indians contributed their metallurgical knowledge to the world by demonstrating their smelting technology, which worked at high elevations where the imported Spanish technology did not. These Indian master metalworkers and miners also soon improved the European mercury amalgamation technique so as to raise the efficiency of extracting silver from ore.

Indian mining technicians and metalworkers further improved imported European machine technology beyond its original level by developing ore-crushing machines and automated coin-minting machines that were an advance over those used in Europe. The interaction of Indian and European miners during the era of forced labor resulted in a great development of mining technology. This synthetic knowledge base was the precursor to later metallurgical developments in the modern industrial era.[148]

MEDICAL SCIENCE AND TECHNOLOGY

The contribution of American Indian peoples to medical practice has been particularly extensive in the field of pharmacology. Many Indian cultures' distinctive, holistic world views and unique experience and relations with the plants, minerals, animals, and spiritual powers of their respective environments provided the foundations for these contributions.

Guided by a holistic worldview, American Indian healers have united their understanding of many facets of human psychology, physiology, pharmacology, biochemistry, nutrition, surgery, and religion into a cohesive, interrelated, organic system of knowledge about life and its processes. Much of this medical knowledge is based upon generations of empirical research, one of the foundations of science. Some of the results of this painstaking 'trial-and-error' effort by American Indian healers led to medical treatments of lasting, proven efficacy.

However, the theoretical explanations of this system generally do not resemble those of modern European-American scientific medicine. In many respects, the traditional Indian systems of medical theory were just as predominantly religious and pre-scientific as were most European medical theories at the time of Contact and for the following two or three centuries.[149]

On balance, available evidence suggests that at the time of Contact, some of the American Indian cultures had developed a superior knowledge of effective drug remedies and had made a few advances in surgical and psychotherapeutic techniques while having no particular advantage in scientific medical theory as compared to other cultures in the world of the late 15th century.

One well-known example of holistic American Indian systems of knowledge is the integration of botanical, religious, psychological and medical thinking that is involved in traditional American Indian usage of tobacco.[150] The ceremonially-controlled use of this potentially addictive plant emphasized its beneficial aspects as a facilitator of conversation and negotiation. In important public matters, tobacco served as a guarantor of truth. This derived from its function as a messenger between humans and the spirit world. Tobacco was also valued for medical uses as a mild sedative, as an emetic, and for its germicidal properties. (This latter does not imply that American Indian doctors had a developed germ theory of disease, but merely indicates that they understood that the juice of the plant would forestall or treat infections in open wounds.)

Tobacco's deleterious effects were generally kept in check by the customs controlling the manner and occasions on which it was smoked,. It was not regarded by American Indians as a health problem so long as it was not indulged in continually or to excess. So cohesive was the Indian system of social, spiritual and medical conventions concerning the use of tobacco that much of this knowledge passed intact into Europe during the early years of tobacco's entry into the customs, folklore, and commerce of the Eastern Hemisphere.[151] Many Indians view it as regrettable that modern commercialization of tobacco around the world has made this plant into a major health problem.

During the historical period of Contact between American Indian and non-Indian cultures, Indian doctors who understood the native plant medicines and who had much experience treating disabling physical injuries repeatedly demonstrated their skills to the immigrants. While scorned by numerous colonial writers, the Indian doctors and healers often proved themselves to the European newcomers as effective practitioners, frequently better than the few doctors who came over from Europe. Virgil Vogel devotes an entire chapter of his book **American Indian Medicine** to documenting the “Services of Indian Doctors to Whites.”

Most early communities of European-American immigrants lacked trained physicians and pharmacists of their own. For example, of the 26 Harvard College graduates known to have practiced medicine in New England before 1700, only two had medical degrees.[152] Until western-trained doctors became more numerous, American Indian medical practitioners were often the only specialists available for a time to immigrants in many frontier communities. This situation persisted from the 17th through the early 20th centuries. This remained true of many rural communities in areas long since passed by the frontier.

A number of examples of the work of the Indian doctors among the immigrants have been recorded. One early 20th century physician stated that “in frontier medicine much, one may even say most, of the settlers’ knowledge in regard to the treatment of traumata has been bodily copied from the Indians.”[153] The following men and women are among the American Indian doctors whom Vogel documents to illustrate the geographic and temporal range of Indian medical practice among the immigrants:

- Dr. John Lederer, a German surgeon, reported to the Governor of Connecticut in

1674 an "Old Indian Doctor" who used red oak bark (active principle, tannic acid) to cure several stubborn, long-standing cases of eye inflammation.[154]

- Joe Pye, an early 19th century Indian doctor from an unidentified New England tribe, was documented in his use of roots of *Eupatorium purpureum* to treat typhus among European-Americans. His revelation has been memorialized in one of the common names for this plant (Joe Pye or Jopi weed) known also as gravel root or purple boneset. Joe Pye weed became a part of the official **U.S. Pharmacopoeia** during the first 22 years of its publication.[155]
- Baptiste, a Dakota (probably Santee) shaman, served as doctor to both the Indian and white communities on the Winnebago agency in Minnesota during the 1850s. After his own people were removed further west in the 1860s, the U.S. government built him a house at the Winnebago agency site and paid for his services to the remaining Winnebago and the European-Americans, government employees and civilians alike.[156]
- Tom Morrison was a late 19th century Catawba healer who served both Indians and non-Indians in his community (unidentified in Vogel's book, but probably in North Carolina).[157]
- Finally, an unnamed Canadian Indian woman doctor received mention in *The Lancet*, the eminent British medical journal, for her services to an injured Scottish railroad worker in the early 20th century. The Scot had reinjured his hand, never properly healed after an old wound. Unable to reach a white doctor before blood poisoning had swelled his arm and caused unendurable pain, he asked for help at an Indian camp on the Great Plains in Manitoba. The Indian doctor, assisted by several other women, used heat from a fire to raise the young man's temperature, sang songs of power, gave massage and applied a leaf poultice to the injured spot on the hand, then put the patient to bed for 18 hours. The result

was a complete relief of the pain and swelling in the arm, and the Scot was able to continue on his way to a white doctor for treatment of the hand injury that started the problem. The *Lancet* report indicated that the latter physician told the railroad worker that he would have lost the entire arm were it not for the Indian doctor's effective treatment of the blood poisoning.[158]

American Indian Pharmacology

A few grade-school textbooks explicitly acknowledge one example of American Indian medical knowledge in reporting the story of the assistance given by the Huron sachem (elected clan or village leader) Donnaconna (sometimes given as 'Donacona') to the French explorer Jacques Cartier. Over the winter of 1535-36, Cartier's three ships were frozen into the St. Lawrence River near the Huron town of Hochelaga (modern Montreal). His men became seriously ill from scurvy, a Vitamin C deficiency disease, as a result of living solely on ships' stores. Some 25 sailors died by March 1536.

Donnaconna, who had met Cartier the previous year, had once suffered from a bout of scurvy himself and knew of a traditional Huron cure which he shared with the French. The bark and leaves of the white pine were gathered, put into water and simmered down into a poultice which was applied to the open sores on the sailors' legs. The sap of the white pine contains Vitamin C and is thus a preventative and treatment for scurvy. The Huron treatment (and the Portuguese alternative of citrus fruits) became common knowledge among European seafarers only in the 1750s, after the British naval surgeon James Lind did research into Donnaconna's cure for Cartier's nutritional problem.

How important was the contribution of Indian medical knowledge to that branch of science? The anthropologist Jack Weatherford has characterized the contribution of American Indian doctors to the world's knowledge of pharmaceutically valuable plants and compounds in these words:

> From the very first contacts between the Old and the New World, European doctors recognized that the Indians held the key to the world's most sophisticated pharmacy. Medicine in most of the world at that time had not yet risen far above witchcraft and alchemy. In Europe, physicians talked about the balance of body humors as they attached living leeches to the patient in order to suck out the "bad blood". Moslem doctors burned their patients with hot charcoals, and physicians in the Orient prescribed elaborate potions of dragon bones mixed with all types of flavorings.
>
> By contrast the Indians of America had refined a complex set of active drugs that produced physiological and not merely psychological effects in the patient. This cornucopia of new pharmaceutical agents became the basis for modern medicine and pharmacology.[159]

Clark Wissler, the noted anthropological curator at the American Museum of Natural History in the first half of the 20th century, affirms that European-Americans early on recognized the depth of Indian medical knowledge. Wissler wrote in his volume **Indians of the United States:**

> Their doctors were keen to find new medicines and so continually scoured the forest for strange plants. The whites held the Indian root doctors in great esteem, often calling upon them for aid, so that even now our folk medicine is rich in Indian recipes.[160]

Weatherford, Wissler and other modern authors and scholars (including Harold Driver, N.G. Tretchikoff and his student Alma Hutchens, G. Reichel Dolmatoff, Erna Gunther, Ralph Roys and Virgil Vogel) have documented many pharmacological discoveries and practices among various American Indian groups. So too did earlier generations of explorers, botanists, doctors, and naturalists, notable among them the anthropologists Franz Boas, Frances Densmore, and James Mooney.

A brief listing of a few of the important American Indian pharmaceutical plants drawn from among these sources and the author's own experience is presented as Appendix B to this Essay. Virgil Vogel's book **American Indian Medicine** offers 147 pages of an alphabetical appendix devoted to North and South American Indian pharmaceutical plants along with 57 pages of bibliographic references he used in compiling the appendix. His extensive compilation is an excellent resource for teachers and older students to use when beginning to study about American Indian medicinal plants.

It is well to remember, however, that a holistic understanding of these plants and much else is needed for anyone to practice in the traditions of American Indian medicine. Traditional Indian doctors insist on training new healers through a long formal apprenticeship. In the course of such training a neophyte can establish the proper and necessary relationships to the plants, the Earth and the spiritual powers of self and the world before being sanctioned to practice as an Indian doctor. To do it any other way, say the elders, invites disaster.

Dr. Vogel notes that some 220 American Indian plant medicines have been listed at one time or another in the two official pharmaceutical handbooks sanctioned by the United States government, the **Pharmacopoeia of the United States** (usually referred to by the acronym USP or as the **U.S. Pharmacopoeia**) and the **National Formulary**.[161] The former began decennial publication in 1820, while the latter was first issued in 1888.[162] The value and effectiveness of the traditional American Indian plant medicines is attested to by the fact that many of them, or their refined derivatives, have remained in the official lists in the second half of the 20th century.

Among the foremost American Indian pharmaceuticals still in use are the salicylate compounds in willow bark and in the bark of some poplars. In refined and synthetic forms, the modern versions of these ancient Indian medicines include aspirin, one of the leading anti-inflammatory agents and a drug prized by many for its ability to reduce headaches, fevers, body pains and arthritic inflammation.

Another of today's valued Indian medicines is one found in the western U.S., the potent yet gentle natural laxative Indians identified in cascara bark.[163] This ingredient was once used in a majority of 20th century commercial laxatives.

South American Indian pharmaceuticals that are prized today include several important drugs. The first effective drug against the debilitating and often fatal disease malaria was the Indian extract of chinchona bark known as quinine. A South American Indian pharmaceutical used by surgeons today in a variety of abdominal operations is the potent (and dangerous, when used improperly) muscle relaxant curare. Curare has also shown value in some treatments for convulsive disorders, Parkinson's disease and certain kinds of psychotherapy.[164]

It is believed that the Indian medical practitioners of the Andes also knew of the anesthetic properties of coca leaves (which contain cocaine and some 20 other alkaloids) and used this knowledge in their skull surgery.[165] A number of derivatives or synthetic substitutes such as lidocaine and procaine (known also as Novocaine™) are widely used as anesthetics in modern medical practice.

Another example of important South American Indian drugs, ipecacuanha root yields a powerful stimulant to provoke vomiting in cases of accidental poisoning. Sold throughout the world as syrup of ipecac, it and related plant and synthetic variations have saved the lives of thousands of children and others who have inadvertently swallowed dangerous chemicals.[166] Other pharmaceuticals from South America are expected as doctors, chemists and biologists learn more from the practices of South American Indian doctors. Molecular pharmacologist John Daly of the National Institutes of Health has recently worked on medical uses of a range of alkaloid compounds found in the skins of dendrobatid frogs, the 'poison arrow' frogs of Central America and South

America long used by American Indians for hunting, medicine and shamanism.[167]

Virgil Vogel remarks that several varieties of modern soft drinks formerly or still use for flavorings American Indian roots, barks and fruits from medicinal plants long prized by various Indian cultures for their healthful properties.[168]

Sassafras bark, used in many root beers, is a noted agent for thinning blood, preventing clotting and relieving congestion and fevers. Indian doctors in the eastern U.S. and Canada often used its powers to assist women having difficulty in menstruation.[169] Dr. Vogel noted these and other medical uses of parts of the sassafras tree among the Iroquois and the Leni-Lenape (‘Delaware’) of the Northeast, the Quapaw, Osage and Caddo of Arkansas, the Houma and Choctaw of Louisiana and Mississippi, the Muskogean Creek of Georgia and Alabama, and the Seminole of Georgia and Florida.[170]

The Choctaw in Louisiana also developed a powdered form of sassafras bark called gumbo filet and later taught its use to the French Canadian ‘Cajun’ immigrants for seasoning in their now-famous gumbo soups.[171] Sassafras was one of the first North American medicinal plants to be exported in quantity to the Eastern Hemisphere. In 1618, sassafras bark rivaled tobacco in economic importance to the struggling colony of Virginia.[172]

Wintergreen and birch oils have also been used in some root beers. Birch beer is still being brewed in the upper Midwest as a specialty soft drink. Wintergreen oil contains methyl salicylate, an aspirin relative, as its active ingredient.[173] This accounts for its use by Indian healers and its adoption by colonial and frontier doctors. Ginger root of several species is another well-liked soft drink (ginger ale) and cooking flavoring that was originally used by Indian doctors in Canada, the U.S. and much of the Caribbean for relieving gastrointestinal cramps, fevers and easing difficult childbirth.[174]

Various species of *Capsicum*, the genus of chili pepper pod plants found from the southeastern U.S. through Mesoamerica and much of lowland South America, have been used to flavor such popular soft drinks as Dr. Pepper™ and Pepsi-Cola™.[175] These fruits are more familiar in the U.S. today as flavorings in 'hot sauces' and much of Latino and Asian cooking. In fact, their use in cuisines of the spicier kind has spread around the world.[176] A part of this popularity of *Capsicum* in cooking is due to its medicinal effects, which include a pronounced but temporary improvement of blood circulation and the ability to promote vigorous corrective muscular action in sluggish or gassy digestive systems. (Please pardon the euphemistic language, but you get the idea.)

The hundreds of recognized American Indian botanical medicines have not exhausted what particular Indian cultures know and might one day share. As an illustration of the remaining potential of American Indian medical knowledge, consider a recent television news report. In October 1989, a pair of researchers from Washington University revealed that Jívaro tribespeople in the northwestern part of the Amazon rain forest had recently taught them about making an extract from the bark of a species of palm tree growing there.

When tested in the laboratory, the researchers found that the extract proved over 98% effective in inhibiting replication and growth *in vitro* of the virus that causes one of the four types of hepatitis. There is no known cure for this dangerous, sometimes fatal disease. However, the knowledge of plant medicines held by contemporary Jívaro doctors has given the world the possibility of an effective treatment of hepatitis for the first time.

This recent contribution of American Indian pharmaceutical knowledge illustrates the importance to humanity of preserving both an intact environment and the knowledge held by traditional peoples who are most intimately familiar with their surroundings. The current risk of losing this potential forever is made clear below. Much has already been lost, as was explained as long ago as 1848 to Henry David Thoreau by a Penobscot doctor who guided Thoreau on a trip through the Maine woods.[177]

The news report on NBC television that announced the palm bark gift also noted that the Amazonian rain forest is losing an area equal to that of Great Britain every year. The Christian Science *World Monitor* edition of December 1989 reported that the Amazon rain forest lost 120,000 square kilometers (46,320 square miles) of its area in 1988 alone.[178] Rudy Haugeneder reported in 1989 that 25% of the 6.5 million square kilometers of Brazilian rain forest has already been destroyed through burning and clear cutting. Dr. David Suzuki, the internationally-known Canadian environmentalist, has been quoted as saying that the Amazonian rain forest will be totally destroyed within 30 years at the current rate of deforestation.

In a program broadcast on the CBC in 1989, Dr. Suzuki also noted that the Indian population of the Amazon Basin has declined from an estimated 5 million in 1500 A.D. to a current level of about 200,000.[179] W. Richard Comstock has published the fact that over 90 tribes became extinct in Brazil in the first half of the 20th century alone.[180]

The Jívaro example illustrates the continuing importance of preserving both the diverse, rich American ecosystems and the indigenous people who know what the land provides. Without the interaction of the American land and its native people, such medical benefits as treatments for hepatitis, malaria, or even a headache might never have happened, and may never happen again. The facts offered by the environmental scientists and the anthropologist above for just one part of the Americas suggest the magnitude of loss faced by Indians and non-Indians alike if a responsible relationship to the land and its people is not established soon.

