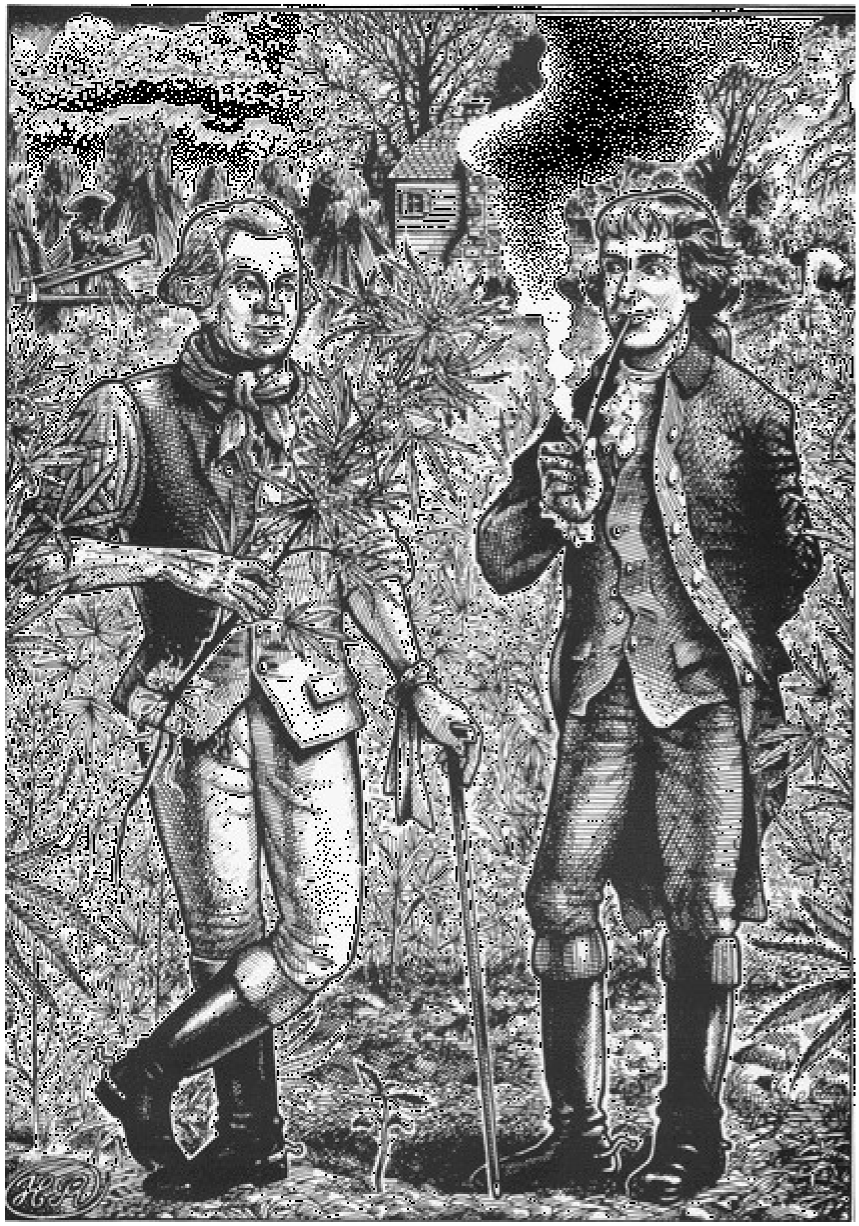


All about Hemp

1.1 ~ Introduction

The fiber of Cannabis, the "True Hemp", is tightly woven into the tapestry of human life. Since earliest times, this great plant ally has provided people with cordage, cloth, paper, medicine, and inspiration. For all the many benefits it bestows, Cannabis hemp is a friendship well worth cultivating. Hemp is many things to many people, and it is known by hundreds of names. Poets sing its praises, and preachers damn it. Executioners hang condemned men with hemp rope, but sailors and mountaineers hang onto it for dear life. Doctors prescribe it as a medicine, yet prohibitionists proscribe it as a poison. Armies and navies make war with hemp, while lovers use it as an aphrodisiac. The resinous virtue generates real happiness, enlightenment and entertainment, equal in quality and worth to the similar joys of love, freedom, and good health --- and it complements them all, and it comforts those poor souls who are without such blessings. Hemp is a most interesting and paradoxical plant, one that defies control and begs understanding. Hemp is one of mankind's best (and few) friends on Earth, yet it is a prisoner within its own cells, bound in a Gordian Knot of laws. Yet again, hemp is Ariadne's Thread, a guideline out of the labyrinth of bureaucratic tyranny and into a new state of liberty and grace. James Allen expressed the sentiment most passionately in the closing words of *The Reign ofLaw* (1900):

"O Mystery immortal! which is in the hemp and in our souls, in its bloom and in our passions, by which our poor brief lives are led upward out of the earth for a season, then cut down, rotted, and broken --- for Thy long service!" **(1)**

1.2 ~ Hemp & Health

Cannabis has been used in medicine since about 2300 B.C., when the legendary Chinese Emperor Shen-Nung prescribed *chu-ma* (female hemp) for the treatment of constipation, gout, beri-beri, malaria, rheumatism, and menstrual problems. He classified *chu-ma* as one of the Superior Elixirs of Immortality. **(2)**

Figure 1.1
Emperor Shen-Nung
(by Waves Forest)

Ayurvedic physicians regularly use *bhang* to treat dozens of diseases and other medical problems including diarrhea, epilepsy, delirium and insanity, colic, rheumatism, gastritis, anorexia, consumption, fistula, nausea, fever, jaundice, bronchitis, leprosy, spleen disorders, diabetes, cold, anemia, menstrual pain, tuberculosis, elephantiasis, asthma, gout, constipation, and malaria. Other folk medicine applications of cannabis include its use as a stimulant, sedative, analgesic and antispasmodic, to induce sleep, as a diuretic, and against hydrophobia, blood in the urine, arthritis, rheumatism, hay fever, asthma, skin diseases, and stomach disorders, and to treat hemorrhoids and burns. **(3)**

Cannabis has been widely used in Asia to treat the diseases of animals. It is commonly fed to elephants and oxen to relieve their fatigue and give them greater endurance and strength. Wild hemp leaves are burned in heaps to disinfect stables and barns, and to treat respiratory problems. A bolus of hemp flowers, sugar and grain is fed to livestock to treat colic, constipation, diarrhea, worms, and rinderpest (a form of diptheria). The leaves are fed to cattle before they mate, and to increase lactation.

In the second half of the 19th century, after Dr. William O'Shaughnessy reported from India on the medical uses of cannabis, it became an official member of the pharmaceutical repetoire in Europe and America. Cannabis was commonly used as a specific to alleviate the symptoms of tetanus, typhus, and hydrophobia. It was employed with varying degrees of success in the treatment of alcoholism, asthma, bronchitis, constipation, dropsy, dysentery, dysmenorrhea and uterine haemorrhage, epilepsy, insanity, migraine, palsy, rheumatism, anthrax, blood poisoning, incontinence, leprosy, malaria, snakebite, tonsilitis, parasites, and a legion of other maladies. **(4)**

Dozens of medical uses have been demonstrated for the major cannabinoids (THC, CBN, and CBD) and other unique chemicals in Cannabis. The cannabinoids find therapeutic applications in cases of glaucoma, asthma, alcoholism, opiate addiction, insomnia, herpes, migraines, and ulcers. Cannabis is used as a diuretic, an anti-asthmatic, anti-convulsant, anti-inflamatory and anti-tumor agent, anti-biotic, anti-emetic, anti-depressant, and it has applications as an analgesic, anesthetic, and in gynecology. **(5-10)**

The public health effects of cannabis consumption, particularly as relates to crime and insanity, have been examined repeatedly by several official panels, beginning with the Indian Hemp Drugs Commission in 1893. None of the studies have found reason to proscribe cannabis, and a few have recommended its legalization: The Indian Hemp Drugs Commission **(11-13)**; The Canal Zone Studies **(14, 15)**; The LaGuardia Committee Report **(16)**; The Wooton Report **(17, 18)**; The Schafer Commission **(19)**; The Jamaica Study **(20-22)**; The Costa Rica Study **(23-26)**; The Greek Study **(27-29)**; The Coptic Study **(30)**; The Expert Group **(31)**; and The Relman Committee. **(32)**

Cannabis is non-toxic. No deaths from an overdose of cannabis have ever been verified. A few poorly documented reports have given cannabis as the cause of death, but closer examination has shown the accusations to be untenable. It has been estimated that it would be necessary to smoke about 800 marijuana cigarettes to kill a human; even then one would probably receive a lethal dose of carbon monoxide first. In comparison, only 60 mg of nicotine or 300 ml of alcohol can kill a person. The LD50 for THC in animals is between 20-40 mg/kg/iv, or 800-1,400 mg/kg orally. **(33)**

Driving performance is impaired by marijuana. Judgment, concentration, and car- handling skills are affected, and the influence may persist for a full day afterwards.**(34)**

Marijuana has been a complicating factor in the emergency treatment of diabetes. Plasma glucose and insulin levels increase after its use. Marijuana should not be used by children or pubescent youths, by pregnant or nursing women, by people with chronic heart, lung, or liver disease, or by diabetics, epileptics, or psychotics. Do not use cannabis with penicillin drugs.

The dust inhaled by soft hemp workers (hacklers and scutchers) can cause byssinosis or cannabosis, and otherwise causes more chronic lung disease and lower forced expiratory volume (FEV) than controls of the same age. A study of 100 Spanish hemp hacklers showed the average age of death to be 39.6 years, compared to regular farm workers whose average lifespan was 67.6 years. **(35)**

1.3 ~ Hemp in America

Cannabis hemp probably evolved in northern China. It was the first fiber plant to be cultivated there at the dawn of human society. Cotton from India and Mediterranean flax were not introduced until thousands of years later. An abundance of archaeological evidence proves the continuous cultivation of hemp from prehistoric times, beginning with a 12,000 year old Neolithic site at Yuan-shan in Taiwan. **(36, 37)**

After a long and illustrious career in Asia, Europe and elsewhere, cannabis hemp officially arrived in North America. Cannabis had already arrived in prehistoric times, perhaps borne by Chinese explorers, birds or storms. The Vikings and other ancient seafarers also brought seeds of hemp and other vegetables, to be planted in the event of shipwreck. The prehistoric Mound-Builders also utilized cannabis. **(38, 39)**

Hemp was so important to the colonists that it was deemed mandatory to cultivate the crop. For many years, taxes could be paid with clean hemp fiber, and it was a strategic war crop during the Revolution. George Washington farmed hemp, and he mentioned the plant several times in his writings. In letters to his foreman, Washington urged him to "Make the most of the hempseed", and "Plant hemp everywhere." Thomas Jefferson also grew hemp, and he kept a record of his enterprises and thoughts on the subject in his account books, *Notes on Tobacco*, and other writings.**(40-44)**

The Civil War later ruined the hemp industry that had developed by then. A brief resurgence of hemp cultivation occurred in the 1870s and 80s, when it was widely grown, especially in Illinois, Nebraska, and California. The increasing use of wire cables on ships, and the introduction of steamships and metal hulls, greatly reduced the demand for hemp rope, sails, and caulking. By the turn of the century, the market for hemp was limited to cordage, twine and thread. **(45, 46)**

Hundreds of hemp-processing machines have been patented since Thomas Jefferson recorded his improvements on the mechanized hemp-break. Only the design perfected by George W. Schlichten worked with the high efficiency required to meet the demands of the market. The Schlichten Decorticator promised to revolutionize the industry by completely eliminating the need to "ret" (rot) hemp.

It was explained thus to the American public in *Popular Mechanics Magazine* (February 1938), wherein hemp was declared to be "The New Billion Dollar Crop":

"American farmers are promised a new cash crop with an annual value of several hundred million dollars, all because a machine has been invented which solves a problem more than 6,000 years old. It is hemp, a crop which will not compete with other American products. Instead, it will displace imports of raw material and manufactured products produced by underpaid coolie and peasant labor and it will provide thousands of jobs for American workers throughout the land.

"The machine which makes this possible is designed for removing the fiber-bearing cortex from the rest of the stalk, making hemp fiber available for use without a prohibitive amount of human labor.

"Under old methods, hemp was cut and allowed to lie in the fields for weeks until it "retted" enough so the fibers could be pulled off by hand. Retting is simply rotting as a result of dew, rain and bacterial action. Machines were developed to separate the fibers mechanically after retting was complete, but the cost was high, the loss of fiber great, and the quality of fiber comparatively low. With the new machine, known as a decorticator, hemp is cut with a slightly modified grain binder. It is delivered to the machine where an automatic chain conveyer feeds it to the breaking arms at the rate of two or three tons per hour. The hurds are broken into fine pieces that drop into the hopper, from where they are delivered by blower to a baler or to a truck or freight car for loose shipment. The fiber comes from the other end of the machine, ready for baling.

"From this point on almost anything can happen. The raw fiber can be used to produce strong twine or rope, woven into burlap, used for carpet warp or linoleum backing or it may be bleached and refined, with resinous by-products of high commercial value. It can, in fact, be used to replace the foreign fibers which now flood our markets... The natural materials in hemp make it an economical source of pulp for any grade of paper manufactured, and the high percentage of alpha-cellulose promises an unlimited supply of raw material for the thousands of cellulose products our chemists have developed.

"It is generally believed that all linen is produced from flax. Actually, the majority comes from hemp --- authorities estimate that more than half of our imported linen fabrics are manufactured from hemp fiber. Another misconception is that burlap is made from hemp. Actually, its source is usually jute, and practically all of the burlap we use is woven by laborers in India who receive only four cents a day. Binder twine is usually made from sisal which comes from Yucatan and East Africa.

"All of these products, now imported, can be produced from home-grown hemp. Fish nets, bow strings, canvas, strong rope, overalls, damask tablecloths, fine linen garments, towels, bed linen and thousands of other everyday items can be grown on American farms... The paper industry offers even greater possibilities... Hemp will produce every grade of paper, and government figures estimate that 10,000 acres devoted to hemp will produce as much paper as 40,000 acres of average pulpland.

"One obstacle in the onward march of hemp is the reluctance of farmers to try new crops. The problem is complicated by the need for proper equipment a reasonable distance from the farm. The machine cannot be operated profitably unless there is enough acreage within driving range and farmers cannot find a profitable market unless there is machinery to handle the crop... This new crop can add immeasurably to American agriculture and industry."**(47)**

An article by George A. Lower in *Mechanical Engineering Magazine* (26 February 1937), also heralded hemp as "the most profitable and desireable crop that can be grown". Because of publishing schedules, however, the articles had been written several months before the passage of the infamous Marijuana Tax Act of 1937 effectively destroyed the hemp industry, so the promise was not fulfilled. **(48, 49)**

Hemp enjoyed a brief comeback as a vital war crop during World War Two after the Japanese invaded the Philippines and cut off America's supply of abaca. The Nazi invasion of Europe also eliminated that source of hemp. The federal government therefore sponsored a crash program to produce enough hemp fiber to meet America's needs. Farmers received the booklet *Hemp: A War Crop* (1942), which brought them up to date:

"In normal times rope and twine made from Manila fibers (abaca) imported from the Philippines constituted a large portion of the supply... Hemp imported from Italy, Russia, France, and Holland, together with a small amount grown in Wisconsin and Kentucky, was used for medium grade wrapping twine and rope. Because we do not have climatic conditions conducive to the growing of Manila or jute, it is necessary to increase greatly the production of hemp. Thousands of acres in the Midwest will be planted and new factories built to handle the crop." **(50)**

Thanks to the perseverance of hemp activist and author Jack Herer and associates, the unique USDA film *Hemp For Victory!* (1942) was rescued from oblivion and represented on video in modern times. The inspiring instructional film was shown to groups of farmers across the land, from sea to bounding sea. The narrator said:

"But now, with Philippine and East Indian sources of hemp in the hands of the Japanese, and shipment from India curtailed, American hemp must meet the needs of our Army and Navy as well as of our industry. In 1942, patriotic farmers at the government's request planted 36,000 acres of seed hemp, an increase of several thousand percent. The goal of 1943 is 50,000 acres of hemp seed... Plans are afoot for a great expansion of a hemp industry as a part of the war program. This film is designed to tell farmers how to handle this ancient crop now little known outside Kentucky and Wisconsin..." **(51)**

Hempseed was supplied to some 20,000 contracted farmers, with further instructions for cultivation from the federally-financed War Hemp Industries, Inc. 42 processing mills were built and equipped at a cost of $360,000 each by the Defense Plant Corporation.

In 1943, the Commodity Credit Corporation contracted for 168,000 acres of hemp straw, and paid $30 to $50 a ton. In January 1944, the CCC scaled down abruptly to only 60,000 acres. Nor did the CCC contract for any hempseed. The CCC had garnered some 500,000 bushels of hempseed in 1943, and the War Production Board was confident that Italy could provide for America's needs. The surplus hempseed was fed to canaries, who sang its praises. The farmers were left holding the bags.**(52)**

Since then, the cultivation of cannabis has been severely suppressed in the USA. Fortunately, hemp still is welcome at home in China, which is the world's biggest supplier of the vital fiber and seed. Cultivars have been developed that produce less than the legal limit of 0.3% THC, thus enabling the development of a fiber market without diversions for drug use. The crop also is cultivated for its fiber in France, England, Canada, Russia, Romania, Hungary, and some two dozen other countries. Over 300,000 hectares of hemp are being planted each year. The French strains Fedora, Felina, Ferimon, Fibrimon, and Futura are the only registered low-THC hemp cultivars that are eligible for farm subsidies from the

EU. **(53)**

Britain lifted the ban on industrial hemp cultivation in February 1993 "to allow UK farmers to gain a share of the market currently occupied by our EC partners." A coalition of farmers calling themselves Hemcore, Ltd. (Felsted, Essex), immediately and successfully grew 600 hectares (1,500 acres) of hemp in East Anglia. They have grown over 2,000 hectares since then. The primary local use of the fiber is for livestock bedding, because the shives are extremely absorbent and they compost easily. Any surplus has a ready market.

In Spring, 1994, Canadian farmers began to plant hemp for fiber for the first time since 1937. Alexander Sumach of the Hemp Futures Study Group congratulated the nation in the *Globe and Mail*:

"We are delighted to learn of the rebirth of the Canadian Hemp Industry. Farmer Joe Stroebel and engineer Geof Kime planted 20 hectares... with plump, innocent government-approved hempseed from the finest European pedigree... It arrived not a minute too soon.

"The real treat is that Canadians actually beat Americans to this great prize. As the [NAFTA] pretty well wiped out the last of a once-thriving Canadian textile industry, we should be glad that hemp is being planted... There is nothing in NAFTA or [GATT] about hemp. There is nothing to stop a great industry from taking off from Canadian soil... The Americans will never get it together within the decade to grow hemp. Their laws will never admit that cannabis has any redeeming quality..." **(54)**

In 1999, Canadian farmers grew 18,000 acres of hemp --- a manyfold increase over the 600 acres grown only a year before. Some 750 farmers applied for permits to grow the crop.In April, 1999, North Dakota became the frst state to legalize the cultivation of hemp when Gov. Ed Schafer signed House Bill 1428; the House and Senate had approved the measure with an overwhelming majority vote. Hawaii followed suit soon after, then Minnesota.

1.4 ~ Hemp Cloth

The oldest known samples of cloth, found in China and in Asia Minor, were made of hemp. Throughout history, the masses of Chinese people have worn hempen clothes. The earliest archaeological discovery of hemp cloth and rope in Europe, dating to the pre-Roman period (600-400 BC), was found near Stuttgart, Germany. More recently, the original Levi Strauss "jeans" were made of hemp cloth imported from the French city of Nimes, from which is derived the word "denim" ("of Nimes").

Even Harry Anslinger, the reprobate director of the Federal Bureau of Narcotics, acknowledged the excellence of hemp fiber in one of his speeches:

"Now, this hemp is the finest fiber known to mankind. My God, if you ever have a shirt made out of it, your grandchildren would never see it wear out. You take Polish families. We used to see marijuana in the yards of Polish families. We'd go in and start to tear it up and the man came out with his shotgun, yelling: "These are my clothes for next winter!"

Hemp fiber is half as strong as silk, one-third stronger than flax, and three times stronger than cotton. Hemp cloth wrinkles less than linen, irons easily, and it can withstand higher temperatures than linen. Hemp cloth is attractive in appearance and drape, and it washes well. Hemp cloth shrinks 7-9% with the first washing, and it stretches only slightly thereafter. Its fineness (85 tex) is lower than flax (32 tex), but extremely fine hemp yarn (33 tex) is produced in China.

The industrial value of the plant is determined by the proportion of the primary and secondary fractions of bast fiber, and by the length and diameter of the xylem fiber. The quality of fiber is determined by the cultivar, weather and other growth conditions, harvesting methods, and the particular process used for fiber extraction.

The relatively high levels of lignin, calcium, and magnesium in hemp make it difficult to dye and finish by conventional methods. The particular qualities of fabric, such as anti-shrinking, anti-pilling, crease recovery, and soft handling, are produced by pretreatments with toxic chemicals. Fortunately, the innovative VUTZ/INOTEX process, developed by the Czeck Textile Finishing Research Institute, meets all criteria for the eco-labeling of hemp fiber.

The ultrasonic process developed by ECCO Gleittechnic Gmbh produces such fine fiber that many new applications now are possible. In addition, a steam explosion method of preparing high-purity hemp fibers has been optimized by the Dutch Institute for Applied Research.

Since 1995, several large fashion design houses have introduced new hemp products. For example, Adidas offers hempen sneakers for skateboarders, and Converse and Vans are manufacturing hemp sneakers. Calvin Klein offers hemp bed spreads. Hemp textiles are now used in all manner of apparel, from baby diapers to work clothes, socks and shoes, and high fashion creations. The industrial textile applications include rope, twine, nets, canvas, tarpaulins, and geotextiles.

1.5 ~ Hemp Paper

The invention of vegetable fiber paper emerged in China during the Han Dynasty when people became frustrated with the bulk and weight of wooden and bamboo tablets and the expensive rarity of *zhi* (silk proto-paper). The dynastic history *Hou-Han Shu* attributes the invention of paper in 205 A.D. to Marquis Cai Lun, who was Prefect of the masters of techniques during the reign of Emperor He Di. Archaeologists, however, have recovered older specimens of hemp paper from the Western and Eastern Han periods in Xinjiang, Inner Mongolia, and Shaanxi. Apparently, Cai Lun actually supervised the art of papermaking by craftsmen, although he also worked to promote its use in the imperial bureaucracy.

Perhaps the oldest specimens of paper extant, dating more than a century earlier than Cai Lun, were discovered in a tomb near Xian in Shensi province. The pieces were found under three bronze mirrors which were wrapped in hemp cloth. The date of the tomb is no later than the reign of Wu Di of the Western Han Dynasty (140-87 BC).

In 1916, the USDA published *Bulletin* # 404: "Hemp Hurds As Paper-Making Material" by Lyster Dewey and Jason Merrill. It was printed on hemp paper that they produced:

"Experienced paper makers commented very favorably on the running of this furnish and the quality of the paper produced...

"In regard to furnish, there is such a diversity of practice that it is difficult to make a comparison, but if the hurd stock can be produced as cheaply as soda-poplar stock, the furnish used in these... tests should be regarded as satisfactory to the book and printing paper industries...

"Calculations on the raw material and acreage for a permanent supply for a pulp mill producing 25 tons of fiber a day for 300 days per annum, or 7,500 tons per annum, give the comparison between hurds and wood:

[Table 1.1]
Comparison of Wood and Hemp Hurds

[Table 1.1]
Comparison of Wood and Hemp Hurds

Material	Pulp Yield	Raw Material/Yr.	Annual Growth/Acre	Acres for Sustained Supply of: 25-ton Mill	1 ton fiber/Yr.
Wood	2 cords yield 1 ton of fiber	15,000 cords	0.37 cord (0.55 ton)	40,500 acres	5.4 acres
Hurds	1 ton yields 600 lb. fiber	25,000 tons	2.5 tons	10,000 acres	1.33 acres

The most important point derived from this calculation is in regard to areas required for a sustained supply, which are in the ratio of 4 to 1. Every tract of 10,000 acres which is devoted to hemp raising year by year is equivalent to a sustained pulp-producing capacity of 40,500 acres of average pulp-wood lands. In other words, in order to secure additional raw material for the production of 25 tons of fiber per day there exists the possibility of utilizing the agricultural waste already produced on 10,000 acres of hemp lands instead of securing, holding, reforesting, and protecting 40,500 acres of pulp-wood land...

There appears to be little doubt that under the present system of forest use and consumption the present supply cannot withstand the demands placed upon it. By the time improved methods of forestry have established an equilibrium between production and consumption, the price ofwood pulp may be such that a knowledge of other available raw materials may be imperative...

Semi-commercial paper-making tests were conducted... on hemp hurds, in cooperation with a paper manufacturer.... Paper was produced which received very favorable comment both from investigators and from the trade and which according to official tests would be classed as a No. 1 machine-finish printing paper. **(55)**

In the "Digest of Conversation of Mr. G.W. Schlichten with Mr. M.A. McRae..." (3 August 1917), Schlichten (inventor of the decorticator) said:

"The time will come when wood cannot be used for paper any more. It will be too expensive or forbidden... Now I tell you, that with the production of an annual, with my by-product, every acre that I produce in hemp... will preserve 5 acres of forest...

"You see, it takes 12 years before you have an acre grown into spruce; in 12 months I have a harvest of 50 tons produced... But as far as paper is concerned, it is actually a crime to chop down trees to get a small percentage of paper...

"Another thing is, at the present time you have to locate your mill near... the supply in the out of the way country. There are long hauls, and then your paper in the roll is shipped from there; now here we only need the digester right on the land where the hemp is produced...

"Wood must have the bark, knots, &c, removed. It must then be cut into small chips, and sieved. Then it is ready for the digester. The preparing of the wood for the digester is a considerable part of the total paper making cost. The hurds are ready for the digester when, as a by-product, they leave the Schlichten machine..." **(56)**

Several small hemp paper companies have been established in the USA and Canada in the 1990s, i.e.: Tree-Free EcoPaper, Ecosource Paper Co., Living Tree Paper Co., Green Man Paper Mill, and Earth Pulp & Paper.Their products are free of chlorine, acid and ink, and contain no wood. As shown by the archaeological and historical record, hemp paper can last for 2,000 years. Acidic wood-pulp paper must be neutralized to improve its shelf-life to a maximum of about 100 years. Recycled paper does little to benefit the environment, except to spare trees (temporarily): 100 tons of recycled paper generates about 40 tons of toxic sludge.

In the 1990s, only two dozen paper mills, mostly in China and India, with a few in Europe, use hemp as a fiber source. The estimated volume of world production of hemp paper is about 120,000 tons/year, increasing annually. By comparison, a typical single wood pulp mill produces at least 250,000 tons/year. Most hemp fiber pulp is used for cigarette papers, filter papers, tea bags, art papers, and paper money.

1.6 ~ Other Hemp Products

After more than 60 years of suppression by the USA and other governments since 1937, the hemp industry is enjoying a renaissance in the 1990s. A study conducted in 1999 by six researchers at North Dakota University showed that imports of industrial hemp have increased 215% since 1995, when it was first available in the USA. Sales of hemp were $5M worldwide in 1993, increasing to $75M in 1995. Hemptech has estimated that sales will exceed $600M by 2001.

The growth and establishment of cannabis among the world's major fiber crops demands a detailed understanding of the parameters and conditions and techniques for its optimal cultivation and processing. Increased coordination is required amongst breeders, universities, industries, merchants, financiers, and governments. Integrated management of the industry will shorten the chain of value-adding middlemen between the farms and markets.

The industrial development of hemp products depends on a guaranteed supply of standard quality raw fiber. The market needs governmental subsidization, private investment, certified quality control, database management of all parameters of the industry (seed, fertilizer, equipment, labor, transportation, storage, fiber processing, and the economics --- costs, investments, subsidies, and market prices). A logistics support system is required to integrate, optimize, stabilize and control the industry from the farm to the end product. The novel fiber products must be introduced and promoted in new markets. Public education about the benefits of cannabis hemp also is imperative.

The International Hemp Association (IHA) was created in 1992 to facilitate the communication of factual information about cannabis and to promote the use of hemp-based products.

The Hemp Industries Association (HIA), founded in 1994, agreed that finished goods must contain 55% hemp to qualify as True Hemp products. Food, cosmetics, and medical products must contain at least 10% hemp seed or oil to meet HIA Certification Standards. Paper products should contain at least 10% hemp fiber to qualify as hemp paper.

Modern research has developed several excellent new hemp products in addition to the traditional uses of hemp for cloth, rope and paper. One of the most promising new products, called Isochanvre (iso-hemp), is a petrified form of hemp hurds mixed with lime and water. The resulting material is fireproof and waterproof. Isochanvre improves over time, and it will last for centuries. In evidence of this, a bridge dating from the Merovingian period (500-751 AD) was found in southern France, built with hemp fiber in a manner similar to Isochanvre. This unique product supports French agriculture, preserves forests, uses no synthetic chemicals, produces no pollution or waste, and it is easy to manufacture and use. Isochanvre is 5 to 7 times lighter than concrete, has high strength and flexibility, does not crack, and requires no maintenance. In fact, it continues to petrify, and it becomes stronger as it mineralizes. Isochanvre also breathes, thus preventing thecondensation of moisture in buildings, and it is self-draining. It is not eaten by termites or rodents, does not rot, and it has fungicidal and anti-bacterial properties. It does not require painting or other finishes. The high thermal inertia of Isochanvre makes it a superior insulating material. Attics insulated with Isochanvre maintain summer temperatures about 30^{o} cooler than conventional insulation.

The French company La Chanvriere also produces Canosmose, Canobiote, and Mehabit hemp hurd building materials, plus Aubiose horse bedding and Biochat cat litter, which absorbs 250% of its weight.

The German company ECCO Gleittechnic Gmbh has developed Iso-Hanf, which is hemp fleece impregnated with sodium silicate and borate for fire resistance. The use of Iso-Hanf to reinforce concrete increases the flexibility by 30%. The drying characteristics and strength of mortar also is improved by Iso-Hanf. The viscosity of paint and its resistance to detergents is increased by Iso-Hanf, and the number of micro-fissures is reduced. ECCO also produces the Setralit product line including several automotive applications for hemp fiber, such as seat covers, brake lining, and insulation.

As early as 1929, the Ford Motor Company investigated the possibility of using hemp in cars. Officials were sent to visit the successful hemp farm of Albert Fraleigh in Alberta, Canada before cultivating a 200-acre crop. In 1941, after 12 years of research, Henry Ford proudly displayed the first automobile "grown from the soil" with a plastic body made from 70% wheat straw, hemp and sisal with 30% resin binder. The plastic reportedly could withstand a blow 10 times better than steel without bending. The only steel in the car was its welded tubular frame.

Estimates range as high as 50,000 for the number of products that could be made from hemp fiber and its component cellulose. The cannabinoid group of biochemicals offers hundreds of medical products. Furthermore, hemp can serve well as a biomass fuel. The present and potential industrial uses of hemp are limited only by the suppression imposed by the USA and the United Nations. The market also is hindered by the lack of a domestic supply and by shortages on the international market. Despite the relentless recidivistic obstruction imposed by the degenerate federal regime, a hemp products industry based on imports has begun to develop inthe USA.

C&S Specialty Builder's Supply (Harrisburg, OR) produces a superlative composite fiber-board from hemp. The medium-density fiber (MDF) composite boards (CB) are 250% stronger than wood MDF-CB, and 300% more elastic.David Seber and William Conde, the company's founders, have stated:

"The composite board industry is one of the fastest growing segments of the wood products industry in the United States, with annual sales of over one billion dollars, and one whose primary raw material is becoming scarce... During the past 20 years we have seen the misuse and mismanagement of our native forests on such a widespread basis that it has caused an industry-wide crisis in the lack of raw materials (namely wood) that now is destroying this industry... We now believe that wood will become a rare commodity that should be used only where it can be directly seen or touched, and an alternative product must be developed for all other construction type products currently made from wood. After a lengthy and detailed survey of the plant kingdom and an extensive historical search of the uses of plants in civilization, we at C&S have come to the conclusion that the absolute best alternative to wood in construction products is hemp (*Cannabis sativa*). In fact, as far as we can tell, hemp has the potential to be vastly superior to wood for everything from lumber to plywood to particle board or any other composite construction material... Hemp hurds have great potential to make glues for composite construction products..."**(57)**

Conservative estimates of novel industrial markets for cellulose fibers exceeds 100 kilotons/year --- several times more than is produced at present. Another 100 KT/yr could be used in reinforced concrete and composite materials, and in all types of cardboard, pulp, and paper products. Hemp fiber can be used in the production of Compression Molded Parts (CMP), caulking and stuffing, and in gaskets, brakes, and clutch linings for the transportation industry. The construction industry can consume all the hempen fiberboard and insulation that can be produced. The fiber also can serve to strengthen cement, stucco, bricks, plaster, mortar, and tarboard. Hemp fiber can substitute for many non-renewable (and toxic) materials such as asbestos. The strength and biodegradability of hemp fiber also makes it well-suited for use in geotextiles.

1.7 ~ Hemp Biodiesel

Hemp yields about 0.4 tons of seed/acre, which yields about 300 gallons of oil. The oil can be used alone or with methanol to serve as bio-diesel fuel, or it can be mixed with petro-diesel. Bio-diesel fuel produces full engine power with much lower emissions (and no sulfur) than does petro-diesel. The latter has a cetane rating (CR) of about 40. The CR of hempseed oil is 60 to 100. Sunflower, safflower, and rapeseed yield only up to about 110 gallons oil/acre.

Biodiesel is easily produced by reacting methanol with sodium hydroxide to produce sodium methoxide. Use 200 ml methanol and 3.5 gr NaOH per liter of vegetable oil. The mixture is stirred for one hour, then left to settle for several hours. The products are biodiesel (upper layer) and glycerine soap. Filter the biodiesel (5 microns) before using it. Another method is even simpler: blend 10-40% kerosene with vegetable oil; 20% kerosene produces a reliable mixture throughout a wide range of ambient temperatures. Unadulterated or unreacted vegetable oil also can be used, but the engine must be started and cooled down using diesel or biodiesel. Therefore a two-tank system and switch valve is required. Go to www.veggievan.org for more information.

Hemp stalks can be converted to ethanol (with about 20% efficiency by fermentation of hydrolyzed cellulose), into methane (by digestion of the stalks, with 50% efficiency), into producer gas (by thermal gasification at 85% efficiency) and into methanol (by pyrolysis of the stalks, or from producer gas). It is estimated that hemp biomass can yield an equivalent of 1,300 gal/acre of vehicle fuel. Chopped stalks also can be used directly as a boiler fuel.

1.8 ~ Hemp: A Renewable Resource

Sustainable, ecological agriculture requires a revival of traditional multiple-crop cultivation utilizing modern equipment and methods of harvesting and processing in order to reverse the trend of global environmental degradation now in effect. Cannabis hemp is arguably if not obviously the best choice for the purpose. The environmental benefits of hemp husbandry are manifold. The use of hemp as a substitute for wood reduces the extent of deforestation. Hemp is easily biodegradable, so its disposal presents no problems of waste management. The plant requires relatively little fertilizer in comparison to other fiber crops, and it needs little or no treatment with pesticides. Hemp benefits the environment and the rural economy while providing a sustainable alternative source of fiber for paper, textiles, and other purposes. **(58)**

America uses as much wood, by weight, as all metals, plastics, and cement combined. Much of what little is left of American lumber, including old growth, now goes to Japan. About 40% of the trees destroyed in America are used to make paper products, most of which are not recycled. Soon we will have no choice but to use hemp and to recycle as much as possible. David Seber and William Conde (founders of C&S Builder's Supply, manufacturers of hemp fiberboard) have stated:

"If we don't [grow hemp] there is a good chance that in 10 years there will be no forests left on the temperate region of the Earth. I think it's the most important issue of our time. And it has to be done, because the over-riding issue about the forests is not about trees, and it's not even about wood; it's about fiber, and how our culture uses fiber... Not only do we have the solution to the forests, we have the only really viable concept of what sustainability is about...

"The way to fix the forest is to use advanced composites from annual fibers like hemp. Anything you can make out of a tree you can make out of hemp. We can leave the forest alone and everyone can go back to work."

In his comments *On the Decay of Rents* (1670), Sir William Coventry gave some sage advise that holds true today:

"For the changing the use of our land two things occur to me most reasonable and most desirable. The one is to encourage the planting of wood and severely to punish... the destruction of it... The other is to encourage the sowing of hemp and flax, which, besides diverting the ground from corn and cattle, would employ all the poor that can be found."

1.9 ~ Other Fiber Crops

Cannabis is the original and only "True Hemp". In the past century especially, several other fiber plants have assumed the generic name of "hemp". Manila hemp is abaca (*Musa textilis*) or wild plantain. Sisal hemp is henequen (*Agave fourcroydes L.*) or century plant (*Agave Americana*), grown in Central America. New Zealand flax (phormium, *P. tenax*) is called hemp; Mauritius hemp is furcraea (*F. gigantea*). Sunn hemp is crotolaria (*C. juncea*). Jute (*Corchorus capsularis L.*) also is known as Indian hemp, not to be confused with *Cannabis indica*, which used to be called Indian hemp, but no longer. A species of hibiscus hemp (*H. cannabinus*) grows in India.

After decades of research, the USDA conveniently ignored the proven potential of cannabis hemp and declared kenaf to be the best fiber for paper-making. In the USA, however, kenaf can be cultivated in bulk only in the southern states of New Mexico, Texas, California, and Louisiana. The yield is low in cool climates.

Flax grows well in temperate climates, but the yield per acre is less than half that of hemp. Flax exhausts the soil, which requires careful preparation for a good crop. It requires a relatively low mean temperature and rather cold soil with a very regular supply of water; flax does not tolerate drought. Flax has specific requirements for fertilization, and the crop must be rotated with others that specially condition the soil. Flax can be grown only once in 6 to 8 years in the same ground. It is sown late, and it grows and matures slowly. Flax is smothered by fast-growing weeds, and it is easily blown down. Flax is expensive to sow, cultivate, and harvest.

Cotton is adapted to a wide range of uses, and it spins easily, but is not so strong and durable as hemp. Cotton also exhausts the soil.

Ramie (China-grass, *Boehmeria*) yields only about one-fourth as much per acre, compared to hemp. Ramie is confined to tropical or semi-tropical climates; dry hot spells or cold snaps will kill the crop.

Sisal and Manila hemp are not suitable for spinning fine fabrics, and cannot be grown in American climates.

Jute produces a yield comparable with hemp, but it requires a warm, humid climate, rich loam soil, and lots of rain during the growing season. This would limit its cultivation in the USA to the southern states. Jute also exhausts the soil, and it contains less cellulose than hemp. Jute does not bleach easily, and the bleached fibers soon disintegrate. Jute is cheap and plentiful and easy to spin, but it is the weakest and least durable of the major textile fibers.

Cannabis hemp grows well throughout most of the US, and it requires little fertilizer, insecticides, or attention. None of the competitive fiber plants can grow in so many climates as cannabis, and none of them compare well with hemp.

S.S. Boyce, author of the treatise *Hemp* (1900), praised the superiority of hemp in no uncertain terms:

"Hemp is the king of fiber-bearing plants --- the standard by which all other fibers are measured; while none but silk is of a finer character, and none other is so universally adapted to a wide soil and climatic conditions and the rude arts of the semi-barbarous husbandman, and the primitive methods and practices attending the preparation of its fiber; yet none is more amenable to the care of exact culture, nor better rewards the skill of fine-art methods of fiber-manipulation. No plant is more susceptible to the processes of producing a fine, white, soft and silky fiber, and there is not one to take its place in the wide and diversified area of its culture and manufacture...

"No plant is more simple of cultivation and manipulation, none more susceptible to the care of the husbandman, none more capable of a widely diversified product, and none is more universally adapted to American soils and climatic conditions, or to supplying raw material of the nature and character required by manufacturers of cordage and fine linen fabrics."

1.10 ~ Hempseed & Nutrition

Legend says that Gautama Buddha ate only one hempseed a day for six years while he waited for nirvana.Hempseed is eaten by many of India's poor people. A mixture called *bosa* consists of the seeds of Eleusine and hemp, and *mura* is made with parched wheat, amaranth or rice, and hempseed. The seeds are said to make all vegetables more palatable and complete foods. Sometimes it is an ingredient in chutney. *Bhang* and ripe hempseed also is used to flavor or strengthen the formulations of some alcohol beverages.

Hempseed has served as a primary famine food in China, Australia, and Europe as recently as World War Two. Medieval Christian monks ate hempseed gruel every day. Even in modern times, mothers of the Sotho tribe in South Africa are known to feed their babies with ground hempseed in pap. **(59)**

Hempseed now is an ingredient in food products, including flour, cheese, ice cream, yogurt, pudding, milk, spreads, candy, and meat substitutes. Prices are kept high by the cost of shipping, steam sterilization, repackaging, domestic shipping, and old equipment.

Hempseed contains all the essential amino acids and fatty acids, and is considered to be a complete food. The seed or achene contains 26-31% crude protein, 65% of which is globular edestin and albumin that is about 84% digestible. Lysine (the limiting protein in edestin) and other components are destroyed by the heat generated when hempseed is pressed for its oil. Addition of 1% lysine hydrochloride will restore the nutritional balance of heat-treated edestin. The meal also contains about 6% carbohydrates, 5-10% fat, 12% crude fiber, 10% moisture, and 7% ash. **(60-62)**

T.B. Osborne studied hemp edestin and reported on its isolation and purification in 1892. Until the passage of the infamous Marihuana Tax Act in 1937, edestin was regarded as a standard example of the seed globulins (the third most abundant protein after collagen and albumin). They are vital to the maintenance of a healthy immune system.**(63, 64)**

The globulin edestin in hempseed closely resembles that found in human blood plasma, and it is easily digested, absorbed, and utilized. Hemp edestin is so completely compatible with the human digestive system, that the Czechoslovakian Tubercular Nutrition Study (1955) found hempseed to be the only food that can successfully treat the consumptive disease tuberculosis, in which the nutritive processes are impaired. **(65)**

When hempseed is fed to poultry on a regular basis, the birds do not go "off feed", and they do not require hormones to fatten them. Egg production also is increased. Hempseed meal has an effect analogous to that of grit in chicken diets inasmuch as the gizzard linings are found to be free of corrugations and erosions. **(66-69)**

John Worlidge commented on this in his *Systema Agriculturae* (1675):

"Hemp seed is much commended for the feeding of poultry and other fowl, so that where plenty thereof may be had, and a good return for fowl, the use thereof must needs be advantageous."

Curtis Weekes, a crop specialist in Alberta, Canada, conducted silage trials with hemp and barley silage for two groups of heifer in 2000. The found that cattle liked both feeds, and their weight gains were equal. The cattle obviously preferred the hemp silage, because they licked the hemp feed bunk completely clean, but always left some barley silage uneaten. The hemp silage contained about 19% protein, and its acid detergent fiber (the indigestible part of the plant) was nearly 41%; the barley ADF was 28.2%. The hemp also contained more calcium and phosphorus.

1.11 ~ Hempseed Oil

The oil of hempseed is used in paints, varnishes, inks and lubricants. When exposed to air, the fatty acids in hempseed oil form a hard film that makes it very useful in the manufacture of paints. The cellulose and other organic chemicals in cannabis can serve as feedstock for the manufacture of plastics and other synthetic substances. The oil has excellent surfactant properties that are put to use in several new hygiene products such as soap, shampoo, cosmetics and balms. For example, SATIVA Gmbh (Germany) manufactures a detergent from hempseed oil and ruptured yeast; it removes stains with high efficiency, due to its very low surface tension. The detergent is used as an industrial cleaner for engines, and to clean petroleum-contaminated soil. It is completely bio-compatible and uses no phosphates, enzymes, or bleaches.