Psychology

Generally speaking, American Indian cultures developed a fairly sophisticated understanding of human desires and emotions, along with such manifestations of the human mind and spirit as dreams and visions. Indian doctors, particularly the spiritual specialists often referred to as shamans, frequently diagnosed and treated psychological and somatic illnesses on the basis of their knowledge about what we now call psychology. Many still do, some even extending their practice into non-Indian institutions.

American Indian psychotherapy generally employs a range of techniques, often in combination or in sequence. The particulars depend on the culture, of course, but the range includes confession, dream analysis, suggestion, hypnotism and self-hypnosis, drug-assisted therapies, community support, some admitted sleight-of-hand performances as well as actions that shamans assert to be purely magical. There is frequent use of sacred paraphernalia, symbols, paints, songs, chants, and drumming or rattling to attract the assistance of the spirit world in the treatment. A few examples of American Indian psychotherapeutic practices are offered below.

James Mooney, an ethnographer employed by the Smithsonian Institution in the late 19th century, found among the Cherokee doctors of his time a general practice of beginning their diagnosis by asking patients about recent dreams. These they analyzed for signs that the illness they were treating might have a psychological basis.[181]

In the Northeastern Woodlands, the Iroquoian cultures believed that unfulfilled desires or dreams that were not acted upon were two of the most powerful causes of bodily (‘somatic’) diseases. In this respect, they preceded the psychoanalytic theory of Sigmund Freud by several centuries. One of the early Jesuit priests who worked among the Iroquois, Father Joseph Jouvency, wrote:

> They believe there are two main causes of disease. One of these is in the mind of the patient himself, which desires something, and will vex the body of the sick man until it possesses the thing required For they think that there are in every man certain inborn desires, often unknown to themselves, upon which the happiness of individuals depends. For the purpose of ascertaining desires and innate appetites of this character, they summon soothsayers, who, as they think, have a divinely imparted power to look into the inmost recesses of the mind.[182]

Father Jean De Brebeuf, with rather less acute understanding, said of the Iroquoian-speaking Huron that dreams were "...the usual Physician in their sicknesses, the Esculapius and Galen of the whole Country..."[183]

The Iroquois and their relatives often had gifted individual members among the practitioners in their medical societies who specialized, at least in part, in what today would be called psychotherapy. The Iroquois were hardly unique in this. The Midewiwin, which is the highest-ranking of the four traditional Ojibwe, Menominee and Winnebago medical societies, includes such practitioners.[184] So, too, did what Dr. Gene Weltfish calls the Doctor Lodge of the Pawnee.[185]

The practitioners of the Navajo curing ceremonials (where the traditional, sacred symbols of the famous sandpaintings are created and destroyed in the course of the treatment) employ a profound knowledge of patient psychology that has won respect form some European-American physicians practicing in the Southwest. Harold Driver mentions the example of Dr. Thomas Noble, an abdominal surgeon who worked among the Navajo and Hopi in the 1940s. According to Driver, Dr. Noble always obtained the sanction and assistance of a tribal medicine man when helping Indian patients, believing

> ...that the patient's chances of recovery were greater if Indian curing rites were retained. Since that time, physicians employed by our federal government in Indian health programs have joined forces with the local medicine men in the belief that treatment by the latter has psychotherapeutic value and can actually contribute to the saving of lives.[186]

In a few places in Canada, traditional shamans have also begun cooperating with non-Indian hospitals and prison health clinics to provide traditional medical and psychological therapies. At the University of Alberta, for example, Russell Willier, a Cree shaman, has spent several years using his skills working in a medical clinic alongside western-style medical doctors and anthropologists who are studying his methods and effectiveness.[187] During the 1970s, several provincial hospitals and prison clinics in the province of British Columbia began including shamans as affiliated staff members. The doctors found that the Native healers succeeded in improving a number of previously intractable medical and psychological cases among both Indian and non-Indian patients.

As is mentioned in the Physical Education/Health Essay, Indian counselors and medical practitioners relying on traditional native psychotherapy techniques have had notable successes in dealing with American Indian patients suffering from alcoholism, even in cases where mainstream approaches had failed. The national Native American Rehabilitation Association and the Thunderbird House in Seattle are two examples of such institutional American Indian efforts. In other Indian communities, such as the Alkali Lake Reserve in British Columbia and many reservations in the U.S., notable recent progress has been made against alcoholism by community-based efforts that include traditional healers.[188] Similar efforts are underway in many Indian communities to combat teen suicide, which American Indian youth in the United States commit at a rate three times higher than others of their age in the general population.

Surgery and Related Techniques

Dr. Vogel's discussion of the literature on American Indian surgery in the early Contact era reveals a variety of views about traditional surgical practice in much of the

Americas. Some early colonial doctors and some later scholars asserted that Indians possessed little surgical knowledge, yet there are oral traditions and written records of Indian-performed amputations, skin and scalp grafting, and the suturing of torn ears and lips in North America. Similar sources provide evidence of trepanation (skull surgery), amputations, skin grafting, use of artificial limbs, and skin wound clipping techniques in South America.[189] Later European-American doctors reported that some of the Indian doctors knew of the functions of the brain, lungs and the circulatory system and that some also knew how to take a pulse.[190]

Antisepsis (the control of infection) was managed in several ways. Cauterizing (searing with hot coals) to control infections, particularly in wounds, was practiced by most North American tribes. The Ojibwe also cauterized after tattooing for the same reason.[191] Some scholars report the use of boiling water by unspecified tribes as an antiseptic measure; the Choctaw and the Illinois are reported to have added certain roots or other plant medicines to the boiling water in order to control infection in cases of gunshot, arrow or ordinary laceration wounds.[192]

Peruvian cultures developed a very effective bactericide for treating wounds and skin inflammations from the resins and oil of the fruits of several species of *Myroxylon* trees. Its preparation was documented by the bilingual Inca historian and herbalist Felipe Guáman de Ayala. This antiseptic, also used as far north as Central America, was adopted for a long time in the **U. S. Pharmacopoeia** under the name of ‘Balsam of Peru’ as an official medicine.[193] Balsam of Peru was also used in South America to clean teeth and promote healthy gums, according to one early Spanish colonist.[194]

Projectile wounds, whether from arrow, knife or lance (and gunshot after Contact), generally were treated with great success by the Indian doctors. The doctors used suction and irrigation to initially cleanse these wounds. Ojibwe and Potawatomi doctors in Michigan used a hollow quill combined with a small animal bladder as a syringe to irrigate deep into wounds with a decoction of medicinal herbs.[195] The treatment to follow depended upon whether the projectile could be removed. In the case of bullet wounds, removal might be done either with a knife or with bullet molds unless the bullet was lodged too deeply or in sensitive organs. In most cases of projectile wounds, the Indian doctors would temporarily keep the wound open with slippery elm bark and treat it with tree resins (as antiseptics) or root medicines until all danger of infection had passed and the wound could safely be allowed to close up.[196]

Suturing (the stitching closed of open wounds or cuts) was done with a variety of fibrous materials. In much of North America, human hair, finely split deer sinews and certain plant fibers, such as those of agave or basswood were used as sutures.[197] Dr. Vogel reports that in parts of South America, Indians collected leaf cutting ants (noted for their large mandibles) and would pinch wound edges together, then hold the ants in position over the wound one by one. As each ant bit into the pinched wound edges, the doctor would twist off and leave behind the ant's head, its jaws holding the wound closed as an early, organic form of skin clip.[198]

In cases of burns, a common dressing that was also effective in controlling infection was to carefully drape a new, clean spider web over the injured skin.

Childbirth was an area of Indian medical practice where American Indians demonstrated several significant advances as compared to European doctors at the time of Contact. Among them was the use of massage during labor and the expression of the placenta following birth to ease the mother's delivery.[199] The ancient practice of expression (manipulating the abdominal wall to force the expulsion) of the placenta was first recorded among American Indians a full century before Dr. Carl Credé advocated it in the mid-19th century.[200]

Indians also identified and used a wide range of plant medicines that eased the pain of childbirth and promoted stronger contractions in cases of difficult birth, all long before European doctors overcame a Christian tradition that women were meant to suffer in childbirth as God's punishment for Eve's original sin.[201] Among the medicines used to ease labor and its pains were a decoction (extract of plant in boiling water) of sumac leaves and berries (Illinois); an infusion (extract of plant in either hot - not boiling - or cold water) of poplar, wild cherry and dogwood bark for control of pain, bleeding and infection (Catawba); corn smut (Zuni); a decoction of wild yam (*Dioscorea villosa*) root (Mesquakie); and a decoction of trillium root (many tribes). The Aztec doctors gave the ground up, inner pulp of prickly pear leaves in water as a drink to help mothers having difficulty due to an improperly positioned fetus.[202]

Delivery in childbirth was frequently made quicker and easier for Indian women with the assistance of gravity. Rather than lying on her back, the delivering woman would often kneel, squat or support herself by hanging onto a pole or strap which had been arranged for her use.[203] In the late 1960s, Dr. Abner Weismann, a clinical professor of obstetrics and gynecology at New York Medical College, displayed a collection of Mexican and South American clay figurines, some of which indicated that Indian doctors in these cultures may also have practiced delivery by Cesarean section, in his opinion.[204]

There exists some documentary and archaeological evidence to indicate that native doctors in a number of American Indian cultures may have performed the minor surgical technique of phlebotomy or bleeding prior to its wider introduction by European doctors.[205] Also called venesection, this technique involved making a small incision or precisely-placed puncture wound into a vein for the purpose of treating swellings, headaches and bodily aches, or certain fevers. For such purposes, the Aztec doctors employed small, extremely sharp, obsidian scalpels known as iztli, the quills of porcupines, or thorns of the maguey, a type of agave plant. We know that the Inca of Peru, the Comanche of Texas, the Maricopa of Arizona and the Montagnais of Labrador all practiced phlebotomy, just to illustrate the geographic range of this technique. It seems to have been more common west of the Mississippi River. Many major cultural groups, such as the Algonkin tribes and confederations of the Northeastern Woodlands, were unfamiliar with it until bled by white doctors.[206]

Dental surgery was relatively uncommon among American Indians, as many Indians traditionally enjoyed a diet which caused little tooth decay. Dental caries seems to have been most prevalent among agricultural tribes dependent on corn.[207] Only one American Indian culture, the Maya, is known to have mastered dental inlay work and the filling of teeth. However, they seem to have used these skills to ornament the mouths of the nobility rather than as therapy, using turquoise, gold, jade and hematite for a striking effect.[208]

Gum diseases such as abscesses were treated when they occurred by lancing or scarifying them to drain the pus or by cauterizing to kill the infection. Several plants, among them sweet bay, the seeds of the Virginia anemone, the bark of the prickly ash tree, and the roots of purple cornflower among them, were used to treat toothache.[209] In post-Contact times, the Ojibwe and the Mescalero Apache dulled toothache by killing the nerves of a decaying tooth with a hot metal pin or the burning coal on the end of a twig shoved into the cavity.[210] Decayed teeth were usually removed by knocking them out with a punch or sometimes pulling out a loose tooth with a sinew cord wrapped around it.[211]

The most serious type of major surgery American Indians are known to have practiced was trepanation, a procedure in which a flap of the scalp is cut and lifted out of the way and a hole is cut or bored through the skull. The purpose of this operation is thought to have been the relieving of pressure on the brain resulting from blows, fractures or possibly internal inflammations or tumors. Skeletal evidence shows that some patients had this procedure performed several times, with bone growth around the edges of the hole indicating a successful procedure and survival of the patient.[212]

It is thought by some doctors that the Andean surgeons employed cocaine as an anesthetic, while the Mexican surgeons may have used peyote for that purpose when trepanning. Trepanation is known to have been practiced from Canada to Peru in the Americas; it is also known from several lithic era cultures in Europe, North Africa and Asia and is thus among the oldest of the major operations which humans in many places learned to perform.[213]

So far as is known, only the American Indian cities in ancient Mexico contained buildings purpose-built for use as hospitals. These were maintained by the governments and served most of the people, those whose families could not afford a private doctor in cases of serious illness or injury. It is reported that they were well staffed with knowledgeable surgeons, physicians (those who worked with the plant medicines) and nurses.[214] The surgeons there may have had the most extensive knowledge of human anatomy in any society in the 16th century, given the opportunities to learn believed to have been afforded by the reported Aztec practice of human sacrifice for occasional religious purposes. Dr. Jack Weatherford has reported that the Nahuatl-speaking doctors of highland Mexico had a technical vocabulary that included names for nearly all of the internal organs recognized by modern anatomists.[215]

Elsewhere, perhaps a majority of American Indian cultures had medical societies, such as the Midewiwin discussed above. These saw to the spiritual and technical training of doctors and healers. While these societies usually had their exclusive meeting places, they usually performed their services in the dwellings of their patients. (Imagine – house calls!) Other cultures passed medical knowledge from individual to individual, as the elder doctor saw fit.

Medical Implements

American Indians gave the world two useful medical inventions based on their mastery of the chemistry required to make vulcanized rubber. In South America they created the rubber-bulbed syringe for injecting medicines and irrigating wounds.[216] (It was noted above that two cultures in the Great Lakes area also developed a type of syringe using hollow quills and powered by an attached animal bladder.) South American Indians also created the rubber hose and bulb for administering enemas.[217]

Mention should also be made of the quality of certain American Indian surgical implements. It may seem difficult to credit some of the above-mentioned surgical capabilities of pre-Contact Indian doctors when one thinks in terms of modern surgical steel instruments – how could a surgeon successfully perform skull surgery, of all things, using stone tools? The answer is that not all American Indian surgical implements were of stone and some of those that were might surprise with the excellence of their qualities.

Among the Ecuadorian and Peruvian cultures were those that were masters of the techniques of bronze making. These craftsmen forged the keen-edged, long-handled, fan-bladed trepanation scalpels and other implements favored by Andean surgeons. Many of these have been found by archaeologists, who have worked out the surgical procedures once used by comparing the instruments with marks on skulls belonging to patients who underwent trepanning.

Much more widely distributed in manufacture, trade and use were the fine microblade scalpels made of carefully-formed obsidian or, more rarely, quartz crystal.

(The major centers of obsidian blade manufacture were in the mountains and lava fields of the West, from Alaska to Chile.) The making of these surgical blades involves techniques that are as old as the earliest stone-tool cultures in the Americas. Quite small, they were usually hafted onto slim, short handles formed of whatever tough, resilient wood was available locally.[218]

A few modern surgeons have tested the utility of these microblades. The author has occasionally heard anecdotal reports of surgeons who conducted comparisons of steel and obsidian scalpels in the course of their surgical practice and favored the stone implement. Based on findings of such modern tests and historical evidence, the anthropologist Jack Weatherford has asserted:

> Even today no steel scalpel has ever been made that cuts sharper than the obsidian implements of the Aztec surgeons. Only the laser beam can cut a finer incision with less bleeding and less scarification than the Aztec surgeons. The fine Aztec scalpels allowed the doctors to cut with minimum blood loss, and the wound healed with fewer scars.[219]

AMERICAN INDIANS IN CONTEMPORARY SCIENCE

Twentieth century American Indians have participated in the development of contemporary science to an extent that often goes unrecognized. (There are still some scientific and technical fields that presently have few American Indian specialists.) The reasons for Indian participation in contemporary science include personal determination above all else, but the increasing employment and educational opportunities for American Indians that resulted from World War II and its aftermath also have played a part in bringing Indians into modern scientific and technical fields.

The causes of limited Indian representation in some scientific fields are numerous. They particularly include difficulties in access to professional training that are consequences of poverty and isolation on many reservations. A real reluctance to leave home, family and friends is common to reservation and urban Indians alike. To these factors are added the frequently poor quality elementary and secondary education many Indians receive. Many are unfamiliar with available opportunities for post-secondary schooling, knowing little about which colleges offer quality programs, financial assistance and the necessary support system of Indian faculty and student organizations.

Even with such support, the culture of most American colleges and universities is a difficult one to adapt to for the majority of American Indian students. Enrollment and dropout statistics have long shown that about half of the Indian students who enroll as freshmen leave college by the end of their first year.

Finally, only a few American Indian youth have had much exposure to Indian role models in science. Most need and do not have the chance to establish mentoring relationships with older Indian professionals that can help a young Indian person to master the social and professional networks of the scientific and technical worlds.

As indicators of the impact of these barriers on American Indian entry into contemporary scientific or technical fields, consider the data on the following professions:

In 1989, the National Institutes of Health (NIH) reported that, of the nearly 12,000 graduate and post-graduate students receiving NIH grants and other support for their studies in various areas of biomedical research, fewer than 20 were American Indians.[220]

American Indian dentists have recently formed the National Association of Native American Dentists. This organization has been able to contact and enroll as members all of the licensed American Indian practitioners in the U.S. In 1990, there were 32 Indian dentists in the country.[221]

Finally, as pointed out in the Mathematics Essay, there have been only 36 doctoral degrees in mathematics awarded to American Indians between the time Tom Storer

(Navajo) earned the first one in 1963 and the graduation of the class of 1991.