30-35% of the weight of hempseed is oil containing 80% of the unsaturated essential fatty acids (EFA), LA (55%) and LNA (21-25%). These are not manufactured by the body, and must be supplied by food. The oil also contains about 8% by volume of palmitic, stearic, oleic and arachidic acids. The 80% EFAs in hempseed oil is the highest total percentage amongst the common plants used by man. Flax oil ranks second with 72% EFAs. The EFAs are very sensitive to heat, light and oxygen. For this reason, hempseed oil must be processed and stored carefully (in the cold, dark, and under vacuum) to preserve the potency of the EFAs. The EFA composition (% of total oil) of hempseed oil is: 18:3w3 (20%), 18:2w6 (60%), 18:1w9 (12%), 18:0 (2%), and 16:0 (6%).

EFAs are precursors to the prostaglandin series (PGE 1,2, & 3). PGE 1 inhibits the production of cholesterol and dilates blood vessels, and it prevents the clotting of blood platelets in arteries. A. Kemmoku, *et al*., found that a diet of hempseed causes the serum levels of total cholesterol to drop dramatically. Blood pressure also decreases after several weeks of eating hempseed, thanks to the steady, adequate supply of EFAs.**(70-72)**

In the opinion of U. Erasmus, author of *Fats that Heal, Fats that Kill*, the proportions of LA and LNA in hempseed oil are perfectly balanced to meet human requirements for

EFAs, including gamma-linoleic acid (GLA). Unlike flax oil and others, hempseed oil can be used continuously without developing a deficiency or other imbalance of EFAs. The peroxide value (PV, the degree of rancidity) of hempseed oil is only 0.1-0.5, which is very low and safe and does not spoil its taste. In comparison, the PV of virgin olive oil is about 20, and the PV of corn oil is about 40-60. **(73-76)**

A series of studies conducted in 1997 by ARUP Laboratories (Salt Lake City) found that hempseed oil contains enough cannabinoids to produce a positive result with standard urine drug test procedures. The subject felt no psychoactive effects whatsoever. Samples continued to test positive for two days after the subject stopped ingesting the oil. This new development has thoroughly upset the drug-testing industry, which has suggested that hempseed oil be banned. The presence of cannabinoids in hempseed or oil is due to minute bits of inflorescence that are not removed when the seeds are cleaned. **(77)**

Table 1.2 ~ General Analysis of Hempseed

Table 1.2
General Analysis of Hempseed
From D. Wirtshafter: "Why Hemp Seed?" in *Hemp Today* (1994, Quick American Archives)

Water	5.7 %	Carotene (Vitamin A)	500 IU/100 gr
Fat	30 %	Thiamine (B1)	0.9 mg/100 gr
Protein	22.5 %	Riboflavin (B2)	1.1 mg/100 gr
Ash	5.9 %	Pyridoxine (B6)	0.3 mg/100 gr
Carbohydrates	35.8 %	Niacin (B3)	2.5 mg/100 gr
Fiber (Total)	35.1 %	Ascorbic Acid (C)	1.4 mg/100 gr
Fiber (Soluble)	3 %	Vitamin D	<10 IU/100 gr
Calories	503/100 gr	Vitamin E	3 mg/100 gr

Table 1.3 ~ Typical Elemental Assay of Hempseed

Table 1.3
Typical Elemental Assay of Hempseed

Al	54.00 mg/100 g	Hg	<0.001 mg
Sb	1.75	Mo	0.51
As	0.30	Ni	5.00
Ba	6.48	P	8302.00
Be	0.04	Pt	9.23
B	9.50	K	6170.00
Cd	0.28	Se	0.02
Ca	1680.00	Si	13.80
Cr	0.65	Ag	0.40
Co	0.53	Na	22.00
Cu	12.00	Sr	7.33
Ge	2.67	S	2394.00
I	0.84	Th	8.12
Fe	179.00	Sn	2.60
Pb	0.027	Ti	1.78
Li	0.062	W	1.84
Mg	6059.00	V	0.84
Mn	95.43	Zn	82.00

Table 1.4 ~ Typical Protein Analysis of Hempseed

Table 1.4
Typical Protein Analysis of Hempseed

Alanine	9.6 mg/gr seeds	Lysine	4.3
Arginine	18.8	Methionine	2.6
Aspartic Acid & Arginine	19.8	Phenylalanine	3.5
Cystathionine	0.9	Phosphoserine	0.9
Cystine & Cysteine	1.2	Proline	7.3
Ethanolamine	0.4	Serine	8.6
Glutamic Acid & Glutamine	34.8	Threonine	3.7
Glycine	9.7	Tryptophan	0.6
Histidine	2.5	Tyrosine	5.8
Isoleucine	1.5	Valine	3.0
Leucine	1.5		

Table 1.5 ~ Properties of Hempseed Oil

Table 1.5
Properties of Hempseed Oil

Specific Gravity (15°C.)	0.923-0.925
Specific Gravity (30° C.)	0.9547
Refractive Index (n45D)	0.1470-1.473
Iodine Number	140-175
Acid Value	16.4
Saponification Number	190-193
Unsaponifiable Matter	0.28-1.6%
Titer	15-17° C
Moisture	0.19%
Smoke Point	165° C
Flash Point	141° C
Melting Point	-8° C
Fat Stability AOM	5 hours
Free Fatty Acid	0.94%
Chlorophyll	6 ppm

Table 1.6 ~ Fatty Acid Analysis of Hempseed Oil

Table 1.6
Fatty Acid Analysis of Hempseed Oil

Arachidic Acid (C20:0), 0.5%	Linolenic Acid (C18:3), 18.9%
Behenic Acid (C22:0), 0.3%	Gamma-Linolenic Acid (C18: 3), 1.7%
Eicosenoic Acid (C20:1), 0.3%	Nervonic Acid (C24:1), 0.2%
Erucic Acid (C22:1), 0.2%	Oleic Acid (C18:1), 12%
Heptadecanoic Acid (C17:0), 0.2%	Palmitic Acid (C16:0), 6.1%
Lignoceric Acid (C24:0), 0.3%	Palmitoleic Acid (C16:1), 0.3%
Linoleic Acid (C18:2), 56.9%	Stearic Acid (18:0), 2.1%

2.1 ~ Introduction

Edward Antil recommended the cultivation of cannabis in his *Observations on the Raising and Dressing of Hemp* (1777), thus:

"Hemp is one of the most profitable productions the earth furnishes in northern climates... It becomes worthy of the serious attention of the different legislatures of the northern colonies, of every trading man, and of every man, who truly loves his country.

"But as the people of America do not appear, from their present management, to be acquainted with the best and most profitable method of cultivating and managing this valuable plant, I beg leave to inform them of some things that may be of advantage to them." **(1)**

The anonymous Farmer from Annapolis also asserted the benefits of hemp husbandry in his *Essay on the Culture and Management of Hemp* (1775):

" Hemp is one of those plants which may be cultivated in many different situations, and in almost every different soil, no plant yielding, in our climate [New England], a crop more certain or more advantageous.

"A most peculiar advantage attending the culture of this plant, that it may be repeatedly sown on the same piece of ground, experience having shown that any dry land... properly prepared with manure, will produce much heavier crops than the richest fresh lands, and that the same piece of ground, assisted with a moderate quantity of manure, will admit of being successively sown, probably to the end of time, without any diminuation of crops.

"How easy therefore it is in every man's power to prepare, even on the meanest ground, a portion of ground sufficient to raise what is necessary to supply, at least, his family's wants? It will not require a fourth, perhaps not a tenth of the ground necessary to produce an equal quantity of flax...

"Hemp also produces a most certain crop, it being by no means subject to those accidents to which flax is exposed, from the uncertainty of seasons; rain, it is true, is necessary at the time of sowing, and it will indeed be something extraordinary if there doth not happen, during the course of ten weeks (for so long the season for sowing Hemp continues) a shower sufficient for this purpose, for its vegetation is so quick, that, in a very few days after it is sown, its leaves entirely cover and shade the ground, protect it from the scorching sun, enable it to retain the moisture, and prevent the seeds of the common weeds from sprouting. From this time the dews alone will prove sufficient to bring it to perfect maturity, and, indeed, heavier crops are produced on ground highly manured, in dry seasons, than in over wet years.

"The more we consider the nature and properties of hemp, and reflect how happily it is adapted to our climate and soil, the more reason there is to wish that the inhabitants of these colonies would avail themselves of its advantages...

"Nothing is wanted but the countenance, example, and encouragement of people of influence; and docility, attention, and industry in the poor...

"Now Hemp does not require half the rain that flax does; this is a circumstance that is well worth the notice and attention of every farmer; and therefore by his raising Hemp... he can with greater certainty supply all the necessary uses for his family; and by selling the overplus, he can purchase such things as his wife and daughters may think convenient on extraordinary occasions. This however need not hinder him from raising some flax every year. But I think that it is more for his interest to fix his chief dependence upon his crop of Hemp, as that is more sure, and in every way more profitable, the general run of seasons considered...

"From experience, then, we have reason to despair of raising flax in sufficient quantities to answer all our demands... A total neglect of flax is not intended to be recommended; where it succeeds tolerably, let the raising of it be continued, but the author hopes to be able to show, that, where the cultivation of flax cannot be carried on to advantage, Hemp may be substituted in its room, and will effectually answer, especially in coarse manufactures, every purpose to which flax hath been applied... Beneficent nature, which has made this plant so usefully, hath also most indulgently suited it to almost every climate, as well as to every sort of soil." **(2)**

Timothy Painne, who edited M. Marcandier's *Treatise on Hemp*, was confident that his fellow Americans would be pleased to grow more of the crop once they learned of its many benefits. That seed of hope remains viable today:

"If they apply themselves to the cultivation of Hemp, and carry to perfection the methods of preparing it, what resources will they not find, in employment so profitable, and at the same time so easy? For to consider only its common qualities, it must be acknowledged, that it is a commodity absolutely necessary. The use of it extends to almost all the purposes of commerce and of life. There is no state nor condition that can be without it. The very person who cultivates it, is the first to make use of it for cloathing, and of all his labours, this is often the only fruit which he retains. There is a singular kind of circulation in this commodity; nothing that bears a near resemblance to it is to be found in the other productions of life. The more it is used, the more you increase its consumption. The cultivation alone is a labor that requires inhabitants, and the consumption of it serves to maintain them. In the different methods of preparing it, young men and women, old men and children, find employment, in proportion to their strength and ability. Some find business in preparing the ground and sowing it; others pull the Hemp, and water-brake it; others make ropes or cloth; all of them join in the consumption, and make use of it; and every one jointly and severally contributes to renew their work." **(3)**

John Bordley assures us likewise in his discourse on *Hemp* (1799):

"If the ground be good and well prepared, no crop is more certain than Hemp sowed in time and when the soil is moist. But, how uncertain is the tobacco crop! Failure of plants from frost, drought, or fly; want of seasonable weather for planting; web-worm, horn-worm, buttening low, for want of rain, curling or trenching, from too much rain; house-burning or funking whilst curing; frost before housed; heating in bulk or in the hogshead, inspection, culling, &c. Cultivating tobacco cleans, but exposes the soil to exhalation and washing away. It is only about a month that it shelters the ground: but Hemp shades it from May 'till about the first of August...

"A planter gaining 20 hogsheads of tobacco from 20 acres of ground, value 600 dollars, might expect 12,000 or 16,000 lbs of Hemp from the same ground, value 1,000 or 1,200 dollars. But, if the income from Hemp should be a fourth less than from the tobacco crop, yet I would, on several accounts, prefer the hemp culture." **(4)**

Edmund Quincey also offered his personal assurance to American farmers in a booklet on *Hemp* (1799):

"It may be expected, that, in the common way of [broadcast] sowing, an acre of good land will produce 7 or 8 bushels, but in the horse-hoeing or drill method, 10 or 12 bushels, and sometimes more. This makes the female Hemp more valuable than the male: and this must continue to be the case for some years in America, while this branch of husbandry is growing, as the American seed, may be more certainly depended on, than any from Europe: and indeed every husbandman who finds he has encouragement to encrease the quantity of his Hemp soils, will annually find a want of the greater part of his best seed, especially in a new country, abounding with so much suitable land for raising hemp, as these American colonies do; for which reason, the Farmer may for some years, almost assure himself, that what seed he can spare will produce him near the same price which he pays for the seed he purchases to begin with: this I mention as a considerable inducement for him to begin upon this profitable branch of husbandry, and am persuaded, he will see the observation to be just..

"When he is told, that the same acre of land will yield him an equally good crop of Hemp, the third year, in case he plows it up as soon as the crop is pulled, and cross-plows it in about three weeks later; and will afford it a summer fallowing, and twice or thrice plowing the following year: I presume the Farmer will be inclined to make the experiment, altho' only upon a quarter of an acre, which I heartily recommend to him; and sincerely wish him success." **(5)**

Thomas Jefferson determined that, "A hand can tend 3 acres of hemp a year." About 20 man-hours per acre are required to produce a crop of hemp. The operations are: plowing, disking, harrowing, seeding, rolling, reaping, bundling, spreading, picking-up, breaking, hackling, baling, and transporting.

David Marcus compared hemp and three other crops in his study of *Commercial Hemp: An Economic Justification* (1997). He showed by comparison to canola, grain corn, and spring wheat, that hemp is by far the most profitable crop of choice:

"I estimate that growing for seed and fiber will generate long term combined revenues of $244-430/acre. The total expected costs of growing hemp for seed are $237/acre; even in a 'worst case' scenario, a minimum return of $7.25 is expected... This is slightly better than the expected return from spring wheat... The median expected hemp yields and prices generate expected returns which are more than double the next best crop, Ontario canola, and the highest estimates (which still should be considered conservative) are really quite exceptional compared to the other crops... Currently, hemp oil sells wholesale for approximately $38.50/kg. At an extraction rate of 25% and seed yields of 0.3-0.5 tons/acre, an acre of seed pressed for oil will gross C$2900-$4800." **(6)**

In comparison, spring wheat and canola cost $102.48 and $108.02/acre respectively. Production costs in Ontario (1995) were about $5/acre higher. Grain corn cost $202.79/acre, and canola cost $121.58. According to farmers' opinions expressed in the *Hemp Commerce & Farming Report* (May 2000; www.hemphasis.com), hemp grain must sell for about 35 cents/lb to be competitive with soy or flax.

Table 2.1 ~ Economic Profitability of Hemp for Seed & Stalk vs. Other Crops

Table 2.1
Economic Profitability of Hemp for Seed & Stalk vs. Other Crops

	Canola	Gr. Corn	Spr. Wheat	Low P/Y Hemp	Ave. H.	High P/Y H.
Av. Yield bu/ac	33	109	41	14.3 bu/ac +2.5 t/ac	19 bu/ac +2.75 t/ac	23.8 bu.ac. +3t/ac
Ave. $/Bu.	$ 6.30	$ 2.86	$ 3.59	$ 7.50/bu $ 55.00/t	$ 8.38/bu. $ 62.50/t	$ 9.25/bu $ 70.00/t
Total $$	$207.00	$311.74	$147.19	$244.75	$ 337.45	$ 430.15
Total Costs	$166.55	$277.80	$140.39	$237.50	$ 237.50	$ 237.50
Return ($/ac)	$ 41.35	$ 33.94	$ 6.80	$ 7.25	$ 99.95	$ 192.65

Table 2.2 ~ Approximate Production Costs ($/Acre) in Saskatchewan (1996)
(Adapted from Gordon Reichert, Publication #60, Ontario Ministry of Agriculture)

Table 2.2

Approximate Production Costs ($/Acre) in Saskatchewan (1996)
(Adapted from Gordon Reichert, Publication #60, Ontario Ministry of Agriculture)

Expenses	Hemp Fiber	Hurds	Seed
Cash Operating Costs	$ 22.9 kg/ac	$ 29.2 kg/ac	6.0 kg/ac
Seed	$ 45.11	$ 57.49	$ 11.83
Fertilizer	$ 29.20	$ 29.20	$ 29.20
Chemicals			
Herbicides	0	0	$ 7.30
Insecticides	0	0	$ 3.65
Machinery Operation			
Fuel	$ 6.94	$ 6.94	$ 6.94
Repair/Maint.	$ 18.98	$ 18.98	$ 18.98
Hired Labor	$ 5.84	$ 5.84	$ 5.84
Crop Insurance Premium	$ 5.11	$ 5.11	$ 5.11
Utilities	$ 1.20	$ 1.20	$ 1.20
Miscell. Overhead	$ 1.83	$ 1.83	$ 1.20
Building Repair	$ 0.84	$ 0.84	$ 0.84
Property Taxes	$ 2.74	$ 2.74	$ 2.74
Interest on Operating	$ 2.80	$ 2.80	$ 2.80
Total Cash Costs (A)	**$125.42**	**$137.82**	**$103.11**
Machinery Depreciation	$ 20.99	$ 20.99	$ 20.99
Building Depreciation	$ 0.84	$ 0.84	$ 0.84
Machinery Investment	$ 12.78	$ 12.78	$ 12.78
Building Investment	$ 1.35	$ 1.35	$ 1.35
Land Cost	$ 16.79	$ 16.79	$ 16.79
Labor & Management	$ 13.87	$ 13.87	$ 13.87
Total Non-Cash Costs (B)	**$ 66.61**	**$ 66.61**	**$ 66.61**
Total Cost (A+B)=(C)	**$192.06**	**$204.44**	**$169.73**

2.2 ~ Soil

It is imperative to analyze soil samples before commencing to sow hemp. Tests should be performed to determine pH, levels of organic matter, and macro- and micro-elements. Soil pH should range between 6.3 to 7.8, and it should contain at least 3.5% organic matter (more is better). Phosphorus should be at least >40 ppm, potassium >250 ppm, sulfur >5000 ppm, and calcium <6000 ppm. The ratios of elements also should be determined. For example, high levels of calcium bind phosphorus and make it unavailable to the plants --- a problem that can be avoided by testing the soil.

Hemp should not be sown on spring-plowed sod. The plowing depth should be about 8 inches so as to give a deep bed for root development. Less than 6 inches of plow-depth gives much lower yields. The land should be given a deep plowing in the fall so the winter weather can crumble the soil. After the field is furrowed, the topsoil is packed and smoothed with a ring roller. It must also be smoothed finely with a disk harrow in the spring. If the topsoil cracks open after sowing, the cracks must be cleared away with a hoe or roller.

The timing of fall plowing significantly affects the overall yield of the following hemp crop: the sooner, the better. Late plowing reduces yields by as much as 30%.

The USDA *Farmer's Bulletin* No. 1935, entitled "Hemp", was issued to farmers in 1943 to initiate them to the subtleties of hemp cultivation. The bulletin advises:

"Hemp should not be grown on poor soils. To obtain good yields and fiber of high quality, it is necessary to have a growth of uniform stalks 6 to 8 feet long. Short stalks, from poor nonfertile lands, seldom produce a high-quality fiber... [Hemp grows well in the Corn Belt, but] if land will not produce from 50 to 70 bushels of corn per acre, it should not be planted to hemp for fiber production." **(7)**

A report by Lyster Dewey in the USDA *Yearbook* (1913) states:

"On the best farms the crop is cultivated four times --- twice rather deep and twice with cultivators with fine teeth, merely stirring the surface." **(8)**

During World War II, the German government published *The Humorous HempPrimer* to educate farmers and encourage its cultivation. Moor land was recommended as proper ground for hemp. That is true, *but only for seed hemp*, not fiber crops:

"He who grows hemp in the moor is carrying on true moor-culture since the options are quite limited: the moor farmer grows potatoes, cabbage, and some grains as well as corn. Little else can grow here.

"When growing other crops in the marsh, even if the seeds sprout nicely, the weed growth is extensive. Hacking and hoeing without rest, as the moisture seeps out, the moor gets dusty and useless. The farmer's efforts are constantly hindered by strong weed growth.

"Here the mighty hemp plant enters as saviour of the moor lands. It grows quick and large and helps cultivate the lands. Most any crop is happy to alternate with hemp, since hemp's shady umbrella forces weeds to their knees. It keeps the moor ground dark, clean and healthy. Also the moor's tendency to late rust doesn't bother hemp a bit. Even virgin soil in the marsh can yield weak hemp production. However, when properly drained, hemp performance is quickly improved. In short, marsh values are increased by sowing hemp!

'In many areas, both in mountains or valleys, hemp removes many inherent weaknesses of the soil if first one lowers the groundwater level... [to] at least 50 cm [20 in.] below the surface." **(9)**

The USDA advised to the contrary in *Farmers' Bulletin* No. 1935:

"Muck or peat soils are not recommended for the production of high-quality hemp fiber. The quantity of fiber produced per acre on these soils may be very high, but experience has demonstrated that the fiber lacks strength, which is the first requirement of hemp fiber for good cordage."

In his *Treatise of Hemp Husbandry* (1775), Edmund Quincey recommended an additional plowing after mellowing the soil:

"The last time the ground must be plowed in ridges of about six feet wide, flat and even on the top as they can be laid, with a small interval between each ridge, sufficient for the pullers to pass, when the male hemp is ready for pulling.

"The reason why the ridges are to be made thus narrow, is for the more convenient pulling of the male Hemp, which is always pulled several weeks before the female... being sowed in ridges you are enabled to pull the former, without bruising or otherwise damaging the latter, which is very prejudicial to the crop."

Hemp loosens, mellows, and shades the soil, and the fallen foliage forms a mulch that preserves moisture and bacteria in the soil. The root system decays quickly after the harvest. Up to two-thirds of the organic matter returns to the soil if hemp is field-retted. Hemp depletes some humus; nonetheless, it is easier on the land than any other crops except alfalfa and clover.

2.3 ~Water

Hemp requires at least 20-30 inches of rainfall during the growing period, and irrigation is necessary if precipitation is less than adequate. Abundant moisture is needed during the germination period. The absorption of water by hemp increases daily until flowering begins. Then the uptake of water decreases considerably, with a subsequent increase occurring at late flowering and during seed formation. In total, 80-130 gallons of water are required to produce 1 kg of dry fiber. Hemp uses twice as much water in light soil than it does in medium soils. There is also a significant correlation between soil moisture and cannabinoid content.

L. Slonov performed extensive tests from 1975-1977 to determine the correlation between water supply and ATPase enzyme activity in hemp:

"The optimal water deficit for normal metabolism in hemp plants was 7-15% of total leaf saturation. Soil moisture should not go below 80% of total moisture capacity during hemp ontogenesis." **(10)**

USDA *Farmers' Bulletin* No. 1935 had this to say about water:

"Drought conditions, if accompanied by high temperatures, appear to hasten maturity before the plants are fully grown... Hemp requires a plentiful supply of moisture throughout its growing season, especially during the first 6 weeks. After it has become well rooted and the stalks are 20 to 30 inches high it will endure drier conditions, but a severe drought hastens its maturity and tends to dwarf its growth. It will endure heavy rains, or even a flood of short duration, on light, well-drained soils, but on heavy, impervious soils excessive rain, especially when the plants are young, will ruin the crop.

"The hemp plants in puddled areas of a saturated field will be ruined within two days; it is imperative that the field be well-drained. On the other hand, if the slope of a field is too steep, precipitation will run off the field before it can be retained. If excess winter moisture or heavy rains are likely, the field should be plowed with water-furrows every 30-40 feet, leading to drainage ditches."

Irrigation --- Three-fourths of the farmland in America could grow hemp up to 15 feet tall if adequate water was available; irrigation is therefore recommended. G. Kr'stev and I. Furdzhev conducted a study of the effect of irrigation on hemp; the yield of dry stems increased by 20%.

The practice of cultivating hemp under irrigation was developed by George W. Schlichten (inventor of the decorticator of that name). He published a small treatise on the subject, providing the following instructions:

"The land upon which hemp is to be grown by irrigation must, of course, be level within the checks, so as to assure an even and thorough irrigation... [After plowing and harrowing,] the checks are to be made and they may need some leveling within the checks. The size of the checks will vary according to the lay of the land and the volume of water available for irrigation. The checks can be made in the same manner and of the same size as those for alfalfa."

"Before planting the hemp the land must be thoroughly irrigated, which is best done by making a number of cross checks within the borders. Within these cross checks the water should be held until the ground is thoroughly soaked. This insures a perfect seed bed and an even germination of the seed.

"As soon as the land is dry enough for working it should be thoroughly loosened up by a spring tooth harrow going lengthwise within the checks...

"Referring to a general practice, the first irrigation of the growing hemp should be given when it is needed, or when it will do the most good, as the timely first irrigation is, so to say, the making of the crop, as far as the stand is concerned. The time to give the first irrigation is when the young hemp plants do not continue a vigorous growth, or indicate otherwise the lack of moisture in the ground, whether they are 6 inches above the ground or 2 feet.

"For the experienced grower it is best that the first irrigation is given as soon as the plants are tall enough to shade the ground. If irrigated before that time, because of lack of moisture in the land, the surface of the ground is liable to cake or harden, and that would necessitate another irrigation about a week or 10 days thereafter, which will bring about that the plants shade the ground.

"The land should be level within the checks and with good solid borders, so there will be no trouble to irrigate properly and thoroughly, covering every part of the check sufficiently with water. If borders have to be reinforced or cross-checks have to be put up by shovel when irrigating, then a certain percentage of the crop is destroyed, to say nothing of the time and labor that have to be applied. It therefore pays to prepare the land right before planting.

"No water should be left standing in the checks, and the ends of the checks must be drained a few hours after the irrigation, or the end water can be let into the adjoining check that is to be irrigated next.

"The subsequent irrigations usually follow at an interval of about 2 or 4 weeks, according to the condition of the soil or weather. The crop must be kept growing steadily and according to that the irrigations have to be timed. Failure to irrigate when it is necessary is liable to stunt the crop, and that checks the growing."

2.4 ~ Temperature

Tamm determined that hempseed needs a minimum temperature of 1-2^{o} C for germination and emergence. It should not be sown until the soil temperature rises to 10^{o} C. The optimum temperature is 35^{o} C; the maximum is 45^{o} C, at which temperature the seeds sprout within 12 days.Young hemp plants can survive frost as low as -5^{o} C, but the plants will stop growing even if warm weather follows. The temperature range for hemp growth is 19-25^{o} C (66-77^{o} F). Hemp enters into its rapid growth stage (about 2 inches/day) when the average temperature rises to 16^{o} C (61^{o} F). If southern varieties of hemp are grown in northern latitudes, however, the fiber might not attain technical maturity within 110-115 days, and certainly their seeds will not ripen. The farmer must consider this when selecting a hemp cultivar for his location.

C. Richez-Dumanois, *et al*., studied the *in vitro* propagation of hemp clones, thus:

"Morphological and chemical development decreased at low temperature and was promoted by a regime of 22^{o} C (daily temperature) and 17^{o} C (night) under 24 hour illumination and 70% relative humidity." **(62)**

The phenotypic expression of cannabis is strongly influenced by the temperatures of the soil and air. This effect can be used to advantage in breeding. C. Nelson conducted such experiments with these results:

Air 30^{o} C/Soil 30^{o} C: Maximum elongation, number of nodes, leaf abscission, and water consumption; earliest maturation; minimum leaf area; many staminate flowers.

Air 30^{o} C/Soil 15^{o} C: Maximum stem weight; minimum plant weight; many staminate flowers.

Air 15^{o} C/Soil 30^{o} C: Maximum leaf size, stem diameter and weight; sex reversals from pistillate to staminate.

Air 15^{o} C/Soil 15^{o} C: Maximum leaf area and root water content; minimum water consumption; latest blooming; many pistillate flowers with sex reversals from pistillate to staminate.

During the flowering phase, the optimal temperature is 16^{o} C (61^{o} F) during the critical night period, and 28^{o} C (80^{o} F)during the photoperiod.

2.5 ~ Sowing

Hemp may require up to three years to acclimatize to a new locale. This fact has caused problems for many new hemp farmers, who expected much higher yields than they actually achieved. It is recommended that experimental plots of seed hemp be grown to develop a localized strain before committing to large-scale cultivation. The best variety must be selected with careful consideration for the differences in yields of seed and stalk, maturation (early or late), and fiber content, etc; an error in this wise can result in a shortfall of 30% or more.

The art and science of producing the finest quality hemp fiber requires that perfect seed be sown at the proper time in prepared soil. Good hempseed is bright gray and plump, and has a nutty taste. White seed will not germinate; green seed is unripe, germinates slowly, and produces weak plants that are smothered by more vigorously growing hemp. Black seeds have fermented due to improper drying after harvesting; they taste rancid.

The USDA warned farmers about "lint seed" (linseed):

"In some instances seed is saved from hemp grown for fiber but permitted to get overripe before cutting. This is known as lint seed. It is generally regarded as inferior to seed from cultivated plants. A good crop is sometimes obtained from lint seed, but it is often lacking in vigor [heterosis] as well as germinative vitality, and it is rare that good crops are obtained from lint seed of the second or third generation."

One bushel of hempseed weighs 21 kg (44 lb). If hempseed is good, at least 95% will germinate, though a germination potential of 85-90% is considered to be acceptable. The water content should be about 12%. **(11)**

As of 1998, only 44 registered varieties of hemp exist, and only 32 are available. Such an extremely limited base could make hemp crops vulnerable to devastating blights. The gene pool is acclimatized to 45-55^{o} N latitude (Europe, Canada, and the northern states of the USA). The IHA has recommended that tropical germplasm, which contain high levels of psychoactive THC, be drawn upon for development.

The most popular French varieties are the monoecious Ferimon-12 and Futura-77, hybrid Fedora-34, and Fedrina-74. The Hungarian variety Kompolti, bred by the renowned hemp breeder Dr. Ivan Bocsa, contains 35-38% "technical" fibers, with a maximum yield of 12 tons/hectare within 115 days. Other available Hungarian varieties are Uniko-B, Fibriko, and other Kompolti cultivars. They are marketed by Fibro-Seed Gmbh (H-3356 Kompolt, Hungary). The hemp grown in Asian countries are landraces, not cultivars, and have little economic significance in Europe. In America, however, Kentucky hemp was developed from a cross of Chinese and European cannabis. This gene pool has become feral since 1937 and needs to be redeveloped. Canadian farmers are permitted to grow about two dozen varieties of seed, including Anka, the first Canadian cultivar.

The yield and quality of fiber is strongly influenced by the seeding rate. Hempseed is sown at the rate of at least one bushel per acre, and up to 5 pecks is common. Germination will be uneven if the seed is planted deeper than 1.6 inches. Shallow seeding also produces erratic germination. The seeds must not be covered more than one-half inch deep. Roller disk drills give better results than tooth drills, and rolling the land after seeding benefits the crop. When compared to other methods, strip sowing considerably improves all the qualitative indices of hemp fibers. **(12)**

S. Losev studied the effects of seeding rates and methods of sowing hempseed. He concluded:

"With continuous sowing of hemp in rows spaced at 15 cm, on well-fertilized soil, about 100 kg/ha of 100% valid seed should be sown (4.5 million seeds). With close-spaced drill sowing (with the rows spaced at 7.5 cm) the rate must be raised to 120 kg/ha (5.5 million seeds). With a shortage of seeds, and on weedy soils, sowing should be carried out in close ribbons (22.5 x 7.5 cm) with a seeding rate of 60-80 kg/ha. This method allows for a single inter-row hoeing." **(13)**

The Czeckoslovakian hemp breeder F. Baxa reported these results of his experiments with sowing density:

"On fertile soils greater yields were obtained when sown in rows 7.5 and 12.5 cm apart. Soils with lower fertility yielded significantly more stalks and fiber when sown in rows 22.5 cm apart. In both cases a seeding rate of 100 kg/ha proved best." **(14)**

Extensive tests have shown that the best growth of a small crop of seed hemp is achieved when the seeds are planted in mounds at least one yard apart, at a rate of a dozen per mound (10-15 kg/ha). When the plants are about a foot tall, they must be thinned to only 4 or 5 per hill, or one plant per 20 inches. Good stands cannot be obtained with thin seeding, and good plants cannot be obtained without thinning. Large crops of dual-use (fiber and seed) hemp are planted in rows up to 16 inches (40 cm) apart. It is sown at a rate of 12-20 kg/ha (60-100 plants/m^2), depending on the row spacing, with 7 seeds per linear foot of row (20 grams per thousand grain weight). When grown for seed alone, hemp is sown in rows at least two feet apart with only two or three seeds per foot. Seed hemp should not be grown more than 800 feet above sea level, because the seeds probably will not mature in due time, even if it is an early variety. **(15)**

The Anonymous Farmer recommended this plan for cultivating a crop for its seed:

"A far better method is to raise the seede apart by itselfe, either on a portion of the ground allotted for the HEMP, or what would be yet more proper, on any good spot that is convenient for this purpose, which must be reduced into proper tilth... This ought to be done as soon as the frosts are over, for, provided that the weather is mild and will permit, the earlier what you intend to raise seed from is put into the ground the better, not only because the forward plants bring their seeds better to maturity, there will be time to sow the ground again.

"The season for sowing being come, the ground should be laid off, either with the plow or hoe, into flat hills, about 4 feet asunder, in each of these hills, about 10 to 15 grains of the HEMP seed may be deposited, and as soon as they are sprung to such a height as to be past danger from frost, or other accidents, the hills ought to be thinned, pulling up the superfluous stalks, leaving about 8 or 9 plants in each hill... An acre of ground, managed in this manner, will produce from 20 to 25 or 30 bushels of seed."

Thomas Jefferson noted the following in his farm journals:

"To make hemp seed, make hills of the form & size of cucumber hills, from 4 to 6 ft apart, in proportion to the strength of the ground. Prick about a dozen seeds into each hill, in different parts of it. When they come up thin them in two. As soon as the male plants have shed their farina, cut them up that the whole nourishment may go to the female plants. Every plant thus tended will yield a quart of seed. A bushel of good brown seed is enough for an acre."

Edward Antil offered these considerations in his *Observations*:

"If you have no convenient place to sow your seed Hemp by itself, then sow a border of 6 feet wide along the north and west sides of your Hemp field; the reason of sowing your seed Hemp in such narrow ridges or borders is that, when the carle or he Hemp is ripe, and has shed its farina on the fimble or female Hemp, by which the seed is impregnated, and the leaves of the carle hemp fall off and the stem grows yellow, you may easily step in along the sides and pull up the carle Hemp without hurting the female, which now begins to branch out, and looks of a deep green colour and very flourishing, and when the seeds begin to ripen, which is known by their falling out of their sockets, you may all along both sides bend down the plants and shake out the seed upon a cloth laid on the ground, for as they ripen they scatter upon being shaken by a hard wind, or otherwise, then it must be watched, and the fowls... kept from it, for they are immoderately fond of the seed."

Fiber hemp crops are thickly seeded using a standard grain drill or modified alfalfa seeder, at a rate of 55-70 kg/hectare (ha = 2.47 acres). The row width should be 4 to 8 inches, and not more than 10 inches. Field studies have shown that the maximum yield of dry plant matter is obtained with a seeding rate of no more than 80 kg/ha (70 lb/acre). Excessive seeding will produce hemp of insufficient height and no value to the farmer. The optimal plant density is about 160 per square meter in nitrogenous soil, up to 260/m^2 in mineral soil. The percentage of bast fiber increases with the seeding rate. 40-50 kg/ha will yield about 200 plants/m^2 at emergence, self-thinning to about 140/m^2 at harvest. Tests conducted in 1972 by J. Ritz determined that there was no influence of stand density on the yield of stems with 100, 125 and 150 plants/m^2.

Analyses of modern fiber hemp production in The Netherlands indicate that crop productivity can be improved by earlier sowing, albeit at risk of suffering from frosts. According to an idealized crop growth model, sowing on April 15 and harvesting on September 15 should yield about 1 ton/ha of dry stems. Sowing on April 1 would increase the yield by 2.3 tons/ha. Sowing on April 30 would reduce the yield of stems by 1.4 tons/ha; sowing on May 15 would reduce the expected yield by 3 tons/ha.

At latitudes south of 35^o hemp can be planted in any month if there is sufficient moisture to germinate the seed before solar heat kills it. That can be prevented somewhat if the seed is covered two inches deep and lightly harrowed.

In the USA, at the latitude of New York City/Indianapolis, hemp can be sown as early as March 25, and harvested in the last week of June. A second crop can be sown and harvested early in October. Only one crop can be planted north of 40^o latitude.

If the field has been prepared for irrigation as described by George Schlichten, the following method should be applied:

"The seeding should be done crosswise over the checks, across the borders and about 10 checks can be seeded at a time. By seeding across the borders, all the land is made productive and the stand will be uniform in size of stalks. If the borders are not seeded, the hemp that grows alongside of same will produce big and branchy stalks (flange stalks) which make an inferior fiber and therefore reduce the average quality of the hemp.

"After seeding, the loose and porous land should be lightly rolled across the checks the same way as the seeding was done; the heavier and more compact soil should not be rolled, but harrowed within the checks, that is, parallel to the border, as harrowing across the borders would reduce their height too much, but the teeth of the harrow must be set slanting."

USDA *Farmers' Bulletin* # 1935 offers another suggestion:

"A good practice in planting hemp for fiber production is to sow around the edge of the field next to the fence a 16- to 18-foot width of small grains, which may be harvested before the hemp. Space is thus provided for the harvester to enter the field and begin cutting without injuring the hemp. It also prevents hemp plants at the edge from growing too rank. Uniform plants are necessary for uniform fiber quality."

Wind and changes of temperature will harden the lignin and render the fibers coarse and "harsky" (harsh). It is important that the stalks grow close together under the shelter of their foliage, thus creating a favorable micro-climate among the plants.

Edmund Quincey recommended this method of sowing hemp, "as has been very exactly experienced":

"The Farmer being sure of good seed, and given his ground the last dressing, and thereby laid it as fine and level, as the border of a garden; the seed must be sown as carefully and regularly as possible, and as it is very tender, and will bear but a slight covering, care must be taken, lest by burying too deep, the vegitation may be prevented. Clods left unbroken with the Harrow and Roller, have the like effect upon much of seed, in the common method of sowing: Negligence in this respect has often ruined more than one-third of a Crop; for a great part of the plants will rise irregularly, and getting bad habit in their first shooting, the produce will be small.

"The preparation of the soil in the drill way of sowing hemp-seed, is the same, as in the common way. The seed must be planted in double rows, with ten or twelve inches partition, and with intervals, for the passage of the hoe-plow, from three or four feet broad, as the soil may be more or less rich; the richer the soil, the narrower may be the intervals. The seed must be planted and covered very shallow, and is not safe in general if covered deeper than about half an inch, unless in very light soils, in which it may grow at one inch depth.

"The seed let into the ground by the drill is less in danger from birds, because it is all covered; but yet may be watched to prevent their getting at it very early in the morning, and towards evening...

"When the Hemp is four or five inches high, the Farmer sends into the field careful laborers with hand hoes, to cut up weeds which may rise in the partitions; once is sufficient, as thereby by the Hemp gathering much strength, it will prevent their rising any more. When the partitions are cleared by the hand hoe, then let the horse-hoe plow be set to work in the intervals, and with this let all the ground between the double rows be turned up deep and broke fine. The weeds will be destroyed by this, and the whole soil made fit to receive the roots, and nourished for their support. The good effect of this kind of husbandry, is in no other respect seen more evidently. The fibres of the roots of Hemp even in the most favorable soils, do not naturally spread, but lie in clusters about the base of the stock, their numbers answering for their shortness, but in the horse-hoeing way, the fibres of the plants of the two opposite rows will meet across, and fill the intervals, and the plant will flourish accordingly... by this means the ground will be several times enriched, while the crop is growing... [the soil] will retain so much of the nitrous quality of the dews and rains, as will render it abundantly capable of producing several crops, though the soil be but of a midling goodness... herein the Farmer is supposed to change his partitions each succeeding year, into the intervals of the past year's crop, these being enriched by the hoe-plow cultivation..."

Lionel Slator gave this advice in his *Instructions* to farmers:

"In the sowing of Hemp, great Care and Judgment ought to be used, that it be not sowed too thick or too thin: In the first Case, it would be apt to lodge, and so lose the crop; In the second, the Hemp will run more to Bunn [coarse] or Straw, than it will to harl or Skin."

Edward Quincey also noted this:

"It is observed by some Farmers, that sowing early thickens the harle or coat of the Hemp."

John Bordley gave notice to this in writing of his experience with *Hemp* (1799):

"My hemp never suffered materially from drought but once, and that of a sowing in May. It was never found necessary to weed what was sowed for a crop: but only such as was sown very thin for producing seed. Sometimes seed was saved from the margin of the field, where the plants had room to branch and were coarse..."

Edward Antil assured early American farmers that they could prophesy truly if hempseed was sown wisely, according to his *Observations on the Raising and Dressing of Hemp*:

"The ground being moist as I said before, but by no means wet so as to clod, which would ruin the crop, and nothing after that, but too much wet, will hurt it... Whereas if the seed be sown, when the ground is dry, the seed that lies deepest where the moisture is, will come up first, and these will shade and starve those that come after, by which means the first comers will be too large, and the last will be much too small, so that the crop will be damaged in every way: So much depends on this one circumstance of sowing the seed when the ground is moist and fit to receive it."

The anonymous 18th century "Farmer from Annapolis" emphasized the importance of right timing in sowing hempseed:

"It may be necessary to observe, that as the Hemp which is first sown, provided it does not meet with any accident, most commonly, yields the heaviest crop... It is however by no means eligible to sow this seed, till you can reasonably expect that no danger is to be apprehended from the frost; nor is it by any means proper to sow when the ground is very dry, or that there is an appearance of a continuation of dry weather; in either of these cases, it will be far more prudent to delay the sowing for a little... the first opportunity ought to be taken to sow the seed, either immediately before a rain, or as soon after as the ground will admit; sowing before the shower ought to be preferred, only because the seed will be covered much better and more equally when the ground is dry, than when it is wet: immediately before sowing, the ground must be laid level with the harrow, and the best and quickest method of covering the seed is, either with a short toothed single harrow, or a bunch of brush, which ought to be dragged once or twice over the land, and directly after, a wooden roller of 15 to 18 inches diameter ought to be run over it; when there is only a small piece of ground sown, the seed may as well be covered with a garden rake..

"As all kinds of birds, but more particularly pigeons and turtle doves, are remarkably fond of this seed, and will, if they are permitted to frequent the ground, destroy great quantities of it, even during some days after it is sprung up; it is necessary to keep them off until it has gathered strength, and the leaves become expanded... No further attention is requisite, until the season for pulling, unless it is to observe that your inclosure is sufficient to keep out such animals as might trample or break it."

Hemp was given extensive treatment in the *Fan Sheng-chih shu*, a Chinese treatise on farming written circa 25 BC. Farmers were advised to avoid the *ch'en* (the 5th in 12) day of the sowing period. Twenty days before being sown, the seeds were treated by immersing them in a decoction of powdered horse bones, aconite, silkworms and sheep dung. They were immediately dried in the sun, then stored carefully, and immersed again just before planting. If horse bones were not available, melted snow could be used instead:

"Snow is the essence of cereals; it causes crops to be drought-resistant. Always take advantage of winter to store snow; fill containers and bury them in the ground... If seeds are treated like this, the harvest will regularly be doubled...

"If you plant hemp too early [the males] will be hard and rigid, with thick skins and many knots. If you plant late then the skin will not be hard. It is better to err in being early than to err in being late."

Ji Sheng's Book (Western Han Dynasty, 206 BC-24 AD), instructed farmers thus:

"If the sowing time is early, the fiber will be thick and strong and can be harvested early. Otherwise, the fiber will not be mature. It is better to sow hemp seed early instead of late...

" First, soak the seed in water and sow them as soon as they germinate. Soak the seed in water for about the same time required to cook... rice. Then spread the soaked seeds on the bamboo bed for about 3 to 6 *cun* [inches] in thickness. Stir the seed several times and after one night they will germinate... Second, in order to avoid plant diseases and insect pests, hemp should rotate with wheat, beans, and cereals. Third, different methods should be used with different soil moistures.

"Disperse the sparrows for several days in order to protect the seeds... When the seedlings have grown for some time, thin out the weak ones so that... good seedlings can grow well."

The venerable *Qi Min Yao Shu* ("Essential Arts for the People", written circa 500 AD) gave these instructions to farmers:

"Generally, male hemp seeds are white. There are two ways to examine the quality of the white seeds. The first is to bite a seed with the teeth, and if the inside of the seed is very dry, it should not be sown. Otherwise the seeds can be sown. The second method is to put the white seed in the mouth for some time. The seeds that do not turn black are good."