It was asserted above that modern American Indians have participated in science and many technical fields to a surprising extent, despite the difficulties of getting training for and entering these professions. This is a trend that has been developing for several generations. Below are some of the accomplishments of a few of the many American Indian scientists and technicians who have shown the way into modern science.

In the 19th century, Ely Samuel Parker, a Seneca, trained as a professional civil engineer and served in the United States Army during the Civil War. His abilities in bridge-building and mining operations brought him to the attention of Ulysses S. Grant, who made Parker his adjutant. It was Parker who wrote out Grant's terms for the surrender of General Lee's forces at Appomattox.

Even before the war, Ely Parker, known as Donehogawah to his Seneca people, made important scientific contributions. He was the principal consultant to the "first scientific study of an Indian tribe."[222] As a young man, he had met and befriended Lewis Henry Morgan. Donehogawah provided the innovative ethnologist with extensive, crucial assistance in the detailed study of Iroquoian lifeways and traditions that led to Morgan's publication of the **League of the Ho-de-no-sau-nee or Iroquois** in 1851. Today, the American Indian Science and Engineering Society's Ely S. Parker Award is its highest honor in recognition of scientific achievement and community service.

The first western-trained American Indian medical doctors both earned their degrees in 1889. They were Dr. Susan LaFlesche Picotte of the Omaha and Dr. Carlos Montezuma, a Yavapai. Their medical work is mentioned in the Chronology; both served reservation communities and also went on to work for the general betterment of the social conditions of American Indian people on the reservations. Another early Indian M.D. was Dr. Charles Eastman, a Lakota who is best remembered today for several religious, philosophical and children's books he wrote from the perspective of his heritage.

Mary Ross, now retired, is a noted Cherokee engineer. She is a great-great granddaughter of John Ross, the elected Cherokee chief who led his people's fight against forcible relocation in the 1830s. In her own right, Mary earned a master's degree in mathematics in 1938 and became a registered engineer in 1942. She became the first woman ever to be employed as an engineer by Lockheed Aircraft in that same year. She worked on fighter and transport aircraft design.

Later, with the coming of the space age, Mary Ross worked on projects ranging from Polaris missile warheads to submarines and she participated in the NASA programs of the 1960s.[223] She was a research engineer on the Agena rocket system used as the upper stage of the Saturn booster for the Apollo program. Her NASA work included the early studies that led toward the United States' orbital station Skylab, the Apollo lunar landing program and the Pioneer and Voyager space probe projects. She retired from Lockheed in 1973 after attaining the position of senior advanced systems staff engineer.[224] In 1986, the Council of Energy Resource Tribes named her as its first recipient of the annual Mary G. Ross Award, given to those whose work brings favorable attention and honor to American Indians in the fields of science, engineering and business.

Colonel William Pogue is a Choctaw mathematician who served in the U.S. Air Force as a fighter-bomber pilot during the Korean War. He later served two years as a member of the Air Force's Thunderbirds air show squadron. In 1966, he was selected by NASA to become an astronaut. He served in the astronaut support teams for three Apollo missions. From November 16, 1973 to February 8, 1974, he commanded the third and last Skylab mission, setting a record for the longest manned space flight up to that time.[225]

Dr. J. E. Henry is an Ojibwe entomologist. He is a specialist in insect control who made a career with the U.S. Department of Agriculture. He is known for his pioneering achievement in finding the world's first commercial biological insecticide for use against grasshoppers. This was based on a protozoan that is harmless to other animals. Following this success, other scientists have extended Dr. Henry's work to include a wide range of other biological insecticides that are far safer than chemical pesticides. Dr. Henry himself went on to share his knowledge with agricultural scientists in Africa, South America and Australia.[226]

Bill Folsom, a Choctaw mechanical engineer who worked for General Electric Corporation, designed the mechanical components and the large-scale integrated control circuits for the world's first data communications printers. His design principles for print heads and their transport systems are in common use in most dot-matrix computer printers today.[227]

David Powless is an Oneida who first gained fame as a member of the 1963 University of Oklahoma Rose Bowl football team. He went on to play professionally for the New York Giants and the Washington franchise. After retiring with an injury, he learned the steel business. In 1976, he began work on a process to recycle the iron oxide by-products of steelmaking. He succeeded in just a few years, working at the Colorado School of Mines. The first oxide recycling plant using Powless' process was built in California by Kaiser Steel at the end of the 1970s. He has continued to do research in recycling and heads a consulting firm helping other businesses to reduce their environmental impacts.[228]

Dr. Michael Horn is a fisheries biologist, a 1969 graduate of Harvard who has conducted research in the U.S., England and Scotland on the complex relationships between fish and algae. His emphasis is on the challenges of conserving fisheries resources in temperate oceans. He uses this information to train a new generation in his zoology courses at the California State University at Fullerton.[229]

During the 1980s, Dr. Richard Myers worked as the Director of the National Weather Service Training Center. He and his staff developed training courses in meteorology, hydrology, electronics and management skills. These courses guide several U.S. government agencies and their employees in connection with the study of weather and the atmosphere. A Powhatan, Dr. Myers has also taught zoology and ecology at the university level.[230]

Al Qöyawayma, Hopi, is a world-famous potter who has worked with the Smithsonian Institution on research into traditional Hopi ceramics. For many years, he has also been manager of the Environmental Services Department of the Salt River Project, a major electricity and irrigation system in the Southwest. Prior to his work in environmental quality, Qöyawayma developed and patented inertial guidance and celestial guidance systems for missiles and aircraft while employed by Litton Systems, a division of Litton Industries.[231]

The scientific or technical careers of these and quite a few other American Indian individuals are briefly presented in two sources that should be of interest to the classroom teacher. The first is a two-volume set of booklets put out in the 1980s by the American Indian Science and Engineering Society. These are entitled **American Indian Scientists and Engineers**. The second source is a chapter from a curriculum unit by Peggy Funches and others entitled **Minority Contributions to Science, Engineering and Medicine**. This was published in 1978 by the San Diego City Schools.[232]

The American Indian Science and Engineering Society

American Indians involved in contemporary sciences and engineering fields organized the national professional organization known as AISES (American Indian

Science and Engineering Society) in 1977. Headquartered in Boulder, Colorado (1630 30th Street, Suite 301, Boulder, CO. 80301-1014; the Society may be reached by telephone at 303-492-8658), AISES has a membership made up of practicing professionals and college students.

In 1990, AISES' professional membership numbered 119 Indian and Alaskan Native scientists and engineers in a wide range of fields; there were also approximately 180 adult non-Indian professionals and Indian non-professional members who supported the goals and activities of the organization. The college student membership totaled some 900 Indian students in scientific and engineering majors; of these, about 90% are undergraduate students.[233]

AISES fills several roles as an Indian scientific professional association. It functions to provide a support and information network for its Indian and Alaskan Native professional members. The Society serves as a forum and clearinghouse for information about Indians in the sciences and in engineering fields, and represents Indian points of view to other specialists, the general public, and political institutions. Beginning in 1978, it has hosted an annual national conference focused on the participation of American Indians in scientific and technical fields.

Since 1985, AISES has published a quarterly journal, *Winds of Change*. This magazine chronicles the views and careers of contemporary Indian scientists, engineers and educators. It provides a forum for these professionals and others to explore and examine publicly the complex challenges of bringing about harmony between the values and knowledge of the traditional American Indian and the Western scientific and technical cultures in which they participate simultaneously.

AISES also provides support for American Indian students who are studying engineering and sciences at the college level. In addition to the information it shares through its journal and meetings, AISES promotes networking between these students and connects them to working professionals through the activities of its campus chapters.

Chapter officers participate in annual student leadership conferences where they are trained in leadership techniques and meet with American Indian science and technical professionals. In 1990, there were 52 chapters on campuses around the United States.[234] A growing number of AISES chapters engage in mentoring programs where the Indian college students serve in local high schools helping to tutor Indian students in the sciences and mathematics.

The American Indian Science and Engineering Society additionally awards merit scholarships to Indian college students in math and science fields. In 1989, 133 students were each awarded $1,000 scholarships to help them continue their education.[235]

Science Education Programs for American Indians

There are increasing educational efforts at the K-12 level to attract and better prepare American Indian and Alaskan Native students to enter careers in the sciences.

AISES funds a number of college-based summer programs for Indian middle and high school students in order to promote interest and skills among young Indian people thinking of pursuing higher education and an eventual profession in the sciences. The organization helps to support and train staff and provides curriculum advice for these summer math and science camps.

AISES also supports K-12 education programs in science-related areas in a number of other ways. It sponsors annual state- and national-level math and science fairs for Indian students, develops and provides exemplary curriculum units, works with tribal communities to provide training for science and math teachers in Indian-controlled schools, and publishes a quarterly *Education Newsletter*. Finally, the American Indian

Science and Engineering Society annually recognizes an Outstanding Teacher and an Outstanding High School Student with national awards.

Some of its teacher training and summer camp activities for students have been sponsored by organizations such as NASA, the U.S. Geologic Survey, the National Science Foundation, Hitachi Corporation, TRW Corporation, the Ford Foundation, and the U.S. Department of Education.

Among its science- and community-based education curricula are the SACAI (*Science of Alcohol Curriculum for American Indians*). AISES staff and members combined contemporary and traditional science learning in a book funded by the National Science Foundation entitled **Hands On/ Minds On: Science Activities for Children**.[236] In 1988, AISES produced a half-hour video entitled *Taking Tradition to Tomorrow*. This highly-recommended video presents a review of major Indian scientific and technical achievements throughout history and introduces a number of contemporary Indian scientists, doctors, engineers, and other professionals studying or working in national and tribal government to promote American Indian science.[237]

The summer math and science camps sponsored by the American Indian Science and Engineering Society mentioned above have begun to provide opportunities for Indian and Inuit students to approach science in ways more oriented to hands-on activities. This culturally-appropriate learning strategy emphasizes actual problem-solving and research techniques over the textbook-oriented approaches predominant in the past. Some school districts, tribal education programs and college-based programs have begun to use this approach more often with Indian students.

It is too soon to tell if these real-world, less abstract approaches will significantly increase the number of young Indian people who will choose to go on to college and study in scientific and technical fields. The American Indian Science and Engineering

Society is sponsoring current research into "the factors that make it possible for Native American students to succeed in postsecondary environments."[238]

Anecdotal reports have well-known limitations as indicators of education program effectiveness. However, a comment from a twelve year-old Seneca girl who attended an AISES science camp in 1989 may suggest the impact that hands-on methods of instruction can have on students typically underrepresented in the sciences: "Before I came here, I liked science, but it was just another subject. Now, I think I'd like to go into a career in medicine."[239]

Four examples of programs that emphasize this practical orientation to science education are outlined below.

In the spring of 1990, educators in the Barrow, Alaska school system hosted a national conference to address issues that included ways to increase the participation of Inuit ('Eskimo') people in the sciences as practiced in the Arctic. They reported that they have formed alliances with professionals working in the fields of wildlife biology and management, atmospheric sciences, geology and oceanography. Through these alliances, Inuit students in the region are exposed to contemporary, local problems in these fields. They gain an opportunity to learn about the scientific techniques used by specialists who seek information about the Arctic environment. As they learn, the students themselves contribute a native perspective on some of the questions raised by the increasing levels of human activity in the Arctic.[240]

Oregon State University has implemented a program it calls SMILE (Science and Math Investigative Learning Experiences) to provide American Indian and Hispanic middle school students in eight rural Oregon school districts with enrichment activities in these fields. Faculty members and students work with the teaching staffs at the school districts to identify and implement classroom activities and curricula that build skills in problem solving and introduce middle school students to the techniques and history of modern mathematics and science.[241]

Northern Arizona University has formed cooperative programs with tribes in Arizona including the Navajo, the second most populous tribe in the United States. These programs provide resources and technical assistance for the academic and economic advancement of the tribes. Among the goals of this effort are the development of appropriate curricula for use in K-12 classrooms and assistance in faculty training and program articulation between NAU and the Navajo Community College. NCC, on the Navajo reservation at Tsaile, Arizona, is the oldest and largest tribally-controlled postsecondary institution in the United States. The joint effort between NAU and NCC aims at increasing the numbers of well-trained Indian teachers, managers, and technical/scientific professionals who are available to the tribes.[242]

In Canada, the federal Department of Indian Affairs and Northern Development has spent about $10.9 million dollars since 1961 on funding college and university education efforts in science programs relating to the Arctic and Sub-Arctic regions of that country. The Northern Scientific Training Program, as it is known, has helped many Indian and Inuit students to obtain degrees in biology, wildlife management, hydrology, mining, forestry and fisheries. NSTP also has helped fund a number of university research projects that have developed a base of knowledge pertaining to economic development of the Arctic. Some 31 Canadian universities and colleges participated in the program in the 1990-91 year.[243]

As a result of efforts like these, increasing numbers of American Indian and Inuit youth are entering the many modern scientific and technical professions. Their accomplishments are sure to continue the ancient traditions of American Indian excellence in applying scientific knowledge to the pragmatic tasks of meeting the needs of people everywhere.

APPENDIX A CHRONOLOGY

A Chronology of American Indian Contributions in Science and Technology

Dates in **boldface** indicate events primarily due to American Indian initiatives; dates in plain type indicate events primarily due to initiatives by others.

ca.-50000 Paleo-Indian skeletal remains are left near Taber in Alberta, Canada [found by Archie Stalker; the dating remains controversial].

ca.-40000 Stone tools and a mysterious semicircular arrangement of stones are paleo-Indian remains at a site in the Calico Hills of the Mojave Desert in California [found by Ruth Simpson and verified by Louis Leakey; the dating remains controversial].

A hearth containing bones, tools and charcoal at Santa Rosa Island near modern Los Angeles; the site implies boat-building skills as well [found by John Woolley].

ca.-31000 At a site in Chile called Monte Verde, Tom Dillehay finds three clay-lined hearths that he thinks may have been in use around 31,000 B.C.

ca.-27000 to -24000 Fossil bone tools at sites on the Yukon River [found by C. R. Harington and by William Irving].

ca.-22000 to -19000 Scrapers, choppers, flake tools, a blade, and a burin (chisel-like tool) at the island site of Tlapacoya in the Valley of Mexico [found by José Luis Lorenzo].

Hunting tools of Paleolithic (Old Stone Age) type at Valsequillo, near modern Puebla in southern Mexico [found by Cynthia Irwin-Williams and by Juan Armenta Camacho].

ca.-20000 Bone tools at an old waterhole (the Dutton site) in Colorado [found by Dennis Stanford; the date is controversial].

ca.-19000 to -14000 Paleolithic tools in Pikimachay Cave near Ayacucho in the Andes Mountains of Peru [found by Richard MacNeish; the oldest material may prove to be as old as 25,000 years].

ca.-14000 to -12000 Techniques for log house construction are used by Indians to build a 12-house village at the Monte Verde site in southern Chile. Archaeologists led by Tom Dillehay find evidence of the use of 27 medicinal plants at the site. [It is possible that three clay-lined hearths also found at the site were in use as long ago as 31,000 B.C., see above.]

ca.-13000 Hunters at Taima-Taima (in modern Venezuela) use pressure-flaked, leaf-shaped spear points, possibly poisoned, to hunt mastodons.

ca.-13000 to -9000 Bands of Lithic-era Indians in the Columbia River basin in what are now the states of Washington, Oregon, and Idaho establish the Old Cordilleran Culture. The flaked obsidian spear points ('Cascade points') of this culture have a distinctive willow-leaf shape with a single side notch at the base and lack fluting. The Old Cordilleran Culture at this time seems to have had big-game hunting as its economic focus.

ca.-12600 Evidence of llama hunters found in a cave site at Los Toldos in Argentina.

ca.-12000 to 1500 The Meadowcroft Rock Shelter near modern Pittsburgh, Pennsylvania is occupied by a succession of peoples who leave tools, baskets and other remains over a very long period. The earliest of eleven levels of remains includes fragments of human bone, estimated by archaeologist James Adovasio to be about 14,000 years old.

ca.-11500 to -9500 In a major technological development of the so-called Early Hunters era, percussion and pressure flaking techniques are combined to produce the famous fluted Clovis point hunting weapons. The techniques for making these spread throughout North America, but are first known from finds in the American Southwest.

ca.-11000 Techniques for construction of large wooden houses are known in the Shenandoah Valley of Virginia at what is now called the Thunderbird site [analyzed and reconstructed by Errett Callahan].

ca.-10700 to -9000 Late Paleolithic hunters inhabit the southern tip of South America, leaving spear points similar to the Clovis type and evidence of the domestication of dogs at Fell's Cave in Chile.

ca.-10000 Paintings of Paleo-Indian hunting techniques and hearths are found in Toca do Boqueirão da Pedra Furada Cave in northeast Brazil [first described by Niède Guidon].

ca.-10000 to -8000 A refinement of the fluting technique used in chipping Clovis points results in the so-called Folsom point. Both types of points are believed to have been the tips of darts that were thrown with an *atlatl* , or spear thrower, which remained in use in central Mexico into historic times.

A technical development by hunters on the Great Plains produces the lance points known as Angostura and Scottsbluff; these also become common in much of Mesoamerica.

ca.-9000 to -5000 The Old Cordilleran Culture shifts into an early mixed economy based on fishing, hunting, and new tools for processing wild plant foods. The change is in response to the extinction of large Pleistocene (ice-age) mammals like the mastodon in the region. There is evidence of the early development of extensive trade networks within and outside of the region for specialized tools and food products, centered on a great gathering and fishing center near The Dalles in Oregon.

ca.-7000 Archaic (incipient agriculturist) phase Desert cultures in eastern Oregon (Fort Rock Cave) and Utah (Danger Cave) leave evidence of skills in basketry, woven mat, and woven sandal making in cave shelters. The Utah basketry finds are believed to be the oldest evidence in the world of human development of skills in basketry. The Danger Cave site also reveals the use by Indians of some 65 different plants for food and household purposes. The Desert Culture complex of peoples is very extensive, as post-Ice Age warming extends desert conditions through most of western North America. Desert Culture groups are found from Oregon south to Belize in Central America, and as far east as Texas. Some of these peoples are known to have descended from the Old Cordilleran Culture and are ancestors of the later Cayuse, Nimipu (‘Nez Percé’), Chinook, Klamath, Palouse, and Modoc tribes which still reside in the Northwest. Other modern descendants of the Desert Culture are the Paiute and Shoshone of southeastern Oregon and southern Idaho.

ca. -7000 to -5000 Archaeological evidence of the cultivation of cotton for the first time in the world by Archaic era farmers in the Tehuacan Valley of the modern state of Puebla southeast of Mexico City.

Burials in the Tehuacan Valley of Mexico show elaborate funerary wrapping of bodies in blankets and nets.

Archaeological evidence shows that the inhabitants of the area of the present-day Mexican state of Tamaulipas have cultivated the pumpkin, bottle gourds, and chilies.

ca. -5000 Tehuacanos have cultivated the avocado, chilies, amaranth, and walnut squash. They have also developed the mortar and pestle, milling stones and manos to process these agricultural products.

The Northwestern peoples of the Old Cordilleran Culture shift to a hunting-gathering lifestyle after about 5000 B.C. The cause of the change is a massive earthquake which creates a huge waterfall interrupting the Columbia River. This waterfall at Celilo blocks the salmon runs on which much of the Old Cordilleran economy depends.

ca. -5000 to -3400 New varieties of cultivated plants are developed or imported into the Tehuacan Valley: bottle gourds, common beans, black sapote (a fruit), warty squash, and, most significantly, maize (corn). Maize also appears in this valley in a wild form, able to propagate its own seeds whereas its domesticated relative cannot.

ca. -3400 to -2300 Additional domesticated plants appearing in the Tehuacan Valley include tepary beans, pumpkins, and hybridized maize; the culture of the Tehuacanos is becoming sedentary with evidence of small villages developing.

-3372 The earliest date recorded in Mayan calendrics. [We lack knowledge of its significance, but it is a date in the Mayan third cosmic era, which they believe preceded our own contemporary era.]

-3114 The earliest date recorded in Olmec calendrics. [Here, too, we do not know to what event the date refers.]

-3113 The ‘base date’ (the beginning of the current, fourth cosmic era) of the Mayan ‘Long Count’ calendric system is recorded. The Maya refer to this date as 13.0.0.0.0 in the Long Count system and as day 4 Ahau 8 Cumku in the Calendar Round system. Scholars believe the Long Count date to correspond to the Christian date of August 11, 3113 B.C. [Long Count dates, such as 13.0.0.0.0, are expressed as positional coefficients of the powers of twenty, beginning with day units on the right. The Maya conceive the processes of time to operate in circular fashion having both positive and negative directions from any given point in the cycle. (The latter part of this Mayan idea resembles the conception of time implied by Einstein’s relativity theories.) In the circular Mayan calendrical system, the passage of time is reckoned in a cycle of 13 ‘baktuns’ of slightly more than 394 solar years each. At the ‘end’ of a cycle, time returns to its beginning point. The new historic cycle reiterates all of time’s processes starting from the basis of the achievements of the previous cycle. The current cosmic cycle of the Maya ends in the year 2012.]

ca. -3000 Domesticated corn is being adopted by peoples outside the Tehuacan Valley; it appears about this time in Tamaulipas in northeastern Mexico and at Bat Cave in New Mexico, over a thousand miles to the north of the Mexican valley.

ca. -2200 Peruvian coastal fishing peoples have begun cultivating cotton, squashes, gourds, and sweet peppers, along with the root crop achira.

ca. -2000 Early Andean Indian farmers have domesticated the potato from a wild nightshade species.

-1200 Archaeological evidence of the Indian use of rubber for the ball used in the important ritual ball game found throughout Mesoamerica. The Indians of the tropical regions in Central America and South America prepare latex sap from the rubber tree *Hevea brasiliensis* by mixing it with sulfur and curing it over fire in a chemical process later called vulcanization. The cured rubber is eventually used by Indians to create waterproof ponchos, rubber-soled shoes, bottles and ropes (a predecessor of the bungee cord) in addition to the balls used in the game pok-ta-pok found as far north as the American Southwest.

ca. 50 The planning and layout of the rising urban center at Teotihuacan shows considerable skill in surveying techniques. Teotihuacan is the first city in the Americas to be laid out using a regular grid design. The city is quartered into districts with the streets and buildings oriented to 15 degrees 25 minutes east of true north throughout.

450-500 The Anasazi culture (a predecessor of the modern Pueblo peoples) in the Southwest develops from its so-called Basketmaker phase to its Modified Basketmaker phase, characterized by the development of pottery, pithouse villages, and the bow and arrow.

800 The Putun Maya, great seafaring and overland traders and mercenaries comparable in many ways to the Phoenicians, introduce metalworking techniques from South America into Central America. Beaten metal and casting techniques, including the lost wax process, come from Peru and Ecuador. The Mexicans work primarily in copper at first, developing gold work to a high level later.

Chichimec invaders from northern Mexico introduce the bow and arrow into Central America, although this weapon is not widely adopted by the descendants of the conquered peoples.

900 Viking sailors from Iceland blown off course return with a report of sighting Kalaallit Nunaat ('Greenland'); first verified European contact with the Americas.

982 Eric the Red, exiled from Iceland for three years due to murder, sails from Iceland to the west following up an earlier Viking sailors' report of land there; he makes landfall on the southeastern coast of Greenland and rounds Cape Farewell on the southern tip of the island. He spends his exile on the relatively pleasant southwest coast of Kalaallit Nunaat, but encounters none of the native inhabitants.

985 Eric the Red establishes two Viking colonies from Iceland on the Greenland coast at Julianehaab and Godthaab. [These colonies thrived into the 13th century, but contact with Europe broke off after 1410; subsequent European explorations in 1605 and 1616 found the remains of the Norse settlements deserted.]

986 Bjarni Herjulfsson, on his way to Kalaallit Nunaat from Iceland, is blown off course and sights the coast of North America, but does not land.

ca. 1000 Leif Eriksson locates land in the region reported by Herjulfsson, and attempts to found a colony he calls Vinland. Additional colonizing expeditions led by his brother-in-law Thorwald Karlsefni and Leif's sister Freydis result in failure after three years. Karlsefni's group is the first known to have encountered American Indians, probably members of the Beothuk tribe of Newfoundland. After initial trading relations become hostile over Viking reluctance to trade anything more valuable than red cloth for the Indians' furs, an armed clash occurs between natives and newcomers. Karlsefni and eight Beothuk are killed and the Viking colony is driven off. [The colony may have been located at L' Anse au Meadow at the northern tip of the Island of Newfoundland, where remains of a Norse settlement were found in 1963 by Helge Ingstad.]

1265 Indians in the interior of the Columbia Plateau are able to return to fishing after a major earthquake this year. The earthquake, mentioned in numerous stories preserved by the tribes in the area, causes a landslide which partially fills in the waterfall at Celilo on the Columbia River. This reduces the height of the falls to a level that salmon are once again able to pass. This same earthquake destroys the Bridge of the Gods, a huge natural stone bridge that had long connected the banks of the Columbia River near the present town of Stevenson, Washington.

1492 Cristoforo Columbo (also known as 'Cristobal Colón' and 'Christopher Columbus'), an Italian seaman sponsored on an exploratory voyage to Asia by the Spanish monarchs Fernando and Isabel, sails west across the Atlantic Ocean. Columbus hopes to prove his theory of a western route to

China and Japan. A western route is of interest to Spain since Portugal has already monopolized the eastern route around Africa. Columbus' crew sights Guanahani Island (or, as Columbus calls it, 'San Salvador') in the Bahamas on October 12th. Columbus lands on Cuba, October 18th; lands on Haiti, December 6th, and wrecks his flagship, the *Santa Maria* off the coast of Haiti ('Hispaniola') on December 25th.

1493-96 Columbus returns to Palos, Spain and embarks on his second trans-Atlantic voyage in September; he returns in June, 1496 after locating Puerto Rico, Dominica, and Jamaica. On Hispaniola he founds Isabela, the first European city in the Americas; it fails to prosper.

1496 Tobacco is described to Europeans for the first time by a monk who was a member of Columbus' second expedition, Romano Pane.

1497 The Venetian navigators John and Sebastian Cabot, under commission from Henry VII of England, explore along the southern and southwestern coasts of Newfoundland.

1498-1500 Columbus explores the Venezuelan coast, and learns of the Orinoco River. [During his absence, the Spanish monarchs send Francisco de Bobadilla to Hispaniola as Royal Governor to investigate and settle disputes and reports of misgovernment by the Columbus family. Upon Columbus' return from the first European contact with South America, Bobadilla arrests Christopher, his son Fernando, and his brother Diego for mismanagement of the colony. They are returned to Spain and freed after a royal hearing.]

1499-1500 Amerigo Vespucci, traveling on Alonso de Ojeda's expedition under Spanish sponsorship, explores the coast of South America and locates the mouth of the Amazon River.

1500 Juan de la Cosa, owner of the wrecked *Santa Maria*, prepares a map of the Caribbean based on his experiences voyaging with Columbus. It accurately shows Cuba as an island, in contradiction to Columbus' assertion that is part of the mainland of Asia.

Vicente Yañez Pinzón, master of the *Niña* on Columbus' first voyage, arrives in Brazil at Cabo Santo Agostinho, near modern Natal, shortly after Vespucci's visit. He explores northward along the coast, sighting the estuary of the Amazon River and eventually stopping at Puerto Rico before returning to Spain.

1501 Rodrigo de Bastides explores along the Caribbean coast of Panama.

The Anglo-Portuguese Syndicate sends its first voyage to North America.

1502 Amerigo Vespucci makes his second voyage to South America, locates the bay at the mouth of the Rio de Janeiro and is the first European to see the Rio de la Plata. [He is believed to have proceeded down the coast of Patagonia as far as the Gulfo de San Julián in the southernmost province of Santa Cruz in modern Argentina.] Upon return to Portugal, Vespucci declares that the lands the Europeans have been exploring are not part of the Orient, but are a 'Western Hemisphere' or fourth continent.

The Anglo-Portuguese Syndicate sends its second voyage of exploration to Newfoundland.

Juan Ponce de León suppresses an Arawak rebellion against the Spanish rule of Governor Nicolás de Ovando on Hispaniola.

1502-04 Columbus makes his last voyage, exploring along the coasts of Honduras and Panama in Central America.

1507 Martin Waldseemüller, in his **Cosmographiae Introductio**, agrees with Vespucci that South America is a new continent and proposes that it be named 'America' in his honor. This book attains far greater circulation in Europe than the reports published by Columbus. It powerfully shapes the early European image of the 'Western Hemisphere'.

1508-09 Juan Ponce de León explores Puerto Rico and founds its first European settlement, Caparra.

1513 Vasco Nuñez de Balboa crosses the Isthmus of Panama and is the first European to see the Pacific Ocean. [In his journal, Balboa records committing atrocities to members of the Cuna people along the way, having some of them killed by dogs for cultural practices he regards as unholy.]

Juan Ponce de León names Florida and explores the peninsula from modern St. Augustine southward. [He had originally set out in search of Bimini Island in the Bahamas. He had been told by Taino Arawak Indians on Puerto Rico that he might find there a miraculous spring said to be capable of rejuvenation, the so-called 'Fountain of Youth'.]

1516 Peter Martyr publishes **Decades**, describing to Europe the knowledge resulting from early explorations of the Western Hemisphere. He is the first to compile the reports of the major European expeditions to the Americas up to his day. This book enjoys wide circulation and influence.

1518 Juan de Grijalva explores the coast of Yucatán and learns of the empire of Mexico. His arrival off the coast is reported to Moctezuma Xocoyotzin, leader of the Aztec.

1519 The Aztec introduce drinking chocolate [xocoatl] to the Spanish. Moctezuma Xocoyotzin offers this beverage of the Aztec nobility to Cortés because he believes that the Spaniard might be the returning Toltec god Quetzalcóatl.

Domenico de Pineda explores the Gulf of Mexico between Florida and Veracruz, Mexico.

Hernán Cortés reintroduces horses into Mexico. [Indians will capture strayed animals and begin a practice of breeding, trading and raiding of horses that transforms traditional tribal life in much of North America by the 19th century.]

1520 Magellan passes through the straits bearing his name at the southern extremity of the South American continent. He and his crew become the first Europeans to sail on the Pacific Ocean.

1521 Ponce de León, exploring the coast of Florida for a second time, combats an armada of 80 war canoes of Calusa Indians and is wounded aboard his ship; he dies from this wound after returning to Cuba.

Francisco de Gordillo explores the coast of North America as far north as modern South Carolina.

1522 Pascuel de Andagoya travels overland from Panama into South America seeking Peru, of which Balboa had heard in 1513.

Francisco Montano becomes the first European to climb the volcano Popocatepetl south of the Valley of Mexico.

1524 Turkeys are introduced into England from South America.

Francisco Pizzaro and Diego de Almagro make their first voyage from Panama in search of Peru.

Giovanni da Verrazano explores the mid-Atlantic coast of North America and learns of New York Bay and the Hudson River.

1526-27 Pizzaro and de Almagro make their second voyage in search of Peru; Pizzaro lands at the village of Túmbez in modern Ecuador, and witnesses a gold-decorated temple. He returns to Spain in 1528, taking gold cups, a llama and two abducted Peruvian youths to show the Spanish king.

ca. 1531 By the time of the Conquest, Peruvian Indian farmers have hybridized about 3,000 varieties of the potato, some of which are destined to become among the world's most important food crops.

1534 On his first voyage to North America, Jaques Cartier explores the coast of Newfoundland, returning to France with two captured Huron boys, Domagaya and Taignoagny, whom he trains as interpreters.

1535-36 Assisted by Domagaya and Taignoagny, Jacques Cartier returns to the coast of Labrador and ascends the St. Lawrence River to the Huron villages of Stadacona (modern Quebec City) and Hochelaga (Montreal). Over the winter, Domagaya, the Huron sachem Donnaconna and the women of Stadacona cure the deathly ill French crews of scurvy by preparing for them an infusion of pine bark rich in Vitamin C, the preventative to this nutritional disease. [Cartier kidnaps Donnaconna and two other Huron leaders, along with Domagaya, Taignoagny and five other children as he leaves the following spring; these Huron die in France before Cartier returns in 1541.]

1538 Gerardus Mercator, famous cartographer, first uses the names America and North America in his work.

1539 Hernando de Soto explores Florida.

1540 De Soto, exploring in Alabama, alienates the powerful chief Tuscaloosa of the Muskogean Choctaw nation. In an attack upon Tuscaloosa's village of Mabila, the De Soto's troops massacre an estimated 2,500 Choctaw.

1540-41 García López de Cárdenas, searching the American Southwest with Francisco de Coronado for the Seven Cities of Cibola (semi-legendary cities reported to exist by the shipwrecked Spanish wanderers Alvar Nuñez Cabeza de Vaca and Estéban the Moor in 1536, and later thought to be identified with the six Zuni pueblos in New Mexico) comes upon the Grand Canyon in Arizona. The Canyon region is occupied by the Havasupai and had been a major Pueblo center of population some 300 years earlier. Despite resistance by various Indian groups to the Spanish intrusion, the Coronado expedition eventually crosses through New Mexico and parts of what is now Texas, Oklahoma and Kansas (Quivira) before returning to Mexico disappointed in their quest.

1541 Hernando de Soto comes upon the Mississippi River.

1541-42 Having broken off from an exploration into the interior of South America led by Gonzalo Pizzaro, Francisco de Orellana descends the Amazon River. His party reaches the river's mouth with reports of encountering female warriors; the river is afterward named for the Amazons of European legends.

1544 The Incan silver mines of Potosí, Bolivia are located by Spanish conquistadors. The mountain of Sumaj Orcko (‘Beautiful Hill’ in Quechua) is called Cerro Rico (‘Rich Hill’) by the Spaniards, who force Quechuan miners to dig about 85 percent of their entire take of Andean silver before 1650 from this one mountain.