Farmers in India sometimes soak the seeds overnight in milk and water before sowing. A traditional Chinese method of stimulating the germination of hempseed is to soak them in an aqueous extract of the plant. According to V.E. Sustrina, this also increases the number of females:

"Hemp seeds were soaked at 10-15^{o} C in extracts of dry inflorescences; the percentage of staminate plants was greatly reduced." **(19)**

In 1924, Luigi Leggieri described his experiments with pre-sowing treatments of hempseed:

"*Confettatura*: a dry method [causes] an organic fertilizer (poudrette, meat powder, bone dust, pulverized sheep manure, pigeon or chicken dung, etc.) to adhere to the seed. The adhesion is facilitated by adding the fertilizing materials to clay and then rolling the seed in this or by the use of gum arabic. Nutritive baths (immersing the seed in water or in solutions of K-sulfate, ammonium nitrate, Na-nitrate, dung, etc.) and disinfectant baths (using solutions of Cu-sulfate, arsenic lime and special preparations) belong to the wet method. Plot tests with hempseed, previously immersed in water, 1% and 3% potassium sulfate solutions and 1% and 3% ammonium nitrate solutions for 6, 12 and 24 hour periods, lead to the general conclusions that (1) the immersion in water has a favorable reaction, (2) the action of saline solutions varies with the seed; sulfate solutions act favorably on the hemp seed, (3) the duration of immersion has a great influence and hence it is necessary to find the optimum duration for each species. **(17)"**

Research conducted by J. Stephan in 1928 showed that ortho-phosphoric acid will stimulate germination when used in 1% concentration for 1/2 to 1 hour even in daylight, which usually inhibits the germination of hempseed.

G. Weeber reported his similar experiments, thus:

"When distilled water was used, germination occurred at least twice as quickly. A further acceleration was obtained by using a 30% solution of hydrogen peroxide; hemp seeds germinated within 12-24 hours." **(18)**

Hempseed can be induced to sprout within 12 hours if it is soaked in a solution of Mg-sulfate (0.8 % Epsom salt) or MgCl and then steamed with ether. Treatment with a 1% solution result in damage to the seeds. Germination occurs within 10 hours when hempseed is soaked in Mn-sulfate (1.5%) plus ether treatment, or with Pb-nitrate (0.5%) without ether treatment. Sprouting takes place within 6 hours when seeds are soaked in a solution of oxalic acid (1%), with or without ether treatment. The germination percentage is higher in darkness than in light. The resulting plants produced up to 88% increase in the dry weight of stems, and the plants' height increased up to 26%. The dry weight and height of the stems varied with formulas of the solutions; therefore this method can be used to improve plants in a systematic manner. Dry ether alone has no such influence; it is effective only in combination with the chemical solutions.

Treatment with carbon dioxide or ethylene before sowing influences positively the growth, budding, flowering, and ripening of hemp. Root development, seed production and total yields also are greatly increased by such treatment.

2.6 ~ Cultivation

Hemp intercrops happily with corn, mustard, broccoli, brussel sprouts, lupine, nettles, hops, and turnips. Hemp is not compatible with tobacco, spinach, cress, pepperweed, or vetch.

The Humorous Hemp Primer offered this encouragement:

" Hemp is not demanding of prior crops. It grows well after fruits, vegetables, grasses and grains. Moreover, shady hemp... does provide the best prior crop, because its tall, wide, dense growth strangles weeds. After hemp, all grains grow well and without problems. Also, fruits which follow hemp bring larger crops, as do grasses, delicate and tender when they lie down in hemp's bed. In short, anything sown in hemp's fields will bring rich harvest and much money."

The USDA *Farmers' Bulletin* No. 1935 noted:

"Old pastures plowed up [in the fall] are well suited for hemp culture. Fields previously cropped to soybeans, alfalfa, and clover are excellent for hemp. A good rotation is to follow corn with hemp, and in Kentucky a fall cereal may follow the hemp.

"When planted after fiber hemp, the yield of winter wheat is often increased as much as 10-20%. This cannot be done after a crop of seed hemp, because it is harvested late in the season."

The introduction of hemp as a new crop into the cycle of crop rotations can help reduce the incidence of diseases and soil pathogens. Hemp improves soil structure, suppresses weeds, and is nearly free of diseases and pests. In ordinary schemes of crop rotation, hemp can occupy the same place as oats or beans. Hemp also responds well to a preceding crop of wheat, peas, or potatoes, but should not follow sod, timothy, or small grain. In latitudes below 40^{o}, two crops of early-maturing hemp can be grown yearly, or a crop of hemp followed by a crop of peas to maintain the fertility and condition of the soil. Farmers in India plant hemp after millet, rice, indigo, tobacco, or coriander. Extensive experiments have shown that hemp is the best green manure for wheat.

Lyster Dewey suggested this scheme of crop rotation for hemp:

1st Year	2nd Year	3rd Year	4th year	5th Year
Hemp	Corn	Wheat	Clover	Grass
Hemp	Sug Beet, Potato, Onion	"	"	"
Corn	Peas, Beans	Hemp	Barley, Oats	Clover

1st Yr	*2nd Yr*	*3rd Yr*	*4th Yr*	*5th Yr*
Hemp	Corn	Wheat	Clover	Grass
Hemp	Sug Beet Potatot, Onion	Wheat	Clover	Grass
Corn		Hemp	Barley, Oats	Clover

S.S. Boyce gave more details in his book on *Hemp*(1900):

"The rotation kept up by rye or vetch, hemp, peas, and again rye, gives as perfect a condition of soil as can be desired. The roots of the hemp decay early, the peas penetrate deeply and leave the soil porous and supplied with nitrogen and humus; while rye and vetch keep the soil employed, and the three furnish feeding material more than paying their cost, while the rotation prevents any cloying of the soil appetite." **(20)**

A failed crop of hemp can be left to mature and then be burned, but better results will be obtained if it is plowed under as soon as it is certain that the crop is inadequate for fiber production. They rot very slowly, so mature stalks and hurds should be burnt rather than plowed under.

Hemp prefers alkaline soil, and it will not grow well on soil that previously was overgrown with either sedges or huckleberry bushes (indicators of acidic soils).

Cannabis is one of the best crops for eradicating weeds because it grows so quickly and suppresses their growth with its secretions of caffeic, ferulic, benzoic and coumaric acids. When hemp is planted in a fallow field, it destroys sowthistle, quack-grass, and cord-grass. Thus it becomes possible to grow two or three grain crops following hemp, whereas after ordinary summer-fallow, the second crop of grain usually is badly infested with weeds. The obnoxious bindweed is held in check by hemp, but the vines must be removed before the hemp goes to seed. Wild morning glory and bindweed vines will climb up hemp stalks.

No herbicides are needed when the spacing is 16 inches or less, because the rapid growth of hemp will suppress the weeds. With wider spacing, herbicides may be required. Dr. Ivan Bocsa recommends that monocotyledons be suppressed with Benefin (1 gal/acre of a 20% solution), applied with disc before sowing. Dicotyledons can be fought with Maloran (50%, 3 lb/acre), Patoran (2 lb/acre), or Pyramine (5 lb/acre), applied immediately after sowing. **(16)**

When hemp is cultivated for seed, Canada thistles may appear among the stands and must be spudded out manually while the hemp is only a few inches high. Canada thistle and quackgrass can be killed completely by one crop of hemp.

Cannabis is damaged by broomrape (*Orobanche ramosa,* chokeweed), a very short plant with yellowish leaves and dull purple flowers. Its seeds stick to the calyx of hempseed and thus are transmitted. Broomrape is parasitic on the roots of hemp, killing the host before it can mature. Broomrape invades when the soil has become exhausted, or "hempsick" through neglect. It is prevented by crop rotation and by clean seeds. An application of calcium carbide to the soil in the fall effectively destroys broomrape seeds. Ammonium nitrate and sulfate will drastically reduce broomrape infestation, but these fertilizers also will affect crop yields. Trisodium phosphate can be combined with ammonium sulfate for greater effect. **(21)**

Cannabis protects potatoes from late blight by *Phytophtora infestans*. When potato tubers are soaked in a solution of kansatin (extracted from hemp leaves), their germination is increased, the sprouts are longer and weigh more, and infestation by *Corynebacterium michiganense* and *C. sepedonicum* is reduced. Infection by stem nematode also is lowered considerably. Extracts of cannabis effectively reduce the incidence of the nematodes *T. brassicae*, *H. indicus*, and *R. reniformis*, and *M. incognita*. The whole plant and leaf extracted in water is generally effective against insect pests.

When treated with hemp leaf extract, tomato seeds increase their germination by 17% and their yield by 33%. **(22)**

When beans are grown together with hemp, the beans will not become infested with brown spot. Hemp is effective against infestation of asters by *Fusirois*, and it protects sugar beets from turnip fleas, and cabbages from white cabbage butterfly. Cannabis also guards peas from pea aphis (*Acyrthosiphon pisum*). Hemp purges may-beetle (*Melontha*) from the soil. Weevils cannot become established in granaries where hemp has been dried.

C. Kok, *et al.*, have shown that the major soil pathogens *Verticillium dahliae* (fungus) and Columbian root-knot nematodes (*Meloidogyne chitwoodi* and *M. hapla*) are strongly suppressed by hemp. Some agronomists suggest that soybeans grown in rotation after hemp shows a significant decrease in soybean cyst nematodes.

Bee breeders use hemp as a pollen insulator; no other plant is so effective as a hedge against pollination.

2.7 ~ Diseases & Pests

During World War II, all hempseed distributed by the USDA was treated with mercury compounds (i.e., ethyl mercury phosphate); these seeds yielded an average increase of 16% in the emergence of plants, up to 100% increase over untreated seeds in some instances. This was the first time that the entire national supply (33,000 bushels) of seed of an important crop was treated for protection against microorganisms.

Cannabis is afflicted by over 100 diseases caused by fungi, bacteria, viruses, nematodes, plants, and abiotic challenges (genetics, nutrients, stress and pollutants) but only about a dozen cause serious problems.

With the exception of striping virus, the most common diseases of hemp (i.e., *Hypochnus solani* and *Pythium sp.*) can be controlled by treatment of the seeds with Clorox (25% sodium hypochlorite) diluted with an equal volume of water and adjusted to pH 9. Soak the seeds for 10 minutes, then rinse thoroughly with fresh water. **(24, 25)**

Cannabis' resistance to diseases and pests can be strengthened by the judicious use of methyl salicylate, which is a major component of wintergreen oil. Aspirin (acetyl salicylic acid) also is effective. Dissolve two tablets in a quart of water and apply the solution as a foliar spray.

Fungi & Bacteria --- More than 90 species of fungi attack Cannabis. Seedlings can be infected by damping-off fungi; the flowers and leaves are vulnerable to grey mold, yellow, brown and olive leaf spots, mildew and brown blight, pink rot, and viruses. The stalk and stems are susceptible to attack by grey mold, hemp canker, *Fusarium oxysporum* canker and wilt, stem nema, charcoal rot, anthracnose, and striatura ulcerosa. The roots can be diseased by *Fusarium*, rhizoc, sclerotium root rot, and nematodes. *Alternaria alternata* Keissler, a common fungal pathogen of many plants, can destroy up to 45% of hempseed in a crop.

K. Roder investigated hemp diseases, and isolated 7 strains of *Sphaerella cann.,* 13 strains of *Phoma* or *Phyllosticta*, and 13 forms of *Phomopsis, Coniothyrium, Vermicularia, Fusarium*, and *Cylindrocarpon*. None of these species can infect the roots of hemp directly, unless the roots are weak or injured.

Gray mold (*Botrytis cinerea*) and hemp canker (*Sclerotina sclerotiorum*) can severely damage a hemp crop in wet years. In temperate regions with high humidity and low temperatures, botrytis can completely destroy a hemp crop within a week. Botrytis and hemp canker can be controlled by spraying alternately with the fungicides vinchlozolin (0.5 kg/ha) and iprodion (0.5 kg/ha) at two-week intervals from June through August. Tetramethylthiuran disulfide also is effective. Van der Werf, *et al.*, however, found from three years of field experiments that one or two applications did not increase actual stem yield. They concluded that, "although fungal diseases may severely reduce hemp yield in the Netherlands, the use of fungicides is not worthwhile". They recommended breeding cultivars less susceptible to *B. cinerea* in particular. Botrytis can be controlled by applications of sulfur followed by "AQ-10", a microbial product. Bentonite clay also can control botrytis; it is better to use California calcium-bentonite rather than the more common sodium variety. Potassium bicarbonate ("Kali-Green") also kills botrytis. **(26)**

Botrytis appears as "damping-off" (moldy germination) on seedlings; it can be prevented by aeration of the soil, by hydrogen peroxide, or by the Burgundy Formula. Dissolve 1 lb of calcium sulfate and 1 lb of washing-soda crystals in 10 gallons of water. Soak the seeds in this solution, then rinse with fresh water.

The Chestnut Formula also prevents damping-off. Mix 2 parts copper sulfate and 11 parts ammonium carbonate in a glass jar. Dissolve 1 oz in 2 gallons of water. Soak the seeds in this solution, then rinse them with fresh water.

Botrytis is a stem disease in fiber cultivars, arising as a gray-brown mycelial mat, later covered with conidia. The stem becomes chlorotic along the edge of the mat, then reduces to soft, shredded cankers; the plant often snaps at that point, or wilts above it. The mature floral bracts of female drug cultivars are most susceptible to infestation. Leaflets turn yellow, then wilt, and pistils become brown. Mycelia envelope the infloresences, which dissolve into gray-brown slime.

Infection by *Botrytis* is directly affected by the level of calicum in the plant; the higher the amount of Ca, the lower the incidence of *Botrytis*. Sprays of Ca-silicate (2,000 ppm) and Ca-formate (2,000 ppm) provide effective control of fungi and are safe alternatives to highly toxic fungicides.

Damping off is caused by other several fungi, mostly by the Protoctistan oomycetes *Pythium aphanidermatum* and *P. ultimum*. Other causative fungi include *Fusarium solani*, *F. oxysporum*, *F. avenaceum*, *F. graminearum*, and *F. sulpurem, Rhizoctonia solani*, and *Macrophomina phaseolina*.

The severity of infection by facultative parasites is affected by the levels of nitrogen and potassium; low N and high K provide resistance; high N and low K invite parasites.

Wilt is caused by *Fusarium oxysporum* f. sp. *cannabis* Nov. & Snyd. It first appears on 3-month old plants as a yellowish-green color and small dark spots on the lower leaves, which die but remain hanging. The plant may bend to the side of the stem that is affected.

In 1999, Ag/Bio Con, a Montana company, offered the world a mutant strain of *Fusarium oxysporum* as a mycoherbicide against cannabis --- an utterly insane promotion that has instigated lawsuits to cease and desist. *Fusarium* mutates very easily and spreads to other crops. It is an environmental disaster.

Verticillium wilt is caused by *Verticillium*(two species); *Macrophomina phaseolina* causes premature wilt (also known as charcoal rot).

Hemp twig blight is caused by *Botryosphaeria maronii* (Cav.) Charles & Jenkins. The leaves quickly wilt and droop and turn brown, but remain attached. The symptoms first appear on the tips of branches. The lower parts become bleached.

Two species of *Colletotrichum* cause anthracnose in cannabis.

Hemp canker, caused by *Sclerotinia sclerotiorumi,* is one of the most important diseases of cannabis. It appears as wet lesions on the branches of plants as they mature; the lesions become dark cankers. The pith fills with white mycelia. Black sclerotia then develop in the stem and in the pith. The plants wilt and collapse. The optimal temperature range for its growth and maturation of is 24-33^{o} C. *Sclerotinia* can be controlled somewhat by proper drainage of the fields.

Yellow leaf spot is caused by two species of *Septoria*; brown leaf spot is caused by species of *Phoma* and *Ascochyta*; *Phomopsis ganjae* causes white leaf spot.

Severe leaf infections also are caused by strains of *Sphaerella* (stem browning)*, Phyllosticta, Cercospora*, *Microdiplodia, Macrosporium cann.*, and *Pseudoperonospora* (olive leaf spot), and *Didymella arcuata*. **(32)**

Didymella arcuata is found in association with the fungus *Ascochyta cann.* Lasch. The optimal temperature for the germination and growth of *D. arcuata* is 19-26^{o} C. Its sporulation is promoted by light; its vegetative development is stimulated by darkness. **(33)**

Leaf spots caused by *Cercospora cannabis* Hara & Fukui are yellow-tan or brown. They are circular at first but become irregular and distinct.

Trichothecium roseum causes pink rot on cannabis drug cultivars in greenhouses.

Hemp rust (*Melampsora cannabina*) appears as orange patches on the leaves. It can be controlled by spraying with thiocarbamate.

Bacteriosis (stripe disease) is caused by *Pseudomonas cannabina* Sutic & Dows. var. *italica* Dows. Scattered reddish-violet spots (under 2 mm), surrounded by a pale yellow halo, appear on leaf blades, followed by rapid shedding. Small necrotic elongate cavities, filled with bacteria, appear on the stems.

Some less common but nonetheless virulent diseases of cannabis are anthracnose (*Colletotrichum atramentarium*) and brown blight, which is caused by species of *Alternaria* and *Stemphylium*.

Many of the bacterial and fungal diseases of cannabis and other crops can be controlled by applications of Bacillus subtilis, which is available in several commercial products (i.e, Serenade, manufactured by Agraquest).

Several bacteria that are pathogenic to humans have been found on Cannabis, including: *Salmonella muenchen*, *Klebsiella pneumoniae*, *Euterobacter cloacae*, *E. agglomerans*, *Streptococcus* (Group D), *Thermoactinomyces candidus*, *T. vulgaris*, *Micropolyspora faeni*, *Aspergillus fumigatus*, *A. niger, A. flavus*, *A. tamarri*, *A. sulphureus*, *A. repens*, *Penicillium chrysogenum*, *P. italicum*, *Rhizopus stolonifer*, *Alternaria alternata*, *Curvularia lunata*, and *Histoplasmus capsulatum*. *Aspergillus* can be killed by baking cannabis at 150^{o} C for 15 minutes, but only about 15% is destroyed by smoking through a waterpipe. Microbial pathogens and toxins, however, are not destroyed by heating or other methods of sterilization.

Insects --- Several species of mites are injurious to stored hempseed: *Tyroglyphidae* (3 sp., especially *T. farinae*), *Glycyphagidae* (6 species, especially *G. destructor*), and predaceous *Cheyletus eruditus*. The maximum number of mites are found in July-August. *T. farinae* occurs constantly. Once introduced into storage, the mites can persist for several years. *Tyrophagus* can be controlled by treatment of the seed with fungitoxic preparations (i.e., Panogen and Aldogen). The mechanical damage of hempseed stimulates the breeding of mites. The miticide "Cinnamite" (cinnamaldehyde), produced by Mycogen, is very effective. **(23)**

Spider mites also plague hemp. Their effect is seen as minute white spots on the top of leaves. The mites appear as tiny black specks on the the underside of leaves. They can be controlled by introduction of another mite, *Phytoseiulis persimilis*.

The seedlings can be attacked by hemp flea beetles, cutworms and white grubs. The stalks and stems can be infested by European corn borers and hemp borers, weevils, and by modellid and longhorn grubs. The larva of the Death's Head moth (*Acherontia atropos*) occasionally bore into hemp stalks. Flea beetles, white root grubs, wireworms, fungus gnats, root maggots, termites and ants will attack the roots of cannabis.

The click beetle (*Agriotes mancus*), also known as wireworm in its juvenile form, infests the top six inches of soil and eats the roots of plants, including cannabis. Wireworm can be controlled by introduction of beneficial nematodes (*Heterohabidis* and *Steinernema* spp.).

Marijuana thrips (*Oxythrips cannabensis Knechtel)* is a sucking insect that is host-specific to hemp. Common thrips (*Frankliniella occidentalis*) eat the calyx of cannabis, causing deformation and affecting viability. Thrips can be controlled by the predators *Amblysieus cucumeris*, *A. degenerens*, and *Orius tristicolor*. The aphid *Phorodon cannabis* Pass. also is found on hemp.

The tarnished plant bug (*Lygus* spp.) has been found on hemp crops throughout Canada It feeds on the apical meristem, which appears malformed and stunted. Brown lesions are visible on the stem where the pest has been feeding. It can be controlled by the predatory Spined Soldier Bug (*Podisus* spp.).

The hemp flea beetle (*Psylliode attenuata*) hibernate in the soil until the temperature of the soil and air rises to 10^{o} C (50^{o} F). Then they emerge and feed on leaves and stems of seedlings. The pest can be controlled by planting 'bait' hemp with sodium fluosilicate (15 kg/ha) one month before the mass planting of the crop. The bait plants are treated again after 10 days. This procedure reduces the number of hemp fleas by 90%. In rare, extreme cases, methyl parathion can be used (50% solution, 8 fluid oz/acre).

The larvae of hemp borer moths (*Grapholita delineana*) damage the stalks to such extent that the quality does not meet the industrial standard. Up to three generations can develop each year. The caterpillars live in the stems and flowers of female plants, where they damage developing seeds (50% or more). After feeding, the caterpillars burrow into the soil and overwinter there. In Hungary, where they were first observed, the period between August 20 and September 7 (when daylight is reduced from 15 to 14 hours) is critical for diapause of the larvae. An earlier harvest will prevent the overwintering of most of the larvae; thus the population of the next year can be considerably reduced. **(27)**

The borers can be fought with 50% methyl parathion (20 fl oz/acre). After harvesting, the stubble and waste stalks should be burned, and the field plowed. Organophosphate insecticides are much more effective than organochlorine compounds. Treatment methods vary according to the intended use of the crop (fiber or seed). Two or three applications of Fenthion (500 gr/ha) are up to 98% effective. **(28)**

The wasp *Trichogramma evanescens* Westw. parasitizes the eggs of the hemp moth; 80,000-120,000 wasps/ha are released at one time. Biological control is more efficacious than of chemical methods. Several Hymenoptera species of parasites and predators will prey on *G. delineana*. Commercially available Persimilis (*Phytoseiulus persimilis*) will destroy spider mites that infest cannabis (See Appendix 1, #34). **(29)**

The European corn borer also damages hemp crops. The hemp greenfly (*Phorodon cannabis*) can damage fiber hemp, but it has never been a major problem.

The most common rootknot nematode, *Meloidogyne incognita*, occurs on fiber cultivars of cannabis. The northern rootknot nematode (*Meloidogyne hapla*) has appeared in European hemp fields in recent years. Nematodes can be controlled somewhat by planting resistant varieties of cannabis, and by applications of aqueous extracts of several common plants (i.e., pigweed, marigold, hyssop and mustard). Aqueous urea is very effective against nematodes, but it must be buffered to prevent damage to the plants. Lesion nematodes (*Pratylenchus spp.*), reniform nematodes (*Rotylenchus spp.*), and spiral nematodes (*Helicotylenchus* and *Scutellonema spp.*) also have been found in hemp crops.

The hemp sawfly (*Trichiocampus cannabis* Xiao et Huang) is one of the main pests of hemp in China. The larva feeds on hemp leaves, making many holes. It produces two generations/year, and the mature larvae overwinter in the soil. The sawfly is controlled by Fenitrothion.

The leaf roller moth (Tortricidae, *Grapholitha zinana*) can damage up to 100% of hemp sowings. The larvae damage the infloresences and seed. N. Kozinets, who discovered the pest in 1964, advised spraying hemp sowing with DDT (15-20 kg/ha) during the flight of the adult moth. **(30)**

Irrigation too early and continuing humid conditions will promote mass attack of hemp stems by *Pyraustis nubialis* Hb. The fiber yield from attacked plants deteriorates by one grade. The pest can be controlled by introduction of *Trichogramma*. The number of caterpillars can be reduced by over 60%, and plant damage decreased by 80%. **(31)**

Cannabis foliage and infloresence possesses phytocidal activity. The antibacterial properties are effective against *Bacillus mesentericus, B. subtilis, B. mycoides, B. cereus, Micrococcus albus, M. aureus,* and *Clostridium welchii*. Hemp is inactive against *Salmonella*, *Pseudomonas*, *Azotobacter*, and *Candida*. The maximum inhibitory effect from leaf extracts occurs in August; the flowers are most potent in September, after which time there is a marked decline in activity. Phosphate fertilizer promotes the antibacterial activity, whereas K- and N-fertilized plants are less active. **(34)**

2.8 ~ Nutrients

The general nutrient requirements of hemp can be satisfied with generous applications of manure. Cottonseed is considered to be a perfect fertilizer for hemp, and holds moisture and mechanically prepares the soil. It is applied at the rate of 500 to 1,000 lb/acre while plowing in autumn. If the preceding crop was soybeans or cowpeas, then 500 lb/acre is sufficient.

S.S. Boyce gave these recommendations for fertilizing hemp:

"An application of 200 pounds of bone-meal in November has the effect to warm the soil and hasten germination where hemp is sown early, and to stimulate the hemp to a quick, early growth, before it comes to assimilate the coarser foods, and to give an increase of a foot to a foot and a half in growth...

"Cotton seed and farm manures of equal proportions, with an addition of 10% of acid phosphate, [can be] applied according to the condition of the soil. The only other addition to the compost of 1,000 pounds of cotton seed, 1,000 pounds barn manure and 200 pounds of acid phosphate, would be 250 pounds of ammonium sulfate [per acre]... This would only be required upon old, exhausted cotton lands, while this amount would be sufficient for 4 or 5 acres, according to fertility, and for 10 acres, provided a crop of cowpeas broadcast had preceded."

Steep-water in which hemp has been retted contains: C (55.66%), H (8.21%), N (6.45%), O (29.68%). R. Antoniu, *et al.*, reported that it makes a valuable fertilizer :

"The wastewaters from hemp retting may be used for irrigation without presenting the danger of polluting the phreatic waters with organic substances because these substances are nearly totally retained on the filtration field. The chloride content of the raw wastewater indicates small quantities that could not produce the soil salinization after irrigations. In the phreatic water below the experimental field, the chloride content is 10-fold reduced. While the waste water is acid, the water under the filtration and irrigated field has a neutral or slightly alkaline reaction. Wastewaters were utilized for the irrigation of seed corn, silo corn, sugar beet (furrow irrigation), and alfalfa. For irrigated seed corn there was an increased production (139-143%) in comparison with the non-irrigated. For silo corn increases varied between 133-177%, for sugar beet between 176-183%, and for alfalfa, 107-416%. For all cultures the irrigation norm varied between 2,250-3,550 m^3/ha."

I. Popescu and I. Afusoae reported this finding from their study of retting:

"Fermentation can help turn hemp boon [hurds] into a suitable product for soil fertilization. During fermentation the boon reaches almost the same level of assimilable N, K, Mn and Cu as in barnyard manure."

If NPK fertilizers are used, it is necessary to know their proper amounts, effects and relationships. These considerations are determined by the class of soil in which the crop is grown, and the nutrient content of the soil.

Fertilizers cause changes in basic soil properties and hemp yield. N.Gorodnii conducted experiments with this problem. He cultivated hemp on two types of loam with 6 variants of nutrients (without fertilizers, with 20, 40, and 80 tons manure/ha/year, with NPK calculated on 40 tons manure/ha, and with N 12:P 90:K 60):

"With continuous cultivation of hemp on a background of ammonium sulfate, superphosphate, and sylvite, the total absorbed bases in the soil, the rate of Ca saturation, and the nitrification ability were decreased, saturation of the absorbing complex by N and NH_4 ions and the exchange and hydrolytic acidity of the soil were increased: the physical properties of the soil deteriorated, the density increased and the percentage of water-resistant aggregates decreased. Applying mineral fertilizers during the first years increased the hemp seed yield 100%, in comparison with the same doses of manure. Application of manure, in comparison with the same doses of mineral fertilizers, increased the weight of common hemp 2-3 fold. **" (35)**

The nutrient uptake by cannabis reaches it maximum just before maturity and blossoming. Nitrogen and phosphorus uptake then increase up to 250%, and potassium requirements increase 400%. The uptake of calcium and magnesium increases 150%. Additional amounts of nutrients must be readily available to the plants at that time in order to produce maximum yields. Hemp consumes about 1 kg of nutrients for each kg of fiber it produces. At least twice as much nutrients must be available than will be removed from the soil by the harvested plants. If hemp is field-retted, nearly half of the nutrients are returned to the soil.

The 1897 USDA *Year Book* listed the amounts of fertilizing elements required to produce 100 pounds of hemp fibers from 600 lb of plant weight: N (6.27 lb), KOH (10.13 lb), H_3PO_4 (3.32 lb). For a yield of 1,500 lb of fiber/acre (9,000 lb of growth), the nutrient requirements would be: N (94.05 lb), KOH (151.95 lb), and H_3PO_4 (49.8 lb).

Fertilizer trials conducted on six soil types at the Iowa Agricultural Experiment Station (1942-43) gave these results:

Where N (25 lb/acre), P (50 lb P_2O_5), and K (25 lb K_2O) were applied singly and in combinations, average increases in acre yield of dry, rettted straw from fertilization ranged from 0.37 to 0.90 ton, P from 0.12 to 0.80 ton, and K from -0.32 to +0.25 ton N at 100 lb/acre produced substantial yield increases over N at 25 lb, which was not enough for maximum yields. Response to P was limited by N deficiency in a number of cases. N-P combinations produced higher yields than did either N or P or PK. In general, K did not increase hemp yields, [which] were usually highest on soil types which contained the greatest quantities of N and organic matter, provided drainage was adequate. **(36)**

Commercial hemp farmers in the temperate zones of Europe generally use a nutrient ratio of 2N:1P:4K. In hot, sunny, and tropical climes, hemp uses less potassium, and a ratio of 2N:1P:2K is more suitable. In areas having a winter or monsoon season, more K and less N is required, so the ratio 2N:1P:3K is used.

Other reports state that a high yield of fiber is obtained with about 160 kg N, 110 kg P, and 90 kg K per hectare. The highest quality bast fiber reportedly is obtained with about 70 kg of P and 60 kg of K per hectare, followed by a later dressing of 90 kg N, 70 kg P, and 60 kg K/ha. This also yields a 100% increase in fiber content in comparison to other NPK ratios. Canadian hemp farmers have applied N at 120 kg/ha, P at 100 kg/ha, and K at 160 kg/ha. M. Molina, who cultivated hemp for 13 years in Italy, stated:

"Fertilization with 300 kg of ammonium sulfate or 450 kg of dried blood, 500 kg superphosphate and 150 kg K-sulfate per hectare is recommended." **(37)**

Dr. Ivan Bocsa summarized the NPK requirements of hemp thus: Class I (rich soil) requires 16-43 lb N/short ton of stalk yield, 8-24 lb P/short ton, and 7-24 lb K/short ton. Soil Classes II and III require 20-46 lb N/short ton, 14-34 lb P/short ton, and 8-27 lb K/short ton.

G.R. Bedak tested the effectiveness of periodic and annual applications of fertilizers in a hemp-hemp and hemp-corn crop rotation. The application of P and K fertilizers every two years does not affect the quality of fiber, and the cost of storing, transporting and applying fertilizers are about 23% less than for annual application. **(38)**

L. Dobrounof reported these findings from his studies of critical periods in the mineral nutrition of hemp:

"There is a long period during which a given nutrient exerts its influence... Beginning when the hemp plant is 6-12 days old, it lasts (in relation to the fiber) in male plants 22-28 days (i.e., until the beginning of flowering) and in the female plants 32-38 days (i.e., until flowering is complete). Within the period, there exists a short critical period during which the mineral nutrition exerts its greatest influence on the direction and intensity of vegetative and reproductive development. In male plants this period is 4-5 days before the buds are completely formed, while in female plants it is the 8-10 days at the beginning of flowering. At the beginning of the period of effective action is the stage when the plant is passing from nutrition at the expense of the seed to independent root nutrition. This stage lasts 4-6 days and begins when the plants are 6-8 days old. **(39)**

N--- Approximately 100-150 kg N/ha (and 80-100 kg P/ha, and 100-180 kg K/ha) is required to obtain 10 tons of stems/hectare (10 kg N per ton of dry stalk).

Though the stem yield is high, the quality of fiber decreases with increasing amounts of N. Under low-light conditions, ammonium sulfate or nitrate stimulates stem growth. The absorption of N is most intensive from 20-25 days after germination. **(40-46)**

Cannabis is nitrophilic, but if the plant is grown for its resin, the supply should be kept under 400 ppm, and it must be reduced to about 100 ppm during flowering. The application of N should be reduced 20% in very hot weather.

The Russian agronomist B. Lesik showed that the form of N substantially affects the growth of hemp and the quality of its fiber:

"When ammonia N was applied, the plants passed through their development cycle more rapidly. The stalks were thinner and there was less development of wood. In comparison with nitrate N, ammonia N caused increases in the yield of long fibers, in the length of the elementary fibers, in flexibility, tensile strength, and uniformity of the fibers, and cellulose content, and there was a decrease in the amount of waste fibers. The retting process also proceeded more quickly, and a smaller amount of extractive substances (organic acids and N) accumulated in the retting fluid. Fertilization with the mixed form gave intermediate results. The thinness of the fibers did not depend on the form of N applied". **(47)**

High N has a "masculinizing" effect on the hemp phenotype; it stimulates the formation of male flowers. The proportion, degree, and number of monoecious flowers increases with increasing N, and the total N content is always higher in monoecious plants than in females, whatever the dose of N. **(48)**

Excessive N causes hemp to grow rapidly as seedlings, but the plants wilt, turn to copper-brown, and die when they begin to flower. High levels of N in the middle of the growth cycle will cause water uptake to increase, and induces a sex ratio as high as females 9:1 males. An excess of N is indicated by abnormally large, pulpy branches and veins, with few flowers. The stem turns brown, and terminal shoots stop developing. Leaves are spotted with dead areas, and they curl, pimple, and turn yellow between veins. The breaking strength of the fibers is reduced by about 15%. The stem texture is herbaceous with a hollow pith and short internodes. Excess N added during preparation of the soil inhibits stem development. Best results are obtained by adding half of the required N in the primary treatment, and the second half at the first feeding.

If the initial growth of a hempfield is slow, it can be aided by a foliar spray of 20 kg of urea in 400 liters of water/ha. The addition of ammonium sulfate or nitrate with sulfur before blooming occurs will increase the growth rate considerably. Ammonium nitrate is more effective than the sulfate. Sodium nitrate gives good results, but the quality of fiber is poor. Cannabis is very sensitive to chlorine; therefore, sulfate salts are recommended over chlorides or nitrates.

A deficiency of N causes the entire hemp plant to turn yellow (chlorosis) within a week. Lower leaves curl and shrivel, and veins turn purple. Stems are abnormally small and hollow with a woody pith. Growth and flowering are retarded, and the plants are mostly male. **(49)**

K. Tulaikova found bacterial cycles in the N metabolism of hemp:

"The requirements of hemp for abundant nitrogen fertilizers were found to be related to the development of numerous and diverse rhizobia on its roots, mainly ammonifying bacteria. During the germination stage, the bacteria are parasitic because they utilize not only the root excretions of plants but partly also the plastic matter which is being transported from leaves to roots. This is demonstrated by the weak development of the root during the first half of the growth period. If N feed is abundant, the relations between the hemp and bacteria are symbiotic... Simultaneous feeding on nitrates by both root bacteria and hemp induces N deficiency in the plants. Therefore, nitrate fertilizers are especially required for hemp development... An improvement in N status observed after bacterization with silica bacteria was probably due to the ability of the latter to fix atmospheric N." **(50)**

There are differences in the root microflora of hemp according to sex. Ammonifying and denitrifying bacteria which decompose organic P predominate on the roots of females, and greatly depend on the food reserves in the soil. Deficiency of soil nutrients increases the concentration of microbes on the roots; thus the number of ammonifying bacteria is much less on the roots of hemp grown in rich soil than in the roots of plants grown in exhausted soil. Silicate bacteria predominate on male roots, which absorb N and K more vigorously than the female up to the flowering phase. **(51)**

P --- Hemp growth, fiber yield, and concentration of THC are positively correlated with extractable phosphate. Cannabis uses 250% more phosphorus at flowering than during the vegetative phase. A deficiency of P shows as abnormally dark dull green leaves with a purple tint on the underside, and downward-curled margins. The stem gradually turns reddish, then black. The roots are long, with few laterals. The plants are slow to mature and set seed.

P. Gorshkov studied the peculiarities of P nutrition for hemp:

"To obtain high yields of hemp, it is necessary to assure the plants an easily accessible source of phosphoric acid by applying granulated superphosphate at the very beginning of development, before the plants have reached the phase of 6 pairs of leaves. At later phases of development the requirement for P may be met by soil P and by less soluble forms of P fertilizer." **(52)**

The Russian agronomist M. Khann confirmed the beneficial effect of superphosphate drilled in with hemp seeds:

"This method allowed for a 3-fold decrease of the superphosphate without lowering of the productivity. The increase in the yield of fiber obtained from 1 kg P_2O_5 drilled in with the seeds exceeded by 3-6 times the corresponding increases from broadcasting 1 kg P_2O_5. The corresponding seed yield increase was 3.5-4.7 times higher." **(53)**

K --- Either potassium sulfate or potash is recommended over KCl because the chloride ion interferes with fiber development. The combination of potash with manure increases yields up to 30%, and increases the availability of phosphorus by almost 200%. A combination of potash, Mg-sulfate and manure produces the greatest yield, increasing with higher levels of Mg. Potash strengthens the stalk and stems and increases the resistance of hemp to broom rape. The absorption of K is most intense in the 4th week after germination.

Additional K increases plant height, thickens the stem, and produces heavy, large, dark green leaves. The growth cycle is shortened by about one week, and the sex ratio is stabilized at about females 7:3 males. An excess of K after the 10th week, or when flowering occurs, will delay maturity and inhibit resin production. White spots appear on leaves, meristematic growth ceases, and the stem is woody and hollow. When cannabis is cultivated for resin, the supply of K should be reduced by 50% during flowering.

I. Berzak reported these results of his experiments on the effect of various K fertilizers on the yield and quality of hemp fibers:

"The highest yields of stems and fibers were obtained with kalimag (K-sulfate/Magnesia/Mg-sulfate), and with K-chloride/K-sulfate mixture, whereas the lowest was obtained with kainite (K-chloride/Mg-sulfate). Male hemp responded to K fertilizers much more than female hemp". **(54)**

Potassium deficiency is indicated by coppery mottling and curled, grey edges or a brown margin on leaves, followed by dark spots and bleaching between the veins. The symptoms first appear on bottom leaves. Old foliage turns dark gray, and new leaves turn yellow and die. Growth is retarded, and the roots and apical meristems turn pale yellow. The stem is herbaceous, and hollow in males, while females are solid. Deficiency can occur in acidic soil or in low-light conditions. The addition of a little detergent will increase the wetness of the nutrient solution and allow K to be more easily absorbed.

When K is deficient, transpiration is reduced, but water consumption is increased, especially in young plants. A deficiency of K decreases the yields of stems and fiber, but contributes the formation of strong, elastic fibers. **(55)**

Ca --- Calcium gives cannabis very strong, fibrous, short stems with dark green leaves and swollen flowers. An adequate supply is vital in the 6th-9th weeks of growth. The largest absorption of Ca is made possible when calcium carbonate is applied together with small doses of humus. **(56)**

Calcium-deficient plants are stunted, weak and flabby. Terminal buds die, and the stem becomes brittle and covered with dark areas. Upper leaves are darker than usual, yellow at the edges, and they crinkle, dry up, and fall off. Any new leaves that form will die. Brown and white spots appear on lower leaves.

Excessive Ca will stunt the early growth of cannabis, and causes terminal shoots to be weak and under-developed. Foliage is less abundant, and blackening occurs around the veins. The stems are fibrous and woody, with a hollow pith. The sex ratio changes to males 7:3 females.

Calcium affords plants considerable resistance to infection with *Botrytis*; the higher the level of calcium, the lower the incidence of *Botrytis*.

Trace Elements --- Micronutrient deficiencies often are caused by alkaline water, which prevents uptake by plants. Such deficiencies usually can be covered by the use of commercially available "transplanting solutions" and by adjusting the soil to neutral pH.

Mg --- Cannabis is very sensitive to magnesium deficiency, which is likely to occur in sandy soils and during seasons of heavy rainfall. Chlorosis begins on the bottom leaves. Grey-white patches, varicose veins, and yellow margins appear on the leaves, which curl and die on the edges. Growth is stunted, the stem is thin, and leaves drop off. The stem texture of males is woody, and females are herbaceous. The pith is hollow. A deficiency can be corrected with Mg-phosphate and brine (1 quart per 100 lb of compost), or with Epsom salts.

Hemp has an extraordinarily high requirement for Mg, and is exceptional in comparison to most other plants, which are killed by applications of Mg alone. Combinations of K and Mg give the highest yields, which increase considerably with an increase in the Mg. **(57)**

A. Haraszty conducted experiments for 10 years to augment the yield of hemp fiber with macro- and micronutrients (tested in over 50 combinations). He found significant effects with formulations containing K, Mn and Mg (applied in the form of their sulfates at 10 kg/ha), by which he achieved up to 32% increases in fiber quantity. The combination of K and Mn gave a 17% increase. **(58)**

Fe --- The symptoms of iron deficiency are the same as for magnesium, but they appear on the upper leaves first. Acidic soils dissolve and chelate iron, making it unavailable to plants. Powdered magnetite (magnetic iron oxide) will supply sufficient Fe, and it stimulates plant growth by the effect of magnetic energy. 10 ppm of Fe gives the best growth of hemp fiber; 5 ppm gives the best yield of cannabinoids.

C. Olsen studied Fe absorption by hemp in hydroponic beds:

"When hemp is cultured in solutions low in Ca and with Fe-sulfate as Fe source, increasing growth inhibition due to Fe intoxication is observed when the pH of the solution decreases from 6 to 4. This is due to the fact that the ferric ion concentration in the solution increases greatly when the pH is lowered to 4. The same is true in soil. Even so, hemp can develop quite normally in solution of pH 4 provided the Ca ion concentration is high, resulting in a sufficient lowering of the rate of Fe absorption to preclude intoxication. This antagonistic situation does not occur in nature since soil of low pH and high Ca concentration does not exist." **(59)**

Mn --- A deficiency of manganese will stunt the growth and flowering of hemp. Leaves appear mottled with grey-brown necrotic spots. The plants lack vitamin C; there are some deaths. Signs of deficiency first appear on shoots. Leaf margins remain green while the rest of the leaf turns yellow or white.

S --- Sulfur stimulates root growth and seed production. S-deficient hemp is pale green, with purple veins. The stem is stiff, woody, and thin; the seeds are immature.

B --- Hemp requires 250 grams of boron per acre. When sufficient P and K are available, an additional application of boric acid (1 kg/ha), Cu-sulfate (1 kg/ha), and Mn-sulfate (10 kg/ha) will produce a significant increase in yields and in the quality of fiber and seeds. A deficiency of B is revealed by cracked, stunted stems and dry rot. Leaves turn purple, terminal shoots curl and die, petioles become brittle, and the flowers are covered with dry areas. New shoots turn gray or brown and die with a burnt appearance. The situation can be corrected with a foliar spray of boric acid.

Cu --- Cannabis does not have a high tolerance for copper, but supplementary Cu-sulfate will improve the quality and yield of hemp, especially in peat, which often is deficient in this element. A deficiency causes stems to weaken and break. Treatment of a field with 10 kg/yoke (1.42 acres) will increase the fiber bundle diameter up to 15%; when the Cu is combined with cobalt, the bundle diameter will increase up to 23%.

Mo --- A deficiency of molybdenum is indicated by yellowing between veins on leaves. The middle leaves turn yellow.

Zn --- A deficiency of zinc is indicated by chlorosis between the veins at the base of shoots, and by the accompanying twist of leaf blades. Flowering is inhibited.

Over-watering produces symptoms resembling nutrient deficiencies or excesses. These usually can be corrected by reducing the water supply, or by drainage.