1546 The Spanish begin exploration of Venezuela in an attempt to locate the legendary El Dorado, or ‘man of gold’. [Actually, ‘El Dorado’ was a Chibcha noble who, on assuming office, covered himself in gold dust and washed it off in a lake as an offering to the gods. He also reportedly submerged a fortune in gold and jewels as part of his offering. Later Spanish and English attempts to locate this treasure result in temporary draining of the lake and the recovery of a small amount of gold; more may lie buried in sediments.]

1546-69 Zacatec Indians are forced by the Spanish to mine silver in their own former mines near Zacatecas, Mexico. (These mines are called ‘La Bufa’ by the Spanish.) The conquistadors in this era also open other Mexican mines at Guanajuato, Taxco, Pachuca, Sombrerete, Durango and Fresnillo. Mortality of the enslaved Zacatec and Tepehuan miners is extremely high. Output of silver from all these mines eventually surpasses that of the mines at Potosí, Bolivia, after about 1650.

1553 The Peruvian Indian cultivated white potato is described for the first time by a European, Pedro de Cieza de Leon, in his **Chronicle of Peru**.

1555 Mesoamerican cultivated tobacco is introduced into Spain as a commercial product for the first time.

1558 The Portuguese introduce a powdered form of tobacco called snuff into Europe.

1560 Jean Nicot is the first to cultivate American Indian tobacco in Europe.

Bernal Díaz del Castillo, who had accompanied the expeditions of Cordova, Grijalva, and Cortés to Mexico, writes his valuable recollections of the Conquest and the Indian social customs of early Contact-era Mexico, **Historia verdadera de la conquista de la Nueva España**. It is first published only in 1632.

1565 Sir John Hawkins (knighted for his creation of England’s African slave trade with the Western Hemisphere in 1562) introduces England to Indian tobacco and sweet potatoes.

1573 Francis Drake, a protégé of Hawkins, becomes the first Englishman to see the Pacific Ocean while on a pirating expedition in Panama.

1576 Martin Frobisher finds the bay now bearing his name in modern Canada.

1577-80 Francis Drake circumnavigates the world; he is the first Englishman to sail in the Pacific Ocean. He learns that the area to the south of Cape Horn is open ocean. Following pirate raids on Spanish treasure ships and towns in Chile, Peru, Panama and Mexico, Drake is believed to have put ashore for ship repairs on the Pacific coast of North America in 1579. Evidence suggests he compels the Miwok in California to help him prepare materials and repair his ship. [Drake's career gives a great impetus to the development of a seafaring tradition among the English that assists their later colonization efforts.]

1582 Richard Hakluyt publishes his compilation of explorers' reports entitled **Divers Voyages Touching the Discovery of America**.

1584 Sir Walter Raleigh lands in Virginia, the first European to do so.

1585 John Davis is the first European to see Davis Strait between Canada and Greenland.

1587 Richard Hakluyt publishes **Notable History, Containing Four Voyages made by Certain French Captains Into Florida**.

1589 Hakluyt publishes **The Principall Navigations and Discoveries of the English Nation**. His three works are the major introduction in the English language to the knowledge gained from the Americas in his era.

1592 Juan de Fuca, a Greek exploring along the Pacific coast of North America on behalf of the Viceroy of New Spain, is the first European to voyage to what is now British Columbia. He is believed to have sighted the strait between Washington State and British Columbia that now bears his name.

1595 Walter Raleigh travels 300 miles up the Orinoco River.

1596 Tomatoes from Mesoamerica are introduced into England.

1604 King James I of England publishes his **Counterblaste to Tobacco**, condemning its use as unhealthy.

1608 John Smith of the Virginia Company, publishes **A True Relation of Virginia** with considerable observations on the land and its native people. For the most part, these are fairly described with only occasional ethnocentric assertions.

1609 Henry Hudson explores Delaware Bay and the Hudson River.

1610 Hudson locates Hudson's Strait and Hudson's Bay.

1612 John Smith produces 'A Map of Virginia'.

English colonists in Virginia make their first attempt at the commercial cultivation of tobacco.

1613 Samuel de Champlain travels up the Ottawa River as far as Allumette (modern Morrison's) Island. This was home to the Algonkin Kichesipirini tribe led by Tessouat, a powerful sachem with whom the French soon ally themselves.

1614 Adriaen Block examines Long Island Sound.

Cornelius Jacobsen Mey explores the lower Delaware River.

1616 William Baffin becomes the first European to enter Baffin Bay between Greenland and Baffin Island while searching for the Northwest Passage.

John Smith releases **A Description of New England**, a parallel to his earlier work on Virginia.

1617 Sir Walter Raleigh leads a second expedition to the Orinoco River but fails in his objective to find Spanish gold sources in the region. Raleigh is executed the following year upon his return to England.

1621 Indian potatoes are cultivated in Germany for the first time.

1624 John Smith publishes **A General Historie of Virginia, New England and the Summer Isles**, adding to his descriptions of those lands and their native peoples.

1630 Francis Higginson, a preacher of Salem, Massachusetts, publishes **New England's Plantation or A Short and True Description of the Commodities of that Country** in London. He describes the land and water resources near Massachusetts Bay, and briefly notes two examples of native technology, pine wood candles and dyes, along with mentions of some techniques of Indian land use and their trade with the colonists.

1634 Jean Nicolet arrives at Green Bay on Lake Superior and explores Wisconsin.

1639 Quinine, an alkaloid extracted from the bark of cinchona trees by Peruvian Indians and introduced to Europeans, is used to treat tropical diseases, particularly malaria. [This is the earliest documented instance of the use by Europeans of an American Indian chemical compound to control an infectious disease.]

1648 Semyon I. Dezhnev sails along the Arctic coast of Siberia through the Bering Strait to the Pacific, becoming the first European explorer to pass through the Strait.

1657 The Mesoamerican practice of drinking liquid chocolate is introduced in London by a Frenchman, the French having acquired the secret for making it from the Spanish a few decades earlier. The practice spreads quickly throughout Europe.

1659 Pierre Radisson and Médart de Grosellier reach Minnesota.

1672 The use of the Peruvian root ipecacuanha (modern 'ipecac') is introduced into Europe for control of stomach and intestinal ills.

John Josselyn publishes **New England's Rarities Discovered**, a description of some of the flora and fauna of the region.

1673 Jacques Marquette and Louis Jolliet, upon instructions from Governor Frontenac of New France, cross via portages and river passages from Green Bay to the Mississippi River at Prairie du Chien in modern Wisconsin. They and five French-Canadian voyageurs travel down the Mississippi to the mouth of the Arkansas River, documenting an accurate description of its course to that point. They are told by the Quapaw, whose main village in Arkansas they visit, that the Mississippi flows southward into the Gulf of Mexico, not westward to the Pacific Ocean as the French had hoped. They return northward after the Quapaw also inform them that the lower Mississippi is controlled by Spanish forces hostile to the French.

1674 John Josselyn publishes **An Account of Two Voyages to New-England Made during the years 1638, 1663** in London; his descriptions include many unflattering and ethnocentric views of the American Indians he encountered.

1678-79 Robert de La Salle explores the shores of the Great Lakes.

1679 The Jesuit Louis Hennepin reaches Niagara Falls.

1689 The Great Salt Lake in Utah is explored by Baron de La Hontan, a French naturalist and adventurer.

1712-24 Cotton Mather publishes a series of treatises and letters on the natural history of eastern North America, **Curiosa Americana**. One of these [1716] describes American Indian hybridizationof corn and is the first documented account of plant hybridizing, a landmark in botanical science.

1728 Vitus Behring explores the strait between Asia and Alaska that now bears his name (the 'Bering Strait').

John Bartram of Philadelphia establishes a botanical garden on a farm near that city; a great explorer, he becomes a foremost supplier of bulbs and seeds of American plants to botanical scientists in Europe. [His garden still exists as a part of the park system of Philadelphia.] He is the first European-American to hybridize American flowering plants.

1736 Rubber is first described in scientific literature by C.-M. de la Condamine and François Fresneau following their journey to South America.

1739 J. F. Gronovius publishes his study of native American plants, **Flora Virginica**.

1741 The Russian explorer Alexei Cherikov arrives in California.

1743 Sons of the French explorer and fur trader Pierre Gaultier La Verendrye come wtihin sight of the Rocky Mountains.

1748 Platinum from South American mines is sent to Europe for the first time.

1756 The first chocolate factory in Germany opens.

1765 The American Indian potato becomes the most popular food in Europe.

The first chocolate factory in British North America opens in Dorchester, Massachusetts.

1774 Ensign Juan Pérez is ordered to undertake a voyage north from the Spanish colonial port of Monterey, California to assert Spanish claims on the Pacific Northwest coast. This voyage is prompted by reports of Vitus Behring's and Alexei Chirikov's explorations. In August, Pérez anchors his frigate at Nootka Sound, initiating a period of Spanish contact with the cultures of the Northwest Coast that lasts until the end of the 18th century. He visits and makes some trades for basketry, gambling sticks and cedar and woolen clothing items among the Nootka on Vancouver Island and the Haida on the Queen Charlottes. Pérez' log and the diaries of Fr. Juan Crespi and Fr. Tomás de la Peña Savaria (chaplains) contain the first ethnographic data on these two important Northwest Coast cultures.

Many of the crew members on this and subsequent Spanish colonial voyages along the West Coast are Indians and mestizos recruited for naval service due to the lack of significant numbers of Spanish sailors in Mexico and California.

1775 Lt. Bruno de Hezeta and Lt. Juan Francisco de la Bodega y Quadra take two ships northward from Mexico, taking observations and briefly stopping at Trinity Bay in California and on the Washington coast in Quinault territory before the former returns. On his way southward, Hezeta becomes the first European-American to sight the mouth of the Columbia River, which he names Rio San Roque. Quadra continues up the British Columbia coast, eventually reaching Alaska near modern Sitka on Baranof Island. His chaplain, Fr. Benito de la Sierra, records a number of observations on the native cultures encountered on this voyage. [A brief and not-too-accurate notice of this voyage's reports is later sent from Madrid to London and hastens James Cook's departure to explore the Pacific Ocean.]

1778 On his third and final voyage, James Cook maps, visits and makes scientific collections along the Northwest coast of North America from Oregon to the Bering Strait. His ethnographic reports reveal the rich cultures of this region to readers in England and her colonies for the first time.

1779 Juan Francisco de la Bodega y Quadra returns to Alaska accompanied by another ship commanded by Ignacio Arteaga. They spend over a month in Bucareli Bay on Prince of Wales Island exploring the region. Fr. Juan Antonio García Riobo, the chaplain on this voyage, records a visit with a group which may have been either Tlingit or Haida. [His records do not specify enough distinguishing information to determine which culture the Spanish contact.]

1788 Fuchsias and hortensias are first imported into Europe from Peru.

1789 William Bartram, naturalist and son of noted American naturalist John Bartram, writes **Observations on the Creek and Cherokee**, an ethnological study of those nations. It is not published until 1853.

The Spanish send out colonizers from San Blas in Mexico to establish posts at Nootka Sound on Vancouver Island and later at Neah Bay on the northwest tip of the Olympic Peninsula. The Nootka Sound settlement eventually has 50 buildings and fortifications. The Neah Bay outpost consists of a fortified compound of 10 buildings. These, the first European settlements in the Pacific Northwest, are abandoned after 1792. While they are active, however, the Spanish outposts bring Northwest American Indian cultures into contact with Indians and mestizos from Mexico and also introduce a number of Mexican crops and building techniques into the region.

1790 George Vancouver explores extensively along the Northwest coast of North America, collecting much ethnographic and geological information. Vancouver's researches also establish the potential for trade with the American Indian cultures in the Pacific Northwest.

1791 William Bartram publishes his **Travels through North and South Carolina…**, a work on the botany and natural history of the region [extending into Georgia and Florida] which is praised by European scientists. In it, Bartram presents extensive ethnographic reports on the Cherokee, Creek and Choctaw peoples of the time. This work, printed abroad in German, Dutch and French as well as English, later influences the English poets Wordsworth and Coleridge with its romantic descriptions of the American Southeast. Bartram's ornithological report on 215 native American birds is the most complete of its time.

1793 Alexander Mackenzie becomes the first European to travel from east to west across Canada; his journal **Voyage from Montreal on the River St. Lawrence, Through the Continent of North America, to the Frozen and Pacific Oceans, in the Years 1789 and 1793** [published in 1801] contains much valuable information on the land and its Native people.

1804 Dahlias are introduced into England from Mexico and Guatemala.

1807 Alexander von Humbolt publishes the first of 30 volumes reporting his natural history studies in South America, **Voyage aux régions équinoxiales du nouveau continent, 1799-1804**.

1829 James Smithson, a British chemist and geologist, leaves a bequest leading to the later establishment of the Smithsonian Institution in Washington, D. C. [The Smithsonian eventually becomes a major center for the scientific study of American Indian cultures and their artifacts. Its scientific practices also lead to conflict with many American Indian nations over disrespectful treatment of Indian burials and sacred artifacts. See below for 1990.]

1830-48 In England, Lord Kingsborough compiles and publishes a nine-volume collection of European explorer and missionary reports on early Contact-era and pre-Columbian American Indians.

1831-36 Charles Darwin sails on the H.M.S. Beagle as a 'gentleman companion' to the ship's captain. He studies the natural history of parts of South America while on this voyage, which contributes evidence toward his theory of species evolution published in 1859.

1839 Caoutchouc, or ‘rubber’, originally developed and vulcanized by Indians in Mesoamerica and South America, becomes commercially useful to European-Americans when Charles Goodyear accidentally learns the secret of the vulcanization process.

1843 The Rocky Mountains are crossed by John C. Frémont, who seeks an overland route to California from the United States.

1846 Formal establishment of the Smithsonian Institution.

Famine strikes Ireland when the potato crop fails there.

1847 Little more than a decade after their own impoverishment following the ‘Trail of Tears’ resettlement, the Choctaw Nation raises a donation of $710 toward famine relief efforts in Doolough, Ireland.

1856 A pure extract of cocaine is first made by European chemists from Peruvian coca [*Erythroxylum coca*] leaves. [Long chewed in natural leaf form without notable ill effects by the Andean Indians to combat fatigue from high-altitude work, the isolated extract proves addictive and physiologically dangerous in its concentrated, refined form.]

1889 Susan LaFlesche, Omaha, completes her medical studies at the Woman’s Medical College of Pennsylvania, graduating at the head of her class. She becomes the first American Indian woman M.D. By the end of the year, she wins appointment as the medical officer on the Omaha reservation and serves her people as government physician for four years. Her professional focus at this time is on improving public sanitation in the Omaha towns and homes. She also frequently appears as a speaker at various ‘friends of the Indian’ associations. She eventually becomes a leading Indian temperance advocate for medical, political and moral reasons. LaFleshe marries Henry Picotte (Yankton Dakota) in 1894. Dr. Picotte, although American-trained and assimilated, actively promotes the preservation of Omaha tribal traditions and stories over the years. She subsequently is asked to serve the tribe in dealings with the federal government over land allotment policy and payments, consolidation of the Omaha reservation with that of the Winnebago, agency superintendent selection, and a host of other social matters connected to the well-being of her people. One of her last health crusades on the reservation is against diseases spread by houseflies, and she teaches many families how to take preventive steps against the insects. She dies in 1915.

Wassaja, also known as Carlos Montezuma, a Yavapai who had been captured by the Pima as a boy and sold to an Italian-American artist, completes his studies in medicine at the Chicago Medical College. He serves as a government medical officer on several reservations before returning to practice medicine in Chicago. By the turn of the 20th century, he becomes well-known as a writer, publisher and speaker defending Indian dignity, tribal sovereignty and traditional values against the colonialism and degradation of reservation life during the era of assimilation and allotment.

1906-18 Vilhjálmur Stefansson, Iceland-born ethnographer and explorer, lives with Inuit villagers for two years, learning their language and technology. Joined by Canadian zoologist Rudolph Anderson in 1908, he uses his acquired skills to travel extensively in the High Arctic, visiting and collecting information from the Mackenzie and the Copper Inuit of the Northwest Territories. The pair then extend their survey of cultures, land, and fauna from Alaska eastward to Coronation Gulf and northward to the last unknown islands of the Queen Elizabeth Archipelago. Stefansson's writings based on this experience include **My Life with the Eskimo** (1913), **The Friendly Arctic** (1921), **Unsolved Mysteries of the Arctic** (1939), and **Discovery** (posthumous, 1964).

1909 An experienced Inuit hunter and accomplished Arctic traveler named Oodaaq and three other Inuit men from Greenland guide U.S. explorer Robert Peary and his companion Matthew Henson, an African-American, on the historic first journey to the North Pole. [A tiny islet discovered in 1978 and believed to be the most northerly land on Earth is named in Oodaaq's honor.]

1911-16 Ishi, the last surviving member of the Yahi band of the Yana people in California, leaves the mountains and faces his fate among the people of the town of Oroville. He is soon befriended by anthropologists T. T. Waterman and Alfred Kroeber when they learn that he speaks an otherwise extinct dialect of Yana. Ishi is offered a home and work at the Museum of Anthropology at the University of California at Berkeley; he performs the tasks of a janitor and caretaker, but also instructs the scientists on the meaning and use of many of the artifacts in their collection, and even teaches them the living techniques of making many traditional upland California objects. His work is extensively photographed and even filmed before his death. Ishi (his name means simply 'man' in Yana) comes to be regarded as the "last Stone Age man in America."