Table 2.3 ~ Symptoms of Nutrient Deficiency/Excess

Table 2.3
Symptoms of Nutrient Deficiency/Excess

LEAVES

Copper-brown (+N); Copper mottling (-K)
Curl (+N, -Mg)
Dead areas (+N)
Green, dull dark (-P); pale (-S)
Margins:

Brown (-K)	Curled, grey (-K)
Downward-curl (-P)	Yellow (-Ca, -Mg, -Fe)

New Leaves:

Brown & white spots (-Ca)	Chlorosis (-Fe)
Dark (-Ca)	Grey-brown & dying (-B)
Grey-white spots (-Fe)	Yellow edges (-Fe)
Yellow & dying (-K)	

Old Leaves:

Chlorosis (-Mg)	Yellow (-Mo)
Dark-grey (-K)	

Pimples (+N)
Purple (-B); Purple on underside (-P)
Spots:

Grey-brown necrotic (-Mn)	Grey-white patches (-Mg)
White (+K)	Dark (-K)

Twisted (-Zn)
Veins:

Blackening around (+Ca)	Bleaching between veins (-K)
Chlorosis between veins (-Zn)	Pulpy (+N)
Purple (-S)	Varicose (-Mg)

Yellow between veins (+N, -Mo); Yellow with green margins (-Mn)
Yellow-coppery areas, dying leaves (+Water)
Wilting (+N)

STEMS

Brittle (-Ca)
Brown (+N)
Cracked (-B)
Dark areas (-Ca)
Dry rot (-B)
Herbaceous (-K, +N, +K, +Ca)
Hollow females (-Mg); Hollow males (-K, +N, +K, +Ca)
Reddish, then black (-P)
Solid females (-K)
Weak, broken (-Cu)

MERISTEMS

Stunted (+K, +Ca, -Mn)

GENERAL GROWTH

Stunted, flabby (-Ca, -Mn, -B)

2.9 ~ Cultivating for Cannabinoids

According to a United Nations study, 5 factors are necessary for the "cultivation of Cannabis for a high resin production": (1) genotype, (2) photoperiod, (3) N-P-K, (4) at least 60-80 cm separation between plants, and (5) "optimal temperature of the ground at the time of sowing". Resin production is minimal at 44^{o} F (See also **2.5** and **2.10**).

The production of cannabinoids (THC, CBN, CBD, etc.) is greatly influenced by nutrients. As soil N increases relative to Mg, CBD increases relative to CBN. Increasing the ratio of N to Cu increases the level of CBD. Increasing amounts of P convert CBN to THC. Low to medium levels of P produces a high level of CBD, but CBD decreases with high levels of P. Low levels (levels less than 40 ppm) of Mg produce more CBD than do high levels of Mg. As levels of Mg increase relative to Ca, the concentration of THC decreases. The concentration of Mg and Fe in leaves is positively correlated to THC levels. Potassium increases the concentration of CBN by effecting the dehydrogenation of THC. An excess of K in the 3rd month will inhibit resin production. Excess Ca will inhibit resin production, and it increases the production of CBD in the resin is produced. Either an excess or deficiency of Mg produces more CBD. 5 ppm Fe gives highest yields of THC.

The recommended "ideal" pattern of nutrient application for cannabinoid production is said to be: high N and K, low Ca, and medium Mg during the first 2 months of growth, continued high N and K, medium Mg, and increased Ca during the next 6-8 weeks, followed by decreased N, K, and Ca, and increased Mg through the flowering phase. Many growers use a commercial 15-30-30 formula throughout the season.

Mel Frank offers this micronutrient formula for high cannabinoid production: Fe-sulfate (5 mg/gal), Cu-sulfate (0.2 mg/gal), Mn-sulfate (2 mg/gal), Zn-sulfate (0.2 mg/gal), Boric acid (2 mg/gal), Molybdenic acid (0.1 mg/gal). Use 1 tspn/gal of nutrient solution, once monthly.

Bill Drake gives this recipe in *Marijuana: The Cultivator's Handbook*: Ca-sulfate (6 oz), mono-Ca-phosphate (4 oz), Mg-sulfate (6 oz), K-nitrate (8 oz), and Fe-sulfate (1 gr). Use 1 tspn/gal.

Many marijuana growers reportedly use a commercial 15-30-30 NPK mixture successfully throughout the growing season.

Since the 1960s, marijuana farmers have developed many special techniques to camouflage their operations and to enhance the production of psychoactive resin. Such cultivators grow the plant for its flowers rather than the fiber. They prefer to grow females because they produce more resin than males. The female is much larger and more vigorous than the male, which does not produce much foliage and dies soon after dispersing its pollen. What little resin the male does produce is, however, about as potent as that of the female, and it can be worth extracting and isomerizing. If the female is kept virgin so that seed production is prevented, it develops more flowers and more resin with greater potency. The mature virgin plant is called "sensimilla" (without seeds). For these reasons, the males are removed as soon as they can be identified.The cultivation of *bhang* (cannabis) is a highly ritualized process in India. Select seeds are kept in the mouth of a dead snake until they are sown under the waxing moon in July. Often a freshly-killed snake (preferably a cobra) is buried under the plants, for it is believed that the venom potentizes the resin. The rites of *nyasa* and *acamana* are performed while facing north or east. Water is mixed with milk and sprinkled over the seeds. When they sprout, water mixed with clarified butter is used. When the first leaves appear, the plants are sprinkled with salt water. During flowering, the plants are sprinkled with water mixed with alcohol and meat, then with water and honey, and finally with water and alcohol. The rites of *stapana*, *sevana*, *tantubandhana*, and *lavana* are performed before the harvest. The rite of *tantubandhana* should be performed by a purified person on the 14th day of the waning moon (in February-March in India). The plants are tied with red, yellow, black and white threads. The *Aghora mantra* should be recited for a week. On the 5th day of the waxing moon, the cultivator meditates on the *bhang* and imagines her as a deity. When the seeds are fat, the plants are harvested while reciting the *Aghora mantra*.

Cultivators of *bhang* often hire a *poddar* to inspect the plants and cull the males before flowering begins. In many districts of India, farmers stick a knife through the stem near the base of the plant and insert a wedge or nail. Sometimes opium, mercury, sulfur, arsenic, or asafetida is stuffed into the crack to increase the potency of the plant. Certainly, the use of mercury or arsenic is not to be recommended.

Indoor crops can be induced to flower by reducing the photoperiod to under 12 hours for 2 weeks. When the plants have flowered, the males can be culled, and the photoperiod is increased again to resume vegetative growth, but overall development is slightly delayed by this procedure.

Breeders now recognize that the content and quality of hemp fiber is not related to the quantity of psychoactive cannabinoids. Certain varieties are rich in both THC and fiber.

Pruning --- Many cultivators insist that Cannabis grows best if it is left untouched. Others argue that judicious pruning not only alters the appearance of the plant, but also increases the amount of foliage.

The lower limbs or their leaves can be pruned to make more energy available to the upper flowers (This interferes somewhat with metabolic processes by reducing photosynthesis). The large, non-floral foliage also shades the ground, thus conserving water.

Removal of the central bud will produce a multi-stem plant with more foliage. After the plant has produced at least three sets of leaves, carefully cut the central bud (apical meristem). The two remaining axial shoots will develop as stems. These two stems also can be pruned in this manner when they have developed sufficiently. The result is a relatively low, bushy plant. The technique should be used only on young plants; late pruning will interfere with flower development.

Stems and branches also can be trained with a trellis, or tied down close to the ground so as to present a low profile, quite unlike normal Cannabis.

Grafting ---- The Humulus hops plant looks nothing like cannabis, and it can be grafted onto hemp, and it will produce cannabinoids. The technique is not considered to be very practical. **(60)**

I. Bocsa and G. Farkas tested the influence of the slip upon the longevity of root-stock with grafts with hemp varieties with different longevities and between individuals of the same variety/different sex:

"The graft can influence the lifespan of the rootstock. A graft with greater longevity will increase (independently of the sex relationships) the life span of the root-stock. Female slips, which have a longer vegetation period than the males, will increase the life span of the male root-stock." **(61)**

Cloning --- C. Richez-Dumanois, *et al*., studied the *in vitro* propagation of hemp clones, thus:

"Morphological and chemical development decreased at low temperature and were promoted by a regime of 22^o C (daily temperature) and 17^o C (night) under 24 hour illumination and 70% relative humidity. Shoot proliferation was obtained with the addition of cytokinin (BAP, 5.10^7 M/liter) and auxin (AIB, 10^7 M/l.). The axillary shoots which developed were used as mother-plants in vitro; they provided numerous cuttings after repeated sub-culturing on the same medium. A long thinning stage was necessary for rooting the microcuttings in the presence of charcoal (2 gr/l.) and AIB (10^5 M). The best method for rooting in vivo shoots involved non-aseptic conditions (3-4 weeks). The further growth of plants at 22^o C/17^o C was comparable to that of corresponding horticultural cuttings and the cannabinoid pattern was similar to that of mother-plants". **(62)**

V. Sustrina cloned hemp as a method of obtaining starting material for selection:

" The best method for the intervarietal grafting of hemp is considered to be by fork grafts of material in the cotyledon phase onto hosts of 7-8 pairs of true leaves... A most promising method is to graft female hemp on males and selfing. The best results were given by the used of female hemp as the host and pollinating the graft with Kavkavskaya hemp."

2.10 ~ Growth Stimulants

The B-vitamins (1 ppm solution) increase the yield of hempseed and its fat content, but somewhat suppresses the growth of leaves, stems, and seed hulls. Potassium permanganate in weak solutions stimulates the development of cannabis in all its phases. Dilute camphor also stimulates plant growth. Vitamin C (1-5 parts in 10,000 water) has the same effect.

The ripening of cannabis flowers can be accelerated by addition of a tablespoon of sugar per gallon of nutrient solution. Do not use this treatment during the initial stages of the flowering cycle, because flowering will be delayed instead.

Auxigro, manufactured by the Auxein Corp. (Lansing, MI; www.auxein.com; US Patent 5,840,656) contains 4-aminobutyric acid, L-glutamic acid, etc.). It increases fertilizer efficiency severalfold and improves plant growth up to 50%. Nutrient accumulation also is increased dramatically.

Triacontanol is a fatty alcohol found in many plants. It increases growth rates and yields up to 25%, and increases the protein content, even during darkness when plants usually are dormant. Triacontanol seems to enhance the growth of plants without increasing their consumption of nitrogen. The simplest way to use triacontanol is to plow under a crop of alfalfa, which contains relatively large amounts of the substance. Triacontanol is extracted from sunflower seeds or alfalfa by chloroform; filter and evaporate the solution to yield crude triacontanol. The dosage is 1 ppm in water.

Carbon Dioxide --- Plants utilize atmospheric carbon dioxide to supply their carbon. The current level of atmospheric CO_2 is about 350 ppm. If the level of CO_2in a closed growing space decreases to below 200 ppm, growth will cease. Levels above 2% can be injurious to both plants and animals. When cannabis is cultivated indoors, the rate of growth and photosynthesis can be enhanced by increasing the concentration of carbon dioxide to about 0.2%. The effects are most influential in the second month of growth. The rate of growth can be increased about 50% by increasing the level of CO_2 to about 700 ppm. If the level is increased to 1,500 ppm during the vegetative phase, the growth rate will increase up to 80%. The number of females also increases slightly under the influence of CO_2. When extra CO_2 is supplied during the flowering phase, the flowers will mature about 2 weeks sooner, and they will increase in weight about 20%.

To calculate the amount of CO_2 required to enrich a growroom, first select the level of CO_2 you desire (assuming 300 ppm atmospheric CO_2). Multiply the cubic feet of the grow space with the corresponding factor (given below) to determine how many cubic feet of gas are needed to raise the level for each cycle of enrichment. The cycle is repeated as the plants absorb the gas or it is vented outdoors (necessarily when the room temperature rises to 85^{o} F). Commercially available equipment will do this automatically.

For 1,000 ppm, factor (.0007) x cubic feet to determine the requisite volume of gas. 1,100 ppm = (.0008); 1,200 ppm = (.0009); 1,300 ppm = (.0010); 1,400 ppm = (.0011); 1,500 ppm = (.0012).

Gibberellin --- When seeds absorb water, the hormone gibberellin (gibberellic acid-A, GAA) appears in the embryo and activates the metabolism to initiate sprouting. GAA has been widely tested in applications to hemp.

When applied to cannabis at a rate of 100 ppm in water for 2 months, GAA increases the thickness and internodal length of the stock. The terminal nodes are weak, branching is suppressed, and the roots develop poorly. Germination is stimulated by GAA, but leaf growth and the production of chlorophyll and cannabinoids are reduced proportionately. GAA treatment does not hasten the generative development of hemp, but does promote plant growth. The stem diameter increases about 250% over control plants, and the fresh weight of the stem increases 300%. Treated plants have a higher ratio of bark:wood. The number of fibers increases up to 100%.

According to G. Davidyan, the greatest effect is achieved with 0.005-0.01% GAA applied before the buds form.

R. Herich tested the histological reactions of hemp by soaking the seeds in 5 ppm GAA for 24 hours with these results:

"The plants showed the following differences from untreated controls: decrease of stem thickness, less lignification, decreased bark development especially in lower parts of stems, decrease in number of secondary bast fibers, increase in number and size of primary bast fibers, and increased differentiation of parenchymatous pith tissue". **(63)**

C.K. Atal also described the effect of GAA on hemp:

"Gibberellin-treated plants showed a greater number of fibers as compared to controls. The individual fibers were larger in diameter, more lignified, and up to 10 times as long as the fibers from the untreated plants." **(64)**

F. Yanishevskii studied the effect of GAA on the nitrogen metabolism of hemp:

"Stem lengthening took place mainly by cell extension. Net weight even decreased somewhat. Chlorophyll concentration decreased noticeably... Plants treated with GAA contained less N than controls. GAA exerted a considerable influence on the N metabolism of hemp plants: in treated plants the amount of protein N decreased 2-fold, but, in contrast, the soluble forms of N increased markedly. Treatment with GAA had almost no effect on the content of N fractions of cell components (nuclei, plastids). Nucleic acid content decreased mainly owing to decrease in the amount of RNA. Accumulation of soluble forms of N under the influence of GAA would indicate that the introduction of nitrogenous fertilizers (as recommended by Witter and Bucovac) would hardly make up for the unfavorable effect of GAA on the N metabolism of hemp." **(65)**

N. Yakushkina and L. Chuikova also tested the action of GAA and Indole-Acetic Acid (IAA, auxin) on hemp:

"GAA intensified the growth of the plants, the average dry weight per plant, the photosynthesis rate, the sugar content (especially of the stem) and that of total N, and the respiration rate, but decreased the content of chlorophyll in the leaves. The separate application of IAA caused a decrease in the growth and yield of the plants, and a considerable increase in the chlorophyll content, but decreased the photosynthesis rate. The simultaneous application of GAA and IAA was accompanied by the highest increase in yield, but this addition of IAA did not exert any substantial influence on the physiological processes.**" (66)**

GAA also increases the length of the growing season. GAA will inhibit the formation of flowers on Cannabis; it must not be used during the flowering phase of growth. GAA will accelerate the onset of budding by about 7 days.

Treatment of plants with 25 mg GAA/liter results in 80% of the plants being male. Female hemp usually undergoes sex reversal to a male expression, but few of the male plants produce female flowers. Thus, G. Davidyan and S. Kutuzova reported:

"Gibberellin causes the formation of male flowers, containing fertile pollen, on genetically female plants." **(67)**

V. Khryanin treated dioecious hemp with GAA (25 mg/liter) and produced monoecious feminized staminate hemp from the common pistillate form:

"Gibberellin, as a hormone of the plant organism, probably depresses genes which participate in the formation of flowers which have been repressed.

"Thus GAA can be used by breeders to develop monoecious cannabis from dioecious forms. Preliminary tests are necessary to determine the most effective concentration and best timing for each cultivar."

Gibberellin is extracted from cucumber seeds, fresh cantelope seeds, dried corn kernels, and from pencil rod, lupine, and pinto beans. Soak 200 grams of powdered seeds in 110 ml of a mixture of acetone (10 parts), isopropyl alcohol (5 p), ethanol (2 p), and water (5 p). Filter the mush and rinse it with 20 ml acetone and 20 ml isopropyl alcohol. Combine the rinse and the mother liquor, then evaporate the solvent. Dissolve the gum in alkaline water for experimental use.

The effect of GAA is removed by abscisic acid (ABA), which will initiate flowering. Treatment of plants with ABA (10 mg/liter) results in all plants being female or bisexual. The ABA can be overcome by increasing the concentration of GAA. **(68)**

2.11 ~ Harvest

Hemp is ready to harvest after the males have shed their pollen. If hemp is harvested before the males die, then the retting of both male and female plants together is more uniform. The harvest period can extend 2 weeks, but late hemp is more lignified. An early harvest may produce fine, soft fiber, but usually it is weak.

Belgian farmers traditionally harvested their hemp on St. Madelin's Day (July 22). On that occasion they would chant, "Harvest your hemp on St. Madelin's Day. If it's not ready, bale it for another week."

According to the experience gained by Canadian hemp farmers in 1998, the crop should be direct-combined when seed moisture reaches 25-30%, and the wet seed should be aerated within 24 hours after combining.

Yield --- The USDA reported that an acre of hemp usually yields an average of about 7 tons of green stalks. After drying and curing in shocks, the stalks weigh about 5 tons. After retting and drying, the stalks weigh about 3 tons, and they yield about 750 lb of long, rough fiber. The yield of hurds is about 2.5 tons/acre. After hackling, the yield is about 350 lb of single-dressed line fiber, 170 lb of short fiber, and 90 lb of hurds and waste.

Research conducted by Dr. H.M.G. van der Werf showed that fiber hemp yields can be increased by about 30% by growing very late-flowering cultivars at a relatively low density (<300 plants /m^2). The crop self-thins due to inter-plant competition, and it is harvested late in September.

According to Dr. Ivan Bocsa, the stalk yield of hemp for Class I (rich) soil is <2.7 to >3.8 short tons/acre. The lower quality Class II and III soils yield <1.8 to >2.9 short tons/acre.

The Hungarian dioecious variety Kompolti, which currently has the highest fiber content in the world, produces yields of about 9 tons stems/hectare. The Polish varieties Beniko and Bialobrzerzie produce about 100 kg seed/ha, plus 9-10 tons of dry stalks/ha. The varieties mature in late September. Ukranian seed such as Zolotonosha and Glukiv USO have been tested in Manitoba and Ontario, Canada. They have vegetative periods of 110-150 days and yield 0.25-0.5 tons seed/acre and 3.25-5 tons of stalk/acre. In Australia, the yields of stalks average from 8-10 tons/ha; in the Ukraine, 8-10 tons/ha; in the Netherlands, 10-14 tons/ha; in the UK, 5-7 tons/ha. The low average is about 6 tons of stalk/ha, yielding a low of 22% bast fiber. The high yield is about 10 tons of stalk/ha, with a high content of 30% bast fiber; thus, yields range from 1.3-3.0 tons of fiber/ha.

Thomas Jefferson simply noted the following regarding the yield of hemp:

"Tolerable ground yields 500 lb to the acre. You may generally count on 100 lb for every foot the hemp is over 4 ft high."

S.S. Boyce (*Hemp*, 1900) stated likewise:

"Hemp yields 150 pounds of fiber per acre for each foot in height, hence the advantage of a tall plant."

Equipment --- The World War Two film *Hemp for Victory!* showed farmers the best equipment then available to harvest the crop:

"Hemp grows so luxuriently in Kentucky that harvesting is sometimes difficult, which may account for the popularity of the self-rake with its lateral stroke. A modified rice binder has used to some extent. This machine works well on average hemp... An improved hemp harvester... spreads the hemp in a continuous swath... In Kentucky, hand cutting is used to open fields for the machine. [The] hemp is shucked as soon as safe, after cutting, to be spread for retting later in the fall.

"In Wisconsin, hemp is harvested in September. Here the harvester with automatic spreader is standard equipment. Note how smoothly the rotating apron lays the swaths preparatory to retting. Here it is a common and essential practice to leave headlands around hemp fields. These strips may be planted with other crops, preferably small grain. Thus the harvester has room to make its first round without preparatory hand cutting... When the cutter bar is much shorter than the hemp is tall, overlapping occurs. Not so good for retting. The standard cut is 8 to 9 feet...

"When conditions are favorable, the pickup binder is commonly used. The swaths should lie smooth and even with the stalks parallel. The picker won't work well in tangled hemp. After binding, hemp is shucked as soon as possible to stop further retting.

"A helper with a hooked pole may be required to pull out problematic "volunteer" stalks, which are difficult to cut. Volunteer hemp grows from seeds scattered by the previous crop. Such seed sprouts earlier than sown hempseed and grows taller than the rest of the crop."

When hemp grows to a height of 15 ft or more, a self-rake combined reaper and mower works well. Modified rice binders also have been used to bundle hemp. A sweep-rake reaper can cut 5 acres or more in a day, and a mowing machine can harvest 7 to 10 acres. The British Hemcore project used a modified rape swather and round balers. French farmers have reported using modified silage maize harvesters. In the French method of harvesting for seed, a combine harvester is used to cut the upper parts of plants, but the cutter bar must be raised to its maximum heigh (about 180 cm). At this height, some fiber yield is lost because more than the seed-bearing portion of the stem is removed. Good timing is of vital importance, but efficiency is low because the seed does not mature uniformly. If the hemp is dual-purpose crop, the fiber can be contaminated with seed and foliage, some stems will be lost under the wheels, and field-drying may not be feasible due to the lateness of the season. After harvesting the seed, the remaining stem can be cut with a finger mower. A narrow draper-style windrower cannot handle tall hemp, but a wide draper or auger windrow may be satisfactory.

The Dutch Hemp Research Programme (DHRP, 1990-1994) cut its hemp with a mower conditioner. The crop was field-dried at least 4 days to reduce the moisture content below 15% so as to avoid the decay of fiber by bacteria during the storage of dry hemp. Because of erratic weather conditions, field drying is not a reliable practice in Europe. The seed was harvested by cutting off the stem tops and threshing them with a combine. The stalks were round-baled. Minor problems caused by pickup blockages can be avoided by reducing the windrow volume and ground speed.

The DHRP also developed a new method of "direct harvesting" using field choppers equipped with a row-independent header. The operation loosens about 90% of the core and bark, but the sharpness of the chopper knives and the throughput of the stalks causes problems with wrapping and blocking. Field chopping is advantageous in that the stalks are not dried in the field; the pieces are immediately stored in a silo, thus avoiding the vagaries of weather. The maturation and harvest periods can be extended, and the labor is reduced considerably.

In their review of the hemp harvest and storage techniques developed by the DHRP, Huisman and de

Maeyer concluded:

"With decortication, the bark could not be cleaned well enough and still contained more than 40% of the core. Bark and loose core should be easily separable by sieving since the size of the bark [0.5-2.5 cm] and of the loose pieces [1-8 cm] greatly differ... It was clear that the quantity of fixed core mainly depended on stem diameter; the smaller the diameter, the higher the quantity of fixed core...

"With field chopping, the bark was not cut as short as the hurds; this made it possible to separate bark and core by sieving or flotation. Sieving of chopped hemp resulted in a "contamination rate" of both bark and core of about 25%... The size difference between the chopped bark and core was not big enough to separate them by sieving. With flotation, very clean bast could be collected, although some bark floated because it stuck to a piece of core, resulting in its collection with the core... Because the bark sinks in water and the core floats, flotation is an easy and effective separation method. This operation perfectly fits into a harvesting system with chopping and [wet anaerobic] ensiling..."

Problems with fiber tangling can be avoided if the stems are cut into lengths of 5-10 mm during the harvest. A modified forage harvester can be used; the cut straw is fed into a hopper bin. A stationary 5-blade chaff cutter has been used, with a uniform cutting length being achieved by feeding the stems end-on into the cutter and minimizing the gap between the blade and cutting face. Over-long pieces can be removed by a sieving table, then fed back into the system.

The Dutch company HempFlax Akkerbouw has developed a cutter mower that chops hemp plants into three half-meter pieces. The machine cuts about 7.5 acres/hour. The machine mows the plants down and picks up the stems. Metal brushes remove the leaf material and push the stalks lengthwise into the chopper. The cut stems are dropped in a row behind the machine to be picked up by a standard bailer. The company also has developed a turning machine that turns over the stalks in the field without causing damage to the fiber. John Deere manufactures the improved HempFlax Kemper cutter.

Experimental plots grown by the Canadian Industrial Hemp Council were harvested with a sickle type of cutter, but the results were unsatisfactory. A disc-bine also was used and worked very well. Robert Guilford commented:

"The added bonus of this machine was that it crimped the stem, allowing for faster retting. The part that I left for the combine ended up being a mistake. Putting all that stalk through to get the top foot was not one of my better ideas. It took me 6 hours to unplug the combine... In 1996 we waited for a frost and then brought in a combine with a straight cut attachment. It cut the plant off at the 4 foot level and so it only had to deal with the top 3 feet or so. We then came in with the disc-bine to cut the remainder of the stalk off for [round] baling... If the hemp can find a place to wrap when it's a bit damp it will."

According to the moisture chart developed in 1999 by the Canadian Grain Commission, hemp farmers should direct combine hemp when the seed moisture is between 25 and 30%. The Canadian farming magazine *Western Producer* (www.producer.com, 9-9-99) offers the following tips for combining hemp safely:

"Raise the cutter bar as high as possible to minimize the amount of material the combine has to process. Lower the cylinder speed to about 350 rpm and have the concave about half open. Use plenty of air to remove leaves, chaff and small or empty seeds.Remove straw chopper and blades.Cover exposed shafts with shields.Go slow. Expect to combine 1.5 to 5 acres per hour. Get off the combine and inspect for fiber wrapping every 45 minutes."

Methods --- The process of harvesting large fields of hemp (over 100 acres) in Hungary includes a preliminary chemical defoliation to remove the unnecessary burden and volume of leaves (up to 20% of the plant weight). Foliage increases the cost of handling, transportation, and storage, and it reduces the capacity of retting basins and discolors the stalks. Manual defoliation is not feasible, and mechanical methods have not been successful. The defoliants Purivel (Metoxuron), Basta (ammonium glufosinate) and Round-up (20% glyposate) are applied by airplanes or orchard spray guns when the 10-15% of the male plants have flowered (within one week of technical maturation). These substances are toxic and pose grave environmental threats.

G. Venturi reported on the use of defoliant-dessicants for hemp harvesting in 1970. Reglone (4 kg/ha in 15 hecaliters of water/ha) was the "most satisfactory" of 18 products tested; it was applied at the usual time of harvesting (when about 75% of the males are flowering) while postponing the mowing up to 7 days. While defoliant-dessicants were useful for fiber production, it was not good when the hemp was to be used for paper production.

The Humorous Hemp Primer also advised farmers on the subject of harvesting:

"Using a bailing mower will save much work, time and effort, but it can only be used with lower-grown crops. That is why German inventors provided us with a hemp mower-bailer which neatly cuts and ties and places hemp to the side.

"So the crops can dry out quickly, carefully stack them in round manner using 16 bundles standing upright. When nicely placed, strong winds can blow right through them for rapid drying.

"Fiber stalks deteriorate quickly if left out to dry too long. They cannot tolerate fall rains. The fibers shrink and gum up and the birds pick at them... Hemp in the shed or stack now browns in the sweating process. This stage of its life lasts about 6 weeks and is healthy for the plants since the seeds grow into full ripeness and readiness

"This period of storage also allows the hemp stalks to ripen, mellow, and cure, to "gather nature" and "quality". This nature and quality is further developed by the subsequent manipulations to which the fiber is subjected, and eventually produces the desired high, silky character."

S.S. Boyce offered this advice for harvesting hemp:

"In whatever way the hemp is harvested, it is at once bound up in small sheaves when pulled, and stood up to dry, and then shocked. The seed is beaten out, the tops and roots cut off, to even it in length, by a sharp cutter. Or after the roots are cut off the hemp is stood up, bundle by bundle, and the taller stalks pulled out."

John Bordley gave this warning to farmers in his pamphlet on *Hemp* (1799):

"In America, Hemp and Flax are commonly dry before they are spread to be dew-rotted. If spread before the last of September, they become sunburnt, red, harsh, and dead."

Mechanical harvesting may not be possible or practical in very small fields of seed hemp or in underdeveloped countries. Therefore, some specific techniques are to be recommended. An experienced worker using a hemp scythe can cut about half an acre in a day.

In the opinion of the Anonymous Farmer, hemp should be harvested as follows:

"This is the best and easiest done when the ground appears to be tolerably dry. When you begin to gather the HEMP, it will be expedient that each person employed clear before him as many feet of ground as the HEMP is high, in order that, after pulling it up by the roots, and beating off the earth that sticks to them, by striking the roots against his foot, he may conveniently spread it on the ground from whence he has pulled it, where it must lie until it is quite dry; it is then to be tied up in bundles, and put under some cover, or carefully stacked on the ground, in which case it must be well thatched with straw to prevent any wet from getting to it. Under this shelter it remains until about the middle of November, when it is spread out to rot; it is spread out in rows, taking care that it is spread so thin that it may get equally wet, and dry nearly alike... from this time it generally lies till towards the beginning of

February... The proper time for taking it up may be easily known by cracking a few of the stalks, or breaking a handful in the brake, and if the bark is found to separate readily from the stems, the HEMP ought immediately to be taken up, which must however be done in clear weather, that the HEMP, when lifted, may be as dry as possible... When it is not convenient to brake it directly, it should be put under cover, so as to be entirely safe from the weather."

Lionel Slator described this meticulous Dutch method of pulling hemp in his *Instructions...* (1724):

"In Holland, they pull the long fimble-hemp separately and apart from the short; especially, such as they perceive to have shed its Leaves and Blossoms, because the short Fimble is longer Time at rating [retting] than the long Fimble is: They are so careful not to break or bruise the Carl-hemp, as they pull the other, that when they pull their Fimble, they are forced to take off their Coats and Shoes, and tuck the Skirts of their Vests within their Breeches, and also have the Sleeves of their Vests made so tight to their Arms, as none of their Cloaths might break or bruise the Carl-hemp...

"The pulling of the long Fimble hemp apart from the short, is not only necessary with regard to the Watering [retting], but also of absolute Necessity in the working of them; for should the long Fimble-hemp be broke, and hackled promiscuously with the short, it would occasion vast waste; for the Artist always holds the Roots in his Hands, as evenly as he can. When he breaks or hackles, he must work the whole Hemp equally down to the Roots; and if they be of a very unequal Length, the Tops of the long Fimble will be over wrought, and rendered useless, if any of them should happen to remain". **(69)**

If the hemp is left laying in the field after mowing, it must be turned over after two or three days. This is done by thrusting a fork under the stalks near the tops and throwing them over on their butts. The stalks are left to dry for another few days, and then the field hand ties them in bundles about 1 foot in diameter with a length of old rope, pre-cut to the right length and looped at one end. One man can bundle from 1-1/2 to 2 acres in a workday.

The stalks should be shocked within a few days after harvest to avoid scalding. Sunburned fiber is unevenly colored and usually weaker. The stalks should be relatively free of leaves so the tops of the shocks are smaller and less rain can enter. Hemp stalks are bound in bundles about 10 inches in diameter, using small hemp stalks to tie them. The stack must be built to shed water, being higher in the center with sloping sides, and capped with an upright bundle.

The stacks of sheaves must dry out for one week (until the moisture content is less than 16%) before they can be handled by a bale-press. Alternatively, if the local weather permits, the stalks can be left in swaths for a month or more while they are repeatedly wetted by dew and dry out. Such "pre-retted" stalks can be water-retted more quickly, or they can be mechanically processed immediately without retting. Baled hemp should be removed from the field as soon as possible. If they are wetted by rain, the bales must be opened and the sheaves stacked to dry out before pressing them again.

The low-quality stalks that remain are gathered and burned (unless prohibited by law) in order to discourage hemp borers and recycle the nutrient ashes. The stubble also should be burned, because it does not decompose easily. Failure to do so will impede subsequent tillage and sowing. The only alternative is to chop the stems and stubble to 0.5 inch or smaller pieces with a chaff cutter. Plow the field and add nitrogen fertilizer to accelerate the process of decomposition.

The complete plant has the following composition: C (38.94%), H (6.06%), N (1.74%), O (48.72%), ashes (4.54%). The stalks contain: C (56.80%), H (6.48%), N (0.43%), O (34.52%), ashes (1.77%). The leaves contain: C (40.50%), H (5.98%), N (1.82%), O (29.7%), ashes (22%). The ashes of the hemp plant contain: KOH (7.48%), $NaCO_3$ (0.72%), CaO (42.05%), MgO (4.88%), Al_2O_3 (0.37%), SiO_2 (6.75%), H_3PO_4 (3.22%), H_2SO_4 (1.10%),Cl (1.53%), CO_2 (31.90%).The ashes of the seeds contain:

KOH (20.81%), $NaCO_3$ (0.64%), CaO (25.57%), MgO (0.96%), FeO_2 (0.74%), H_3PO_4 (35.52%), $CaSO_4$ (0.18%), NaCl (0.09%), H_2SiO_3 (13.48%), C (6.19%).

2.12 ~ Hempseed

A frost not exceeding 6° below freezing will not injure hemp except to stop further seed production and make the seeds shatter more easily. If possible, the seeds should be harvested on a cloudy day before noon when moisture helps prevent the loss of seeds by shattering. If a combine harvester is used, the weather should be sunny and dry. If the plants are manually harvested, they are cut down with corn knives, and shocked up around a few plants that have been left standing. After two weeks of drying, an entire shock is thrown onto a tarpaulin and thrashed with long sticks. The shock is turned over and beaten again. Two or three pecks of seeds can be collected from a shock of hemp. Because the seeds fall so easily from the dry plants, it is impossible to remove them without great loss and difficulty. The plants are so tall and branched that they cannot be fed easily into a thrashing machine.

If the crop is cultivated for both seed and fiber, the plants are harvested in two stages: (1) the seed-bearing tops of the plants are cut off and threshed; (2) the remaining stalks are harvested. An axial-flow combine harvester with an elevated cutting table can be used, but the rollers must be modified to avoid damage to the machine, and it must be operated at high speed so that the cut pieces will fall into the chopper.

Hempseed is cleaned first through a clod sieve with quarter-inch round slits, then through a seed sieve with 0.08 inch elongated slots, then through a fanning mill. Properly cleaned hempseed weighs 44 lb/bushel. A low yield of hempseed is about 300 kg/acre; a high yield is about 500 kg/acre, or 0.7-1.2 tons/ha. Some fiber yield is lost in the harvesting of seed hemp crops. The average yield is about 25 bu/acre, or about 700 kg/ha. The collection and cleaning of hempseed can be done only in dry weather.

Hempseed should be aerated within 24 hours after combining. Freshly threshed hempseed contains up to 20% moisture, and must be dried until the moisture content drops to 12%, preferably between 9 and 10%. Artificial drying should not exceed 40° C (105° F). One year of aging at 7-15° C with 65-75% humidity increases their viability about 15%. Hempseed should be kept cool and dry, as it spoils quickly under warm and damp conditions. Another method of preserving hempseed is to dry at 80° C for 15 minutes, or at 50° C for 4 hours. The temperature must be even: beginning the drying at a lower temperature and ending at a higher temperature will reduce the power of germination. The loss of germination potential can be prevented for about two years by cold storage (0-5° C/32-40° F) at low humidity. The germination rate can be maintained at 90% for up to five years by storage at -10° C (14° F).

Francesco Crescini studied the environmental and genetic factors that cause variations in seed germination, and developed a simple method for increasing their viability:

"Seed kept in in paper bags after harvest for 8-9 months, at 7-15° C and 65-75% air humidity, have a 10-15% greater viability than those after-ripened only 2-3 months. The physiological final ripening of the seeds is accomplished on the plant by drying the female stems after harvest at a shady place for 7-10 days... Lines of different germinating power may result, even from pure lines, under conditions of self-fertilization. Cross-pollination eliminates lethal factors which are responsible for low germinating power. The percentage of viability and the readiness to germinate are independent genetical characteristics. The longevity of hemp seeds does not seem to be hereditary and is not correlated with either their viability or their readiness to germinate." **(70)**

The Humorous Hemp Primer has this to say about the storage of hempseed:

"Never place the seeds in sacks, since they would get terribly hot and sweat themselves to death. Rather, use the proven method of spreading seeds gently on the floor, up to 10 inches deep. Use your hands and a shovel to gently turn and keep the seed alive. Early on it must be turned every other day. To avoid damage, wear felt shoes or cover your shoes with sacks. Hemp seed is only ready for storage when its humidity has sunk to 8%."

In fact, hempseed can be stored in sacks after it has been dried sufficiently, but it cannot be kept in a dry storeroom because the seed will lose its viability or become infested with bacteria. Hempseed should be sacked in 2-bushel bags; these are piled in groups of two, side by side, then two across.

Edward Quincey warned posterity to exercise caution in handling hempseed:

"The Farmer must be very careful in saving his seed, which by no means must lye too thick upon his floor, lest it heat and thereby be spoiled; to prevent which, let him stir and turn it frequently till it be dryed."

Lionel Slator gave this description of the traditional Dutch method of handling hempseed:

"When the Seed is thus thrash'd out of their Hemp, they convey it to a well-boarded Floor, where it is laid... about two or three inches thick, and they turn it once a Day regularly, during the first three Weeks, not suffering the Man who turns it, to have either Shoes or Pumps on, lest he should break or bruise the Seed by treading on it. About three weeks afterwards, they clean their Seed again, but not entirely from the Chaff or Dust... They leave that to remain with the Seed, until such time as the Seed is compleatly dry; because it is their Opinion, that this Dust and Chaff prevents the heating of the Seed as it lies drying... They continue the Seed still on the boarded Floor, and observe to turn it twice a Week, till the Season comes for sowing it."

The Anonymous Farmer from Annapolis advised against the Dutch method of collecting seed:

"Though this is the method... generally used for raising seed, yet it is by no means to be approved of; separating the seed plants from what you pull up occasions a great deal of trouble, and takes above double the time to gather and secure the HEMP from off the same ground... A far better method is to raise the seed apart by itselfe... An acre of ground, managed in this manner, will produce from 20 to 25 or 30 bushels of seed."

Edward Antil recommended this method of harvesting seed hemp:

"As the first seeds are the fullest and best, they are worthy of some pains to save them: and the best way to do that is, to bend down the plants all along... and shake them over a cloth spread on the ground to receive the seed; if one side of the plant be rooted out of the ground by forcing it down to shake out the seed, there will be no damage, for the seed that remains will ripen notwithstanding; and the plant must thus be shaken every two or three days, till all the seed be ripe and thus saved; and this is much better than pulling up the plants by the roots, and shaking them on a barn floor... for by this method, which is the common practice, one third of the seed at least never comes to maturity."

2.13 ~ Apologia

The anonymous Farmer from Annapolis ended his *Essay on the Culture and Management of Hemp* (1776) with this apology:

"Surely it is unnecessary to enlarge further on this head, and indeed the author fears that he may be thought too prolix, especially by those already acquainted with the subject, but when it is considered that these instructions are intended for the information of thousands, who have perhaps never seen the plant, he apprehends that the directions could not be too minute or particular."

Lionel Slator offered the same reason in his *Instructions* (1725):

"I shall conclude this Section with this general Apology in my own behalf, for being so large in my Observations and Remarks through this System of flaxen and hempen Agriculture, That I conceive it to be so much my Duty, fully to inform all Persons engaged or to be engaged in this important Matter, that I submit rather to be censured as prolix than deficient."

S.S. Boyce gave a similar accounting for himself in his treatise on *Hemp* (1900):

"There should be no necessity for an apology or an excuse for preparing a work upon hemp culture at this time. The hemp plant is the most widely diversified and, commercially and industrially, the most important plant in cultivation in Europe. It was among the first introduced into America, and one of the most extensive in cultivation among the colonists; and there is no good reason existing why it should not, but every reason why it should, today be among the first as a basis of another great and grand national industry, employing hundreds of millions of capital and hundreds of thousands of work-people."

2.14 ~ References

Table 2.5 ~ Hemp Farming

Operations: Plow ~ Disk ~ Harrow ~ Drill ~ Roll ~ Reap ~ Bundle ~ Thresh/Clean Seed ~ Spread ~ Pickup ~ Decortication ~ Bale ~ Transport ~ Storage; (Section 2.1)

Soil: Fall: plow (8"); apply amendments ~ Spring: disk harrow & roller; (Sect. 2.2) ~ Water furrows to ditch every 30-40 ft as needed ~ Microbial formulas (Bacillus subtilis, &c)

NPK: Manure, compost, cottonseed meal, bonemeal (200 lb/ac) &c; (Sect. 2.8) ~ NPK: N 100-150 kg/ha (<400 ppm); P 80-100 kg/ha; K 100-180 kg/ha ~ Gibberellin &c (Sect. 2.10)

Seed: Grain drill or alfalfa seeder (modified); (Sect. 2.5); Fiber Crop: 7.5 or 12.5 cm rows, 55-100 kg/ha; maximum depth 1.5"; Seed Crop: 10-15 kg/acre ~ 2 ft rows ~ 2-3 seeds/ft; thin to 1 plant/20" ~ Fiber & Seed

Crop: 12-20 kg/ha < 16" rows ~ 7 seeds/ft . Drill in with superphosphate/confettatura ~ Electroculture (Chap. 5)

Water: 20-30" +; 70% relative humidity; irrigate; 80-130 gal/kg fiber; (Sect. 2.3)

Temperature: Soil: 35^{o} optimal @ sowing; air: 19-25^{o} C optimal; (Sect. 2.4)

Intercrops: Mustard, broccoli, brussel sprouts, lupine, nettles, hops, turnips; (Sect. 2.6)

Crop Rotations: Corn, potatoes, onion, peas, beans, wheat, clover, barley, oats, grass; (Sect. 2.6)

Calendar: 100-115+ days, <frost - frost>, April 1+

Equipment: Tractor ~ plow ~ disk ~ harrow ~ drill ~ roller ~ J. Deere Kemper harvester (or: self-rake reaper-mower, sweep-rake reaper, modified rape swather, mower conditioner) ~ baler (or: modified rice binder) ~ clod sieve (seed-cleaning: 1/4" round slits) ~ flatbed truck/trailer ~ forklift ~ pumps ~ tools ~ fuel ~ barn ~ scales ~ Hill/Agra Decorticator

Expenses: ~ $200/acre (Sect. 2.1)

Yield: Seed: ~ 0.4 ton/acre (300 gal. oil) > 1.2 tons/ha; (Sect. 1.7, 2.11, 4.7) ; Fiber: average ~ 2 tons/ha; maximum: ~ 12 tons/ha @ 115 days (Kompolti).

3.1 ~ Retting

Hemp bast fiber must be separated from the woody core by mechanical means (decortication) or by the process of "retting" (rotting). Natural retting is considered to be impractical for modern industrial purposes, but this low technology will always be appropriate somewhere, and never completely obsolete.

When hemp begins to rot, dark flecks of fungal colonies appear on the bark, continuing until the surface turns to a steel-gray color. The most frequently occurring fungi belong to the genera *Alternaria*, *Hormodendrum*, *Fusarium*, *Cephalosporium*, *Phoma*, and *Trichothecium roseum*, which decompose the pectin and polyuronide hemicellulose in the stalk. *Cephalosporium* attacks cellulose to a slightly greater extent than other fungi. *Pseudomonas fluorescens* and *Clostridium felsineum* are dominant during retting. Enzyme sprays have been developed to facilitate the retting process in a controlled manner. **(1)**

The ripples in hemp stalks cause the retting action to be irregular, beginning in the convex parts. The process starts earlier in females than in males, but pectin fermentation proceeds more rapidly in male plant. The difference, however, is balanced by the end of the process.

Dew-retting (field-retting) is accomplished by spreading stalks on the ground to be exposed to rain and dew. Hemp that is to be field-retted should be cut as close to the ground as possible. If the stalks are laid out on tall stubble, they will dry out quickly when the wind blows under the swath. Retting requires about 30% moisture content. Field-drying will decrease the humidity to below 20% within a week, or sooner if the crop is harvested with a mower crusher. The stalks should be wetted with a sprinkler if necessary. The farmer's control of the process is otherwise largely limited to turning the hemp at least once to promote uniform retting. It must be picked up at the right time to prevent over-retting. Turning of the stalks is done with poles pushed under the stalks near the head end. The stalks are turned over without moving the butts. The work is begun in the middle of the field, the first swath being turned over into the empty space in the center, and so forth.

If an early-maturing crop has been cultivated over 1000 feet above sea level, then altitude becomes an important consideration because the temperature may inhibit or prevent the processes of drying and retting. High altitudes tend to be sloped, and this too may cause problems. A high, sloped field must face south to allow stalks to dry sufficiently on the stubble.