1921-24 Inuit-Danish explorer and ethnographer Knud Rasmussen undertakes the longest recorded dogsled journey yet across the Arctic from Greenland to Point Barrow, Alaska. He contacts nearly all the Inuit cultures along his path, collecting information on their cultures and traditional migration routes. His ethnographic records are published in 1927 in **Across Arctic America**. [Rasmussen lived and studied among the Inuit from 1902 into the 1930s; he introduced reindeer culture into Greenland and founded the trading settlement of Thule there in 1910. His other major publications are **Greenland by the Polar Sea** (1919), **Iglulik and Caribou Eskimo Texts** (1930), **Intellectual Culture of the Copper Eskimos** (1932) and the three-volume **Intellectual Culture of the Hudson Bay Eskimos** (1929-30). Several volumes of his research notes on the Greenland, Alaska and Mackenzie Delta Inuit were also published posthumously.]

1942-45 Arnold Anderson, Tuscarora-Mohawk-Cayuga, works as a chemist on the Manhattan Project to help the United States develop the first atomic bomb.

1942 Mary Ross, Cherokee, becomes the first woman engineer ever to work for the Lockheed Aircraft Corporation.

1947 Thor Heyerdahl makes his 101-day voyage on the balsawood raft 'Kon-Tiki' to demonstrate the possibility that Indians from Peru had the technical capability and opportunity to have colonized the islands of the South Pacific as progenitors of the Polynesian peoples. This demonstration, a landmark in speculative anthropology and ethnology, provokes a debate among scientists who seek to understand ancient migration and possible trade patterns across the oceans.

1954 D'Arcy McNickle, Salish/Kootenai historian, publishes **The Runner in the Sun**, a novel containing a history of the development and spread of corn by American Indian farmers.

Congress transfers the Indian Health Service from the Bureau of Indian Affairs to the Public Health Service.

1956 George Blue Spruce, Laguna Pueblo, becomes the first fullblood Indian to earn the doctoral degree in dental science.

1965 Yale University Press publishes a 'Vinland Map' alleged to have been produced in Switzerland in 1440 showing the expeditions of Leif Eriksson and the Norse colonizing expeditions which followed him to North America – those of his brother-in-law Thorwald Karlsefni and his sister Freydis. [These Vikings are traditionally reported to have established a colony at a place Eriksson called Vinland, now believed to be a site in northern Newfoundland. Tests made in 1974 on the ink used in the map show it to be a forgery, and Yale University retracts its claim in that year.]

1966 Jerry Elliott, Osage-Cherokee, joins the National Aeronautics and Space Administration as a flight mission operations engineer. Over the following decade, he works on spacecraft systems, mission operations, computer systems, scientific experiment systems, flight trajectory calculations and earth support resources, serving on both the Apollo and Apollo-Soyuz mission teams.

1969 In an effort to stop damage to tideland shellfish beds and control littering and other environmental damage being done by non-Indians, the Quinault reservation closes 25 miles of its beach lands to access by non-tribal members. [In prior years, the Quinault beaches had been used by motorists for recreational driving, ocean access and as roadway to otherwise inaccessible parts of the reservation.]

Thor Heyerdahl has a team of African boat-builders assemble a replica of an ancient style of Egyptian papyrus reed boat, which he names the *Ra*. With this craft, he attempts a crossing of the Atlantic Ocean, sailing from Safi in Morocco. The point of this journey is to demonstrate the technical feasibility of trans-Atlantic voyages by the Egyptians and later African cultures. An error in duplicating the Egyptian design causes a structural failure on the *Ra*, however. Heyerdahl abandons this voyage before reaching the island of Barbados, a few days sail to the northeast of Venezuela.

1970s-present Oil from the seedpods of the jojoba plant long used by Indians in the Southwestern United States and northern Mexico becomes an increasingly popular basis for soaps, shampoos and hair conditioners. In addition, it is used as a substitute for the fine grade of oil formerly obtained from sperm whales.

1970 Aymara craftsmen from the Lake Titicaca region of Peru and Bolivia build Thor Heyerdahl a second, smaller replica of the ancient Egyptian papyrus reed boat using reeds from Lake Titicaca. Heyerdahl and his small crew succeed in sailing the *Ra II*, as this craft is known, across the Atlantic from Morocco to a landfall on Barbados in the West Indies. Heyerdahl publishes the account of his two trans-Atlantic voyages in 1971 in a book entitled **The Ra Expeditions**.

Jerry Elliott, Osage-Cherokee, helps bring home the crippled Apollo 13 spacecraft while serving in NASA as the retrofire officer. For his role in rescuing this mission, he is later awarded the Presidential Medal of Freedom Certificate.

1971-74 Outraged by continuing inadequate Bureau of Indian Affairs administration of timber harvests on the Quinault reservation in Washington State, tribal chairman Joe Delacruz and other tribal members blockade the access road leading to the logging site. [The Bureau of Indian Affairs had let contracts for the cutting of Quinault timber to outside corporations beginning in the 1940s, but had failed to regulate illegal clear-cutting, see to the implementation of a promised reforestation program and to properly account for funds owed to the tribe as a result of the harvest of its timber resources. The clear-cutting of the Quinault cedar stands nearly completely wiped out these important trees on the reservation. Poor forestry practices by the firms cutting the timber also led to the devastation of the salmon-spawning streams on the reservation.] Through lawsuits and negotiations, Delacruz and the Quinault government are ultimately able to force significant changes in the way in which the BIA-leased harvests of Quinault timber are managed. Clear-cutting on the reservation is ultimately banned. The Quinault Nation takes control of supervision over the remaining contracted harvests. They also start their own tribally-controlled timber industry, including a tribal sawmill. Reforestation and salmon stream rehabilitation efforts are also begun on the reservation as a result of this tribal activism.

1971-present The provincial government of Quebec, Canada, announces its plans for a huge hydroelectric project in the Inuit and Cree territories around James Bay and Hudson's Bay. The development plan calls for dams and flooding that affect twenty major river systems. The Cree and the Inuit organize political and legal resistance to the development of this project, but are eventually defeated in the provincial and national parliaments and court systems. The resulting settlement forces thousands of Indians and Inuit off their traditional homelands and hunting grounds. The first phase of the construction by Hydro-Quebec, known as James Bay I, is completed in 1985 and drowns over 6,000 square miles of Cree and Inuit lands on three river systems. James Bay II is currently in the planning stages of its development. Cree and Inuit resistance to further development of the James Bay Project continues as the adverse environmental and cultural impacts of the first phase become clearer. These include a devastating rise in the release of mercury into the water from ores covered by the lakes behind the dams. [Bacteria feeding on rotting vegetation in the lakes interact with the mercury dissolved in the water to produce methyl mercury. The methyl mercury evaporates and is later redeposited onto the land and other water systems by rain. There it enters the food chain and builds up in the tissues of fish, animals, and the Cree Indians and Inuit who eat them.]

1973 Dr. Frank Dukepoo, a geneticist and the first Hopi to earn the Ph. D., joins the faculty of San Diego State University. His researches over the next several years include studies into the genetic bases of aging (especially among minority populations), correlations between alcoholism and ethnic background, and into certain characteristics of geneticists' classic study animal, the fruitfly. His published works earn him wide professional respect and positions on several important national, tribal and professional advisory bodies.

1974 Dr. Marigold Linton, a Cahuilla-Cupeño from Morongo Reservation in

California and a psychologist, leaves a full professorship at San Diego State University to work on research on long-term memory as a professor of psychology at the University of Utah. She continues work with developing Indian education programs, especially for gifted Indian children. [Dr. Linton later also becomes a contributing editor to the *Journal of California Anthropology*.]

1975 Twenty-five tribes organize the Council of Energy Resource Tribes (CERT) to coordinate tribal policies and practices relating to energy development on their reservations. CERT is partially funded by the federal Department of Energy. Often called the 'Indian OPEC', the council eventually grows to a membership of 43 tribes. CERT's principal function is to seek greater Indian control over Department of the Interior energy resource extraction policies and leasing practices in order to preserve reservation resources and obtain a return to the tribes that is closer to world market prices for energy resources. CERT also presents a united front in tribal dealings with non-Indian energy corporations, whose practices on the reservations are believed by many Indians to present serious long-term health and environmental threats to Indian ways of life. By the late 1980s, CERT and its member tribes are also increasingly involved in engineering work on hazardous waste cleanup projects at mining sites, nuclear materials extraction facilities, and waste disposal sites on a number of reservations.

1976 The Indian Health Care Improvement Act is passed by Congress to provide increased levels of funding over seven years for tribal health clinics and the Indian Health Service.

1977 American Indian scientists and technical professionals establish the American Indian Science and Engineering Society. Headquartered in Boulder, Colorado, this national organization begins a multifaceted program of support and promotion for Indian science and engineering professionals and students.

Kevan Green, Mohawk-Onondaga and a chemical engineer, is named New York State's Small Businessman of the Year for his achievements in polymer resin design and manufacturing.

1978 James Williamson, an Ojibwe engineer whose work includes directing the design of solar electricity power systems for the Voyager and Viking space probes as well as the large experimental solar power system near Barstow, California, is appointed to the Domestic Policy Review Panel for Solar Research by President Jimmy Carter.

Walton Youngblood, a Tewa and an environmental scientist, serves in the New Mexico State Environmental Protection Agency as regional services director for Health and Social Services, one of the top field posts in that organization.

1979 O. Tacheeni Scott, Navajo, becomes the first American Indian to earn a doctorate in microbiology.

Over half the United States' annual production of uranium is coming from mines on Navajo and Pueblo tribal lands in New Mexico. The largest open pit uranium mine in the world is at Mt. Taylor on lands belonging to the people of Laguna Pueblo. The actual miners in these operations on the Southwestern reservations are local Indians for the most part. They are dying of radiation-induced lung cancers at greatly disproportionate rates.

1989 As part of the official celebration of the centennial of Washington State, Indians from 17 Washington tribes and the Bella Bella tribe of British Columbia employ the techniques of crafting the traditional Northwest ocean-going canoe. As a focus of this revival effort, 20 new or restored cedar canoes converge at the former site of a longhouse built by Duwamish Chief Sealth's (also known as 'Chief Seattle') brother on the Suquamish reservation. From there they stage a mass canoe crossing of Puget Sound, the 'Paddle to Seattle'. The Quileute Nation of the Washington coast sends a canoe which paddles 160 miles from their community of LaPush to central Puget Sound. The Bella Bella, residents of the B.C. coast north of Vancouver Island, provide a modern demonstration of the sea-worthiness of the traditional cedar canoe by paddling over 450 miles to join the celebration.

1990 The American Indian international organization COICA ('Coordinating Body for Indigenous Peoples of the Amazon Basin') holds its first environmental conference in Quito, Peru. COICA consists of national and tribal representatives of Indian peoples from Peru, Colombia, Bolivia, Ecuador and Brazil. The conference establishes the involvement of the Indian organization with the regional activities of environmental groups including Friends of the Earth, Oxfam America, the Worldwide Fund for Nature and Greenpeace. The joint efforts of COICA and these organizations are coordinated to make use of native management techniques and manpower in protecting the Amazonian rainforest and reducing timber cutting and burning in the Amazon Basin.

U.S. President George Bush signs into law the Native American Graves Protection and Repatriation Act, Public Law 101-601. This federal statute places restrictions on the removal and holding of American Indian human remains and funeral objects. It affects public museums and federally-funded private collections holding such remains. The act has provisions for repatriation (return) of burial remains to the tribes, along with penalties for illegal trafficking in American Indian human remains. The Smithsonian

Institution long opposed the principles of this act but announces it will comply by contacting tribes and setting up procedures for the identification and return of American Indian human remains and objects taken from Indian burials.

The Canadian government of Prime Minister Brian Mulroney, in reducing federal support to provincial governments and Indian organizations, cuts $20 million from the Indian and Inuit Health Program of Health and Welfare Canada. Federal budget cuts, combined with provincial government reductions of support for education, are also expected by the president of the Association of Universities and Colleges of Canada to significantly reduce the number of Native Canadian science and medical students attending college.

1991 The White House Council on Environmental Quality, in its 1991 Report to President Bush, states that approximately 500 plant and animal species have become extinct in North America since the arrival of Christopher Columbus in 1492.

Venezuelan President Carlos Andrés Pérez decrees the setting aside of 30,000 square miles in the headwaters region of the Orinoco River as a 'biosphere reserve'. His stated intention is to protect the Yanomamo villages in the area along with the biological diversity of the fragile jungle ecosystem. However, the decree does not recognize the autonomy of the Yanomamo or their land rights. It leaves in place Constitutional provisions and earlier Venezuelan laws that encourage missionary control over the tribes as well as resource development in the upper Orinoco region. [The Yanomamo have experienced increasing development pressures in the area since the 1960s. Their successful management of the delicate rainforest ecosystem has been increasingly disrupted by illegal beef cattle ranching, mineral exploration by corporations and military patrols in this area which borders Brazil.]

1992 Environmental groups join the tribal council and members of the Western Shoshone Nation in demonstrating against continued nuclear weapons testing at the Nevada Nuclear Test Site north of Las Vegas. Shoshone leaders declare their people to be "the most bombed nation on earth" as a result of the many above-ground and underground nuclear explosions since 1951 (averaging more than one dozen per year) held on Shoshone lands guaranteed by the Ruby Valley Treaty of 1863.

American Indian governments and international Indian environmental organizations publicly protest against their exclusion from the treaty negotiations at the 'Earth Summit' in Rio de Janeiro, Brazil. Their demands for full and equal participation in the environmental talks on proposed international accords is supported by famed oceanographer

Jacques Yves Cousteau and many of the represented environmental organizations.

The Grand Council of the Cree are joined by the Canadian environmental group Probe International in winning an international hearing about two of the proposed components of the huge hydroelectric power project being developed in the Hudson's Bay region by Hydro Quebec. The International Water Tribunal, a division of the International Court of the Hague, agrees to examine environmental impacts of the Great Whale Project and the Nottaway-Broadback and Rupert Projects. Between them, these components of the James Bay Project hydroelectric development will require the flooding of 3,500 square miles of Cree lands. Hydro Quebec refuses to attend and present its side of the matter at the February hearing of the Tribunal.

APPENDIX B AMERICAN INDIAN PHARMACEUTICALS

Some Important American Indian Pharmaceutical Plants

Indian or Common **Name**	***Scientific Name***	**Used As or in Treating**
alumroot	*Heuchera americana*	astringent (stops bleeding, dries up ulcerated tissues and excess mucus)
annedda white pine, hemlock	*various species*	cambium (inner bark) treats scurvy (Vitamin C deficiency; James Lind read Jacques Cartier's account of this use to guide him to the 'discovery' of Vitamin C)
ash tree	*Fraxinus americana, other species*	cambium an astringent; antidote for rattlesnake bite; relief of insect bite itching
balsam fir	*Abies balsamea*	pitch is used to relieve a range of respiratory problems; antiseptic treatment for external sores and cuts
Balsam of Peru	*Myroxylon pereirae*	external antiseptic; kills skin parasites
birthroot	*Trillium erectum*	relief of pain in childbirth
blackberry	*Rubus villosus*	roots boiled to treat several stomach and intestinal problems including dysentery
blue flag	*Iris versicolor*	root as remedy for sores on legs; emetic; earache treatment; cholera treatment
boneset	*Eupatorium perfoliatum*	fevers; stimulant; tonic (improves nervous system function); emetic
butterfly weed or pleurisy root	*Asclepias tuberosa*	respiratory problems; expectorant (clears phlegm); fevers; pleurisy

Indian or Common **Name**	***Scientific Name***	**Used As or in Treating**
cascara	*Rhamnus purshiana*	most commonly used laxative in the world
coca	*Erythroxylon coca*	source of cocaine and several other alkaloids; suppresses hunger; improves oxygen uptake at high altitudes; anesthetic used in trephination; leaves provide flavoring in soft drinks
cocoa	*Theobroma cacao*	seeds are the source of chocolate, a nerve tonic and mild stimulant much used by Aztec (and now the world!) as a beverage and flavoring
cohosh blue cohosh	*Caulophyllum thalictroides*	menstrual difficulties; relief of pain in childbirth
cotton	*Gossypium hirsutum*	fiber for bandaging; seeds and oil for nephritis; root and bark for easing childbirth and as abortifacient
curare	*Chondodendron species*	powerful muscle relaxant and surgical anesthetic; used in hunting as poison
creosote bush	*Larrea mexicana*	stomach problems; diarrhea; cancer; respiratory problems
dogwood	*Cornus species*	bark used against malaria; aches and fevers generally
elm (slippery elm)	*Ulmus fulva*	cambium valuable against inflammations, wounds, ulcers; usually mixed with other herbs, it supports their action
garlic	*Allium canadense*	this native garlic, like the European (and like onions and leeks) good against viral infections
ginseng	*Panax cinquefolium*	tonic; supports the stomach and reproductive system of both sexes; extremely popular export to Asia