Conditions of temperature and moisture usually are most favorable early in the fall. As winter sets in, low temperature limits bacterial activity even though adequate moisture is present. Hemp can winter up to 4 months without suffering serious damage, but often it will be over-retted. Alternate freezing and thawing spells gives best results in winter field-retting.

Retting at 20^{o} C requires 7-8 days of retting. At 12^{o} C, 15-17 days are required; at 7^{o} C, 30-45 days are necessary. The shortest retting period is achieved in 3 days at 37^{o} C. Retting does not occur at all at 5^{o} C (bacteria are inactivated) or 40^{o} C (destruction).

During the 1940s, Lyle Hessler (Kentucky Agric. Exp. Station) worked to develop improved methods of retting, summarized as follows:

"Retted hemp fiber is composed of about 80% cellulose and lignin, while the remaining 20% or partially soluble fraction is made up of N compounds, pectic substances, pentosans, ash, and other extractable substances. Unretted hemp fiber consists of about 30% of the partially soluble fraction. By retting, part of it is removed in order to free the fiber. When the fiber is exposed to microbial action, it is weakened and, as a result, the breaking strength varies inversely with the length of the retting period. Exposure to the sun shortens the time of retting. Damage to hemp fiber during retting may occur to a greater extent when the fresh green plants are retted than if the plants are allowed to cure by shocking; further, the younger top part of the plant may readily result in weaker fiber. Winter retting compared with fall retting usually has been observed in practice, and substantiated by these experiments, to result in a better color but weaker fiber. This condition is probably due to the slower, longer retting period. The chemical composition of winter-retted fiber was lower in the more soluble fractions, which indicates more retting...

"N fertilizers increase the growth of hemp and give greater yields of dew-retted hemp fiber, but at the same time the quality may be inferior because the fiber is coarser and weaker... The cellulose content of the fiber was significantly increased where the complete fertilizer was used, but during retting the more labile secondary constitutents tend to level off in concentration regardless of fertilizer treatment. Correlation coefficients show that encrusting material plays a part in increasing or decreasing strength of fiber. Fineness of fiber as measured by centimeters per gram gave a significant positive correlation coefficient of breaking strength. Correlation between fiber constituents and fineness was not significant. All encrustants showed a negative correlation with the primary fiber constituents, cellulose; lignin, protein, and ash gave highly significant correlation coefficients, while pentosans gave a significant *r*." **(2, 3)**

Hessler also studied the removal of encrustants from dew-retted hemp fiber in order to find a more uniform basis for testing:

"The formation of cellulose nitrate and the detection of degree of polymerization and percentage of N may be used as an index to encrustant removal and good fiber degradation and quality. NaOH and N_2CO_3 are good chemicals to use in removing encrustants. The former is more effective, but it causes some degradation of the cellulose chain. Increasing the concentration of Na_2CO_3 over the 1% level did not give better removal of encrustants, although it caused some cellulose degradation. The lower boiling alcohols such as methyl, ethyl, butyl, isobutyl and amyl are not very effective in removing encrustants; but they do open up the fiber and allow other mild reagents to act more effectively. Of the two high-boiling alcohols (ethylene glycol and glycerol), ethylene glycol was better in the removal of encrustants and caused slightly less degradation of cellulose. The higher boiling alcohols have a tendency to make the fiber more subject to oxidation in bleaching. Increasing the boiling time over one hour did not greatly increase the removal of encrustants, but, especially in the case of glycerol, it did cause a lowering of the degree of polymerization. These tests indicate that degumming of bast fibers can be undertaken with a minimum of cellulose degradation and that encrustant removal to a common cellulose base will result in more uniform physical testing." **(4)**

The end-point of retting is determined by simple tests:

1. Bend some dried stalks back and forth. The fibers should not break when the woody core breaks. The hurd fragments should fall free from the fibers when shaken. If retting is incomplete, some hurds will adhere to the loose fibers. To test the strength of fibers, break some strands. They should break with great difficulty and a snap; otherwise, the hemp has been over-retted.

2. Peel the fiber near the base of the stem. If it peels easily, it is adequately retted. If retting has been insufficient, the fiber will break after only a few inches of peeling.

3. Break several stems all at once in several adjacent areas. If the wood separates easily from the fiber, the retting is complete.

4. The reduction in the total uronic content in the stalks indicates the progress of retting better than any other means. Well-retted hemp has a total uronic content of 5%, compared to 10% in unretted bark. Over-retted hemp contains less than 5% urones.

The retted stalks may be picked up by hand and bundled on a sloped "buck" rack, but a pick-up binder is most efficient. It is important to keep the stalks well butted when bundling them. This minimizes problems with tangled stalks at the mill, and results in a higher yield with less waste.

Retting pools must be designed to accommodate the expected yield of stalks. S.S. Boyce gave very detailed instructions for the various methods of retting in his excellent treatise *Hemp* (1900):

For this [to accommodate 1-5 acres of harvest] a pool of a size to hold 2 to 10 or 12 tons of hemp will be required, although these pools are usually 4 or 5 feet deep, 10 to 12 feet long, and 5 to 8 feet wide. The sheaves of hemp are packed with the butts alternately one way and the other, until the pit is full, or all the hemp is used up. It is then weighted down by stones and the pit filled with water. The same water may be used over several times, until all the hemp is steeped. The method is wasteful, the steep-water not being utilized, while the stench ... is something unbearable. Nor is the product of much greater value than by the more primitive method of spreading the hemp on the ground.

"The best results are obtained when hemp is grown upon a large scale and the hemp retted by being steeped in running water. Quite often the hemp is placed in crates holding a ton or more of stalks, and then weights of stones placed upon them to hold the hemp under water for 5 to 8 days, according to the temperature of the water. Part of the more modern practice is to dig pools 5 to 7 feet deep, which will hold 10 to 25 tons of hemp, and into which, if the pits are so situated, a small stream of water may be conducted and the overflow allowed to run out upon the land as a fertilizer...

"A later practice is to place the hemp in the water for 4 to 5 days and then take it out and dry it, returning it again to the retting- or steeping-place for 4 to 6 days more. This gives a better fiber, of a creamy white color, and a more evenly retted product. Or, after first being in the water for 5 to 6 days the hemp is dried, and when afterwards [decorticated] the hemp is 'boiled off'... to completely remove the [lignin, etc.]... Another process of retting consists in placing the hemp in tanks of convenient size, holding 5 to 10 tons of stalks, which are filled with water first impregnated with acid, and then emptied and refilled with water containing alkaline preparations, or *vice versa.* In some instances the hemp is first broken or decorticated and the fibrous material only subjected to steeping. This requires much less space, and after steeping the fiber can be hung up to dry.

"One method of 'boiling off' the fiber before spinning consists in first passing the partly water-retted hemp through a softening machine consisting of 16 sets of fluted rollers... The fiber is then macerated in a nearly boiling solution of carbonate of soda and soap, then washed, first in cold water and then in water containing a small amount of muriatic acid, and again steeped in water containing soda without soap, to remove the acid; it is then placed in a solution of one part of acetic acid and one part of water and afterward in water alone, and dried and again softened. The process is too long, but is well rewarded in producing an exceedingly fine, soft, valuable fiber, highly adapted to the manufacture of fine linen, lawns and laces." **(5)**

Such extremely fine hemp thread nearly equals silk. It can be hand-spun to such fineness that 600 miles of lace thread can be produced from 2-1/2 pounds of fiber. Cotton and wool cannot exceed 350 miles per 2-1/2 pounds. Boyce continues:

" There are three methods of retting hemp practicable where hemp is grown upon a large scale in the United States. If not grown upon a scale of at least 300 to 500 acres by one planter, there should be arrangements for uniting several smaller growers, or that the hemp grown upon a smaller scale should be disposed of to the middle man prepared to ret the hemp and prepare the fiber and properly classify it.

There is little economy in the small acreage system... where the working up is done by others. If there is sufficient profit in raising hemp with a yield of 3 to 5 tons of hemp straw or stalks per acre, and disposing of them to the middle man or manufacturer of fibers... then it may be done so; but it is a division of profits against the farmer, as he loses all fertilizing matters where the hemp stalks are carted from the farm.

"The first method is the ordinary water retting. For this method a system of square wooden tanks... is constructed.... To handle 500 acres of hemp, growing 15 feet high, requires preparations to handle 2,500 tons of stalks. If the work of retting goes on continuously from March to November... it will require the handling of at least 10 tons of stalks per day. If there is an interruption [for plowing, planting, and harvesting], the capacity should be sufficient to handle 15 or 20 tons per day --- that is, of emptying tanks holding 20 tons and putting the stalks out to dry and refilling the tanks, and also taking in 20 tons of dried retted stalks and putting them under cover to be broken at a later day... The breaking can be done from December to March...

"To handle 20 tons of hemp stalks per day will require 8 retting tanks 8 x 15 feet and 5 to 6 feet deep. These should be situated upon the more elevated portions of the ranch... or the tanks may be so constructed upon timbers as to be moved from place to place once a year as the ground around the tanks becomes fertilized by water and refuse from handling the hemp. The steep-water and the foliage and waste from the hemp are high in fertilizing elements...

"The stalks are held down firmly by cross-pieces and the tanks are filled with water... In 6 to 10 days, according to temperature, the bark of the hemp stalks will be found to readily slip off when the stalks are broken in the hands, and the hemp should then be taken from the tanks and dried and and put under cover to be broken, shaken from the woody matter and baled...

"The above method will produce a prime cordage hemp for use where a strong, serviceable fiber is desired. Another process is to take the hemp stalks from the retting vats in 5 days and dry them by standing out or spreading, and again returning them to the vats for 5 to 8 days longer. This produce a fiber corresponding to the best Italian hemps.. and is adapted for fine cordage, coarse threads, carpet warps, canvas and similar products.

"Another method is to place false end pieces across the tanks some 2 inches from each end of the retting tanks and reaching down to within 2 to 4 inches of the bottom. A half-inch stream of water is let flow into the tank upon the top. This carries all impurities downward and out under the ends of the false ends and up and out over the real end, made an inch the lowest, and thus maintains a circulation of water which produces a fiber of much lighter color, especially if the water used is slightly hard and impregnated with lime.

"After the hemp is retted in water in the tanks for 5 days it may be taken out, dried and broken, and will furnish an exceedingly strong fiber for many uses. After water retting and drying the stalks, they are put under cover to further ripen and mellow. In all the work there should be some 6 weeks between the time of harvesting the hemp before it is retted, and the same length of time between the retting and the breaking, so that there will of necessity have to be a storage room for at least a supply for the work of 6 weeks.

"In retting, the tanks are emptied one or more each day, the contents put out to dry and again filled, so the work goes on steadily. Rain and snow and frosts do not injure the hemp after it is retted; in fact, the washing from a rain is an advantage, while a sharp frost serves to disintegrate the fibers.

"Another process is to first break the hemp stalks by passing them through a breaking machine [to remove the hurds]... As it requires 5 to 6 tons of hemp stalks to yield a ton of fiber, it can readily be seen that first breaking the hemp and disposing of four-fifths of the weight and bulk leaves a much less amount to be handled and very much saves labor in the work; besides, a tank holding 5 tons of stalks would hold all the fiber from 25 tons of stalks. If the hemp is first broken the retting tanks may be of much less size, while it is much easier to handle the fiber alone than the stalks, and in retting the water attacks the fiber evenly on all sides alike, whereas with the stalks the water only comes in contact with the outside of the fiber. In drying the fiber after it is so retted 25 tons may be hanged may be hanged upon an acre of ground if placed upon bars, horses, or other frames, for support. After drying in some 4 days, the fiber is put under cover to be again run through the breaking machine, and is in much finer condition for market. In all this work, if the retting tanks are filled with 1 pound of potash lye to each hundred pounds of hemp stalks or fiber, the retting will be done in 4 days instead of 8. When this is done with the fiber alone, the fiber is afterwards put into a solution of muriatic acid, 1 pound to 100 gallons of water, and again rinsed in water...

"Instead of potash, some 2 to 4 pounds of neutral soap, free from resin, may be used and the hemp fiber retted without the use of the acid bath, the fiber being rinsed in soft water. Also the retting will be done in 2 or 3 days if the weather is warm, and there will be but little of the bad odor attending ordinary water retting. If this solution of soap and water is made hot, the retting will be done in 12 hours. If perforated steam pipes are inserted at the bottom of the tanks and live steam turned in for boiling, the retting will be complete in 1 to 3 hours, according to the strength of solution used and the degree of fineness required. If the hemp which has previously been water retted and broken is boiled for half an hour in such a saponaceous solution a nearly perfect fiber results. After boiling and rinsing and drying, and the hemp has lain 4 to 6 weeks to mellow, ripen and gain nature and quality, it is run through the breaking machine, softened and baled, as is done with cotton.

"The steam can be produced at no cost by using hurds as fuel. The ashes of hurds contain about 12% potash, which can be extracted with water to make soap, soften water, and ret the hemp as described above, besides serving as fertilizer."

The research conducted by W. Fuller and A. Norman in the 1940s investigated various controlled methods of retting, with these results:

"Retting under anaerobic conditions was more rapid than any of the aerobic methods, and produced a fiber with more desirable characteristics. Retting under anaerobic conditions was most rapid if the temperature was kept at 37^{o} C, the acidity of the solution was kept to a minimum, the solution was undisturbed, and an enrichment culture was added initially as inoculum in an amount equal to 10% or more of the total tank solution... Acid accumulation and consequent retardation of the retting process was prevented by aeration, and later return, of a portion of the retting solution in a separate tank... Under controlled anaerobic conditions about 1/2 of the water-soluble constituents and the furfuraldehyde-yielding constituents were removed in the first 36 hours. Attack upon the cellulose was negligible until after 48 hours... The progress of retting was invariably accompanied by an attack on the polyuronide hemicelluloses proportionately as great as that upon the pectin... There was no indication that *Trichothecium roseum* was any more vigorous in cellulose decomposition than any other organisms normally present on hemp straw.

"The loss in weight of the hemp and production of volatile [acetic and butyric] acids may be used to a limited extent as indicating the rate and degree of retting on a laboratory scale, providing that uniform material of the same source and maturity is employed... The reduction in the total uronic content of the bark reflected the progress of retting better than that of any other constituent. Well-retted hemp bark had a total uronic content of about 5-6% as compared to 9-10% of the unretted bark." **(6)**

J. Kulas and L. Nowackiewicz also studied anaerobic retting:

"The weight-ratio of water during retting, the rinsing of straw after retting and the intensity of spraying during pressing were more important for fiber quality more than a change of the water during the retting. A weight-ratio of 1:20 during the retting of hemp straw gives the best results. Rinsing of the straw with 18 m^3 water sprayed per ton improves the quality. A total quantity of 55 m^3 of water per ton of straw is necessary." **(7)**

US Patent #1,448,391 describes an improved method of retting in which hemp stalks are stacked in superimposed layers in an inclined position; after they have been cured, they are subjected to moisture while still in stacks but without submersion, and they are aerated after retting.

US Patent #2,457,856 teaches a chemical retting process for hemp by immersion in a mixture of hydrogen peroxide (0.5%), ammonium phosphate (0.5%), and urea (1%) at 50^o C; the bath is then heated to 100^o C. The xyloid material is to be removed by decortication.

In some parts of Asia, hemp fiber is prepared by soaking the stalks in water for a day or two, then steaming them for 3 hours. Then the fiber is peeled off by hand or by scraping. The resulting product is a stiff ribbon which is not well suited for spinning. Steam retting results in a considerable loss of fiber, and the remaining fiber has weaker tensile strength than water-retted hemp. **(8)**

Edward Antil added a precaution about fresh-water retting in his *Observations on the Raising and Dressing of Hemp* (1777):

"If the Hemp be rotted in a brook or running water, the sheaves must be laid across the stream, for if they be laid down lengthways with the stream, the current of water will wash away the lint, and ruin the Hemp. It must be laid down heads and points, two, four, or six deep, according to the depth of the water and the quantity of the Hemp..."

The anonymous Farmer from Annapolis advised against the practice of fresh-water retting in his *Essay on the Culture & Management of Hemp* (1775):

"Before placing the Hemp in the water, it will be necessary to take care that the bundles have not been made too large, and that the Hemp is tolerably even at the roots, as well as near the top; care however must be had not to bind it too close, an error, here, being of more consequence than may be imagined, the watering never succeeding thoroughly when the bundles are hard tied, the fermentation going on unequally in the several parts, as they are more or less confined...

"We are apt to imagine that a fine clear stream would be fitter to accomplish this end, because, at the same time that it dissolved, it would also purge and wash it from that gum and filth, thereby leaving the hemp in a purer state, but experience, against which there is no reasoning, convinces us, that the properest places for watering Hemp, are deep ditches, or pits of stagnated water, such as mill-ponds, or deep pools, where the water is seldom or never changed. The more still and putrid the easier it ferments, and penetrates the hemp more quickly, as well as more effectually, and though that which is watered in a limpid stream will appear far whiter, at the brake, than that which is watered in stagnated water, yet, upon minute examination, the first will be found inferior in quality to this last, it appearing in a manner exhausted and dead as it were, and of a pale white, whilst the other appears with a fine lively gloss, with a bluish cast that never quits it; for the cloth made of this Hemp most readily attains a perfect degree of the purest white, whilst the cloth made of the river watered Hemp, notwithstanding all the efforts of art, will still retain a yellowish cast, and without great care, will increase as the linen is used...

"If possible, [the retting pit] ought to be in such a place... that a small quantity of soft water, free from any mineral, may, when clear, be let into the pit, near the surface, which, else, from the excessive power of the sun at this season, would be much warmer at the top, and consequently the Hemp there would be sooner watered than at the bottom. Where no fresh water can with convenience be admitted, the pit may be shaded by means of a few more green boughs...

"To fit these pools the better and sooner for the purpose, it will be necessary to have them dug two or three months before they are used, and to throw therein, to rot, succulent weeds or plants, which may be taken out immediately when the Hemp is ready to be laid in, by which means the water will be stirred up from the bottom, and mixed with that at the top...

"If it is perceived that the Hemp has been taken out too soon, it is only permitting to lie a few days longer where it is spread, and the dew or rain will not only compleat what the water has left undone, but it will also take off some of the harshness of the Hemp."

Lionel Slator made this recommendation in his *Instructions for Cultivating Flax and Hemp* (1775):

"Unless the Ponds be made in a gravelly soil the bottom of the Ponds will be apt to be muddy or foul, which may be injuring to the Hemp; therefore, to prevent such Mudd, the Bottom of the Ponds may be either flag'd or planked, where there is not a solid Bottom of Gravel."

3.2 ~ Hurds

"Hurds" are the pieces of the woody core of hemp. Hurds are a valuable commodity with many uses, especially such as paper and Isochanvre, a petrified form of hurds manufactured by Chenovette Habitat in France.

The value of hemp hurds was recognized by the anonymous Farmer from Annapolis:

"A most considerable advantage comes from the coarse tow, or hards, of the first hackling, which, by means of the second watering, becomes an object of great utility, being thereby excellently prepared to make the best sorts of coarse linens... and preferable in strength and quality to imported osnabrigs, being greatly superior to the coarse tow prepared in the mill."

Marcandier mentioned a mixture of hemp and wool, known as *berlinge,* that was widely used in France:

"Hards or Tow, in the modern method of its preparation, being equally mixed with Wool, Cotton, Silk or Hair, is with much credit and advantage wrought into a variety of hose, caps, stuffs, cloths, and many other articles, to the reduction of the usual price of the whole, and the consequent encrease of commerce...

"Now this hards, that was formerly an object of discouragement... by this new operation becomes a matter of very great advantage. By carding them like wool, they produce a fine, marrowy, and white substance, the true use whereof was never discovered till now. It may not only be used alone, as it is, for the making of wadding, which, in many respects, will have the advantage of the ordinary sort; but moreover, it may be spun, and made into very beautiful thread. It may also be mixed either cotton and silk, with wool, and even with hair; and the thread, that results from these different mixtures, affords, by its vast variety, materials for new essays, very interesting to the arts, and of vast utility to several sorts of manufactures...

"The principal advantage that Hemp, intended for these uses, will have over wool, grogram yarn, and cotton, is, that it may be used without spinning or even combing. It will be in no danger from those worms, which commonly eat woolen cloth; and the beauty, as well as the lasting nature and the low price of it, will render it preferable to any other material. The different trials, that have been made of this sort, leave no room to doubt of success in other attempts of the kind."

Japanese Patent #42,193 describes the manufacture of imitation cotton from waste hemp:

"Purified waste hemp fibers are wrapped on a spool to a thickness of about 2 cm and one side is then cut to form a sheet. These sheets are immersed in NaOH solution at 5-15^{o} for 20 minutes, neutralized with dilute sulfuric acid treated with Marseilles soap and non-drying oil as usual, and loosened to a cotton state."

According to Japanese Patent #42,179, threads of hemp, cotton, etc., can be whitened by immersion in a solution of 20 gr $BaCl_2$ or $CaCl_2$, 1 gr of sodium acetate, 1 gr of glycerol or phenol, 20 gr of milk and a small amount of gum Arabic in 180 cc of water. After drying, the textile is passed through cold sulfuric acid, washed with water, then dried in the air by heating.

US Patent #2,450,586 was granted for a process to saccharify hurds (and other agricultural residues), which can be treated to produce $C_{5\text{-}6}$ sugars:

"The cellulosic materials are treated with 1-6% sulfuric acid at 100-120^{o}C to convert pentosans to pentoses and furfural. The treated material is washed free of soluble pentose and other sugars with additional dilute sulfuric acid. The residue is dewatered and dried, then comminuted and mixed with 0.15-0.55 parts of 80-87% sulfuric acid per part of cellulosic material at a temperature below 40^{o} C, whereby a free-flowing powder is formed. The total amount of both dilute and concentrated acid used is not more than 0.35 part/part of the original cellulosic material by weight. The acid-mixed material is then subjected at a temperature of or below 45^{o} C for 1-5 minutes to mechanical mastication so as to develop continuously-changing directional pressures on the solids in excess of 100 lb/sq. in. and just short of the formation of dextrose, whereby a pronounced physical and chemical change is effected to convert powder to a stiff plastic mass. The resulting mixture is then diluted and hydrolyzed to produce dextrose."

Hurds also can serve well as a fuel, and can significantly reduce the cost of processing the fiber if used to generate steam power to operate the machinery. During World War II, hemp mills in the USA dried the damp stalks by conveying them through a long, heated drying tunnel before delivering them to the decorticator and scutching machinery. The hurds were burned to provide heat for the drying tunnel.

I. Popescu and I. Afusoae discovered another use for hurds:

"Fermentation can help turn hemp boon [hurds] into a suitable product for soil fertilization. During fermentation the boon reaches almost the same level of assimilable N, K, Mn and Cu as in barnyard manure...

"Hemp boon will absorb up to 792 mg ammonia/gr of boon in ammonium nitrate and sulfate solutions." **(10)**

3.3 ~ Decortication

When retting is complete, the stalks are dried and sorted by grades, then crushed in a mechanical decorticator. The classic hemp-brake is a manually operated wooden press of intersecting boards that break the stalks so the hurds can be removed. The operation consists of placing some stems with the butt end first across the break, then lowering the upper boards by the handle, breaking the stems as the boards intermesh. This is done repeatedly as the stems are fed in up to the tips. An experienced hemp worker can hand-break about 250 lb of fiber per day.

Thomas Jefferson wrote: "A hand will break 50 or 70 lb a day, and even to 150 lb if it is divided with an overseer; divide it as prepared." But the work was very tedious, and the slaves complained of it. Jefferson proceeded to invent an improved hemp break, for which he received US Patent #1. He described it in a letter to George Fleming (29 December 1815):

"Flax is so injurious to our lands and of so scanty produce that I have never attempted it. Hemp, on the other hand, is abundantly productive and will grow forever on the same spot, but the breaking and beating is so slow, so laborious and so much complained of by our laborers, that I have given it up... But recently a method of removing the difficulty of preparing hemp occurred to me, so simple and so cheap. I modified a threshing machine to turn a very strong hemp-break, much stronger and heavier than those for the hand. By this the cross arm lifts and lets fall the break twice in every revolution of the wallower. A man feeds the break with hemp stalks... where it is more perfectly beaten than I have ever seen done by hand. I expect that single horse will do the breaking and beating of 10 men...

"Something of this kind has been so long wanted by the cultivators of hemp, that as soon as I can speak of its effect with certainty, I shall probably describe it anonymously in the public paper, in order to forestall the prevention of its use by some interloping patentee." **(11)**

After breaking hemp, the fiber is "scutched" and "hackled" to remove the hurds, broken fibers, and extraneous material. The fibers are cut into shorter lengths, then combed to remove short and tangled segments. The long fibers are parallelized and smoothed in a hackling machine, then repeatedly drawn through sets of sharp pins or combs to produce a product ready for wet or dry pre-spinning into roving yarn. The low quality scutching and hackling tow discarded from the preseding process is shaken and carded, etc., or it is "cottonized" to remove the sticky pectin and lignin and produce loose bast stock. Then it is wet- or dry-spun into coarse yarn, twine, or other specialty products such as insulation..

The Schlichten Decorticator --- Hundreds of hemp-processing machines, or decorticators, have been patented since Thomas Jefferson made his improvements on the hemp break. Only the design perfected by George W. Schlichten met the needs of the industry. The Schlichten Decorticator promised to revolutionize the hemp industry by eliminating the need for retting. As described in his U.S. Patent #1,308,376, "The fiber produced is at once ready and suitable for carding or combing without any further treatment such as degumming or retting, and leaving the fiber soft, pliant, adhesive, and in its unimpaired natural strength and color..." In 1916, after 18 years of development and $400,000 investment, Schlichten tested the market for the hemp fiber his machine produced. He sold his entire first batch to a spinning plant owned by John D. Rockefeller, and was paid a record premium of $100/ton. Afterwards the mill offered to buy the exclusive rights to the invention, and at a higher price than Schlichten had wanted, but he declined the offer.

Field-dried stalks are introduced to the decorticator on a corrugated feed table or through revolving disks that keep the stalks separated and straight. The stalks pass through denting rollers, then through splitting and spreading rollers. The stalks then pass between a series of primary and secondary breaker rollers. Next, a high speed rotating coarse comber begins to clean the fiber and degums it by separating the non-fibrous products along with the short "tow" fibers. Corrugated softening rolls then massage the fiber and hold it in position for another series of combing and softening rollers. Finally, an endless slatted carrier eliminates any remaining small waste particles and delivers a continuous, folded "sliver" of fiber, ready to be hanked and baled (Fig. 3.1). **(12)**

The machine came to the attention of the industrialist Henry Timken (inventor of the roller bearing) in 1917, and he was very impressed by its possibilities. He arranged to meet Schlichten and offered him the use of 100 acres of his ranchland in Imperial Valley, California, to grow a crop of hemp to test in the decorticator. The bumper crop was 14-16 feet tall and attracted national attention from coverage by the Pathe, Mutual, and Hearst newsreel companies.

Timken also tried to interest newspaper magnate Edward W. Scripps in the idea of making newsprint from hemp hurds. Timken called Schlichten's decorticator "the greatest invention in the world." Scripps' associates Milton McRae and Edward Chase investigated the feasibility of the proposition. In his enthusiastic report, Chase wrote:

"I have seen a wonderful, yet simple, invention. I believe it will revolutionize many of the processes of feeding, clothing and supplying other wants of mankind.

"Mr. Schlichten raised 5 tons of hemp stalks to the acre on a 100-acre patch... He will pay the growers $15 per ton for dry hemp stalks delivered to his machine... Thus the farmer gets $75 an acre for this crop which matures in 100 days. The stubble and that part of the leaves and tops which remain on the field (containing in excess of 50% of N), are wonderful fertilizer. Moreover, the hemp kills all weeds. The farmer's land is left in fine condition for immediate planting of other crops.

"From each ton of dry hemp stalks, costing him $15, Mr. Schlichten gets the following:
About 500 lbs. hemp fiber at $0.16/lb $80.00
1250 lbs. hurds at $5.50/ton .... $ 3.44
(Worth that figure as stock feed or for paper stock)
250 lbs. leaves, tops, &c. at $5.50/ton .... $ 0.69
From each ton, about $84.13
From each acre, about $420.65
From 100 acre experimental patch, about $42,065.00

One of Schlichten's machines will produce per day (2 shifts of 8 hrs. each):
2 tons of fiber worth about.. $600.00
5 tons of hurds.. $27.50
1 ton of tops, leaves, &c., worth about $5.50
Total: $633.00

"This will be at a total cost of less than $200 --- less than $100 per ton of fiber for growing the hemp, passing it through the machine and baling the output ready for market. One fairly good machinist and three common laborers... are required per machine for each shift. This one new machine... turned out in the two days I was there:
3 tons of fiber worth... $900.00
About 7 tons of hurds worth... $38.50
About 1 & 2/5th tons of leaves, &c.. $7.70
Total: $946.20"

McRae waxed eloquent with praise in a letter to Henry Timken (11 August 1917)

"Mr. Schlichten impressed me as being a man of great intellectuality and ability... he has created and constructed a wonderful machine...

"[That] Schlichten decorticating business... I believe, is one that is worthy of any man devoting his time and money to, because it appears to me that the successful development of that industry means clothing all the people of the world, eventually, at considerably less cost than is now required.

"You know, Lord Bacon had a theory, or philosophy, that in this industrial age the real benefactor of mankind was not one who evolved or preached a beautiful theory, but one who assisted in clothing and feeding the world more economically than in the past... that means shorter working hours, and shorter working hours eventually means the spiritual development of the world..."

The Schlichten decorticator remained dormant until the mid-1990s, when it was redeveloped by Jim Hill, the founder and owner of Hill Agra Sales (Shelburne, Ont.), manufacturer and distributor of bulk vegetable harvest machinery. Jim Hill described the project in an interview with *Hemp Magazine* (1997):

"We have it working, and it does what we expect of it. The machine is two feet wide and eight feet long. It is on a two wheel trailer with jacks on either end. It is hydraulically driven. The high and low speed rollers have variable speed controls with flow dividers. It can be run by a tractor of 60 horse power using the hydraulic pump on the tractor.

"The [Fibre X Model 1460] machine will do approximately [3-4 tons] per hour. We have worked on other designs for fiber extraction. The Schlichten model is only one of several we have been working on...

"Basically, what I've done is to study the Schlichten papers, patents and drawings. The way that machine is drawn up, there is no possible way that the machine could work, based on that drawing. Back in those days, people changed their drawings from the original machine, so that they couldn't be copied. They never trusted anybody...

"The original machine that he built required four people to operate. That means two people putting the stalks in at one end, one person shoveling the hurds out from underneath, and a fourth person who had to be a good mechanic in order to keep the machine working. There were no bearings. The thing probably sounded like a flock of canaries when it was running. So, between oiling it and keeping the hemp from tangling up in the shafts, he must have been a very busy fellow...

"Our main goal was to maintain all the advantages he had built into his unit; such things as holding the rollers apart from one another, and having them spring loaded. Obviously, we had to put a high grade bearing in and have it protected against wrapping up in the fibers going through. Instead of putting an inside bearing, we put an external bearing that actually has its shaft continue over the mounting plate. This means that there is no chance of getting fibers caught in the bearing...

"Two people can run it. Operating this machine is more just a question of watching it to make sure that the material flows smoothly. It can be hand fed, or machine fed. There are all kinds of developments that can be added to this machine. The hurds that come out underneath the machine can be dropped on a conveyor and blown off into large plastic bags for later use. Our idea for the decorticator is that it should be used out in the field. This puts the dust right back in the ground for fertilizer...

"The decorticator is portable so you can move it from field to field instead of moving all the material to a central location for processing. That means that several growers can get together and buy the equipment and handle this as any other crop. After that, you can handle the product output many different ways. You can upgrade your product at the farm gate and have that value ready to ship out as goods. This will allow the growers to realize more of the profit available from their crop."

Austrian company Rohemp also manufactures a mobile hemp breaker which separates field-retted hemp into fiber and hurds at a rate of about 1 ton/hour and produces round bales of straw.

3.4 ~ Hemp Fiber Technology

The certified classification and value of hemp stalks is determined by the quantity and quality of the long fibers in particular. Fine fibers are most valuable. The content of fine fibers is indicated by a numerical index that is determined by the ratio of the length and diameter of the stalk. Grade I stalks are no more than 0.4 inches (10 mm) thick along at least 60 inches (150 cm, 85%) of the plant's length. Grade II stalks have a maximum thickness of 0.5 inch (12 mm) and a minimum technical length of 40 inches (100 cm). Grade III stalks are a maximum 0.6 inch (14 mm) thick and 25 inches (60 cm) minimum technical length. The maximum moisture content for all three grades is 16%.

No matter what the method of cultivation, all hemp must undergo some primary processing near the farm. Schlichten-type decorticators or "mini-mills" with 50-300 tons daily capacity would be ideal.

Several modern technical developments have made hemp fiber processing more economical and ecofriendly. Traditional methods of retting can pollute the environment and are subject to failure. The new methods produce high yields of standard-quality fiber at competitive prices for industrial purposes. The absorptive properties, temperature stability, etc., can be modified by pre-treatments such as drying, carbonizing, impregnation, and mineralization. A very efficient method of steam explosion (STEX) that produces high-quality hemp fiber has been developed in Europe. STEX enables the production of custom-made fibers that meet special requirements for singular products. The parameters of the process can be steered to optimize the objective qualities of the resultant fibers. It is possible to produce yarns of Nm 10-15 fineness (the running length of thread per gram of yarn weight) without making any special modifications of the process. Even after cottonization, steam-treated hemp has a value of about 60 cN/tex (cotton has a value of about 35 cN/tex).

Cleaned fibers (70 mm) are pre-treated with alkali and introduced to a reaction vessel. High-pressure steam (up to 12 bar, 175 psi) is injected to penetrate between the bast fibers and dissolve the lignin, pectin, etc., for 30 minutes or less. The pressure is released suddenly to explode the fiber bundles without causing disintegration of single cells. The additives and other substrate ingredients are blown out and collected for extraction and recycling. The resultant fibers are washed, rinsed, and dried with hot air. Then the fibers are opened with a saw-tooth opener and any remaining dust or wood is removed with a multi-stage cleaner. Lesser amounts of dyes and other chemicals are required for further processing because the STEX process produces very high purity fibers.

The Xymax Corporation has perfected a patented process using steam explosion to reduce plant material to cellulose, hemicellulose, and lignin. The "Xylanizer" produces "cottonized" or flock hemp that can be refined by existing cotton/wool-processing equipment. It also produces "BondoMass", an inexpensive plastic-like wood which is stronger and more flexible than lumber. Xylanized cellulose also produces twice as much ethanol as fermentation processes, and the residue can be made into paper pulp at a lower cost than from wood. The only byproduct is steam. **(13)**

Ecco Gleittechnic Gmbh (Germany) has demonstrated a novel ultrasonic breakdown method and apparatus to remove dirt, lignin, and pectin from hemp straw. The resultant fiber is of high purity and consistency, "a completely new type of natural fiber" possessed of "extremely high and fast water absorption, and a high degree of whiteness [70]." Only 1% hydrogen peroxide is necessary to reach 90 degrees of whiteness. The process replaces the retting process and mechanical decortication, and it excludes the degradation of cellulose caused by chemical treatments. The lignin and pectin can be recovered for other uses, such as binders for particle boards.

Alcell Technologies, a division of Repap, has experimented with pulping whole hemp stalks. Separating the longer fibers before processing them is too expensive. Alcell's technology fractionizes the fibers in a Thermo-Mechanical Pulping (TMP) process to produce both newsprint and high-quality wood paper from a single source of fiber.

Hurds are useful as papermaking material, but they contain more lignin than the bark. Therefore, hemp bark is more valuable than hurds for papermaking. The lignin must be removed in the papermaking process. Delignification generally is done with chlorine, which is the major source of pollution from pulp mills. Digestion with sodium hydroxide at about 170^{o} C also promotes delignification. Hydrogen peroxide provides a superior alternative, producing high quality pulp with minimal pollution.

novel chemi-mechanical hemp pulping technology developed by the Dutch ATO-DLO allows fiber length to be adjusted, and eliminates the need for a hollander beater. The process uses a twin-screw extrusion pulping machine that combines shear forces and small amounts of alkali and catalyst to remove only about 50% of the lignin. Thus, hemp paper can be manufactured at a lower cost than from wood. **(14)**

The closed-cycle Alcohol-Ammonia-Sulfite (AAS) pulping process makes possible the production of hemp pulp without pollution. AAS pulping can use the woody core to produce long bast fibers with very low levels of lignin, and it does not require that the bast fiber and woody shives be separated beforehand. The selectivity and "soft" conditions of AAS-pulping enable bast fiber pulping to be separated into low-lignin long fibers and high-lignin short fibers. The AAS-pulping process produces hurd pulp equal in quality and superior in yield to wood kraft pulp, and it is about 15% brighter. Its breaking length also is very high.

The AAS process uses aqueous ethyl or methyl alcohol (water 65:35 alcohol vol %) as a solvent, but polyols (glycerine, diethylene glycol, etc.) or cellosolves (ethylene glycol monoethyl ether, etc.) can be used, though they are more costly. The process cooks the shives with ammonia-sulfite (1:0.2-2.5 % by weight) in aqueous alcohol at 150-185^{o} C for 75-180 minutes. The liquor to shive ratio is from 4-4.5:1 The ammonia consumption is 5-25% of the weight of raw material. The alcohol, water, and by-products (alcohol, acetone, ethyl acetate, etc.), can be recovered for recycling. The yield varies from about 55-68%.

Table 3.3 ~ Colorimetric Identification of Hemp Fiber

Reagent	*Colo*r
Iodine-Sulfuric Acid	Blue-green
Zinc cholor-iodide	Blue/violet, trace of ellow
Calcium chlor-iodide	Rose-red
Aniline sulfate	Yellow-green
Ammoniacal Fuchsin	Pale red
Ammoniacal Copper Iodide	Blue/Blue-green
Ammonia	Faint violet

A wide range of lignin content has been reported for hemp, from a low of 4-8% to a maximum of 30%. The dry weight of male hemp is 13-16% lignin; females contain 23-25%. As many as 4 chlorinations are necessary to delignify hemp cellulose. If the residual lignin exceeds 0.8%, the fiber is brown and hard to handle. In comparison, straw contains about 15% lignin, sugarcane bagasse about 20% lignin, bamboo is about 23% lignin, jute is 11% lignin, and retted flax is 2% lignin.**(15, 16)**

When viewed under a polarization microscope, interference colors appear in the orthogonal position, which are different for flax and hemp.

A typical analysis of hemp fiber gives: Ash (0.8%), hygroscopic water (8-9%), aqueous extract (3.5%), fat and wax (0.%), cellulose (78%), lignins and pectins (9.5%). The woody core contains about 7.7% glucan, 6.7% xylan, 1.2% mannan, and 2.1% lignin. The bast fibers contain about 6.7% glucan, 1.5% xylan, 1.9% mannan, and 4% lignin.

3.5 ~ Hemp Paper Manufacture

Most of the few hemp pulp paper mills each produce about 5 kilotons/year of specialty papers for cigarettes, filters, insulation, security and art. Hemp paper is superior to pulp in most respects, but the paper industry is not equipped to handle hemp pulp, and the cultivation of hemp is not yet extensive enough to supply the market.

The pulp and paper industry also does not use hemp hurds for several technical reasons. Hurds are relatively difficult to delignify. Unbleached hurd pulp produced by conventional processes gives lower yields and has higher Kappa numbers than hardwood pulp. The fiber length of hurd pulp is only half as long as hardwood pulp. Hurd pulp has an extremely low rate of drainage and low mechanical and papermaking properties when prepared by conventional methods. These factors are of little importance when AAS pulping is used.

The production of paper from hemp hurds is a relatively simple process. The hurds must be sorted or screened according to size so as to ensure uniform quality of the finished fibers. Smaller pieces are reduced sooner than large hurds by the caustic cooking process, and the over-treated hurds result in a lower yield of cellulose fiber, and a mixture of over- and under-treated fibers. The hurds must be sieved to remove dirt before cooking.

Such preparations are unnecessary if the Schlichten decorticator, AAS pulping, or steam explosion is employed. Edward Chase pointed out the advantages of Schlichten's mechanically decorticated hurds in his report to Howard Scripps:

"On page 22 of [USDA] *Bulletin* #404, paragraph 2, you will note:

"The weight of hurds which are capable of being charged into a rotary (digester) is a decidedly unfavorable factor.

"(This in comparison with the weight of a cubic foot of wood as now charged into the digesters at the paper mills.) This would not be the case with the hurds from the Schlichten machine... Dry hurds in hydraulically pressed bales would weigh about as much per cubic foot as wood.

"You will also note that the bales of hurds from the retted hemp must be covered, which would not be the case with the Schlichten hurds. Also, hurds from retted hemp must be screened or sorted, and the various sizes treated separately and differently. None of this work is necessary with the Schlichten hurds..."

The following excerpts from a "Digest of Conversation of Mr. G.W. Schlichten with Mr. M.A. McRae..." (3 August 1917), illustrate the enormous potential of hemp hurds for purposes of paper production:

"In speaking about the rise in price of paper, etc., Mr. Schlichten said ...

"I came in contact with Mr. Merrill [sic] of the Paper Plant Investigation Bureau of the Agriculture Department; he is the head of it... I gave to Merrill some hurds... The hemp hurds is a practical success and will make paper of a higher grade than ordinary news stock. The Government has made on a large and practical scale paper --- a beautiful sheet --- and I can show you governmental reports printed on paper made from hemp hurds... This paper has been made from hurds produced from the fermented [retted] hemp... but I produce from the unfermented stock, and therefore the inner part is more valuable for paper stock because it has a certain amount of natural glue contained in it, which acts in the cooking as a natural binder for the fiber...

"In the cooking and beating of these hurds, less caustic soda, resin, and ... clay will be needed than when ground wood is used;

"Sulphite must be mixed with ground wood pulp, but not with [hurd] pulp...

The USDA report by Merrill states:

"This comparison, satisfactory in many respects, develops two factors which are decidedly unfavorable to hemp hurds, namely, raw-material storage and digester capacity, and they must be taken into full account in considering the paper-making value of this material... Material progress was being made at the conclusion of this preliminary work...

"Calculations on the raw product and acreage for a permanent supply for a pulp mill producing 25 tons of fiber a day for 300 days per annum, or 7,500 tons per annum, give the comparison between hurds and wood..."

[Table 3.4]
Comparison of Wood & Hemp Hurds

[Table 1.1]
Comparison of Wood and Hemp Hurds

Material	Pulp Yield	Raw Material/Yr.	Annual Growth/Acre	Acres for Sustained Supply of: 25-ton Mill	1 ton fiber/Yr.
Wood	2 cords yield 1 ton of fiber	15,000 cords	0.37 cord (0.55 ton)	40,500 acres	5.4 acres
Hurds	1 ton yields 600 lb. fiber	25,000 tons	2.5 tons	10,000 acres	1.33 acres

The most important point derived from this calculation is in regard to areas required for a sustained supply, which are in the ratio of 4 to 1. Every tract of 10,000 acres which is devoted to hemp raising year by year is equivalent to a sustained pulp-producing capacity of 40,500 acres of average pulp-wood lands. In other words, in order to secure additional raw material for the production of 25 tons of fiber per day there exists the possibility of utilizing the agricultural waste already produced on 10,000 acres of hemp lands instead of securing, holding, reforesting, and protecting 40,500 acres of pulp-wood land." (17)

Paper is manufactured by "cooking", the process by which fibrous raw matrials are reduced to cellulose pulp by chemical treatment with alkali. The most satisfactory results are obtained with sufficient caustic solution (29.5% sodium hydroxide at a concentration of 107 gr/liter having 84% causticity) to supply 25-30% actual NaOH (calculated from the dry weight of hurds in the charge). Merrill used a larger amount of caustic than was necessary in his experiments because his steam supply was problematic. The batches were contained in a rotary charger at 1/2 rpm. After 5 minutes, steam (120 psi) was admitted at such a rate that the charge was heated to 170^{o} C in 1 hour. The heating was continued 5 hours, then the steam pressure was released, and the stock was emptied into a tank to be drained and washed.

The cooked stock, brown in color, was washed for 1 hour in a cylinder covered with 60-mesh wire cloth so as to remove dirt and chemical residues. The water was drained off, the stock was steam-heated to 40^{o} C, and a solution of 11.3% chlorine bleaching solution and 1/2 pint of sulfuric acid was added, equivalent to 10% of the weight of the fiber. The mixture was bleached overnight, then drained and washed. If the color was not sufficiently white, more bleach was added, and the process was repeated.

The best results in the process of furnishing in a beating engine was obtained with a charge of 16.5% sulphite, 22.3% soda poplar, and 61.2% hurd stock loaded with 22% clay and 1.38% resin size. The furnish was given a hard brush for 1 hour and given a blue tint before it was run on a papermaking machine with no problems whatsoever. Merrill commented that, "Experienced paper-makers commented very favorably on the running of this furnish and the quality of the paper produced," which was classed as a No. 1 machine-finished printing paper. The USDA *Bulletin* No. 404 was printed on the hempen paper they produced. The bulletin then continues with a proviso:

"The weight of a cubic foot of hurds is about 5.4 lb compared to 8.9 lb/cu ft for poplar-chips charge. This represents a cooking charge of 60% of the weight of a poplar-chips charge, yielding about 38% as much fiber as a wood charge. The smaller weight of a hurd charge constitutes one of the main objections to the use of hemp hurds in paper manufacturing, but the weight of the charge can be increased by steaming or tamping. The relatively high cost of hemp fiber pulp is due to the inefficient processes currently used to produce pulp. In addition, hemp is harvested once a year --- usually in August --- and it needs to be stored until used at the mill, resulting in higher costs."

Cooking of hemp fibers with water gives a product which can be used for Kraft paper. Digestion with sodium hydroxide gives a pulp containing as much as 20% pentosans. The Ritter-Kellner method is more suitable: the fiber is cooked at 140-150^{o} for 12-13 hours with 4% sulphite liquor to produce pulp containing about 64% crude cellulose of which 10% is pentosans**(18)**

As explained above, hemp fiber is not entirely practical for paper-making when it is subjected to soda and sodium anthraquinone pulpings. Furthermore, the bast and woody fibers of hemp are so different from each other that it is impractical to pulp them together. The qualities of hemp fiber are different from other pulp materials; it requires special beating and refining processing and equipment. The process is much less efficient when conventional papermaking machinery is modified for hemp pulp. For example, it is not worthwhile to use a disk refiner, whereas low-speed hollanders are suitable. It is also characteristic of hemp pulp that the "freeness" increases during the papermaking process. It must be watched closely to prevent over-beating.

Hollander beaters impair the drainage properties of hemp pulp to such extent that the paper-making machine must be run at a slower speed in order to dewater properly. Thermo-Mechanical Pulping (TMP) eliminates the need for hollander beater. TMP employs mechanical shear forces combined with small amounts of alkali and catalysts.Wade Chute, Senior Research Engineer of Agrifibres at the Alberta Research Council, made a comparative study of the properties of mechanical pulps made from hemp bast fiber and whole-stalk mechanical pulps. Significant problems were encountered with fiber tangling and plugging of the refiner inlet. The primary processing procedure was therefore made particularly aggressive to prevent recurrence of the problem, but this manner of processing caused excessive damage to the fibers, resulting in significantly lower quality results than were expected. Chute found that whole-stalk mechanical pulps are weaker than bast fiber pulps, resulting in lower tear strength because short hurd fibers are present. More refining energy is required to process whole stalk hemp pulps, compared to bast fiber pulps.

The French BiVis process, developed in 1975, uses a twin-screw extruder to cut the long bast fibers to a length that conventional papermakers can handle without adversely affecting the drainage. The BiVis rocess has been adapted to handle hemp fiber efficiently with an overall yield of 75-80% w/w (compared to about 50% efficiency for chemical pulping). The process uses hydrogen peroxide (40 kg/ton) and alkali (50 kg/ton) to produce chlorine-free paper with 82 point brightness. Water consumption is 12 m^3/ton, and most of the waste is biologically degradable.

US Patent #982,170 describes an electrified preparation of hemp for the manufacture of paper:

"Hemp is cut into small pieces, then boiled in 0.5-8% sulfuric acid. Immerse the hemp in a solution of Na_2CO_3 and NaCl, and subject it to the action of an electric current."

US Patent #2,099,400 describes "An improved method of producing bleached pulp from hemp tow (hurds)":

"[Subject] the tow to a cooking operation in a digester with a solution of water of approximately 2-1/2 to 4 times the dry weight of the fiber, and 14% to 20% sodium hydroxide and 1% to 4% sulfur, the quantitites of the chemicals employed in the solution being based on the dry weight of tow; then wash the cooked fiber to remove shive fiber and water soluble impurities, and bleach the fiber."

Sadly, the mass-production of hemp paper probably will not become established as a major industry until the insatiable demand for wood has utterly decimated the forests of the world (circa 2020 AD) and there is no other alternative.

A "Market Analysis for Hemp Fiber as a Feed Stock for Papermaking" was suppressed by the Justice Department in 1997 after an anonymous chemical engineer, employed by a public institution in Wisconsin, released the paper. A bootleg copy was obtained and published "in the name of academic freedom" in *Hemp Magazine* (May 1998), excerpted here:

"The value of bast fibers as a component in paper pulp is widely acknowledged. An analysis of the bast fibers shows that they are composed of 70% cellulose and 8% lignin. Given that this material is chemically quite different than the hurds, it likely would have to be processed separately, but would likely have a 70% yield to fiber. If one does a weighted average of 50% yield for the hurds and 70% for the bast fibers, one obtains a value of 55% fiber yield from retted hemp stalks: (0.25)(70%) + (0.75)(50%) = 55%...

"Making assumptions about hemp yield per acre (3.9 tons/acre/year) and the pulp yield per ton of retted hemp (55%), one can estimate the number of acres of hemp required per year to meet the current Wisconsin demand:

(3,178 tons pulp/day (360 days/yr) = 533,000 acres (3.9 tons hemp/acre/yr)(0.55 tons pulp/tons/hemp).

"The price of bleached pulp varies widely, $300 to $1000/ton, due to fluctuations in supply and demand. Give this wide variation estimating the value of hemp fiber is rather difficult. It is likely that fiber formed from the hurds will be viewed as similar to hardwood fiber. The current price of bleach pulp is near $425/ton. The production costs will be similar to the production cost of fiber from wood. In fact, an implicit assumption of the following analysis is that only minor modifications to a pulp mill would be required to switch from wood to hemp. A recent analysis of the pulp making process suggests that the raw material, chemical and energy costs for pulping and bleaching wood chips is $233/ton of ECF bleached pulp. Of this cost, $155 was the cost of the wood chips, assuming wood chips cost $55/ton. If one includes a 50% increase in the cost/ton to account for labor, overhead and capital, one finds that the break even point is likely near $350/ton. If one assumes that the average yield from the hemp fibers would be 55%, then a direct replacement for wood chips would suggest a value of $75/ton for the retted hemp stalks. This price is based on numbers that were generated in 1993. If one uses the chemical price index to adjust this to 1997 one gets a value of $85/ton... A more realistic future value is likely $100-125.

"It is likely that the bast fibers would be reviewed as a higher value material on the pulp market. If, for example, one were able to produce fibers similar to cotton linters or cotton rags, then the market would likely offer $1000/ton of fiber. To translate this value to a price of the raw materials one must make several assumptions. If one assumes that the processing costs are the same as that for wood, $195/ton, that the yield to fiber is 70%, and that the required profit margin is $100/ton processed, the paper company could pay $500/ton for the bast fibers: ($1000-$295)/1.43 tons hemp/ton fiber = $493/ton hemp.

"If one uses a value of $100/ton for hurds and $500/ton for bast fibers, the estimated market value of retted hemp stalks is $200/ton. A study of hemp cultivation in Iowa suggested an average yield of 3.9 tons/acre. Combining the market price and the yield per acre one obtains a crop value of $780/acre. Since the production, storage and transportation costs will be similar to those of corn, $300/acre, a farmer could make a profit of $480/acre growing hemp. If the farmer were to only market the fiber, however, the profit drops to $190/acre...

"The profitability, for the farmer, hinges on the separation of the bast fibers from the hurds and the selling of the bast fibers at a higher price. For the purpose of this analysis, it was assumed that the paper industry would use the bast fibers, but it is also likely that other markets, e.g., textiles and building materials, could be found for them. Furthermore, one must develop markets for both the hurds and the bast fibers, if this enterprise is to be viable."

Table 3.1 ~ Traditional Hemp Processing

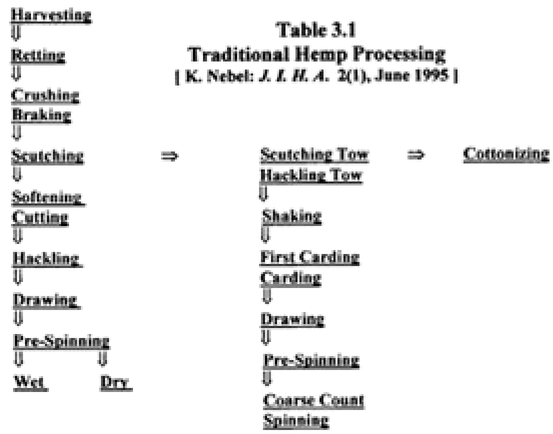


Table 3.2 ~ Typical Breakdown of Green & Dry Hemp

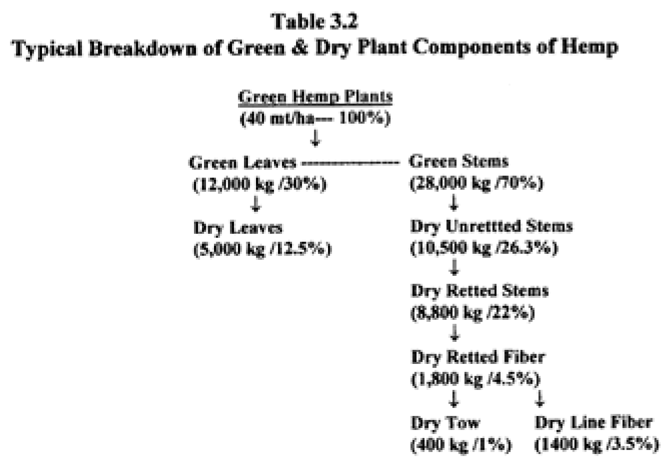
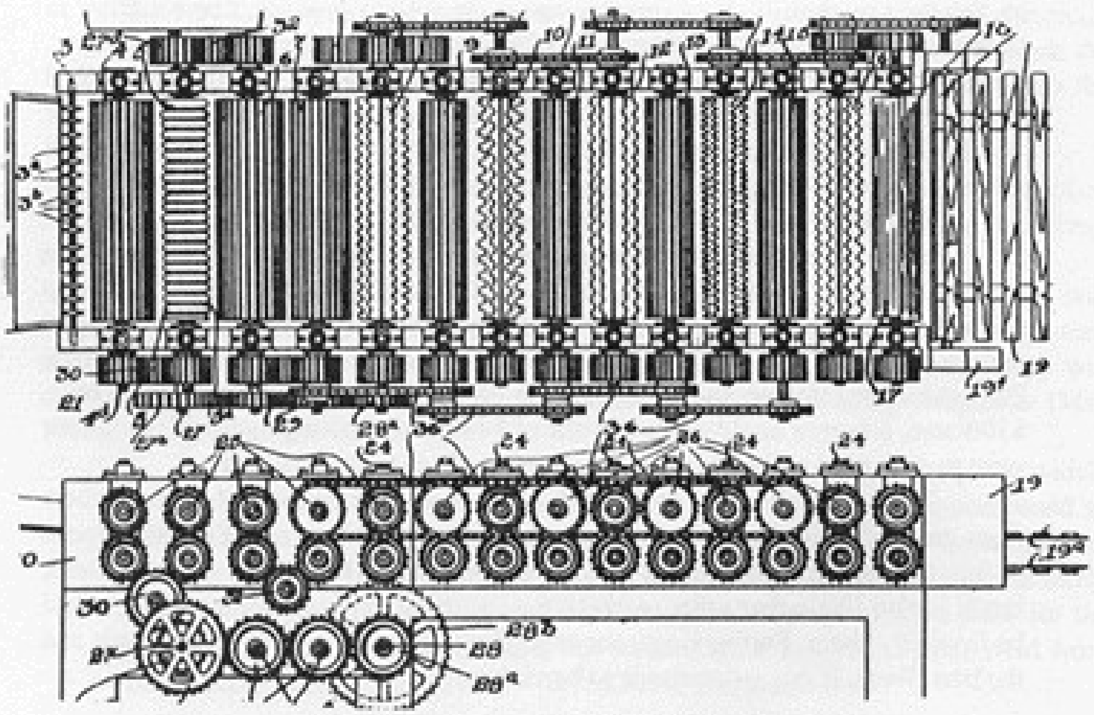


Figure 3.1 ~ The Schlichten Decorticator (USP # 1.308,376)

Figure 3.1
The Schlichten Decorticator
US Patent #1,308,376



4.1 ~ Classification

Class: *Angiospermae*
Subclass: *Dicotyledonae*
Superorder: *Dilleniidae*
Order: *Urticales*
Family: *Cannabinaceae*
Genus: *Cannabis*
Species: *sativa, indica*
Subspecies: *sativa*
Varieties: ruderalis, vulgaris, spontanea, gigantea, chinensis, etc.**(1-4)**

4.2 ~ Botanical Description

USDA botanist Lyster H. Dewey published this official "Botanical Study of Hemp" in 1913:

"THE PLANT --- The hemp plant, Cannabis sativa L., is an annual, growing each year from the seed. It has a rigid, herbaceous stalk, attaining a height of 1 to 5 meters (3 to 16 ft), obtusely 4-cornered, more or less fluted or channeled, and with well-marked nodes at intervals of 10 to 50 cm (4 to 20 in). When not crowded it has numerous spreading branches, and the central stalk attains a thickness of 3 to 6 cm (1 to 2 in), with a rough bark near the base. If crowded, as when sown broadcast for fiber, the fluted stems are without branches or foliage except at the top or on the shortened branches, appearing fascicled, are palmately compound and composed of 5 to 11 --- usually 7 --- leaflets. The leaflets are dark green, lighter below, lanceolate, pointed at both ends, serrate, 5 to 15 cm (2 to 6 in) long, and 1 to 2 cm (3/8 to 3/4 in) wide. Hemp is dioecious, the staminate or pollen-bearing flowers and the pistillate or seed-producing flowers being borne on separate plants. The staminate plants are borne in small axillary panicles, and consists of five greenish yellow or purplish sepals opening wide at maturity and disclosing five stamens which discharge abundant yellow pollen. The pistillate flowers are stemless and solitary in the axils of the small leaves near the ends of the branches, often crowded so as to appear like a thin spike. The pistillate flower is inconspicuous, consisting of a thin, entire, green calyx, pointed, with a slit at one side, but remaining nearly closed over the ovary and merely permitting the two small stigmas to protrude at the apex. The ovary is one seeded, developing into a smooth, compressed or nearly spherical achene (the "seed"), 2.5 to 4 mm (1/10 to 3/16 in) thick and 3 to 6 mm (1/8 to 1/4 in) long, from dark gray to light brown in color and mottled, The seeds cleaned for market nearly always include some still covered with green, gummy calyx. The seeds vary in weight from 0.008 to 0.027 gram, the dark-colored seeds being generally much heavier than the light-colored seeds of the same sample. The light-colored seeds are often imperfectly developed. Dark-colored and distinctly mottled seeds are generally preferred.

"The staminate plants are often called the flowering hemp, since the pistillate flowers are rarely observed. The staminate plants die after the pollen is shed, but the pistillate plants remain alive and green two months later, or until the seeds fully developed.

"THE STALK --- The hemp stalk is hollow, and in the best fiber-producing types the hollow space occupies at least one-half the diameter. The hollow space is widest, or the surrounding shell thinnest, about midway between the base and the top of the plant. The woody shell is thickened at each node, dividing the hollow space into a series of partly separated compartments. If the stalk is cut crosswise a layer of pith, or thin-walled tissue, is found next to the hollow center, and outside of this a layer of wood composed of hard, thick-walled cells. This layer, which forms the "hurds", is a very thin shell in the best fiber-producing varieties. It extends clear across the stem below the lowest node, and in large, coarse stalks grown in the open it is much thicker and the central hollow relatively smaller. Outside of the hard woody portion is the soft cambium, or growing tissue, the cells of which develop into the wood on the inside, or into the bast and the bark on the outside. It is chiefly through this cambium layer that the fiber-bearing bast splits away from the wood in the processes of retting and breaking. Outside of this cambium is the inner bark, or bast, comprising short, thin-walled cells filled with chlorophyll, giving it a green color, and long thick-walled cells, making the bast fibers. These bast fibers are of two kinds, the smaller ones (secondary bast fibers) toward the inner portion making up rather short, fine fibers, many of which adhere to the wood or hurds when the hemp is broken, and the coarser ones (primary bast fibers) toward the outer part, extending nearly throughout the length of the stalk. Outside of the primary bast fiber is a continuation of the thin-walled stalk, chlorophyll-bearing cells free from fiber, and surrounding all is the thin bark.

"THE FIBER --- The hemp fiber of commerce is composed of the primary bast fibers, with some adherent bark and also some secondary bast fiber. The bast fibers consist of numerous long, overlapping, thick-walled cells with long, tapering ends. The individual cells, almost too small to be seen by the unaided eye, are 0.015 to 0.05 mm (3/1000 to 12/1000 in) in diameter, and 5 to 55 mm (3/6 to 2-1/8 in) long. Some of the bast fibers extend through the length of the stalk, but some are branched, and some terminate at each node. They are weakest at the nodes." **(5)**

4.3 ~ Trichromes

Most of the aerial parts of cannabis, especially the female bracts, possess minute hairs, or trichromes, some of which excrete glistening drops of resin, so the flowers seem to shine with sticky amber dew which has a characteristic minty odor. It is thought that cannabis produces its resin as a protective measure against ultraviolet radiation, insects or water loss. Three types of trichromes occur on cannabis:

1) Bulbous and cappitate (sessile and stalked), resin-producing, glandular hairs on the flowers, leaves and stems;

2) Non-glandular hairs having no apparent function; 3) Crystoliths which resemble the non-glandular hairs, but are shorter and contain deposits of calcium carbonate. **(6-8)**

4.4 ~ Phenotypes

The expression of a trait in a plant strain is termed a phenotype. The interactions of genetic potential (genotypes) and environmental conditions (ecotypes) produce unique phenotypes. The phenotype system of distinguishing varieties reconciles many of the arguments about the species of hemp, all of which can be allocated to phenotypic groups. The phenotype system is based on the analysis of the relative amounts of cannabinoids: Tetrahydrocannabinol (THC), Cannabinol (CBN), and Cannabidiol (CBD). **(9-13)**

The Phenotype Ratio (PR) is calculated thus:

$$PR = \frac{\%\ THC\ \&\ CBN}{\%\ CBD}$$

Phenotype I: The resin is composed primarily of THC. The fresh, manicured flowers contain more than 0.3% THC, and less than 0.5% CBD. Both the male and female plants produce large amounts of the resin. Phenotype-I plants usually originate from countries south of Latitude 30^{o} N, where the tropical climate allows a long growing season. Often it is called Cannabis indica, the variety cultivated primarily for drug use.

Phenotype II: The resin contains approximately equal amounts of THC and CBD. This group is not sharply distinguished from P-III, but P-II plants usually contain more THC than do P-IIIs, and the females are more potent than the males. P-II hemp usually originates from countries north of Lat. 30^{o} N, and it flowers early in the summer since it is adapted to temperate climes. P-II may represent hybridization between P-I and P-III.

Phenotype III: The resin contains primarily CBD (more than 0.5%) and less than 0.3% THC. The female produces more cannabinoids than does the male plant. P-III hemp usually originates north of Lat. 30^{o} N, and is known as Cannabis sativa, cultivated primarily for fiber and seeds.

Phenotype IV: The resin may contain large amounts of THC, and traces of Cannabigerol Monomethyl Ether (CBGM) and Cannabiverol (CBV). P-IV hemp originates in northeast Asia, and usually is known as Cannabis ruderalis.

The phenotypes rich in THC always possess Cannabichromene (CBC), sometimes in large amounts. Phenotypes rich in CBD also contain CBC.

4.5 ~ Genetics

Cannabis has a haploid number of 1n=10; its somatic number is 2n=20. Some researchers have counted 2n=18 + (XX) or (YY). In the male plants, 9 pairs of the normal genomic pairs of chromosomes are equal in size, and the tenth pair (XY) consists of one chromosome about the same size as the members of the other pairs, plus one much larger sex chromosome. Heteromorphic pairs of chromosomes have been observed in monoecious strains of cannabis. **(14, 15)**

K. Hirata concluded that (x) has a higher male tendency than (X), and that (y) has a higher female tendency than (Y). The (X) has a net female tendency, and (Y) has a net male tendency. The male tendency in (Y) overbalances the female tendency in (X) so that a heterogeneous (XY) male is normally male, and a (XX) plant is normally female. Female hemp genes are (XX), (XXX), and (XXXX). The (XXXY) and (XXY) individuals are female or female intersexes. The males are (XY), (XYY), and (XXYY).

S. Hennick, *et al*., and others assert that this classification is impractical for purposes of breeding hemp, and have developed a new classification based on the theories of Grishko, Neuer, and Migal. The sex of dioecious hemp is determined by two tightly linked genes, both with two alleles. The Y chromosome carries the male allele M and the allele *l*, which expresses loose inflorescence. The X chromosome carries the female allele F and the allele *i* (compact inflorescence). Alleles M and *l* dominate over F and *i*. A recessive third allele, with a frequency from 0.5-1%, probably exists for monoecious hemp. The sex type of monoecious hemp is determined by autosomes. The sex chromosomes of diploid cannabis carry the genotype *li*MF and *ii*FF. The theory, however, does not explain how the loose or compact types of inflorescence are determined in monoecious hemp.**(16)**

N.D. Migal (All-Union Res. Inst. Fiber Crops, Glukhov) studied the genotypical determination of the sex of hemp. They summarized their finding as follows:

"Monoecious and dioecious hemp plants differ from one another in many phenotypical characters. As a result, a great variety of sex types is formed, which, in some way, complicates their classification...

"While studying spontaneous sexual mutations of dioecious and monoecious hemp, some peculiarities of interaction of genetic factors of sex chromosomes and autosomes were found out. They were used in further development of the theory of genotypical sex determination in this plant... The polyfunctional nature of sex determinations connected with monoecious hemp are conditioned by interactions of gene alleles of sexual chromosomes and genetical sexual factor in autosomes of different valency...

"Chromosomal mechanism of sex determination in dioecious hemp plants does not often correspond to expected correlation of the sex types 1:1. This fact, in some way, connected with sex gene mutation in sexual chromosomes and their interaction with autosomal factors." **(17, 18)**

Table 4.1 ~ Cannabis Genotypes

Table 4.1
Cannabis Genotypes

Cannabis	Diploid Chromosomes	Haploid Chromosomes
Super-male	18+Y+Y	9+Y, 9+Y
	18+y+Y	9+y, 9+Y
	18+x+y	9+x, 9+Y
Male	18+X+Y	9+X, 9+Y
	18+x+y	9+x, 9+y
Male Intersex	18+y+y	9+y, 9+y
	18+X+y	9+X, 9+y
Female Intersex	18+x+X	9+x, 9+X
	18+x+x	9+x, 9+x
Female	18+X+X	9+X, 9+X

The Sengbusch Classification system defines five degrees of monoecious forms: (1) 80-90% male flowers; (2) 60-70% male flowers; (3) 40-50% male flowers; (4) 10-30% male flowers; (5) less than 10% male flowers. The second and third degrees types are considered ideal for monoecious cultivation.

The methods developed by R. von Sengbusch and H. Neuer (1943) are the foundation of the breeding technology for monoecious hemp:

"Several trial fields were established in an effort to breed monoecious hemp in a region where no hemp is cultivated. In these fields the progeny of four strains which contain a great number of monoecious plants are cultivated. One field was devoted to plants with many male flowers and only a few female flowers; the second field, to plants with an equal number of male and female flowers.

"Investigation of the distribution of the different types of intersexuality among the progeny of these plants showed that among the progeny of the plants from the first trial field there was an increased number of plants with few female and many male flowers, while in the second field the number of plants with equal number of male and female flowers was increased. This would seem to indicate that selection for different types of intersexuality is possible. While the number of pure male plants in the first year was 10-20%, after repetition of this selection, the number of males decreased to 0.8%, indicating that the male plants have arisen by pollination with pollen of a normal dioecious plant. This result shows that it is necessary to breed and to augment the monoecious hemp in a region where no dioecious hemp varieties are cultivated.

"In the trial field II the number of normal female plants was somewhat increased (11.9%), while in the trial plot I a large number of pure male flowering plants with a female habit (25.5%) appeared, demonstrating that it is impossible to breed from plants with few female and many male flowers a non-segregating variety, and that therefore it is necessary to eliminate these plants in the breeding field before blossoming.

"Trial plot I included, besides the monoecious plants, female plants of a dioecious variety. In the trial plot II there appeared, besides the monoecious plants with the same number of male and female flowers, dioecious plants which practically were females and had only a few male flowers; female plants which arose from monoecious plants, and normal females from a dioecious variety. The progeny from the crosses between these different types were analyzed. The cross of normal females with dioecious plants yielded female plants almost exclusively. This shows that the monoecious plants have the genetic constitution xx, and that dioeciousness is dominant over monoeciousness. This dominance, however, is incomplete; in crosses between pure monoecious plants a small number of female plants arose. The monoecious plants with a very small number of male flowers in crosses with monoecious plants with an equal number of male and female flowers gave about 80% monoecious plants and only

17% female plants. The plants with the same number of female and of male flowers gave, in crosses with the same type of dioecious plants, a small percentage of females, a large percentage of monoecious plants, and a very few male flowering plants. The monoecious plants with a great number of male and a small number of female plants, crossed with the same type of monoecious plants, gave practically no female plants in their progeny, but the greatest number of male flowering plants with female habit. Because these male flowering plants with a female habit have arisen from crosses between two monoecious plants, they must also be xx plants.

"The investigation of descendants of single plants shows great variability in their composition as to sexual types; similar differences could be found between the different strains. The authors explain these observations by the hypothesis that the series of monoecious plants, beginning with the pure female and finishing with male flowering plants with female habit, involve a series of alleles of sex-realisators. The pure female plant xx has the sex-realizator F_{50} (XX $F_{50}F_{50}$). The sum is 100 and effects a complete suppression of male flowers. With decrease of the realisator sum the male character of the infloresence increases.

"The male flowering plants with female habit (XX F_{25} F_{25}) have the same sum as the normal male plants (XY F_{50}f)=50. The greater realisator value is almost wholly dominant over the smaller. This explains why in crosses between female and monoecious plants only female plants arise in the F_1. The incomplete dominance of the greater realisator value also explains why in crosses between monoecious plants 5-15% female plants always arise. The number of monoecious plants with equal number of male and female flowers which produce monoecious plants is very different among single strains. For breeding therefore it is necesssary to select strains which produce a great number of 'ideal' monoecious plants.

"Two methods for this selection are described. In one the seeds are ascertained in the trial field and in the next year only these strains are cultivated together, and only the seeds from these plants are used. The other method produces results more rapidly. From all strains, those with the greatest number of 'ideal' monoecious plants are established and from these strains the ten best monoecious plants are selected. All other plants are eliminated and the selected plants are cut back. After this treatment the plants begin to sprout and flower again and produce seeds, all of which are derived from selected plants." **(35, 36)**

The research of W. Hoffmann cast doubt on the theory of realisator-genes:

"Several complimentary genes in the autosome influence the sexual habit of the plant. In the normal dioecious hemp the polymeric habit factors are also influenced by the XY mechanism, so that the male flowers are always combined with the male growth habit, and female flowers with the female growth habit. In the feminized and masculinized types this balance is disturbed and XY types with female growth habit and XX types with male growth habit arise. Because a continuous series exists of feminized forms with many to few male and female flowers and of masculinized forms with many to few female and and male flowers, it would seem that the genes for growth habit can also influence flower formation. The existence of different sex types in segregation proves that the genes for growth habit can also influence flower formation. The existence of different sex types in in segregation proves that the masculinization and the feminization genes are not alleles but independent genes. In the normal dioecious hemp plant, the XY mechanism assures the predominance of one factor over the others. In the intermediate forms of hemp the sum of the efficiency of the genes of the autosomes predominates so greatly that the XY mechanism is not decisive and on the lowest grade the growth habit, on further increase of the efficiency of these genes, also affects flower formation. On the assumption that both dominant and recessive genes are effective as masculinizing and feminizing genes, the large number of sexual and morphological segregates is readily explained."

4.6 ~ Polyploidy

Cannabis usually is a simple diploid plant, but polyploids having several sets of chromosomes can be produced by mutation. Polyploid cannabis usually is larger, produces more resin, and reproduces better than diploids. It is distinguishable by its darker, thicker foliage, and by microscopic analysis. Tetraploid monoecious hemp plants are selected by examination of the number and size of stomata, the number of epidermis and stoma cells, the size of pollen grains, and their number of pores. **(19)**

Polyploids are valuable for their genetic diversity, but they are unpredictable and usually are unstable in the first generation. They also tend to be sterile and must be propagated by clonal cuttings to be useful for subsequent breeding.

Studies by Warmke and Zhatov revealed that the normal sex ratio for diploids (2n) is nearly 1:1, but tetraploids (4n) form a new class (XXXY) and develop about 7.5 females:1 male, plus female-hermaphrodites. The XXXX is female; XXXY is female-hermaphroditic; XYYY is male-hermaphroditic, and YYYY is male. The XY determination of sex does not account, however, for the development of some monoecious strains. Seemingly, the sexual expression of hemp can be controlled by some other gene set(s) influencing different aspects of flowering. Environmental conditions also can overpower the genetic expression of Cannabis' gender, especially in the final stages of flower production. **(20-23)**

A. Zhatov (1979) reported these results of his research into hemp genetics:

"Change of ploidy... induced changes on some economically valuable characteristics and biological features. Tetraploid plants of dioecious hemp are characterized with sharply pronounced dioecism: plants with sexual deviations appear in the population of tetraploid hemp. Sex chromosomes of hemp on the tetraploid level play a paramount part in sex determination, but the process of determination is affected by autosomic genes...

"The viability of microspores of polyploid hemp is lower as compared with microspores of diploid hemp. During the storage, polyploid pollen loses the ability to produce pollen tubes of normal length. Selection of plants with the best regulated meiosis may raise the viability of polyploid microspores." **(24, 25)**

A. Zhatov, N. Migal, and other researchers have used gamma-irradiation of hempseed to mutate the subsequent plant. Presowing irradiation causes a drastic decrease in the survival rate of dioecious male plants and monoecious heterozygotic plants. Male sterility is manifested by empty pollen grains. The proportion of male plants in M_1 is reduced to about 14%, and the height of plants is reduced by almost 75%. The number of branches and seed yields are increased, and the fiber content is increased by 30%. **(26)**

W. Hoffman and E. Knapp treated hemp seeds with x-rays, with these results:

"With increased dosage, the damage to the plants increased, the number of survivors decreased, and the sex ratio changed in favor of the females... With increased dosage, an increasing number of divergent types arose, especially of monoecious plants, and of male-like females. With increased dosage of x-rays, an increased percentage of tendrilled plants was also found... It is possible by means of x-ray treatment to change the sexuality of hemp and to get the normal dioecious hemp to a constant monoecious strain."

When hemp pollen is treated with ultraviolet light for one hour, the seed obtained from the resulting plants produces twice as many females as males.

Colchicine--- Tetraploidy can be induced by the mutagenic alkaloid colchicine, which is found in the autumn crocus, (*colchicum autumnale*). Colchicine allows a cell to double its chromosomes, but prevents meiosis (the splitting of cells), thus forcing the cells to become polyploid. When applied to cannabis, colchicine produces tetraploid plants which tend to be taller, with greater stem diameter, seed and pollen size. The THC content can increase up to 250%.**(27)**

A. Zhatov, *et al*., reported these findings from their research:

"The greatest % of polyploid plants is obtained when hemp plants are treated with 0.5% colchicine solution for 2 hours in the phase of cotyledon leaves. The treatment with colchicine solution inhibits growth. This inhibition continues for 2.5-3 weeks, after which the surviving plants resume normal growth and development. The guard cells in the leaves and the pollen grains of tetraploid plants are larger and the number of pores on the pollen grains are greater. Tetraploid plants are taller and the diameter of their stems, seed size and weight of 1000 seeds are greater. The anatomical structure of the stems differs from the diploid plants in a greater amount of primary and secondary fiber. The pollen viability of the tetraploid plants is lower than that of diploid plants. Vegetation period in tetraploids continues 8-15 days longer than in control plants." **(28)**

Colchicine also can sprayed on the seeds while they are developing on the mother plant. The flowers of plants treated in this manner should not be smoked because the concentration of colchicine may be dangerously high. A third method is to soak seeds in the solution for 2 to 4 hours. Colchicine stimulates the development of the taproot at first, but this effect ceases within a week; then the seedlings go into shock. About 30% of the survivors will be polyploid.

Colchicine can be bought, or prepared by grinding 100 grams of colchicum seeds to powder and percolating with 2 volumes of ethanol and 1 volume of water. The solution contains approximately 4 milligrams of colchicine. Label the bottle and store it safely: colchicine is toxic. Always wear rubber gloves when handling colchicine.

4.7 ~ Breeding

The great American horticulturist Luther Burbank (1849-1926) bred cannabis and suggested that other plant developers make further explorations of its possibilities. He also described his technique for breeding giant hemp:

"The hemp plant... is cultivated in this country exclusively for the fiber, its seed being almost altogether neglected. Yet the seed of this plant is prized in other countries for its oil, and its neglect here illustrates the same principle of wasteful use of our agricultural resources...

"My experiments with the hemp... have grown out of a suggestion that I made a number of years ago to a large Boston paper manufacturer, to the effect that... hemp might be used as a substitute for wood pulp in the manufacture of paper.

"The experimental work is only at its beginnings, but it seems to be of considerable promise... The hemp, as is well known, is a dioecious plant, and it may be well to mention the simple but uncommon method of making crosses. All the varieties are first planted separately; and only a few of the largest and tallest male and female plants of each variety are left to bloom. When the heads blossom, the tallest of each variety obtained from different sources are crossed with pollen of the tallest male plants.

"After two seasons of this selection and crossing of different strains from different countries, the varieties were combined by crossing, as before, by selecting the largest and tallest plants, out of which a new race was produced of giant hemp...

"Paper made from the fiber of the hemp is found not generally used heretofore, and must certainly be more prized as other pulps become scarce.

"I mention this line of investigation here merely to suggest the wide range of opportunities what will open up for the plant developer when he has learned to cooperate with workers in other industries.

"Hitherto we have been prone to take it for granted that all the valuable textile plants have been investigated and perfected. The newer studies suggest that there is still almost boundless opportunity for progress, not only through the improvement of the plants that have been utilized, but also through the introduction of species that have been ignored or neglected." **(29)**

In an interview with the *Journal of the International Hemp Association* (October 1994), the eminent Prof. Dr. Ivan Bocsa (breeder of Kompolti hemp, which gives the highest yield of fiber in the world) explained that he has bred only dioecious and unisex hybrids because self-pollinated inbreeding of monoecious hemp produces about 20% lower stem yield than dioecious varieties:

"The natural state in which hemp appears was and is dioecious. Monoeciousness is artificial in hemp, and it can only exist with the help of man, and without selection, the dioecious state will return in two or three generations. It is therefore very hard and demanding to keep 90 to 95% monoeciousness during seed multiplications. Apart from that, however, monoecious hemp is appropriate only when the crop is grown for so-called double use, i.e., when both stem and seed are harvested... In a dioecious crop, the male plants will be strongly deteriorated when the crop is harvested at seed ripeness, so in this case one needs monoecious cultivars. In Hungary... this double use is unknown. Here fibre hemp is grown as a dense crop which is harvested at the time of male flowering ('green hemp'), while the seed production takes place in crops grown at a low plant density and with completely different growing techniques...

"Furthermore, monoeciousness has two large disadvantages. In the first place... we have established that 20-25% of self-pollination takes place in monoecious hemp, and this is the cause of... [10-20%] lower stem yield. In the second place, in monoecious hemp, the genetic progress for fibre content is slow, because the so-called Bredemann principle cannot be used. The Bredemann principle consists of the rapid determination of fibre content in male plants before they flower, so that only the males with the highest fibre content are allowed to pollinate the female plants... In monoecious hemp this approach cannot be used, so the rate of genetic progress is only 50% or less of that in dioecious hemp. In spite of these disadvantages, we use a monoecious hemp cultivar in breeding, but only as a parent for unisexual hemp.**" (30)**

The Bredemann Principle for the estimation of fiber content is practiced as follows:

"According to the recommended method, just before budding commences, the stalks of hundreds of male plants are vertically cut in half and the bark is stripped off. The stems are boiled for 3/4 hour in 1.5% NaOH solution, to soften the woody matter. The latter is removed mechanically, care being exercised to avoid loss of fiber. The fibrous mass is then boiled again with dilute NaOH solution, washed, dried and weighed. The woody matter may be weighed or detected by difference. As the resulting fibers are purified more than those of commerce, the weight of hemp so found should be multiplied by 1.25 before computing percentages." **(31)**

The testing must be performed within a narrow window of only a few days, because the plants will quickly proceed to the flowering stage. Only those males with a high fiber content are allowed to flower; the others are culled. The Bredemann method thus enables breeders to increase the fiber yield of dioecious hemp to 35% within a few generations.

The fiber content of stems is determined by sampling numerous plants from a zone situated between points 30-40% up the stem. In practice, find the middle of the stem and cut from that point downward 15%. After retting or mechanical decortication, the correlative standard of the fiber content is calculated from two weighings of the dry weight of the bark divided by the dry weight of the stem. **(32)**

The production index of bark fiber content makes it possible to calculate the amount of bark per unit of stem surface, and to discover which parents are productive of dry matter and rich in fiber. The index is derived from the ratio of dry weight of bark to the surface of stem (obtained from the product of height times the median diameter).

H. Neuer, R. von Sengbusch, and H. Prieger developed a rapid method of analysis to select plants for high yield of long fibers and seed:

"The stems are cut into 2 or 3 pieces, and 100 such pieces are put in special frames in which the stems of each individual plant are isolated. In these frames the stems are boiled in 0.25% NaOH for 30 minutes. The bast is removed and put in sieve-boxes which are shaken by machine for 1 hour in 2% NaOH with an addition of Persil. The individual fibers are isolated by the shaking and the perenchymous tissue is pulverized. After shaking, the fibers are washed, dried and weighed. The values so obtained are somewhat too high. For the selection of the different stem weights the fiber content classes are detected by investigating 10 plants. For each weight class the mean fiber content is ascertained and only those plants selected whose fiber content is above the mean of the corresponding weight class. Furthermore, the quantity of fibers is recorded in relation to the surface of the stem. A correlation table for fiber weight to surface of stem is made and all plants with high fiber content are examined with the aid of this second table to eliminate plants with low percentage of wood.

"In the course of the investigation this method was further developed. In order to find plants with many fibers, plants with high bast content must be selected: the stems are cooked for 30 minutes in 0.25% NaOH, and the bast is removed, washed, dried and weighed. The plants with high bast content are investigated as to fiber content to eliminate plants with high bast but low fiber content. The bast is cooked in 2% NaOH for 3 hours, washed, dried and weighed. By this method it is possible to investigate in the same time twice as many plants as by the first method.

"Comparative investigations with the different methods proved that generally high bast content corresponds to high fiber content, but that individual plants with high bast content may have few fibers. These two methods do not make it possible to investigate a very great number of plants; von Sengbusch therefore developed a microscopic method for the examination of the bast- and fiber-structure; stem cutting 3-4 cm long are put in water for 5 minutes until the bast is thoroughly soaked. The cutting then is intensively lighted, but the upper part is darkened. By this manner of illumination the parenchymous tissue remains dark, while the fiber cells show clearly. The stems are investigated by binocular microscope (50x). Plants with a thick bast layer containing many fibers are selected and investigated, by the previously described methods, as to bast- and fiber-content. Only the plants with the highest fiber content are propagated.

"For cross-pollinating hemp the breeding system is the same as that devised by Laube for rye: the seed of each selected plant is divided. In the first year, one half is sown as A-strains and tested as to quality. From the best A-strains, the remainder of the seed is sown the following years as A-strains. In the same way the B-strains are obtained and the strains with lower fiber content are eliminated. The B-strains are used for the production of material for new selection and for the production of super-elite, and elite plants and improved seed." **(33)**

Prof. Dr. Bocsa developed a unisex cultivar in the 1960s after hempseed for sowing became scarce:

"From the research conducted by McPhee, von Sengbusch and Hoffman we know that when a monoecious hemp plant pollinates a dioecious female the offspring (F1) consists of over 90% of females, or 3-5% of monoecious plants bearing mainly female flowers and only 3-4% of true males. This small number of males however is sufficient to ensure adequate pollination of the crop. As the stand consists mainly of seed-bearing (female and dioecious) plants, with the same habit, we called it unisexual hemp. Such a stand yields 60-80% more seeds than a dioecious cultivar. The seed produced on this stand (F2) is used as sowing seed for fibre production. We called this cultivar Uniko-B. It is, in fact, a 'single cross' between Kompolti and Fibromon, but it is the F2 generation which is commercialized. Von Sengbusch and Hoffman described the phenomenon, but they did not think of its practical use... we make the cross between Kompolti and Fibromon on a surface of 5 hectares; this yields 2500 kg of F1 seed. The F1 seed is sown on a surface of 500 hectares, yielding 400,000 kg of F2 seed, which is used to sow 3,000-3,500 hectares of fibre hemp.

"Unisexuality also can be used to exploit the effect of heterosis [hybrid vigor] which occurs when Chinese and European (Kompolti) cultivars are crossed. This heterosis can increase stem yield by 8-15%. to be able to cross two cultivars we have to construct a female parent which is 'male sterile'. A unisexual F1 can be used as such. In order to obtain a unisexual Chinese line we used Fibrimon as the donor, which was backcrossed many times until we obtained a monoecious line with a Chinese habit. We crossed this line with the original dioecious Chinese cultivar to obtain a unisexual Chinese F1... [with] an unsurpassed seed yield potential of up to 1,500-1,600 kg per hectare...

"In some of my cultivars, bark content is 38-40%; this corresponds to a bast fibre content of 32-34%. If the bark content is higher than 40% the crop may lodge...

"Fibre quality is negatively related to fibre content. As we continue to select for fibre content, we unwillingly increase the proportion of secondary fibre, which has a negative effect on fibre quality."

The fiber content of monoecious cultivars can be increased by 60-100%, up to triple the content of the parent stock, with a content of 30% or more of cleaned fibers.

Monoecious (intersex) varieties of hemp are capable of self-pollinating, which soon leads to inbreeding and depression of desired traits. The cultivation of monoecious hemp is feasible only where hemp is cultivated for both fiber and seeds, to be harvested simultaneously. The strains are not stable and so must be maintained by human intervention.

V.P. Soroka studied the formation of male reproductive system in monoecious and dioecious hemp, and reported that the differences between them at very stage of growth prove that dioecious hemp is biologically superior. **(34)**

Z. Loseva reported these findings:

"The degree of the manifestation and change in monoecism depends on the growing conditions. When hemp is isolated from other varieties (1.5-2 km) and when the strains are carefully separated at the right times, monoecious hemp preserves 80-90% of the monoecious plants and 0.5-1.5% of the common staminate hemp for many years. If monoecious hemp is grown along with dioecious varieties, monoecism disappears. After two years of growing under such conditions, the monoecious hemp actually becomes converted into dioecious hemp." **(37)**

The French strains of industrial hemp are "pseudohybrid unisexual" cultivars which are more easily produced and reliably maintained than monoecious varieties:

Parent Stock: (Dioecious) x (Monoecious) = F1 Generation: (Unisexual) x (Monoecious) = F2 Generation: Marketable Seeds. Dioecious cultivars are bred as follows: Parent Stock: (Dioecious Female) x (Monoecious Male) = F1 Generation: (Female 1) x (Monoecious male) = F2 Generation: (Female 2) x (Monoecious Male) = F3 Generation: (Stable Dioecious Cultivar).