Indian or Common **Name**	***Scientific Name***	**Used As or in Treating**
guaraná	*Paullina cupana*	seeds provide a popular, caffeine-rich beverage
ipecacuanha ipecac	*Cephalaelis ipecacuanha*	amoebic dysentery; popular and powerful general emetic
kelp	*Macrocystis species*	goiter; iodine source
lobelia	*Lobelia inflata*	intestinal worms; syphilis; fevers; emetic; stimulant; muscle relaxant
magnolia	*Magnolia species*	bark used to treat colds, itching, skin lesions, fevers
maize corn	*Zea mays*	intestinal, bladder and kidney problems; lactation difficulties; skin rashes and wounds
mint	*various genuses in the family of mint plants*	some native and some naturalized; most used to treat colds, fevers, body aches
mizquitl mesquite	*Prosopis juliflora*	eye lotion
oak	*Quercus species*	native oaks long used for antiseptics (as well as food)
Oregon grape or mahonia	*Berberis aquifolium*	bark or root as tonic; blood purifier; appetite stimulant; relieves gastric distress
pine	*Pinus species*	cambium and resins effective as an antiseptic in serious external wounds; respiratory infections
pinkroot	*Spigelia marilandica*	intestinal worms

Indian or Common **Name**	***Scientific Name***	**Used As or in Treating**
pipsissewa wintergreen	*Chimalphia umbellata*	astringent; eases stomach troubles; used to promote sweating in various diseases; relieves pain
poke green hellebore; also the different plant known as American nightshade	*Veratrum viride* *also Phytolacca decandra*	Hellebore: scurvy sores (external use); kills lice; reduces heart rate and blood pressure Nightshade: root treats inflammations, fevers, pains; berries treat rheumatism
poplar also cottonwoods	*Populus species*	bark contains aspirin-like substances good against pain, fevers
puccoon bloodroot	*Sanguinaria canadiensis*	powerful emetic (provokes vomiting in cases of accidental poisoning)
pumpkin	*Cucurbita pepo*	seeds expel worms and other intestinal parasites
quina-quina or **chinchona** quinine bark	*Cinchona sp.*	malaria, fevers, heart disorders, cramps, chills
raspberries	*Rubus species*	roots for stomach pains, eye aches; leaves are astringent and an excellent source of Vitamin C; fruit used to flavor other medicines
sage or wormwood	*Artemisia species*	not the *Saliva* of Europe and parts of the Americas; sacred plant used in many ceremonies; sweatlodge; heals wounds
sarsaparilla	*Aralia nudicaulis*	root bark used as tonic; flavoring with other medicines, cough syrups, soft drinks
sassafras	*Sassafras officinalis*	bark treats fevers, thins blood, flavors soft drinks and soups (filet gumbo)

Indian or Common **Name**	***Scientific Name***	**Used As or in Treating**
vanilla	*Vanilla planifolia*	used by the Aztec for flavoring chocolate and in a medicinal compound; currently a component of the pharmaceutical kaomin
wild cherry also choke cherry	*Prunus virginiana and P. serotina*	bark and stems useful in treating fevers, worms, diarrhea, sore eyes, pains in childbirth, respiratory problems
wild ginger	*Asarum canadense*	emetic; heart palpitations and pains; emmenagogue (eases painful or difficult menstruation); flavoring; strengthens stomach; ear ache
willows	*Salix species*	fevers, headache; provides salicin, a form of aspirin
witch hazel	*Hamamelis virginiana*	eye inflammations; soreness in muscles and joins; astringent; relieves pain; hemorrhoids
yerba santa	*Eriodictyon californicum*	rheumatism; paralysis, respiratory problems; stomach problems; syphilis

REFERENCES

Science Chronology

Adler, Mortimer J. (ed.), **The Annals of America.** Chicago: Encyclopædia Britannica, Inc., 1976.
Akwesasne Notes , the official publication of the Mohawk Nation of Akwesasne. Akwesasne, NY: Mohawk Nation, various editions from 1988-90.
Arvelo-Jiménez, Nelly and Cousins, Andrew, “False Promises” in *Cultural Survival Quarterly*, vol. 16, no.1, Winter 1992, p. 10-13, an article on the decree of a Venezuelan “biosphere reserve.”
Brotherston, Gordon, **Image of the Western Hemisphere: The American Continent Portrayed in Native Texts.** London: Thames and Hudson, 1979.
Coe, Michael D., **Mexico.** London: Thames and Hudson, Inc., 3rd edition, 1984.
Editors, “Cultural Survival Canada” in *Cultural Survival Quarterly*, vol. 16, no.1, Winter 1992, p. 8, on the challenge of Cree leaders to Hydro Quebec developments.
Edmunds, R. David (ed.), **Studies in Diversity: American Indian Leaders.** Lincoln: University of Nebraska Press, 1980.
Funches, Peggy (ed.), **Minority Contributions to Science, Engineering and Medicine**. San Diego: San Diego City Schools, 1978.
Gallant, Roy A., **Ancient Indians: The First Americans.** Hillside, N.J.: Enslow Publishers, Inc., 1989.
Goetz, Philip (ed.), **The New Encyclopædia Britannica.** Chicago: Encyclopædia Britannica, Inc., 1988 (15th Edition).
Grun, Bernard, **The Timetables of History.** New York: Simon and Schuster, 1979.
Lancaster, John, “A New Approach to Saving Creatures Great and Small” in *The Washington Post Weekly Edition*, vol. 8, no. 41, August 12-18, 1991 edition, p. 38, citing the White House Council on Environmental Quality **1991 Report**.
Moses, L.G. and Wilson, Raymond (eds.), **Indian Lives: Essays on Nineteenth- and Twentieth-Century Native American Leaders.** Albuquerque: University of New Mexico Press, 1985.
Native Monthly Reader. Crestone, CO.: International Traditional Education Systems, Inc., various editions, 1990-91.
Noble, David Grant, **Ancient Ruins of the Southwest: An Archaeological Guide.** Flagstaff: Northland Press, 1981.
Olien, Michael, **Latin Americans: Contemporary Peoples and Their Cultural Traditions.** New York: Holt, Rinehart and Winston, Inc., 1973.
Schele, Linda and Freidel, David, **A Forest of Kings**. New York: William Morrow and Company, Inc., 1990.
Smith, Alan H. (ed.), **Encyclopedia Americana International Edition.** Danbury: Grolier Inc., 1984.
Stewart, Hilary, **Artifacts of the Northwest Coast Indians.** Vancouver, B.C.: Hancock House Publishers Ltd., 1973, 1981.

Thornton, Russell, **American Indian Holocaust and Survival: A Population History Since 1492.** Norman: University of Oklahoma Press, 1987.
Waldman, Carl, **Atlas of the North American Indian.** New York: Facts on File Publications, 1985.
Weatherford, Jack, **Indian Givers: How the Indians of the Americas Transformed the World.** New York: Crown Publishers, Inc., 1988.
Winds of Change, the quarterly journal of the American Indian Science and Engineering Society. Boulder: AISES Publishing, Inc., various editions 1989-1992.
Yenne, Bill, **The Encyclopedia of North American Indian Tribes.** New York: Crown Publishers, Inc., 1986.

Footnotes

[F]**ootnotes**

[1]For several views on various forms of the Medicine Wheel and its symbolic interpretation, see De Mallie, Raymond, **The Sixth Grandfather.** Lincoln: University of Nebraska Press, 1984, p. 40, 48, 84-86, 114-123, 131-134, 136-137, 208, 215-225, 237-240, 392-393; see also Lame Deer, John and Erdoes, Richard, **Lame Deer Seeker of Visions**. New York: Washington Square Press, 1972, p. 100, 105; also see Weltfish, Gene, **The Lost Universe.** New York: Ballantine Books, 1965, p. 136, 308-316. There are numerous other interpretive texts and references available; none are exhaustive.
[2]For an expression of the similarities between traditional American Indian philosophy and the view of reality held by modern physicists, see Simonelli, Richard, “The Longest Road”, *Winds of Change*. Boulder: AISES Publishing, Inc., vol. 4, no. 4 (autumn, 1989), p. 13-21; also consider the description of “The New Physics” in the chapter of that name in Capra, Fritjof, **The Turning Point.** New York: Bantam Books, 1983, p. 75-97.
[3]Deloria, Vine, “Traditional Technology”, *Winds of Change*. Boulder: AISES Publishing, Inc., vol. 5, no. 2, p. 13-17. A useful book for those teachers who would like to begin to study some of the many Indian cultural tradtions that are the context for “meaning: as it is known to Indian people is Peggy Beck and Anna Walter’s **The Sacred: Ways of Knowledge, Sources of Life**. Tsaile, Navajo Nation: Navajo Community College Press, 1977. Also useful but limited by an outsider perspective is Ruth Underhill’s **Red Man’s Religion**. Chicago: University of Chicago Press, 1965.
[4]McNickle, D’Arcy, **They Came Here First**. New York: Perennial Library, 1949, 1975, p. 50.
[5]Weatherford, Jack, **Indian Givers: How the Indians of the Americas Transformed the World.** New York: Crown Publishers, Inc., 1988, p.71 for the proportion figure; the weight figure is an approximation computed by the author from the often-lumped data for several years in the late 1980’s on 30 major food crops, as provided in the *Annual Report* of the United Nations Food and Agriculture Organization. Some authors have reported the contribution by weight of American Indian-derived foods at percentages as high as 75% of the world’s annual total.
[6]Fadden, Ray, “Tehanetorens - Ray Fadden on the Indian Contributions to the World” , *Akwesasne Notes*, the official journal of the Mohawk Nation. Rooseveltown, N.Y.: Mohawk Nation, vol. 18, no. 4, Summer, 1986. Also Weatherford, p. 100-115.
[7] Weatherford, p. 100-115; Braudel, Fernand, **The Structures of Everyday Life: Civilization and Capitalism, 15th-18th Century, Volume 1.** New York: Harper & Row, Publishers, 1981, p. 158; see also the chapter by Max Schmidt “Comments on Cultivated Plants and Agricultural Methods of South American Indians” in Lyons, Patricia J. (ed.), **Native South Americans.** Boston: Little, Brown and Co., 1974, p. 60-68.

[8]Weatherford, p. 70, 72; see also the discussion in Thornton, Russell, **American Indian Holocaust and Survival: A Population History Since 1492.** Norman: University of Oklahoma Press, 1987, p. 56-57 for the impact of the potato elsewhere in Europe.
[9]Weatherford, p. 73; Braudel, p. 166-167; Thornton, p. 57.
[10]Weatherford, p. 72, 74; Braudel, p. 167.
[11]Weatherford, p. 72, 74-75: Braudel, p. 167. Henry Dobyns, in his **Native American Historical Demography** (Bloomington: Indiana University Press, 1976, p. 6) , says that the introduction of Native American foodstuffs into Asia resulted in a tripling of the Asian population between 1650 and 1850.
[12]Weatherford, p. 82-84; Schmidt in Lyons, *op. cit.*, p. 64.
[13]Weatherford, p. 83.
[14] Weatherford, p. 83.
[15] Weatherford, p. 82.
[16]Weatherford, p. 84-85.
[17]See the article by Robert L. Carneiro in Lyons, p. 73-91.
[18]Carneiro in Lyons, p. 79.
[19]Weatherford, p. 88.
[20] Coe, Michael, **Mexico.** New York: Thames and Hudson, Inc.; 3rd edition, 1984, p. 150-151.
[21]Schmidt in Lyons, p. 65.
[22] Coe, p. 156.
[23] Weatherford, p. 88-89.
[24]Weatherford, p. 59-62.
[25]Schmidt in Lyons, p. 65-66.
[26] Weatherford, p. 42-46.
[27]Weatherford, p. 57.
[28]Weatherford, p. 63; Braudel, p. 167. Weatherford notes that his research shows that the Andean Indians had developed over 3,000 varieties of the potato crop by the time of Contact; Braudel is surely in error in claiming that Pre-Columbian America had only "five or six varieties of potato" (p. 172).
[29]Weatherford, p.41.
[30]Weatherford, p. 66-70; Braudel argues that population growth was already underway in northern and eastern Europe at the time of the introduction of the potato, and that it may have been only one of the causes supporting that growth (p. 167-168).
[31]Weatherford, p. 42-43; Braudel, p. 314-315, 326-327.
[32]Weatherford, p. 43-44.
[33]Weatherford, p. 55.
[34]Cardini, Franco, **Europe 1492.** New York: Facts on File, Inc., 1989, p. 194, 196.
[35]Weatherford, p. 45-46; see also Braudel, Fernand, **The Wheels of Commerce: Civilization and Capitalism 15th-18th Century, Volume 2.** New York: Harper & Row, Publishers, 1981, p. 169.
[36]Weatherford, p. 46.
[37]Weatherford, p. 46-47.
[38]Weatherford, p. 47.
[39]Weatherford, p. 48.
[40]Weatherford, p. 64.
[41]Weatherford, p. 90.
[42] Weatherford, p. 91.
[43]Braudel, p. 341; **Encyclopaedia Britannica**, XVth Edition, Vol. 12, p. 353-354.
[44] Weatherford, p. 94; Lyons, p.26, 105.
[45]Lame Deer and Erdoes, p. 93.
[46]Noble, David Grant, **Ancient Ruins of the Southwest: An Archaeological Guide.** Flagstaff: Northland Press, 1981; see pages 13, 33, 44-45, 93, 118, 138, 143.

[47] Cronon, William, **Changes in the Land: Indians, Colonists, and the Ecology of New England.** New York: Hill and Wang, 1983, p. 29-30. See also Weatherford, p. 84. Also consult Boag, Peter, “The Valley of the Long Grasses”, in *Old Oregon*; Eugene: University of Oregon, vol. 72, no. 2, Winter 1992, p. 18-22 on the Kalapuyas' use of controlled buring in the Willamette Valley of Oregon. David Buerge, Seattle historian, confirms that the practice was used in the Puget Sound country as well [personal communication to the author, 1983].
[48] Haines, Francis, **The Buffalo**. New York: Thomas Y. Crowell Company, 1970, p. 66-69; ; see also Grinnell, George Bird, **The Cheyenne Indians**. Lincoln: University of Nebraska Press, 1972, Vol. I, p. 264-265.
[49] Haines, p. 67-68; see also Grinnell, p. 266.
[50] Haines, p. 84.
[51] Grinnell, p. 267.
[52] Hoebel, E. Adamson, **The Cheyennes: Indians of the Great Plains.** New York: Holt, Rinehart and Winston, 1978, p. 69-70.
[53]An excellent source on the fishing techniques of the Northwest Coast is Hilary Stewart's **Indian Fishing: Early Methods on the Northwest Coast.** Vancouver: Douglas & McIntyre Ltd., 1977.
[54]Deneven, William, “Campa Subsistence in the Gran Pajonal, Eastern Peru”, in Lyons, p. 105.
[55]Waldman, p. 56.
[56]Utley, Robert, **The Indian Frontier of the American West, 1846-1890** Abluquerque: University of New Mexico Press, p. 239-240.
[57]Utley, Robert, p. 240 and see the *Annual Reports* of the Commissioner of Indian Affairs for the 1880s.
[58]Olien, Michael, **Latin Americans: Contemporary Peoples and Their Cultural Traditions.** New York: Holt, Rinehart and Winston, Inc., 1973, p. 91.
[59]Aveni, Anthony F., “Concepts of Positional Astronomy” in Aveni, Anthony (ed.), **Native American Astronomy**. Austin: University of Texas Press, 1977, p. 16-17, 19.
[60]Aveni, in Aveni,p. 15-16.
[61]Aveni, in Aveni, p. 17-18.
[62]Aveni, in Aveni, p. 15-16, 19.
[63]Eddy, John, “Medicine Wheels” in Aveni, p. 149-150, 153.
[64]Eddy, in Aveni, Anthony, p. 159.
[65]The Association on American Indian Affairs, a national Indian rights organization, reports in its journal *Indian Affairs* (Winter-Spring 1992, p. 4-6) that the U.S. Forest Service proposed in 1991 to develop the Big Horn Medicine Wheel as a tourist site and to conduct logging activities nearby. Either activity would seriously impair the integrity of the site for its traditional scientific and religious purposes. However, in January 1992, after turning down previous requests for consultation over a five year period, the Forest Service agreed to include representatives of the Medicine Wheel Coalition in future negotiations regarding plans for the use and development of this important sacred and scientific site that has long served the Cheyenne, Shoshone, Arapaho, Lakota and Blackfeet peoples.
[66]Eddy, in Aveni, Anthony, p. 159.
[67]Eddy, in Aveni, Anthony, p. 149-153.
[68]Wedel, Waldo, “Astronomy and the Plains Caddoans” in Aveni, Anthony, p. 140-144.
[69]Williamson, Ray, Fisher, Howard and O'Flynn, Donnel, “Anasazi Solar Observatories” in Aveni, Anthony, p. 205-207.
[70]Williamson, Fisher and O'Flynn, in Aveni, p. 207-212.
[71]Williamson, Fisher and O'Flynn, in Aveni, p. 213-214; see especially the table of alignments presented on p. 214 as Table 14.1.
[72]Krupp, Edwin , **Echoes of the Ancient Skies: The Astronomy of Lost Civilizations**. New York: Harper & Row, Publishers, 1983, p. 238-241
[73]Zuidema, R. Thomas, “The Inca Calendar” in Aveni, p. 220-221. He referes to a paper in Spanish that he published in 1976 on the details of the sucanca which I am not competent to examine; this 1976 paper will likely be of interest to the bilingual or Spanish-speaking science teacher who needs to understand the astronomical practices of the Inca in greater detail.
[74]Zuidema, in Aveni, p. 226-227.