Male plants with insufficient fiber content are removed from the crop before they pollinate; thus, the females are fertilized by the best males only. The seeds of females with the best fiber content are sown the next spring. The selection process is repeated annually.

G.S. Stepanov reported on characteristics of heterosis in unisexual hemp hybrids which he obtained by crossing maternal dioecious hemp with the paternal monoecious form:

"The F_1 generation consisted almost completely of female plants (88.3-98%). Heterosis was established for seed yield, which represents a complex expression of many interrelated reproductive qualities. A discrete character of heterosis for elements of productivity is suggested, based on the height and weight of stem, weight of seeds and weight of fiber." **(38, 39)**

In a report on the "Phenonemon of unisexuality and heterosis in first generation hemp hybrids", Stepanov declared:

"Intervarietal hybridization of dioecious forms with monoecious forms is a highly effective means for increasing the yield of hemp. The unisexual hybrids are promising for use under commercial conditions, since they can be harvested without hand-picking of staminate hemp, and they have a high yield of stems, seeds and fiber. Depending on the combination, heterosis can be noted either only for individual elements of the structure or for an entire complex of characters...

"The F1 unisexual hybrids of hemp obtained from crossing dioecious and monoecious varieties most often manifest heterosis in seed yield. The hybrid plants (as compared to the parental forms) are characterized by a higher homeostasis of development... Heterosis has a discrete nature in relation to elements of productivity."

In his "Evaluation of hybridization capacity of hemp cultivars in breeding for heterosis", Stepanov reported:

"Common and specific capacities for hybridization in hemp cultivars are slightly different genetically. Specific capacity for hybridization of the crossing components is of the greatest significance for heterosis manifestation in the first generation hybrids. To obtain a high heterosis effect it is necessary to choose for breeding in the first turn the cultivars with high specific capacity for hybridization...

"When crossing varieties that are equal in height, the variation scope in hemp varietal hybrids exceeds the limits of the ranged series of the parental forms. The highest heritability index (0.79-0.87) is obtained in simple and complex hybrids. To create heterosis hybrids both parents should be selected out of the tall-stalked varieties." **(40, 41)**

Breeding techniques can be used to stabilize a seed line, to incorporate a desirable trait, or to remove an undesirable charcteristic. The simple process of "line breeding" serves well to maintain the stability of a seed line. Select at least several female plants for seed production, and pollinate only a few of their flowers. If the variety is very inbred, it is advisable to collect pollen from several male plants in order to preserve any diversity in the seedline. Thus, the line can be stabilized for several more generations.

The method of "back-crossing" can be used to stabilize new hybrid seedlines, but it takes several generations to do so. As the name implies, seeds from an earlier generation are crossed with those of later crosses. A second generation (F2) hybrid female is crossed with an F2 male to produce the F3 seed. The F2 and F3 seeds are planted and a worthy F2 female is crossed with a choice F3 male. A male is selected from each subsequent generation (F4, F5, etc.) to be backcrossed with a female grown from F2 seed.

Stepanov reported on the "Variability and heritability of principal elements of productivity in intercultivar hemp hybrids" in 1977:

"The significant effect of backcrosses of paternal forms on the degree of the determination of characters in hemp hybrids was studied. Maternal forms have such an effect for simple and complex intervarietal hybrids. The highest phenotypical variability obtained was connected with the number and weight of seeds per plant. The effect of genotype on the phenotypical manifestation of symptoms is evidently a result of simple and complex intervarietal crosses, so it is easier to make the selection of populations of such hybrids than in back population because environmental conditions insignificantly hide hereditary differences among plants." **(42)**

In 1978, however, Stepanov reported on "The ineffectiveness of the back-crossing method selection of hemp for heterosis":

"In back crossings the additive effect of the genes predominates. The selection of the characters controlled by the additive genes leads to the homozygous increase of the population and reduced vitality of the plants. The repeated crossings of the heterozygous hybrid plants with the parental form homozygous for the recessive gene increases the quota of the genes of the latter. It results in the intermediate type of inheritance for all the elements of the backcross hybrid productivity...

"The use of the **inbreeding method** in hemp breeding... as a method of differentiating a heterogenous population and selection of the most valuable biotypes is the first stage in the creation of controlled heterosis. The investigated hemp cultivars were heterozygotic not only for numerous characters but also for combining ability, which even after 5-fold self-pollination was manifested in different families to a different degree. The magnitude of combining ability of the line was higher, the more strongly it was differentiated genotypically relative to all other lines. In the first stages of practical breeding, the inbreeding methods can be used in creating heterotic variety-line hybrids.

"Heritability of main productivity elements and their anticipated gain in populations of various types of intervarietal hemp hybrids... plant height and fiber content in a stem, are highly-heritable irrespective of the crossing types. Low heritability is typical of such integral characters, as the number and weight of seeds from one plant; they are modified depending on the growth conditions. The higher the heritability coefficient, the greater the genetic gain of characters. Other conditions being equal, selection is more efficient. From the theoretical view point the expected gain of all the productivity elements at simple and complex intervarietal crossing is considerably higher than at reciprocal ones." **(43-45)**

M.A. Fedin reported concerning "The efficacy of gametocides inducing male sterility" in 1984:

"The heterotic breeding method is more effective than the methods used before. The breeding process is shorter. It is possible to produce the necessary quantity of hybrid seeds in a shorter period." **(46)**

K. Goncharova and N. Migal observed "Deviations in meiosis in four sources of hemp male sterility":

"Microsporocytes dying off, migration of the chromosomes beyond the borders of the spindle division in the metaphase and anaphase, lagging chromosomes in the anaphase, formation of the micronuclei in the telophase, and asynchronous division of the microsporocytes." **(47)**

N.D. Migal also studied the inheritance of the length of the vegetative period:

"Families with different intervals between ripening of male and female plants were revealed in dioecious hemp. This permits breeding for simultaneously ripening forms by selecting families with a minimum interval." **(48)**

Migal's research also revealed another useful finding:

"The dwarfs of monoecious hemp represent a recessive mutation form valuable for studying peculiarities of natural mutagenesis and changes in the development of sex expression." **(49)**

The intersexual form of male sterility in the plants of monoecious hemp is characterized by a complete lack of pollen. It is inherited by the next posterity through the monofactorial type of inheritance, which makes it possible to use it as a maternal form in the process of hybridization.

The transition of male to female flowers can be accomplished by wounding the infloresences of male plants. The anther lobes will transform into ovules. The earlier this process begins, the more normal is the development of female flowers. Bisexual flowers also are obtained. **(50)**

R. Savelli and N. Soster reported the induction of monophylly by wounding hemp:

"[Wounds were inflicted by] extirpation of the apex of the principal bud, cutting of lateral branches, cutting back the plant at various heights, and in all cases total exfoliation... High mortality resulted. The best cases of monophylly occurred in plants cut back 20-25 cm from the ground. Lateral buds grew rapidly in place of the terminals removed. Monophylly is homologized with a juvenile form. The wounding was ineffective in changing the sex ratio."

Monoecy of hemp also can be induced by control of soil moisture. Z. Loseva grew hemp in different watering regimes, with these results:

"Soil moisture of 60-80% proved most suitable for the establishment of monoecy. The seed yield increased with the increased soil moisture. In order to obtain a more widespread monoecy and higher seed yields, hemp should be grown on fertile low-lying fields...

"When the monoecious variety is grown during a shorter day, a smaller number of monoecious plants and lower seed yields are obtained. On the other hand, lengthening of the day, improvement of the water regime, and reasonable ratio of NKP favors a rise in the percentage of monoecious plants and an increase in the seed yields." **(51, 52)**

Loseva and Arinshtein found these conditions to be optimal for monoecious hemp:

"When grown isolated from other hemp varieties and varietal purity maintained, monoecious hemp consists of 98-99% of monoecious and simultaneously ripening plants. If pure seed is not used, next year the percentage of common fimble will increase 4-6% and a year later to 8-12%. Monoecious hemp cannot be grown on seed plants without isolation or alongside dioecious varieties. The greatest number of monoecious hemp plants was observed under natural day length (79-90%); the smallest, under a short day (32-63%). Consequently the transfer of monoecious hemp varieties into shorter day conditions results in a reduction of seed yield, owing to the decrease in monoecious plants. Optimal conditions for monoecy development are attained by complete mineral fertilizer replacement and by soil moisture equal to 69-80% of the total moisture capacity." **(53)**

4.8 ~ Light

Cannabis' rate of growth is proportional to the intensity of the light it receives, and is inversely proportional to the length of the photoperiod.

Cannabis responds to light in accordance with the intensity, wavelength, and photoperiod. Cannabis is a "short-day" species: it flowers when the photoperiod decreases to about 8 hours. The plant requires at least 3 hours of light daily just to survive, and at least 8 hours daily to thrive. While the plant is young, up to 3 months old, it responds vigorously to increasingly longer periods of light (up to 16 hours). Daily photoperiods of 16 hours or more will cause cannabis to grow indefinitely in a vegetative phase. The plant will grow about 25% faster under 24-hour lighting. Nutrient consumption increases proportionately. **(54)**

The photoperiod must be shortened to less than 10 hours to induce flowering and complete the growth cycle. Cannabis flowers quickest with a photoperiod of 8 hours. Thus, mature plants will develop flowers within 2 weeks of short-day treatment. Immature plants require up to one month of long nights to induce flowering. A short light period usually will bring cannabis into bloom within a month after emerging from the ground, but of course the plants will be very small. Short photoperiods inhibit the growth of stems and foliage, leaves produce fewer serrations in the margins. Flowering is hastened. The number of serrations correlates well with the degree of lighttime treatment.

Erratic lighting will confuse cannabis. V. Sofinskaya studied the conditioning of hemp with lighttime, and observed the following effects:

"The decrease in day length favored the acceleration of light stage completion but was unfavorable to plant growth. A prolonged short-day treatment resulted in a greater growth delay and in stunted plants, especially when plants were grown under short-day conditions since their emergence. Sharp changes of light conditions during the light stage resulted in various morphological alterations and in the appearance of hemp forms widely differing in habitat. Changes in light conditions during the light stage caused transgression in the normal course of the stadial plant development, resulting in considerable morphological changes of infloresence development as well as in the shape and size of leaves." **(55)**

Cannabis must not be disturbed during its night; unscheduled illumination during the dark period will inhibit flowering. Total darkness is required. The flowering response of hemp is controlled by the length of the dark night, not by the length of daylight. As little as 0.03 footcandles (FC) of red light interrupting the dark period will inhibit the anthesis of hemp. A long night thus becomes two short nights separated by an extremely short day, such as 1 minute of illumination.

Very long nights cause hemp flowers to ripen more quickly. This technique is most effective after the 4th week of the flowering phase. Far red light (supplied by incandescent spotlights) can reduce the time required for the flowering phase by about one week.

Cannabis will grow with as little as 800 FC of light, but the growth will not be vigorous. A minimum of 1500 FC is required for a healthy crop. When grown in a short-day regime under low-intensity light, cannabis becomes starved for photons. The hypocotl elongates excessively during the first 2 weeks after the plant emerges. It may reach a height of 6 inches before any internode leaves develop in the plumule. If the illumination is intensified, the plants may survive, and they will develop a clockwise spiral twist in the cotyledon.

Low light levels also produce smaller, thinner leaves, elongated internodes, reduced concentrations of chlorophyll, and less dry weight. High levels of light shorten the growth period, stimulate branching and budding, and increase the production of red anthocyanin pigments. Excessive light causes dessication, bleaching due to photodestruction of chlorophyll, and then necrosis.

Laser light has similar effects. G. Krustev, *et al.*, used a He-Ne laser (632.8 nm/15 & 30 minutes) and a nitrogen laser. The sowing qualities of the seed are improved, the phases of plant development are shortened, the plants are more vigorous, and the yield of seeds and stems. **(83)**

Rejuvenation --- The growth cycle of cannabis usually lasts about 16 weeks. When cultivated indoors, however, cannabis can be rejuvenated after it has bloomed and begins to go into senile decline. Some varieties are very amenable to rejuvenation after their flowers have been harvested. The plants should be cut back to the second branching node. Let as many leaves as possible remain, and a few buds. Give the plants at least 18 hours of light daily. New meristems will develop within three weeks. Extra nutrients (especially N) must be supplied at this time, or the new flowers will be male. The process can be augmented with foliar sprays of Indole Acetic Acid (IAA) or Napthalene-AA. The soil should also be treated with the hormones. Hemp can be rejuvenated repeatedly with such treatment, thus living several times longer than usual. Even without continuous-light rejuvenation, female hemp may live several months longer after flowering if the plant remains unpollinated. If female plants become senile between rejuvenations, then sex-reversals usually occur, especially under the influence of short-day photoperiods after the continuous-light treatment. In such a case, about 90% of the females reverse to male or hermaphroditic intergrades. **(56-60)**

Rejuvenated cannabis blossoms from the terminal bud or from lateral buds below the infloresence. Usually the first few leaves on rejuvenated plants are entire (smooth edged). After several such leaves have developed, subsequent leaves again have the usual serrations. When grown under continuous light, the phyllotaxy of the branches changes from opposite to alternate at some point after the seventh node. Plants grown with normal long-days do not change their phyllotaxy until 12 internodes have developed. Rejuvenated plants are very sensitive to tobacco smoke and can be killed by it.

D. Kohler researched the effects of short and long days on hemp morphology, and found another way to rejuvenate cannabis, based on its response to light:

"In short-day and long-day hemp the first leaves are simple and comparatively broad, the later are divided, their leaflets being comparatively narrow. The size of the leaves following one another is continuously increased. Plants begin to flower (qualitatively reacting short-day hemp in short-day only). The shape of the leaves produced in the infloresence is determined in the first days of flowering: they become more and more simple and their leaflets comparatively broader. The leaf size is influenced by the length of day. The leaves of plants kept in flower-inducing daylength grow less and less due to competition between reproductive and vegetative organs, whilst the leaves of flowering plants, which are transferred into longer day, grow larger and larger. In this case the latest leaves are of the same size and shape as the earliest one; a second life-cycle starts, whilst the plants in the original daylight are dying. Considering the photoperiodic response of hemp, leaf-size is a measure of the physiological age. With monoecious hemp a certain leaf size is necessary for the formation of male flowers. If female plants are put into longer day during blossom, they do imitate the male habit." **(61)**

Ocra Wilton found a correlation of cambial activity with cannabis' flowering and regeneration:

"A study was made of cross-sections of all the internodes from the tips to the bases of the stems... When Cannabis sativa has reached an advanced stage of reproductiveness, the meristematic tissue of the stem tends to become entirely differentiated into xylem and phloem elements. This anatomical condition is a possible explanation of the death of such plants at the close of one reproductive cycle. The cessation or decline of cambial activity which accompanies the production of flowers in C. sativa progresses from the region of the infloresence toward the base of the plant, which it may or may not reach depending on the degree of reproductiveness which the plant attains. Vigorously vegetative plants have an active cambium throughout their stems... a certain amount of at least potentially meristematic tissue is necessary for a renewal of vegetative growth in stems."

Photoperiodism ---- Photoperiodic control can be very useful to the cannabis breeder. If yield is not important (as is often the case in the early stages of a breeding program), the time required for the life cycle can be greatly reduced by using short photoperiods. Thus, several generations of plants can be produced each year. Under such conditions, cannabis will flower when it is only a few inches tall. **(62)**

Photoperiodic control makes it possible to synchronize the flowering dates of male and female plants, thus making possible their cross-breeding. Most importantly, photoperiodic control enables breeders to stimulate the production of male flowers on female plants. Self-pollination can be accomplished only by means of such flowers. Male flowers on female hemp do not contain the Y (male) chromosome; they produce only female pollen. When this is used to fertilize female flowers on female plants, they will produce purely female seeds. The pollen from male flowers is of two kinds, and usually produces a ratio of males 1:1 females. A few viable seeds can be obtained from female flowers produced on male plants and self-pollinated, but such seeds are only weakly fertile and produce mostly female plants.

The following procedure will produce seeds which will grow 100% female hemp:

Cultivate two separate groups of female plants indoors. The plants should receive at least 50 watts of light per square foot of growing area. One group must not receive more than 7 hours of light daily. This will induce male flowers to manifest on the female plants. The second group of females must receive about 16 hours of light daily to ensure that no male flowers develop on them. The long photoperiod also inhibits the development of flowers so much that the short-day plants will mature 2 or 3 weeks before the long-day group. Therefore, begin cultivating the long-day females at least 2 weeks before planting the short-day plants.

As the two groups approach maturity, remove any males which may appear. A few weeks before the male hemp begins to flower, the internodes of the stem begin to elongate very quickly. The dominant male enzyme andrase produces thin plants with a tuft of leaves at the top. The leaves are smaller than those of the females, and have fewer leaflets (usually 5). Tiny buds sometimes appear in the nodes about 2/3 up the stalk. The future sexual expression of hemp may be determined by examining these premature flowers. If the buds remain erect, the plant is female. If the buds droop, the plant is male.

When clusters of female buds begin to appear on plants in the long-day group, cover each bud with a transparent plastic bag sealed with a rubber band around the stem below the bud cluster, so as to protect the flowers from accidental pollination.

When male buds appear on some of the female plants in the short-day group, cover each bud with a transparent bag sealed with a rubber band around the stem below the bud cluster, so as to protect the female flowers from accidental pollination.

When male buds appear on some of the females in the short-day group, carefully cut off every male bud and store them in a glass jar. Any new male buds which appear also must be pruned. Within a few days the anthers of the clipped buds will open and release pollen. Collect this pollen and apply it with a thin brush to the stigmas of the bagged flowers in the long-day group. Because this pollen contains only female chromosomes, the fertilized female flowers on the long-day female group will develop seeds which will produce only female plants.**(63-66)**

Another method of manipulating the gender of cannabis involves treatment of the male pollen with ultra-violet light for about 1 hour. This doubles the ratio of the females to males, perhaps by neutering the weaker male chromosomes. **(67, 68)**

The viability of hemp pollen can be preserved by the method of Migal and Arinshtein:

Storage of pollen in a refrigerator will protect breeding material for 38-45 days, which is important for crossing different varieties of hemp. Hemp pollen can also be stored in the dark placing it in a desiccator over calcium chloride or concentrated sulfuric acid. Here the pollen grains retain the viability to germinate for 12-18 days. The pollen of dioecious varieties of hemp retain viability longer than the pollen of monoecious varieties. **(69)**

G. Davidyan found these effects of light on the root development of hemp:

"The growth of the root system in hemp was found to be more intensive than that of the stem at the vernalizaton and light stages. The root system is less vigorous in short than in long day conditions. At the stage of rapid development --- the beginning of budding up to flowering --- an intensive stem and root system growth is observed. The root system of female hemp plants is superior in vigor to that of male plants." **(70)**

4.9 ~ Sexual Expression

The sexual expression of cannabis is determined by its genetic makeup, and by its metabolic temper, which is regulated by the male enzyme andrase and the female enzyme gynase. Environmental conditions (light, nutrients, soil and water) may suppress the formation of the dominant enzyme, and allow the opposite sex to express itself partially (hermaphroditism) or completely (sex reversal). **(71, 72)**

E. Galoch found that cytokinin is important for the sexual expession of hemp:

"Transition of female and male hemp plants from the vegetative to the generative phase is associated with a rise in cytokinin level while that of male inflorescences proceeds at a decreasing cytokinin level. The activity of cytokinins apparently is associated with an enhancement of the female tendency..." **(73)**

Gibberellin will inhibit the formation of flowers on cannabis, but sometimes it will otherwise cause the growth of fertile female flowers on genetically male plants. Silver nitrate or cobalt chloride causes masculinization of flowers of female hemp, possibly due to blockage of ethylene synthesis. High levels of N salts --- and long photoperiods --- have a masculinizing effect on hemp.**(74-76)**

According to K. Conrad, there are sex-linked differences of the auxin content in male and female hemp plants:

"During blossoming the vegetative parts of the males contain more auxin than those of the females. In the dying leaves and stems a remarkable increase of auxin can be observed." **(77)**

J. Heslop-Harrison studied auxin and sexuality in Cannabis:

"Dioecious hemp plants were grown to an age of 20 days in a day-length of 21-22 hours, then given an inductive treatment of ten 8-hour days to initiate flowering. After return to long days and during the period of differentiation of flower buds, a total of 0.5 gr lanolin paste containing 0.5% NapthaleneAcetic Acid (NAA) was applied to leaves at the 3rd and 4th nodes. In genetically male plants, female plants were subsequently formed in sites which would normally be occupied by males, a result which appears to be regulated by the level of native auxin in the vicinity of meristems during the period of differentiation of flower primordia. Secondary effect of auxin treatment were evident in an over-all reduction in intensity of heteroblastic development, the trend towards a reduction of leaf lobing and serration which normally accompanies plants passing through a period of flowering than in untreated controls." **(78)**

Nitrogen fertilizers masculinize the phenotype by stimulating the formation of male flowers. The proportion, number and degree of monoecious plants increases with increasing N, and the total N content is always higher in monoecious individuals than it is in females. **(79)**

Treatment of hempseed with ethylene gas will increase the resulting number of female plants by about 50%. Ethylene is produced by certain plants (i.e., bananas, cucumbers and melons), and these can be used to treat hempseed in a simple manner. About two weeks before you plan to sprout the seeds, place them in a paper bag or envelope and put that in a plastic bag with the peels of a ripening banana or cucumber. Replace the peels after a couple of days, and change the bags to prevent mold.

Hempseed can be feminized while they are forming on the plant. Fruit peels are spread around the area for two weeks before the plants enter the flowering phase. Remove the skins when the plants begin to flower. Otherwise, treatment with Etephon will accomplish the same effect.

When hempseed is treated with the female hormone estrogen, percentage of females that are produced will increase by about 10%. Dissolve a birth control pill in water and soak the seeds overnight in the solution. After the initial soaking, continue to treat the seeds by sprouting them on a paper towel soaked in the solution. **(80)**

A.I. Zhatov tested the effects of ethrel on hemp:

"Treatment of hemp plants with an aqueous solution of ethrel changed the ratio of male to female flowers. The greatest effect was observed when plants were treated during flowering of male flowers." **(81)**

Electricity also can change the sexual expression of cannabis; B.R. Lazarenko and I.B. Gorbatovskaya reported:

"Under the influence of the electrical current, the numerical proportions between hemp plants of different sexes was changed by comparison with the control **to give an increase of female plants by 20-25%... The characteristics acquired by the plants in electrically treated soils are transmitted by inheritance to the third generation...**" [emphasis added] **(82)**

Photoperiodism is a most useful tool with which to control the sexual expression of cannabis. For example, J. Limberk made a careful study of lighttime on the sexual index of hemp, and reported thus:

"Male plants usually flowered earlier than female. Female plants flowered only when the period of daylight was shorter than 14 hours; male plants flowered even when the day was longer than 14 hours. Reduction of light intensity in the first stages of plant development lead to increases of female plants by 4.3%. Intersexual plants (22-30% of the total) were present in conditions of 11-13 hours light per day. Grafting of plants did not change sex."

Monoeciousness effected by short days is not fixed in the descendants. **(84)**

The probable future sex of a pre-floral hemp plant can be guessed at by calculating the Leaf-Mass Index (LMI): Count the points (3, 5, 7) on 3 leaves in the center of a cluster. Divide that number by 3 to determine the average number of points. Repeat the process several times, and figure that average also. Multiply the two averages to determine the LMI. A high LMI indicates that the plant will be female.

The phyllotaxy changes to alternate just before the onset of flowering. Then the sex of the plant can be determined by making a close examination of the upper nodes of the main stem. The onset of flowering is indicated by the appearance of undifferentiated primordial buds behind the stipules at the nodes of the petioles (along the stem at the base of branches). Within a few days they differentiate. The male pistils are flat or knobby with a curved shape and 5 open petals about 5 mm. long; they have a single tiny stalk. Overlapping vegetation often disguises their appearance.

The female develops pairs of flowers surrounded by pointed bracts of protective leaves that will enclose the seed. The female stigma usually appear as 2 fuzzy white hairs forming a "V" that protrudes from a bract. Resinous hairs (glandular trichromes) cover the calyx (2-6 mm long).

5.1 ~ Introduction

The application of electricity, magnetism, monochrome light, and sound can stimulate the growth of plants to a great extent. This little-known technology, called Electro-culture, can accelerate growth rates, increase yields, and improve crop quality. Electro-culture can protect plants from diseases, insects and frost. These methods also can reduce the requirements for fertilizer or pesticides. Farmers can grow bigger and better crops in less time, with less effort, and at a lower cost.

The several approaches to Electro-culture include: antennas, static electricity, direct and alternating current, magnetism, radio frequencies, monochrome and intermittent lighting, and sound. The energies are applied to the seeds, plants, soil or the water and nutrients.

Concerning cannabis, B.R. Lazarenko and I.B. Gorbatovoskaya announced:

"Reports that ***the characteristics acquired by the plants in electrically treated soils are transmitted by***

inheritance to the third generation *are particularly interesting.*

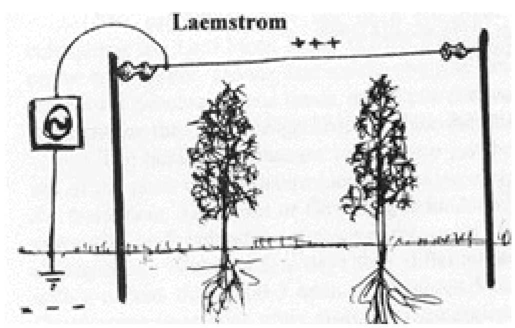
"Under the influence of the electrical current, the numerical proportions between hemp plants of different sexes was changed by comparison with the control to give an increased number of female plants by 20-25%, *in conection with a reduction in the intensity of the oxidative processes in the plant tissues*." **(1)**

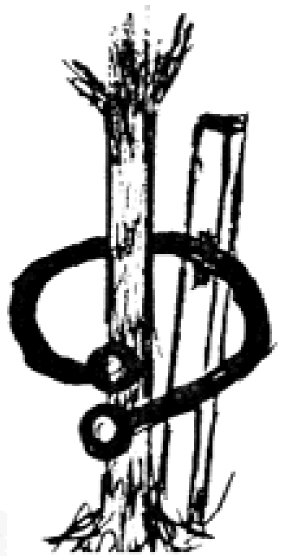
5.2 ~ Antenna Systems

The French farmer Justin Christofloreau attracted attention in 1925 with his apparatus to collect atmospheric energy for his crops. Clover treated by his method grew 7 feet high. Christofloreau's apparatus consisted of a 25-ft wooden pole; at the top was a metal pointer aligned north-south, and an antenna. Copper and zinc strips were soldered together to generate electricity from solar heat. Several of the poles were set about 10 ft apart, and the wires leading from them extended about 1000 yards. Christofloreau claimed that the accumulated electricity destroyed parasites and promoted beneficial chemical processes in the soil.**(2)**

In 1924, Georges Lakhovsky devised his Oscillator Circuit, a one-turn copper coil with overlapping ends separated by a gap. Capacitance generates oscillating currents that benefit the plants. The ring is supported by an insulator such as a plastic rod. This extremely simple arrangement stimulates plant growth (**Fig. 5.1**). **(3)**

Other configurations also enhance plant growth. A conical coil of stiff wire wound with 9 turns (counter-clockwise in the Northern Hemisphere, clockwise in the Southern), when stuck in the ground about 1 ft north of a plant, will collect atmospheric electricity. Connect a wire from the fence to a metal rod near the plants. A tv antenna also can be used. Rebar can be sunk into the ground at each end of a row of plants, connected by a bare wire under the soil and/or in the air. A north-south orientation will take advantage of geomagnetic polarity.





Lakhovsky

5.3 ~ Electrostatic Systems

Experimental study of the effects of electricity on plant growth began in 1746, when Dr. Maimbray of Edinburg treated myrtle plants with the output of an electrostatic generator, thereby enhancing their growth and flowering. Two years later, the French abbot Jean Nolet found that plants respond with accelerated rates of germination and overall growth when cultivated under charged electrodes.

Beginning in 1885, the Finnish scientist Selim Laemstrom experimented with an aerial system powered by a Wimhurst generator and Leyden jars. He found that the electrical discharge from wire points stimulated the growth of crops such as potatoes, carrots, and celery for an average increase of about 40% (up to 70%) within 8 weeks. Greenhouse-grown strawberry plants produced ripe fruit in half the usual time. The yield of raspberries was increased by 95%, and the yield of carrots was increased by 125%. Crops of cabbage, turnips, and flax, however, grew better without electrification than with it. The Laemstrom system comprises a horizontal antenna suspended high enough to permit plowing, weeding and irrigation. The voltage applied to the antenna varies from 2 to 70 KV, depending on the height of the antenna. The current is about 11 amps. **(4, 5)**

Spechniew and Bertholon obtained similar results a few years later, and so did the Swiss priest J.J. Gasner in 1909. Also that year, Prof. G. Stone showed that a few sparks of static electricity discharged into the soil each day increased soil bacteria up to 600%.

In the 1920s, V.H. Blackman reported his experiments with an aerial system similar to that of Laemstrom. He applied 60 volts DC/1 milliamp through 3 steel wires each 32 ft long and suspended 6 ft apart and 7 ft high on poles. This arrangement yielded an average increase of about 50% for several plant types. **(6)**

In 1898, Grandeau and Leclerq studied the effect of atmospheric electricity on plants by covering part of a field with a wire net which shielded them from natural electrical action. The uncovered plants grew 50-60% better than the shielded plants.

Wet soil improves current flow. Electro-cultured plants require about 10% more water than control plants because the charged water is perspired more rapidly than under normal conditions. Positive results are always obtained except when ozone is formed by ionization. Negative aero-ions intensify cellular oxidation reduction processes, while the positives depress them.

5.4 ~ Direct Current

In the 1840s, W. Ross of New York reportedly obtained a severalfold increase in the yield of a field of potatoes when he buried a copper plate (5 ft x 14 ft) in the earth, and a zinc plate of the same dimensions 200 ft away. The two plates were connected by a wire above ground, thus forming a galvanic cell. In similar experiments by Holdenfleiss (1844) with battery-charged zinc and copper plates, yields increased up to 25%.**(7)**

From 1918 to 1921 some 500 British farmers developed a shared system to treat their grain in an electrified solution of nutrients. The grain was dried before sowing. The farmers cultivated about 2,000 acres with the seed. The results were reported in *Scientific American* (15 February 1919):

"In the first place, there is a notable increase in the yield of grain from electrified seed... the yield of the electrified seed exceeds that of the unelectrified by from 4 to 16 bushels... The average... is between 25 and 30 % of increase... The increase in weight has ranged from 1 pound to as much as 4 pounds per bushel... Besides the increase in the bulk of the yield and the increase in the weight per bushel, there is an increase in the straw... whereas the bulk of the unelectrified seeds had thrown up only 2 straws per seed, the electrified had thrown up 5.... The straw growing from the electrified seed is longer... The stoutness and the strength of the straw is increased... the crop is less likely to be laid by storms... Corn growing from seed thus treated is less susceptible to the attacks of fungus diseases and wireworm.

"The effect produced upon the seed is not permanent; it will retain its enhanced efficiency only for about a month after electrification, if kept in a dry place. It is therefore desirable that the seed be sown promptly after it has been electrified... The grain must be steeped in water that contains in solution some salt [sodium nitrite] that will act as a conductor... The seed is steeped in it, and a weak current of electricity is passed by means of [iron] electrodes of large surface attached to two opposite end walls of the tank. The seed is then taken out and dried."

Seed that is to be sown on one kind of soil will yield better results with a calcium salt, and seed that is to be sown on another kind of soil will yield better results with a sodium or other salt. One kind of seed will need treatment for so many hours, and another kind for many hours more or fewer. Barley, for instance, needs twice as long treatment as wheat or oats. The strength of the solution and the strength of the current must be appropriate, and are not necessarily the same in each case. The drying is very important. The seed must be dried at the right temperature, neither too rapidly nor too slowly; and it must be dried to the right degree, neither too much or too little. **(8, 9)**

In 1964, the USDA performed tests in which a negative electrode was placed high in a tree, and the positive electrode was connected to a nail driven into the base of the tree. Stimulation with 60 volts DC substantially increased leaf density on electrified branches after a month. Within a year, foliage increased 300% on those branches! **(10)**

Electricity also can cure trees of some diseases. A method was developed in 1966 to treat avocado trees affected with canker and orange trees with scaly bark. An electrode was inserted into the living cambium and phloem layers of the tree and the current passed into the branches, roots or soil. The treatment is best administered in the spring. The length of treatment depends on the size and condition of the tree. New shoots appeared after only one cycle of treatment. After the bark was removed, the trees began to bear fruit! The period of grafting stratification also can be shortened in this way.

The passage of an electric current modifies the physico-chemical properties of soil. Its aggregation increases, and its permeability to moisture is improved. The content of absorbable nitrogen, phosphorus, and other substances is increased. The pH changes. Usually, alkalinity is reduced, and evaporation increases. Both alternating and direct electric currents have a bacterial action which also affects the soil microflora. Up to 95% of cabbage mildew and other bacteria and fungi can be destroyed by electrical disinfection.

Brief exposure of seeds to electric current ends their dormancy, accelerates development throughout the period of vegetation, and ultimately increases yields. The effect is greater with seeds that have a low rate of germination. The metabolism of seedlings is stimulated; respiration and hydrolytic enzyme activity is intensified for many types of plants. Lazarenko and Gorbatovskaya reported these results:

"At the end of vegetation the experimental cotton plant possessed twice or three times as many pods as the control plant. The mean weight of the seeds and fiber was greater in the experimental plants also. In the case of sugar beet the yield and sugar content were increased, and in places near the negative pole the increase in sugar content was particularly high. The tomato yield increased by 10-30%, and the chemical composition of the fruit was modified. The chlorophyll content of these plants was always greater than that of the control... Corn plants absorbed twice as much nitrogen as control plants during the vegetative period... The transpiration of the experimental plant was higher than that of the control, especially in the evening...

"The stimulating action of the alternating current was greatest when the current with density of 0.5 mA/sq cm... A direct current with density of 0.01 mA/sq cm had approximately the same action. When these optimal current densities were used in hotbeds, the yield of green mass could be increased by 40%."

P.V. Kravtsov, *et al*., reported that the population of ammonifying bacteria (especially the sporogenous type) increases about 150% when soil or compost is exposed to continuous low-power DC. The symbiotic activity of nodule bacteria with bean plants was characterized by massive nodules near the base of the root. Field experiments were conducted on 40 hectares. The peas treated with electrified inoculant produced 34% more yield than a control crop. Carbon dioxide evolution in the soil increased over 35%. The authors also reported that treatment of seed with electric-spark discharge destroys microflora and activates the germination process. **(11)**

An electrified fence was invented by Henry T. Burkey in 1947 to keep fish out of irrigation ditches. The fence consisted of a free-swinging row of electrodes connected to a generator which slightly charged the water to shock fish without hurting them.**(12)**

5.5 ~ Alternating Current

When using AC, great care must be taken to prevent electrocution of oneself and the plants. AC generally tends to retard plant growth except within certain narrow parameters of voltage and amperage. Dicotyledon plants increase in weight at 10 KV and 100 KV, but decrease in weight (as much as 45%) between 20 to 60 KV. Current must be very low, or plant growth will be retarded.

L.E. Murr used aluminum wire mesh electrodes charged up to 60 KV, and found that monocotyledons increase in dry weight in an electrostatic (ES) field, but decrease in weight in an oscillating field. The dry weight of dicots increases about 20% when grown in an oscillating field, but decreases above 50 KV. The concentration of minor elements (Fe, Zn, Al) increases several hundred percent in active leaf tips, due to an increase in oligo-enzymes. The activity of these substances is accelerated so much that cellular respiration is impeded, resulting in deterioration and death. There appears to be no benefit from continual exposure of plants to an alternating electrical field. If such a system is used, voltages should not exceed 10 KV, and the current must be very weak.**(13-15)**

The results can be worthwhile. In a similar system, the maximum energy supplied was 50 watts (50 KV/1 mA) per acre for 6 hours daily for 6 months. The total energy supplied was less than 0.2% of the energy actually absorbed by the plants from sunlight alone. Only a fraction of this additional energy was available to the plants, yet the increase averaged above 20%, up to 50%! Furthermore, it was found that an electrical discharge applied during the first month of the growing season may be as effective as continued treatment throughout the season.

In November 1927 and January 1928, *Popular Science Monthly* announced H. L. Roe's invention of an electrified plow which sent 103 KV between the plow shares to kill pests in the soil. In 1939, Fred Opp invented a garden cultivator that used high-tension electric current to increase the nitrogen content of the soil. The system was described in *Popular Science Monthly* (October 1939):

"A generator with an output of 110 volts AC, a storage battery for exciting the armature field, and a transformer that steps up the current to 15 KV... [is] mounted on a walking-type garden tractor equipped with a small gasoline motor that drives both the tractor and the generator. Current is conducted through a pair of electrodes to furrows in the soil made by a cultivator. As the electrodes are dragged along, soil falls on top of them, making the contact."

The same method was incorporated into the "Electrovator" built by Gilbert M. Baker, as reported in *Popular Science* (September 1946):

"It is a trailer containing a... 12.5 KVA generator and a special transformer. Two rakes with copper electrodes for teeth apply the high-voltage, low-amperage current to weeds as the machine is drawn at 1 mph... The weeds burn, from the tops to root-tips, leaving the land ready for new crops. The treatment can be repeated for successive growth."

In 1911, Emilio Olsson patented an irrigation system using electrified rain. The water was contained in an insulated iron tank, positively charge with 110 V/0.5 A. The negative pole was insulated copper wire, stripped bare at the tip. The sprinklers were mounted 5 meters high. Olsson successfully cultivated a 600-acre plantation with this method. The city of Buenos Aires adopted the system for use in its parks.**(16)**

The treatment of seeds in an electric field before sowing gives a consistent increase in yield, usually about 15-20%. L.A. Azin and F.Y. Izakov reported these results of their research:

"The electric field of the corona discharge differs from the electrostatic field by possessing considerable homogeneity and by the precession of space charges of the same sign in its working zone. Because of this any particle, including a seed, receives a charge of the same sign in such a field. The [ES] field is homogenous and does not possess space charges, although charging may take place here because a seed, if placed on the metal electrode, acquired a charge by contact, corresponding in its sign to the polarity of the electrode."

N.F. Kozhevnikova and S.A. Stanko experimented with AC effects. They found:

"After treatment in optimal conditions, the yield of green mass is increased by 10-30%, and the yield of grain by 10-20%. Besides the increased yield, treatment of seeds with an alternating current may improve other economically valuable properties of cultivated crops: the leaf cover of the plants may be increased, the vegetative period may be shortened, the absolute weight of the grain may be increased, and so on..."

The seeds were treated with 2-4 KV/cm, with 8 KV on the electrodes of the working chamber. Exposure was for 30 seconds, or for 1 hour. It was found that if treated seeds were kept for 10-17 days before sowing, the mature plants would contain up to 86% more chlorophyll and 50% more carotenoids than the controls! **(17)**

B.R. Lazarencko and J.B. Gorbatovska reported similar results achieved under various conditions of corona discharge treatments of seeds:

"After electric treatment of this type, an increase in their germination rate and, in particular, in the energy of germination was observed. The improvement was especially marked in the properties of seeds located on the negative electrode during treatment. In this case an increase in yield of 2-6 centners/hectare was obtained with nearly all the conditions of treatment used. The increase in yield was smaller for plants whose seeds were treated on the positive electrode. Corn seeds, treated in a constant electric field, gave good yields which developed rapidly. Green tomatoes ripen faster if they are placed in an electric field close to the positive electrode or between the poles of a magnet, especially close to the south pole.

"The viability and the fertilizing power of the pollen at first increased and then decreased as the duration of its treatment in a constant electric field was lengthened. In optimal conditions this fertilizing power was increased from twice to four times. The use of high voltage electric fields for the treatment of pollen has led to the modification of its bioelectrical properties and has made it possible to influence the fertilization process: the setting rate of fruit has been increased during hybridization of varieties of more distant forms, and the failure to cross distant species of fruiting plants has been overcome." **(18)**

Seed-borne bacteria, fungi and insects can be destroyed without injuring the seeds, by application of high-frequency ES fields between capacitor plates. Pests are destroyed when a lethal degree of heat is developed within a few seconds. A longer exposure is required to cause decreased germination of seeds than is necessary to kill pests. **(19, 20)**

By this same method, it is possible to increase the power of germination of old seeds or seeds which are naturally difficult to germinate. Starch is increased, invert sugar is increased, and albumin is changed by such treatment. A greater percentage of treated seeds sprout sooner than untreated seeds. High-frequency ES fields also can be used either to inactivate or enhance enzymatic metabolism of fruits and vegetables, thus prolonging their stability, or hastening their ripening. In an ES field of 36 KV/m, the negative pole positioned above the seeds enhances their germination. The positive pole above the seeds inhibits germination. In the 1930s, V. Lebedev used very low power ultrashort waves to irradiate seeds, resulting in 20-45% accelerated plant growth. Similar results were obtained with potato tubers, and gladiolus bulbs were grown without cold pre-treatment.

The effects are thought to be caused by conduction currents or dipole antenna resonance. The lethal effect begins at about 10.4 meters wavelength (29 MHz) when the condensor plates are 2-3 cm apart. Other researchers have reported similar effects with the following parameters: Plates, 12 cm diameter; Current, 5.5 amps; Wavelength, 5.6 meters (50 MHz); Temperature, 30-40^{o} C. The lethal effects depend on the wavelength and the voltage gradient of the field strength (the distance between the condensor plates). Increasing either the frequency or the field strength while other factors remain constant increases the speed of the effect on pests. An increase of either factor requires more current, yet at certain frequencies (around 3 MHz), much less current is required for effective results (about 4 KV per linear inch). The higher the frequency, the shorter the lethal time. The thickness of the seeds and their moisture content also changes a lethal dose. The temperature of the seeds and pests may rise up to 60^{o} C. A similar method was developed to destroy termites in wood, using a 20 MHz signal for the purpose.

Experiments conducted by H. Kronig showed that after a week of development, seeds exposed to extremely low frequency (0.5-20 Hz) fields, wheat seeds grew an average of 23% greater length than non-electrified controls.

Other experimenters have found that the high-frequency currents generated by a Tesla coil will protect plants from temperatures as low as 10^{o} F, which destroyed unprotected plants. **(28)**

In 1920, Thomas Curtis used a large, oil-immersed Tesla coil (10 KV/500 W) to supply high-tension current over a 200 sq ft plot planted with radishes and lettuce. The electrified crops were at least 50% larger than the normal crops.

5.6 ~ Magnetism

Plant breeder Alberto Pirovano published some 50 papers on inherited changes in plants induced by treatment with low frequency or constant magnetic fields.

Albert R. Davis received U.S. Patent #3,030,590 for his system of gardening with magnetism. Davis said:

"We found... that treating above ground seeds with the South Pole of a magnet [1,500-2,500 gauss] increases the germination and growth, and the leaves of these vegetables are larger.

"If you treat seeds [of]... beets, potatoes, carrots or turnips, you will produce a better result by using the North Pole of the magnet."

The magnetic influence also softens the surface tension of water, which then is more readily absorbed by the seeds and plants. U.J. Pittman conducted extensive field experiments with these results:

"Earth's magnetism can effect the direction of root growth of some plants, and also the growth rate of some seedlings... The roots of some plants [winter and spring wheat, and wild oats] normally align themselves in a N-S plane approximately parallel to the horizontal face of Earth's magnetic field... Winter wheat seeded in rows running at right angles to the magnetic N often out-yield wheat seeded in other direction by 3-4 bushels/acre because the roots grow in a N-S direction and utilize nutrients in the inter-row areas more extensively.

"Seeds of some varieties of wheat, barley, flax, and rye were found to germinate faster and grow more during their seedling stages when their long axes and embryo ends are pointed toward the N magnetic pole than when they are pointed in any other direction.

"Many seeds germinate and grow about two times faster if they are exposed to the N pole of an artificial field before they are planted than they are not so treated --- wheat seed in particular grows about 5 times as much in the first 48 hours as unexposed seed.

"In some species the enhanced growth rate persists through to maturity. Green snap beans thus mature more uniformly and yield more than those from untreated seed planted randomly.