[75]Kidder, Alfred, in Jennings, Jesse D. and Norbeck, Edward (eds.), **Prehistoric Man in the New World.** Chicago: University of Chicago Press, 1964, p. 463; Coe, p.81; Noble, p. 15.
[76]Kidder in Jennings and Norbeck, p. 458.
[77]Armillas, Pedro in Jennings and Norbeck, p. 305.
[78]See the recruiting advertisement placed by the Lockheed Corporation on page 41 of *Winds of Change* magazine, vol 6, no. 2, Spring 1991 edition.
[79]The foregoing description of Hohokam canals comes principally from Noble, p. 15-23; see also the brief mention given by Reed, Erik in Jennings and Norbeck, p. 182.
[80]Kidder in Jennings and Norbeck, p. 458.
[81]Kidder in Jennings and Norbeck, p. 463.
[82]Kidder in Jennings and Norbeck, p. 465-466.
[83]Kidder in Jennings and Norbeck, p. 467-468.
[84]Kidder in Jennings and Norbeck, p. 470. See also Brundage, Burr, **Lords of Cuzco.** Norman: University of Oklahoma Press, 1967, 1985, p. 89.
[85]Brundage, p. 88-92.
[86]Brundage, p. 222-223.
[87]Coe, p. 81.
[88]Coe, p. 92; he indicates that some estimates of the peak population of Teotihuacan run as high as 200,000 inhabitants.
[89]See the discussion of Sanders' arguments and the evidence for irrigation in Armillas in Jennings and Norbeck, p. 305 and in Coe, p. 100-101.
[90]Coe, p. 100-101.
[91]Armillas in Jennings and Norbeck, p. 321.
[92]Coe, p. 151.
[93]Coe, p. 148.
[94]Armillas in Jennings and Norbeck, p. 324 and Coe, p. 150.
[95]Wauchope, Robert, in Jennings and Norbeck, p. 332.
[96]Gallenkamp, Charles, **Maya.** New York: Viking Penguin, Inc., 1959, 1985, p. 82; also Morley, Sylvanus, **The Ancient Maya.** Stanford: The Stanford University Press, 1956, p. 77, 264-265.
[97]Morley, p. 264-265.
[98]Gallenkamp, p. 82.
[99]Wauchope in Jennings and Norbeck, p. 348.
[100]Ekholm, Gordon, in Jennings and Norbeck, p. 493-495.
[101]McClintock, Walter, **The Old North Trail.** Lincoln: University of Nebraska Press, 1910, 1968, p. 3, 434-437.
[102]Weatherford, p. 246.
[103]Waldman, Carl, **Atlas of the North American Indian.** New York: Facts on File Publications, 1985, p. 179-181.
[104]Waldman, p. 179.
[105]Brundage, p. 73-74, 77.
[106]Brundage, p. 150-154.
[107]**Encyclopaedia Britannica**, XVth Edition, Vol. 6, p. 277b.
[108]Weatherford, p. 244.
[109]Brundage, p. 168, 173.
[110]Weatherford, p. 243-244.
[111]Brundage, p. 33, 109.
[112]Gallenkamp, p. 83.
[113]Gallenkamp, p. 83.
[114]Morley, p. 309-311.
[115]Numerous examples of ocean-goingdugout canoes are in museum collections; dozens are still in use and more arebeing built today by tribal craftsmen. The Chumash boats are known only from fragmentary archaeological remains. The design of the Inuit kayak has been copied into other materials and is a popular recreational craft around the world; the original design and materials are still in use in the Arctic, principally for seal hunting. The umiak, called a baidar by the Aleuts and a bidarki by the Russians, once

commonly used across the Arctic from Greenland to Siberia, now numbers less than 100 examples in use in Alaska, the Aleutians and Siberia, according to scholars. The capacities of some of these oceanic canoes and skin boats are impressive; a large Greenland umiak of the mid-1700s measured 60 feet in length and could carry 12 tons. See Bruemmer, Fred, "Last of the Umiaks" in *Natural History*. vol 101, no. 10, October 1992, p. 40-47.
[116]Waldman, p. 10.
[117]Coe, p. 118-119.
[118]Gallenkamp, p. 192-193.
[119]Gallenkamp, p. 194; Coe, p. 126.
[120]Kidder in Jennings and Norbeck, p. 458-463.
[121]Kidder in Jennings and Norbeck, p. 476-477.
[122]Coe, p. 121.
[123]Kidder in Jennings and Norbeck, p. 466.
[124]Waldman, p. 55; also see Waldman, Carl, **Encyclopedia of Native American Tribes**. New York, Facts on File Publications, 1988, p. 63.
[125]Stewart, Hilary, **Cedar.** Seattle: University of Washington Press, 1984, p. 49.
[126]Stewart, **Cedar**, p. 48.
[127]Stewart, **Cedar**, p. 50.
[128]Costo, Rupert, **The American Indian Reader: History.** San Francisco: The Indian Historian Press, Inc., 1974, p. 8-9.
[129]Axtell, James, **The Invasion Within.** New York: Oxford University Press, 1985, p. 72-73.
[130]Waldman, **Atlas of the North American Indian**, p. 55.
[131]Olien, p. 281.
[132]Cardini, Franco, **Europe 1492**. New York: Facts on File Publications, 1989, p. 66-69.
[133]Olien, p. 281.
[134]quoted in Coe, p. 149.
[135]Coe, p. 149-151.
[136]Olien, p. 29.
[137]Davies, Nigel, **The Aztecs.** Norman: University of Oklahoma Press, 1973, p. 37-40, 48, 52-53, 58.
[138]Coe, p. 90-91.
[139]Olien, p. 195.
[140]Olien, p. 195.
[141]see a portion of the drawing in Highwater, Jamake, **Many Smokes, Many Moons: A Chronology of American Indian History Through Indian Art.** Philadelphia: J.B. Lippincott Company, 1978, p. 70.
[142]Kopper, Philip, **The Smithsonian Book of North American Indians Before the Coming of the Europeans.** Washington, D.C.: Smithsonian Books, 1986, p. 150-154.
[143]Brudage, p. 150-152.
[144]an introduction to the ruined sites in the Southwest is Noble, *op. cit.* ; a source for reference to the living communities is Swanton, John, **Indian Tribes of North America.** Washington, D.C.: Smithsonian Books, 1984. There are numerous sources for information on particular Pueblo communities; two used in researching the comments here include Page, Susanne and Page, Jake, **Hopi.** New York: Harry N. Abrams, Inc., Publishers, 1982, and Dozier, Edward, **Hano: A Tewa Indian Community in Arizona.** New York: Holt, Rinehart and Winston, 1966.
[145]Weatherford, p. 49.
[146]Narrative in *Taking Tradition to Tomorrow*, a video documentary produced by the American Indian Science and Engineering Society. Boulder: American Indian Science and Engineering Society, 1988.
[147]Weatherfor, p. 187.
[148]Weatherford, p. 49-52; Braudel, p. 326-327.
[149]See Vogel, Virgil, **American Indian Medicine**. Norman: University of Oklahoma Press, 1970, p. 7-12 for examples on the relative merits of contemporary American Indian and European medicine in the early and middle Contact era.
[150]Wissler, Clark, **Indians of the United States.** Garden City: Anchor Books, 1940, 1966, p. 47-59.

[151]Braudel, p. 261-262. Wissler also mentions Jean Nicot's treatment of Catherine de Medici's migraine headaches with tobacco powder in 1560.
[152]Vogel, p. 111-113; see p. 112 for the source of the example cited.
[153]Dr. Harlow Brooks, from his report "The Medicine of the American Indian," *Bulletin of the New York Academy of Medicine*, 2nd Series, Vol. V, No. 6, June 1929, p. 519 as cited in Vogel, p. 117.
[154]Vogel, p. 117.
[155]Vogel, p. 119.
[156]Vogel, p. 120; the approximate dates are deduced from information on the reservation history of the Winnebago and Dakota peoples found in John Swanton's **The Indian Tribes of North America.**
[157]Vogel, p. 122
[158]Vogel, p. 120-121.
[159] Weatherford, p. 183-184.
[160] Wissler, p. 74-75.
[161]Vogel, p. 267.
[162]Vogel, p. 6.
[163]Hutchens, Alma, **Indian Herbology of North America**. Ontario: Merco, 1973, p. 69.
[164]Vogel, p. 177-179.
[165]Vogel, p. 163.
[166]Vogel, p. 323-324.
[167]Pennisi, Elizabeth, "Pharming Frongs", *Science News*, vol. 142, no. 3, July 18, 1992, p. 40-42. Among the medical uses South American Indians have developed for these tiny, colorful terrestrial frogs is rubbing the skin secretions into wounds and cuts; Pennisi reports that particular species generate powerful antiseptic peptides. Other frogs' secretions are used to help heighten the sensory abilities of tribal hunters. Dr. Daly is working on a frog skin alkaloid that appears to have potential as an effective alternative to morphine as a pain-numbing agent.
[168]Vogel, p 168-169.
[169]Hutchens, p. 242-243.
[170]Vogel, p. 365.
[171]Vogel, p. 364-365; Weatherford, p. 110.
[172]Vogel, p. 361-362.
[173]Vogel, p. 168-169.
[174]Hutchens, p. 136.
[175]Weatherford, p. 191-192.
[176]Weatherford, p. 101-107.
[177]Quoted in Vogel, p. 119.
[178]NBC morning television news report of October 10, 1989; *World Monitor*, December, 1989, Vol. 2, No. 12, p. 12.
[179]Haugeneder, Rudy, "Rain Depends on Tropical Trees", *Akwesasne Notes*, Late Fall, 1989, Vol. 21, No. 5, p. 6, 23. Also, Suzuki, David, "Let's Not Forget How We Treat Our Own Native Peoples", *Akwesasne Notes*, Late Fall, 1989, Vol. 21, No. 5, p. 6.
[180] W. Richard Comstock, "Seeing with the Eye of the Native European" in Capps, Walter H., **Seeing with a Native Eye.** New York: Harper & Row, Publishers, 1976, p. 73.
[181]Vogel, p. 21-22.
[182]Quoted from Thwaites, Reuben (ed.), **The Jesuit Relations and Allied Documents**, vol. I, p. 259, in Vogel, p. 20.
[183]Quoted from Thwaites, vol. X, p. 169-71, in Vogel, p. 21.
[184]Brown, Jennifer S. H., "Northern Algonquians From Lake Superior and Hudson Bay to Manitoba in the Historical Period", in Morrison, R. Bruce and Wilson, C. Roderick (ed.s), **Native Peoples: The Canadian Experience**. Toronto: McClelland & Stewart, Inc., 1986, p 223.
[185]Weltfish, Gene, **The Lost Universe: The Way of Life of the Pawnee**. New York: Ballantine Books, Inc., 1971, p. 375.
[186]Driver, Harold, **Indians of North America**. Chicago: University of Chicago Press, 2nd edition, 1969, p. 402.
[187]Morrison and Wilson (eds), p. 521.

[188]For accounts of several community successes in Canada, see Morrison and Wilson (eds.), p. 529-530.
[189]Vogel, p. 191-193, 389, 396.
[190]Vogel, p. 191.
[191]Vogel, p. 107, 193, 194-195.
[192]Vogel, p. 194, 227.
[193]Vogel, p. 195-196.
[194]Vogel, p. 246.
[195]Vogel, p. 196, 227-228.
[196]Vogel, 226-228.
[197]Vogel, p. 192-193.
[198]Vogel, p. 193.
[199]Vogel, p. 235.
[200]Vogel, p. 231-232. Vogel notes that Dr. George Engelmann reported in 1882 that among the Makah a specialist handled this task; he also reports that the Lakota women used a type of belt immediately after giving birth to apply the pressure needed to quickly expel the placenta, see p. 235.
[201]Vogel, p. 231-234.
[202]Vogel, p. 233-234.
[203]Vogel, p. 234-235.
[204]Vogel, p. 159-160.
[205]Vogel, p. 56, 63, 179-180.
[206]Vogel, p. 179-181.
[207]Vogel, p. 245-246.
[208]Vogel, p. 246.
[209]Vogel, p. 247-248.
[210]Vogel, p. 248.
[211]Vogel, p. 246-248.
[212]Weatherford, p. 187.
[213]Vogel, p. 160,193-194
[214]Vogel, p. 196; also see Weatherford, p. 187-188.
[215]Weatherford, p. 188.
[216]Vogel, p. 196, 411; Weatherford, p. 188.
[217]Vogel, p. 184-185, 411; Weatherford, p. 188.
[218]Only one complete, hafted microblade has ever been recovered in the Americas, although examples are known from Siberian tribes. It was found in 1987 by an archaeology student excavating in a 3,000 year-old buried village site called Hoko near the Makah Reservation in Washington State. The blade was lashed with cherry bark strips onto a six-inch handle about the diameter of a soda straw, according to a report in the *New York Times* published on August 11, 1987.
[219]Weatherford, p. 188.
[220]From a National Institutes of Health announcement of a forum on Programs for Support of Native Americans in Science, held on October 9, 1989 in Anchorage, Alaska.
[221]Personal communication with Debra LaFountaine of AISES, June, 1990.
[222]Major John Wesley Powell, quoted in the Introduction to the 1962 edition of Morgan's **League of the Iroquois**. New York: Citadel Press, 1962, p. v. Powell was the founder of the Bureau of American Ethnology, a division of the Smithsonian Institution; he was a formidable early anthropologist in his own right and a still-respected 19th century authority on the discipline of scientific anthropology.
[223]Card, Ann (ed.), **American Indian Scientists and Engineers**. Boulder: American Indian Science and Engineering Society, 1984, Vol. 1, p. 23. This two-volume set of booklets profiles the careers of 56 contemporary American Indians in scientific and technical fields. The second volume was published in 1986.
[224]Brant, Linda, "Mary Ross: A Pioneer" in *The Minority Engineer*, Spring 1984 edition, p. 87-88.
[225]Card, vol. 1, p. 20.
[226]Card, vol. 1, p. 11.
[227]Card, vol. 1, p. 3.
[228]Card, vol. 1, p. 22.

[229]Card, vol. 2, p. 11.
[230]Card, vol. 2, p. 19.
[231]Card, vol. 2, p 22.
[232]Copies of the AISES volumes are available for reference use in the Portland School District's Multicultural/Multiethnic Education Office; the Funches volume is in the district's Professional Library.
[233]Personal communication with Deborah Baldridge, at that time the Director of Teacher Training, AISES, June, 1990.
[234]Ramsey, Jack, "AISES Chapter List is Still Growing", *Education Newsletter*. Boulder: American Indian Science and Engineering Society, vol. 6, no. 1 (Winter, 1990), p. 9.
[235]Shendo, Benny, "Scholarship Update" , *Education Newsletter*. Boulder: American Indian Science and Engineering Society, vol. 6, no. 1 (Winter, 1990), p. 9.
[236]AISES, **Hands On/Minds On: Science Activities for Children**. Boulder: American Indian Science and Engineering Society, 1990.
[237]**Hands On/Minds On** is available for research use in the Portland School District's Multicultural/Multiethnic Education Office. *Taking Tradition to Tomorrow* is available in the district's audiovisual collection.
[238]Ginsberg, Margery, "AISES Research Activities", *Education Newsletter*. Boulder: American Indian Science and Engineering Society, vol. 6, no. 1 (Winter, 1990), p. 2.
[239]Nora Haring, quoted in Hilaire, Karen, "Science Camp Inspires Indian Youth", *Winds of Change*. Boulder: AISES Publishing, Inc., vol. 4, no. 4 (autumn, 1989), p. 66.
[240]*Northwest Report* . Portland: Northwest Regional Educational Laboratory, April 1990, p. 5.
[241]*Oregon State University SMILE Update*. Corvallis: SMILE Newsletter, vol 1, no. 5 (May, 1990) and personal communication with Sue Borden, SMILE Coordinator, June, 1990.
[242]Stern, Stephen, "NAU and Navajo Nation Sign Agreement to Advance Educational and Economic Opportunities for Navajos", *Winds of Change.* Boulder: AISES Publishing, Inc., vol 5, no. 2 (Spring, 1990) , p. 54-55.
[243]"Funding for Northern Studies Programs Announced", *Akwesasne Notes*, vol. 22, no. 3, p. 10 (late summer 1990 edition).

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