"The effects of magnetic treatment before germination appear to remain active within some seeds for at least 18 months after application. The magnetic intensity required to give maximum response appears to be between 0.5 and 100 Oersted when applied for 240 hours. For some unknown reason a greater growth response occurs if the seeds are subjected to magnetism for 48, 144, 240, or 336 hours than if exposed for intermediate periods. An exposure for 240 hours produces maximum responses in most seeds..."**(21)**

Pittman discovered that the sexual determination of monoecious plants such as corn and cucumbers also is affected by the geomagnetic field:

"If the embryo radical of such plants is oriented toward the North, a greater number of female flowers is formed than in the case of seeds oriented toward the South. Since cucumber fruits are produced from the female flower, Northward orientation of the seed radicals will lead, of course, to greater yield per plant."

In general, Northward orientation of the embryonic radical (particularly of corn) promotes masculinity. The response of seeds when oriented toward the geomagnetic poles depends on the left- or right-handedness of the seed and the sexual characteristics of the plant type. When oriented with the tip of the embryo radical towards the S geomagnetic pole, l-rotary seeds demonstrate higher rates of growth, respiration, and enzymatic activity, and up to 50% greater yields. D-rotary seeds respond with up to 50% enhanced growth rates and yields when their embryo tips are pointed at the N pole.

When conifer seeds are grown with their embryo radicals oriented S, they germinate 4-5 days earlier than seeds oriented toward the N pole. Lunar phases also have a profound effect on the germination of conifers. They will sprout much faster when their embryo radicals are oriented S during a full moon, than they will if germinated during the new moon.

If there is any doubt about the directivity or gender of seeds, positive results can be obtained in any case by treating seeds for 2 weeks in the magnetic null, the quiet region where the magnetic pull is balanced between N and S. This region is located by observing the patterns formed by iron powder scattered on a glass pane placed over the magnet.

Pittman also grew potatoes from excised, magnetically treated eyes. The field-grown crop yielded 17% more marketable tubers that weighed 38.5% more than those grown from untreated eyes! Pittman concluded:

"Pre-germination magnetic treatment of the eye may have effected a change in the metabolic process in the bud that eventually promoted earlier and greater tuber initiation. Tubers initiated early would have had more time to develop size than those initiated later."

The exposure of seeds to magnetic fields also increases the percentage of germination of apricot and apple seeds, increases the yields of snap beans, accelerates the growth of legume and cereal seedlings, and the rate of tomato ripening.

P.W. Ssawsotin reported that a low intensity (60 Oe) field may affect some biological processes as much as high intensity (1,600 Oe) magnets. Some of the effective "windows" are quite narrow. Strevoka, *et al*., found that a field strength of 60 Oe increased the growth rate of beans, cucumbers, lupines, maize and rye, but the rye was unaffected by a 100 Oe field. The greatest results were obtained at the temperatures which are optimal for the growth of each type of plant. **(22)**

Other Russian researchers found that wheat and barley seeds pre-magnetized (2,000 Oe) for 30 minutes with the major axis aligned with the magnetic flux will germinate much more vigorously than control seeds. Germination actually is retarded when seeds are aligned against the flux. Corn seeds respond differently according to their left (*l*-) or right (*d*-) orientation or symmetry (*s*) when treated by a constant magnetic field (7 kOe) for 15 minutes. *L*-seeds are most responsive, showing increased potassium and water uptake and free amino acids 24 hours after treatment. The effect on *l*-seeds is strongest when the water-swollen embryo is oriented towards the N magnetic pole. Lazarenko and Gorbatovskaya also reported other strange effects:

"Even more curious results were yielded by experiments in which seeds were heated in a test tube left for 30 minutes in boiling water... Compared to the control seeds, the seeds heated (in the dry state described above) and exposed to the magnetic field exhibited greater sprouting activity..."

Other experiments have shown that treatment of soil with magnetized water and/or low-frequency current (0.5 or 5 A) activates soil potassium and phosphorus, thereby increasing their bioavailability. **(23, 24)**

A.V. Krylov also demonstrated magnetotropic phenomena in plants:

"Germination of seeds in a constant magnetic field accelerated growth of the shoots and rootlets and development of the plant, while an increase in its positive sign promoted aging, disease and death. Polarity also plays a role in plant immunity. Seedlings with their rootlets turned toward the N pole were thickly infested by parasites and molds, and the resistance of these seedlings was obviously depressed. The appearance of seedlings facing the S pole (with all other conditions the same) was completely different."

In a 1,500 Oe field, the largest number of germinating seeds was found after an exposure of 10-30 and 300 minutes. Other gains were found at 2,800 Oe. If the magnetic field is too intense, germination can be retarded. Strevoka reported a contrary finding: a non-homogenous 12,000 Oe field suppresses the germination of beans up to 40%.**(25)**

DeLand's Frost Guard ---The "Frost Guard Tower" developed by John DeLand in the 1940s used magnetism to replace obnoxious smudge pots. He obtained high yields from orange trees formerly considered to be too old to be productive. The DeLand system can protect one acre of trees from frost, but it is ineffective for small plants.

George van Tassel gave this description of the device:

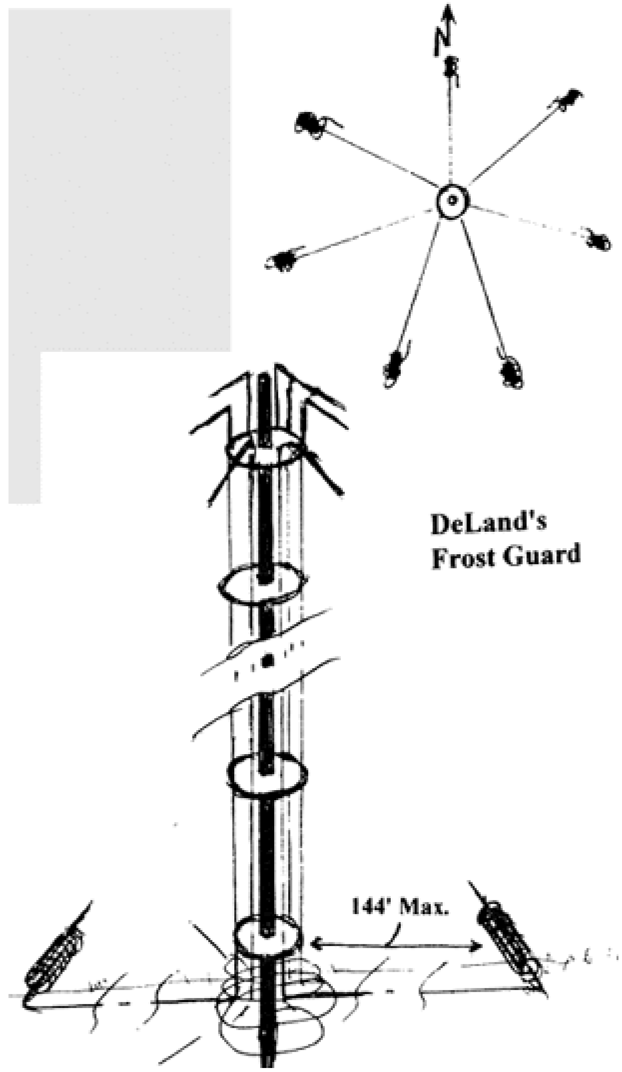
"The DeLand Frost Guard Tower is about 32 feet high. It is composed of three 12-ft lengths of standard galvanized steel pipe. The lowest section is 2-inch pipe, set 3 ft deep in concrete. On top of this a 12-ft section of 1.5 inch pipe is screwed on by means of a reducer. Above this the top section of 12-foot pipe, 1-inch in diameter, is screwed on by means of a reducer. Resting horizontally atop each reducer and at the mast head is a 1-ft diameter disk of waterproof, 3/4-inch plywood. Near the outer diameter of each plywood disk or collar is drilled 7 holes. These holes are parallel to the center mast and are equally spaced around the diameter, 51-1/2 degrees apart.

"Beginning at the top of the mast, with an extension of 6 or 7 inches parallel to the ground, #10 gauge bare copper wires are run down through the concrete foundation's outer edge. From there they branch out, in 18-inch deep trenches, to a distance of not more than 144 ft from the mast's center. At this point, each wire is wrapped several times around an Alnico-V permanent magnet. The end of each wire is brought above ground and pointed back toward its other end on top of the tower. The magnet is given a coat of plastic to protect it from rust and to hold the windings in place.

"The trenches and magnets are covered with earth. The 18-inch depth is to protect the wires from cultivation, they must remain uncut if the system is to function. One wire on the tower, and hence in the earth, must point toward magnetic North. The placing of this first magnet must be done very accurately, and the others should be accurately placed.

"The magnet sets are inclined toward the mast at 34 degrees to the surface of the ground. Pointing the buried bar magnets toward the North magnetic pole, but also setting them so they point or tilt toward the central mast gives a skew to the flux or flow of energy.

"This system has protected groves when temperatures have fallen to as low as 20^{o} F. The system does not alter the air temperature in the grove. Rather, it seems to effect a condition in the plants themselves, so that lower temperatures will not induce freezing. Fruit laying on the ground will freeze." **(26-28)**



5.7 ~ Electrogenic Seed Treatment

In the 1970s, A. Zaderej and C. Corson formed Intertec, Inc., to develop and market their "Electrogenic Seed Treatment". The Intertec system simulates a variety of atmospheric conditions are known to benefit plant development. The seeds are conditioned and rejuvenated, resulting in more rapid germination and increased yields.

Seeds are sprayed with a solution of minerals and enzymes that is implanted into the seed coat by electrophoresis; this accelerates chromosomatic activity. A second exposure to high voltage negative ions increases the implantation. Then the seeds are exposed to infrared radiation in order to reduce the hard-seed dormancy and increase the metabolism of ATP.

The next stage uses an electrostatic charge to give cathodic protection. This reduces the mortality rate of seeds by providing a source of electrons to buffer the reaction with free-radical nutrient ions. Seeds must be moist when treated with cathodic protection. Dry seeds may be damaged by this treatment, but damaged seeds can be repaired somewhat if they are moistened. Cathodic protection increases viability and germination up to 200%.

The final stage of the Electrogenic process treats seeds with select radio frequencies that stress the memory of DNA molecules, charges the mitochondria, and intensifies other metabolic processes. This treatment increases the degree of water absorption, electrical conductivity, and oxygen uptake. The frequencies range from 800 KHz to 1.5 MHz with a field intensity of 3.2 W/sq cm.

The seeds need to be treated at or near where they are to be sown. For some unknown reason, the effects of Electrogenic treatment apparently do not travel well.

5.8 ~ Sound

The growth of plants can be stimulated by sound alone. The effect continues up to 50 KHz. Frequencies of 4-5 KHz are particularly effective for increasing germination, enzyme activity, and respiration.

Normally, the streaming movement of protoplasm in plant cells slows down in the early morning and evening, but this streaming can be accelerated by an audio frequency generator used for 30 minutes at a distance of about 5 feet from the plants. As a result, the amount and rate of growth increases. Plants should not be treated thus for more than 3 hours daily, or the plants are likely to die within a month or two, depending on the quality of the sound and its intensity. Very loud, high frequency sound causes cellular disruption and death. Some rock'n roll music also does so.

A revolutionary process called "Sonic Bloom", invented by Dan Carlson, uses a 3 KHz tone (modulated to produce birdlike chirps and whistles) and a foliar spray (55 trace minerals, seaweed, gibberellin and amino acids) to produce "indeterminate growth in plants". His first success was with a Purple Passion houseplant that normally grows only about 18 inches. Under the influence of Sonic Bloom, the plant eventually grew over 1,200 feet, and earned itself a place in the *Guinness Book of World Records*. **(29)**

Growers using Sonic Bloom report dramatic increases in yield, better tasting vegetables and fruits, and more brilliant flowers. Cultivators can expect increased production and early maturity. Alfalfa sprouts will increase in weight by 1,200% within 3 days. The sprouts will have a much longer shelf life (2-3 weeks) than usual (3-4 days). Experiments with Sonic Bloom in Africa produced plants which survived extremely hot weather and flooding. Sonic Bloom also will produce fruit on first year trees. Apple farmers have reported triple-sized yields, 8-month shelf life, and a huge increase in nutrient values: 126% more potassium, 326% more chromium, 400% more iron, and 1,750% more zinc. Losses to diseases and pests have been reduced more than 80%. Because Sonic Bloom contains Gibberilic Acid (GA3), it cannot be used indiscriminately with hemp, as GA3 strongl affects the development of cannabis.

Otherwise, the possibilities are unlimited. For example, Carlson says:

One of our greatest breakthroughs to make everyone understand how easy it is to feed large amounts of people, involved a sucker on a tomato. A sucker is normally a sterile branch which appears in between a side shoot and the main branch. Our tomato plants grow 2 inches a day so if we allow a sucker to grow for seven days, it's about 14 inches long. If we then cut it off, put it in the shade and spray it once a day with a 1/4 ounce per gallon solution of Sonic Bloom, in 10-14 days it becomes fully rooted and starts to grow 2 inches per day. Fifty-five days later, it is 7-9 feet tall. Now, normal production on tomatoes is 90 days. We're doing this in less than 55, plus we're producing at least twice as much fruit in almost half the time."

Water is added to the concentrated Sonic Bloom formula. The cassette (containing a 3 KHz signal and nature sounds) is played at high volume with high treble and medium bass for 10 minutes before spraying the plants. The plants are then sprayed while the cassette is playing, and the sound is continued for another 20 minutes after spraying. Both sides of the leaves should be saturated. Treatment is best performed early in the morning (before 9 am), preferably in foggy weather. On cold mornings, spraying should be delayed until late afternoon. Do not spray plants when the temperature falls below 50^{o} F. The formula also can be administered in the regular weather supply, by drip-feeding, hydroponics, etc. The nutrient solution should be applied once a month for the first month, then twice weekly thereafter. Seeds should be soaked in dilute nutrient solution for 8 hours or overnight while the sound tape is played continuously on a cassette deck with auto-reverse capability. Plant the seeds immediately. The tape ought to be played daily for at least 30 minutes during daylight hours.

5.9 ~ Monochrome & Pulsed Light

Plants respond to light with a complex variety of reactions that are affected by the duration (photoperiod), intensity, and wavelength of the light. During the 19th century, Edward Babbitt and others reported that the germination of seeds increases by 50% under the influence of blue light (provided by blue glass filters). Plant vitality is increased, growth is accelerated, stem and leaf development are improved, and yields are increased.

In 1861, General A.J. Pleasanton constructed a 2,200 sq ft greenhouse in which every eighth pane was blue. Pleasanton obtained phenomenal results in terms of increased yields, improved flavor, etc, and he received US Patent # 119,242 for "Improvements in Accelerating the Growth of Plants and Animals." He recommended a ratio of white 8:1 blue light for optimal plant growth, and a ration of 1:1 for best animal development. Blue light stimulates the directional response of plants to light. Plants' pores open more widely in the presence of blue light (use it with Sonic Bloom). Evaporation and photosynthesis are intensified and chlorophyll production is accelerated. Some cells may rupture, however, and mitosis may be inhibited.

The He-Ne laser (632.8 nm) can influence the phytochrome-controlled germination, growth and development of plants from a distance of more than a quarter-mile. The maximum effect is obtained by only 1 or 2 minutes of exposure to reflected laser light. More than 10 minutes of irradiation will inhibit the phytochrome response. In some cases, successive nightly irradiations of low intensity have a significantly greater effect than a single exposure of greater length or intensity. The response can be reversed by alternating exposure to laser and infrared light. **(30-32)**

G. Krustev, *et al*., investigated the effect of laser irradiation on hemp production, and determined that **laser treatment improved the sowing qualities of the seeds, shortened the phases of plant development, produced more vigorous plants, and increased the yields of both stems and seeds to a considerable extent**. The researchers used a He-Ne laser for 15 and 30 minutes, and a nitrogen laser with 225 and 450 impulses. **(33)**

Red light can be used to increase the growth of some plants (beans, etc.) up to ten times the normal rate by stimulating phytochrome activity. Red light at 660 nm stimulates growth, development, flowering, and fruiting. When red light at 700 nm is available with 650 nm red light, photosynthetic activity is considerably greater than with either single frequency. Blue light at 420 nm enhances the effect of 650 nm red light. Photosynthesis occurs at approximately 440 nm.

Photosynthesis can be increased up to 400% by means of intermittent light. The researchers used a rotating disk with a cut-out section to chop the light from a lamp. They found that 75% of the light from a given source could be blocked without decreasing the rate of photosynthesis. The improved yields produced by intermittent light depends on the frequency of the flashing. A frequency of 4 flashes/minute resulted in 100% increased yields. The amount of work done by the light can be increased by shortening both the light and dark periods. For example, yields can be increased 100% by using 133 flashes/second. Emerson and Williams improved the yield (compared to continuous light) by 400% by using only 50 flashes/second. The light flashes must be much shorter than the dark period.

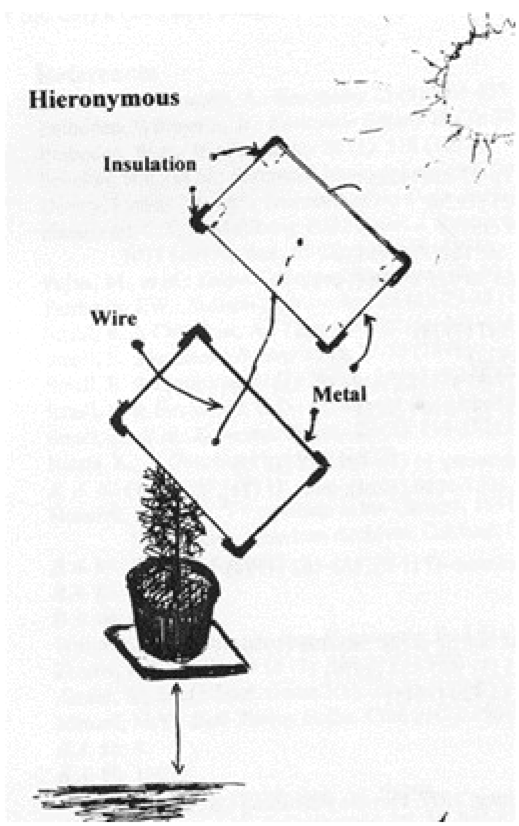
The minimum dark period is about 0.03 at 25° C. The light reaction begins with about 0.001 second/flash, and it depends on the concentration of carbon dioxide.

A. Shakhov, *et al*., developed several methods of applying Concentrated Pulsed Sunlight (CPSL) to stimulate the photoenergetic activity of seeds and plants. The flashes of CPSL last from 0.2 to 1 second and produce significant effects on physiological processes and increase plant productivity. The CPSL effect is not caused by the thermal action of concentrated light, but by endowing plants with a "photoenergy reserve" that increases yields of vegetable crops by 20-30%, and grain crops by 5-10%.

Arrays of aluminum and glass dishes are used to concentrate sunlight up to 100 times. The apparatus is shaken lightly by various means to pulse the irradiation as it is directed on seeds or plants. In one such device, a large semi-conical aluminum reflector is rotated by a motor at 100-130 rpm. The seeds arrange themselves in a single layer on the wall of the pan and receive intermittent irradiation as they pass through a fixed focal spot on the inside wall. Artificial lighting (70,000 lux) pulsed 120 flashes/min. was found to produce effects even though the light energy was much lower than that of CPSL. With duckweed, maximum growth was obtained with a pulse period of 0.004 second.

Another system uses tinted mirrors to produce single colors. S.A. Stanko irradiated soy plants with pulsed red light for 30 min/day for a week, resulting in a 8% increase in the protein content of the beans.

Thomas G. Hieronymous discovered that a plant can be grown in complete darkness indoors if it is connected by an insulated wire to a large metal surface that is exposed to sunlight. The plant must be at least 6 feet above ground and insulated to generate a voltage potential or antenna effect. The optimal size of the metal sheet must be determined by experiment so as to avoid sunburn (too large) or yellowing (too small). Plants cultivated in this manner will develop normally, while control plants will be stunted.



Dr. Wilhelm Reich (of Orgone fame) also found that plants could be grown without light if they were grown with magnetite that had been exposed to sunlight. The magnetite absorbs and reradiates solar energies that are utilized by plants.

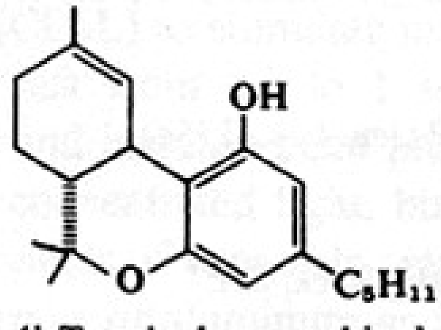
6.1 ~ The Cannabinoids

Cannabis' notorious resin is a complex mixture of cannabinoids, terpenes, and waxes, etc. There are about 100 known cannabinoids that occur only in hemp, with the exception of Cannabichromene, which is found in a few other plants. The entire hemp plant contains several hundred known chemicals.**(1-3)**

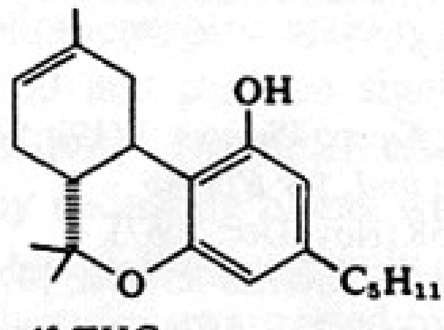
The cannabinoids are thought to be formed by condensation of monoterpene derivatives such as geraniol phosphate with a depside-type olivetolic acid. This leads initially to the formation of Cannabigerol (CBG) and Cannabichromene (CBC) and their carboxylic acids, then to Cannabidiolic Acid (CBDA), which undergoes ring closure to form TetraHydroCannabinol (THC) and its acid (THCA). The latter decarboxylates to form THC. Other biogenetic pathways featuring CBC have been proposed by De Faubert Maunder and by Turner and Hadley. **(4, 5) (Fig. 6.1)**

Figure 6.1 ~ Cannabinoids

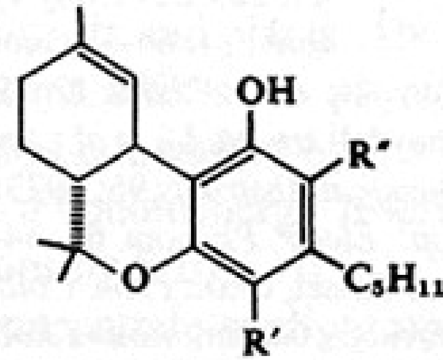
Figure 6.1
Cannabinoids
(R. Mechoulam)



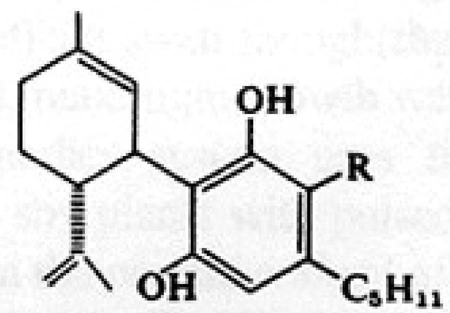
Δ^1-Tetrahydrocannabinol,
Δ^1-THC (Δ^9-THC)



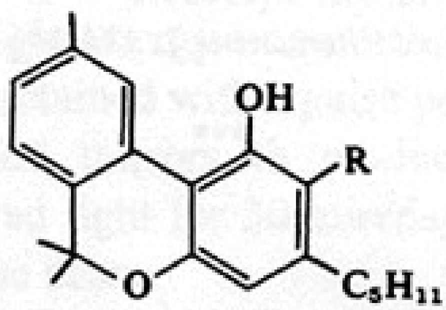
Δ^6-THC
($\Delta^{1(6)}$-THC, Δ^8-THC)



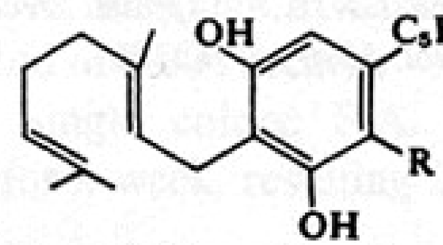
R′ = H and R″ = COOH
Δ^1-THC acid A
R′ = COOH and R″ = H
Δ^1-THC acid B
(Δ^9-THC acids)



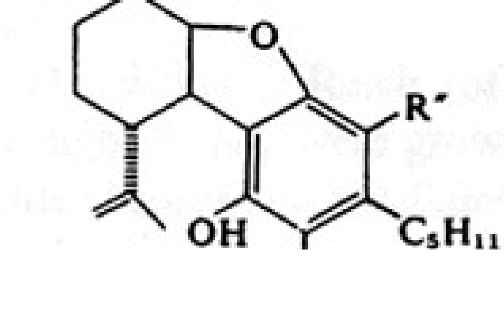
R = H, Cannabidiol (CBD)
R = COOH,
Cannabidiolic acid

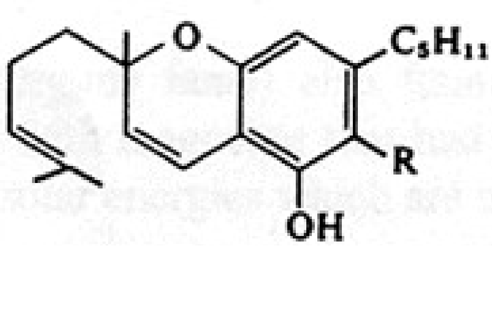


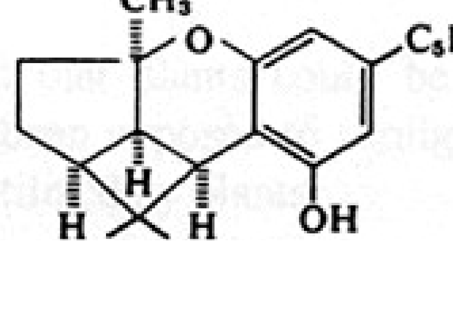
R = H, Cannabinol (CBN)
R = COOH,
Cannabinolic acid



R = H, Cannabigerol
R = COOH,
Cannabigerolic acid
(methyl ethers of bo
are known)







The acids comprise up to 40% of the cannabinoid content of young plants. THC dehydrogenates to form Cannabidiol (CBD). THC is a primary psychoactive cannabinoid. The minor constituent Cannabiverol (CBV) possesses only about 20% of THC's activity. CBD and CBN are not psychoactive, but they have valuable medical properties. **(6-10)**

Many synthetic analogs of THC are more or less potent than the parent molecule. The dimethylheptyl derivative is over 50 times more active, with effects lasting several days. Some nitrogen and sulfur analogs also are psychoactive.

The total synthesis of THC has been accomplished in many ways, most of which are difficult. However, the extraction of cannabinoids, their purification, isomerization and acetylation are easy experiments for dilettante *souffleurs* who would possess this elixir.

6.2 Extraction ~

Cannabis must be dried be it is extracted, because it is not possible to remove more than 50% of the cannabinoids from fresh material THC-Acid is difficult to extract If you plant to convert the THCA to THC, the plant material should be thoroughly decarboxylated by heating it under nitrogen at 105° C for 1 hour before performing a solvent extraction.

Chloroform is the most efficient solvent for the extraction of THC from cannabis. A single extraction will remove 98-99% of the cannabinoids within 30 minutes. A second extraction removes only 88-99% of the cannabinoids within 30 minutes. A second extraction removes 100% of the THC. Light petroleum ether (60-80°) also works well, but a single extraction removes only 88-95% of the cannabinoids; a double extraction removes up to 99%. Ethanol also can be used, but it removes ballast pigments and sugars which complicate the purification of the resin **(11, 12)**

Extract the dried cannabis with a suitable solvent for several hours at room temperature or by refluxing. Filter through charcoal to clarify the solution, then chill overnight to precipitate waxes, then filter the solution again. Concentrate it to one-half volume, and extract it with 2% aqueous sodium sulfate (to prevent oxidation). Separate the aqueous layer, and strip the solvent. The residue is crude hemp oil.

The odoriferous terpenes can be removed by steam or vacuum distillation. Cautious distillation in vacuo yields a fraction of crude red oil (bp 100-220° C/3 mm). This can be purified by redistillation or column chromatography. Use ethanol to remove the residue from the flask while it is still hot. Filter the solution through charcoal, and strip the solvent. Distill the residue to yield pure red oil (bp 175-195° C /2 mm). Distillation must be stopped if smoke appears, indicating decomposition. **(13, 14)**

Because THC is heat-sensitive, it is preferable to isolate the cannabinoids by column chromatography. The simplest method of column chromatography is performed with ethanol and ether extracts of hemp on alumina, yielding two major fractions: (1) chlorophyll, CBD, and CBN, and (2) THC. A second, more difficult method is performed on Florisil (use 10 times the weight of the oil) with the solvent system hexane:2% methanol. This yields a doubly-concentrated, viscous oil which can be repeatedly chromatographed on alumina to separate the THC and CBD. **(15)**

6.3 Isomerization ~

The potency of marijuana can be increased by about 50% simply by simmering a water slurry of the material for 2 hours. Add water as necessary to maintain the level. Cool and filter the mixture, and refrigerate the aqueous solution. Dry the leaf material at low heat. Drink the tea before smoking the marijuana. The effects are much more intense and last longer than those from the untreated leaves. The boiling water treatment isomerizes the inactive CBD, and decarboxylates THCA to THC.

Although Cannabidiol (CBD) has no psychoactivity, it does antagonize THC and produces other valuable sedative, antibiotic, and anti-epileptic effects. CBD can be isomerized to THC. If the plant is Phenotype III (containing mainly CBD in its resin), isomerization can double the yield of THC.

The CBD fraction of column chromatography can be distilled (bp 187-190° C/2 mm; pale yellow resin) to purify it. Isomerization can be accomplished with any of several solvents and acids. Alcohol and sulfuric acid isomerizes only 50-60% of CBD to THC; p-TolueneSulfonic Acid (p-TSA) in petroleum ether or other light, non-polar solvent will convert 90% of CBD to THC upon refluxing 1 hour at 130° F. **(16, 17)**

Reflux 3 gr CBD in 100 ml dry benzene for 2 hours with 200 mg p-TSA monohydrate until the alkaline Beam test (5% KOH in ethanol) is negative (no color). The Beam test gives a deep violet color with CBD. Separate the upper layer, wash it with 5% sodium bicarbonate, wash again with water, and strip the solvent. The remaining viscous oil should give a negative reaction to the Beam test. The crude THC can be purified by distillation (bp 169-172° C/0.03 mm), or by chromatography in 25 ml pentane on 300 gr alumina. Elute with pentane 95:5 ether to yield fraction of CBD and THC. Combine the THC fractions and distill (bp 175-178° C/1 mm).

Reflux 2 gr CBD in 35 ml cyclohexane, and slowly add a few drops of sulfuric acid. Continue to reflux until the Beam test is negative. Separate the sulfuric acid from the reaction mixture. Wash the solution twice with aqueous sodium bicarbonate, the twice again with water. Purify by chromatography, or distill (bp 165° C/0.01 mm). Any unreacted CBD can be recycled.

Another method is to reflux a mixture of 6 gr dry pyridine hydrochloride and 3 gr CBD at 125° C until the Beam test is negative. Wash the reaction mixture with water to remove the pyridine, then extract the mixture with ether. Wash the ether with water, evaporate the ether, and distill the residue i.v. to yield pure THC.

Similarly, reflux 3 gr CBD in 150 ml ethanol with 50 ml 85% phosphoric acid until the Beam test is negative. Work up the reaction mixture, and purify the THC.

Alternatively, reflux 3 gr CBD in 100 ml absolute ethanol containing 0.05% HCl for 19 hours. Extract the ether, wash the ether with water, dry, evaporate, and chromatograph on 400 gr alumina to yield:

(a) 0.5 gr 1-EthoxyHexaHydro-CBN (EHH-CBN: mp 86-87° C); elute with pentane 98:2 ether. Recrystalize from methanol and water.

(b) 2 gr THC; elute with pentane 95:5 ether. Repeated chromatography will separate the less polar forms.

(c) 0.5 gr EHH-CBN, eluted with pentane 93:7 ether. It can be isomerized to THC by refluxing in benzene for 2 hours. Cool the reaction mixture, wash it with water; separate, dry, and strip the solvent layer i.v. to yield THC.

CBD also can be isomerized by irradiation of a cyclohexane solution in a quartz vessel with a mercury lamp (235-265 nm) for 20 minutes. Workup of the reaction mixture yields 7-13% THC. **(18-20)**

6.4 ~ Acetylation

THC gives an acetate (ATHC) which is as potent as THC. The mental effects are quite subtle and pleasant. Wohlner, et al., prepared ATHC by refluxing the crude distillate of cannabis oil with approximately 3 volumes of acetic anhydride. It is purified by distillation i.v. or with steam.

Cahn prepared ATHC thus: add 150 ml acetyl chloride (dropwise with stirring and cooling) to 185 gr crude resin in 500 ml dry pyridine. Crystals may separate during the addition, or on standing a few hours at room temperature. Pour the mixture into dilute hydrochloric acid/ice. Separate the oil, then dissolve it in ether. Wash this solution with dilute acid, then with aqueous sodium carbonate, and again with water. Dry the solution with calcium chloride. Strip the solvent and distill the residue (240-270 C°/20 mm). The mixture of acetylated cannabinoids is separated by dissolving 2 gr in 100 ml benzene and chromatography over silica (150-200 mesh). Elute with 800 ml benzene. Combine the washings and the original effluent solutions, then strip the benzene i.v. to recover about 60% yield of light yellow oil. The material remaining on the column contains CBD and other cannabinoid acetates which can be recovered with ethanol and worked up.**(21)**

6.5 ~ Identification

Colorimetric tests are the simplest method of identifying cannabinoids. Hundreds more sophisticated analytical methods have been developed, as a review of *Chemical Abstracts* will reveal.

The Beam test is relatively specific. It gives a purple color with 5% ethanolic KOH, based on the oxidation of CBD, CBG, etc., and their acids to hydroxyquinones. However, THC does not react to the Beam test. Only two plants (Rosemary and Salvia) out of 129 common species tested give a weakly positive reaction. Among some 50 pure vegetable substances such as mono- and sesqui-terpenes, aromatics, etc., only juglone, embelin, and alkyl dioxyquinone develop a color reaction close to that of Cannabis. The reaction is not always dependable; it can be absent if the ethanol is hot. **(22, 23)**

A modification of the Beam test uses absolute ethanol saturated with gaseous hydrogen chloride. When added to an extract of suspect material, it gives a cherry red color which disappears if water is added. However, the test also gives more or less similar red color reactions with pinene, tobacco, julep, sage, rosemary, and lavender, etc..

The colorimetric test of Duquenois and Moustapha is not so specific as the Beam test, but it is very sensitive. The test reacts to CBN and CBD, but not to THC:

Vanillin (0.4 gr, acetaldehyde (0.06 gr) and 20 ml 95% ethanol is stored in a bottle. Extract the plant material with petroleum ether, then filter it and evaporate the solvent. Add exactly 2 ml of reagent and 2 ml concentrated hydrochloric acid. Stir the mixture; it turns sea-green, then slate gray, followed by indigo within 10 minutes. It turns violet within 30 minutes and becomes more intense.

The Duquenois-Negm hydrogen peroxide/sulfuric acid test is suitable for following the development of the resin and its potency. Macerate cannabis in chloroform or light petroleum ether for several hours. Evaporate 0.2 ml of the extract in a porcelain dish. Add 2 drops 30% hydrogen peroxide and 0.5 ml concentrated sulfuric acid. Rotate the dish gently, and observe the color of the liquid after 5 minutes. A pink color indicates CBD; blood-red color indicates a high concentration of THC. Violet or strong brown indicates THC. CBN produces a green color which quickly turns green-brown. **(24)**

The identification of cannabinoids has been made irrefutable by the modern development of gas chromatography, especially when combined with mass spectrometry.

Laboratories which do not possess these technologies can use diode-array and programmable variable-wavelength ultraviolet absorption detectors in conjunction with thin-layer chromatography (TLC) or high-performance liquid chromatography (HPLC), or a combination of both, and make comparisons with published data in conjunction with the specific absorption spectrum for the cannabinoids (200-300 nm). The combination of these techniques can overcome the problem of errors due to interference which often occur when single methods are used. **(25)**

6.6 ~ Neurology

In 1984, Miles Herkenham and his colleagues at NIMH mapped the brain receptors for THC, using radioactive analogs of THC developed by Pfizer Central Research. They found the most receptors in the hippocampus, where memory consolidation occurs. There we translate the external world into a cognitive and spatial "map". Receptors also exist in the cortex, where higher cognition is performed. Very few receptors are found in the limbic brainstem, where the automatic life-support systems are controlled. This may explain why it is so difficult to die from an overdose of cannabis. The presence of THC receptors in the nasal ganglia --- an area of the brain involved in the coordination of movement --- may enable the cannabinoids to relieve spasticity. Some receptors are located in the spinal cord, and may be the site of the analgesic activity of cannabis. A few receptors are found in the testes. These may account for the effects of THC on spermatogenesis and as an aphrodisiac.

S. Munro, *et al*., located a peripheral CX5 receptor for cannabinoids in the marginal zone of the spleen. The Anandamide/cannabinoid receptor site, a protein on the cell surface, activates G-proteins inside the cell and leads to a cascade of other biochemical reactions which generate euphoria. **(26-31)**

The brain produces Anandamide (Arachidonylethanolamide), which is the endogenous ligand of the cannabinoid receptor. It was first identified by William Devane and Raphael Mechoulam, *et al*., in 1992. Anandamide has biological and behavioral effects similar to THC. Devane named the substance after the Sanskrit word *Ananda* (Bliss). The discovery of Anandamide and its receptor site has unlocked the door to the world of cannabinoid pharmacology. **(32-35)**

CBD antagonizes THC and competes with THC to fill the cannabinoid receptor site. THC also exerts an inhibitory effect on acetylcholine activity through a GABA-ergic mechanism. It significantly increases the intersynaptic levels of serotonin by blocking its reuptake into the presynaptic neuron. THC also elevates the brain level of 5-hydroxy-tryptamine (5-HT) while antagonizing the peripheral actions of 5-HT. **(36-39)**

In 1990, Patricia Reggio, *et al*., developed a molecular reactivity template for the design of cannabinoid analgesics with minimal psychoactivity. The analgesic activity of the template molecule (9-nor-9b-OH-HHC) is attributed to the presence and positions of two regions of negative potential on top of the molecule. The template places all cannabinoid analgesics on a common map, no matter how dissimilar their structures. **(40)**

Tables: **1. Properties of Hempseed Oil**
2. Fatty Acid Analysis of Hempseed Oil
3. General Analysis of Hempseed
4. Typical Mineral Assay of Hempseed
5. Typical Protein Analysis of Hempseed

Cannabis sativa, the "True Hemp", is tightly woven into the tapestry of human life. Since earliest times, this great plant ally has provided people with cordage and fabric, paper, medicine, and inspiration. For all the many benefits it bestows, Cannabis hemp is a friendship well worth cultivating. Hemp is many things to many people, and it is known by hundreds of names. Poets and musicians sing its praises, and preachers damn it. Executioners hang condemned men with hemp rope, but sailors and mountaineers hang onto it for dear life. Doctors prescribe it as a versatile medicine, yet prohibitionists proscribe it as a poison. Armies and navies make war with hemp, while lovers use it as an aphrodisiac. It is the warp of the mind's veil of illusion, and the woof of politicians, who "lead us in the manner dogs lead a parade" (Mark Twain). The resinous virtue generates real happiness, enlightenment and entertainment, equal in quality and worth to the similar joys of love, freedom and good health --- and it complements them all, and comforts those without such blessings. Hemp is a most interesting and paradoxical plant, one that defies control and begs understanding. Hemp is one of mankind's best (and few) friends on Earth, yet it is held prisoner within its own cells, bound in a Gordian Knot of laws. Yet again, it is Ariadne's Thread, a guideline out of the labyrinth of bureaucratic tyranny and into a new state of liberty and grace. We should be thankful for Cannabis.

1.
Traditional Materia Medica

Cannabis has been used in medicine since about 2300 BC, when the legendary Chinese Emperor Shen-Nung prescribed *chu-ma* (female hemp) for the treatment of constipation, gout, beriberi, malaria, rheumatism, and menstrual problems. He classified *chu-ma* as one of the Superior Elixirs of Immortality. In the 2nd century AD, the renowned physician Hua Tuo formulated *ma-yo* (hemp wine) and *ma-fei-san* (hemp-boiling powder) as anesthetics for the many surgeries he performed. The 14th century text *Ri-Yong-Ben-Cao* (*Household Materia Medica*) by Wu Rui described the use of hempseed as a medicine.

Chinese herbalists recommend *huo ma ren* ("fire hemp seeds") in doses from 9-15 grams, up to 45 grams, to nourish the Yin (feminine) in cases of constipation in the elderly, "blood deficiency", and to recuperate from febrile diseases. Hempseed is "sweet" and "neutral" and "clears heat". It operates through the channels of the stomach, large intestine, and spleen. It promotes the healing of sores and ulcerations when applied topically or ingested. Excessive, prolonged use may result in "vaginal discharge" or spermatorrhea. **(1)**

Both the ancient Ayurvedic system of Indian medicine and the Arabic Unani Tibbi system make extensive use of hemp for healing. Usually, it is mixed with other vegetable, mineral and animal substances which neutralize the narcotic effects and enhance the therapeutic virtues. The 9th century medical text *Susruta Samhita* describes bhang as an antiphlegmatic against catarrh. The Sanskrit book *Rajbulubha* recommends hemp for the treatment of gonorrhea. The 10th century treatise *Anandakanda* describes the rejuvenating qualities of cannabis:

"Bahnagini is that which breaks the three types of miseries... gives happiness to mind... gives pleasure, lustre, intoxication and beauty... intoxicates like alcohol... helps to overcome death... helps in the excretion of nectar located at the *Brahmarandhra*... accomplishes the objects of mind... liberates living creatures from the bonds of the world... cures all diseases... has attained *siddhi* [spiritual perfections]... and endows *siddhi* on others."

Ayurvedic physicians regularly use the juice of hemp to treat dozens of diseases and other medical problems including diarrhea, epilepsy, delirium and insanity, colic, rheumatism, gastritis, anorexia, consumption, fistula, nausea, fever, jaundice, bronchitis, leprosy, spleen disorders diabetes, cold, anemia, menstrual pain, tuberculosis, elephantiasis, asthma, gout, constipation, and malaria. **(2, 3)**

The *Materia Medica of the Hindus* (1877) states:

"The leaves of Cannabis sativa are purified by boiling in milk before use. They are regarded as heating, digestive, astringent, and narcotic [sleep-inducing]. The intoxication induced by *bhang* is said to be of a pleasant description and to promote talkativeness. In sleeplessness, the powder of the dried resin is given in suitable doses for inducing sleep or removing pain." **(4)**

The ancient Egyptian Ebers Papyrus (E.821) offers "A remedy to cool the uterus":

"Smsm t [hemp] is pounded in honey and administered to the vagina. This is a contraction."

A mixture of hemp and carob was employed as an enema, or combined with other ingredients for use as a poultice (E. 618). The Ramses III Papyrus (A. 26) offers an prescription that is prescient of the modern use of cannabis in the treatment of glaucoma:

"A treatment for the eyes: celery; *smsm t* is ground and left in the dew overnight. Both eyes of the patient are to be washed with it in the morning." **(5)**

The Greek physician Pedacius Dioscorides (1st cty. AD) described *kannabis emeros* (female) in *De Materia Medica* (3:165, 166):

"The round seed, which being eaten of much doth quench geniture, but being juiced when it is green is good for the pains of the ears... The root being sodden, and so laid on hath ye force to assuage inflammations and to dissolve Oedemata, and to disperse ye obdurate matter about ye joints."

The 16th century humorist Francois Rabelais heaped praise on Pantagruelion (hemp) in giving passing notice of its healing properties in his novel *Gargantua and Pantagruel*:

"I won't stop to tell you how the juice of this marvelous herb, squeezed out and placed in the ears, kills every manner of putrefied vermin that could possibly have bred in there, as well as all other creatures that might have crawled in. Put this juice in a small pail of water and you'll see the water suddenly coagulates like clotted milk --- that's how powerful it is. And this coagulated water is a sovereign remedy for colicky horses, and also those with short breath...

"If you want to cure a burn, no matter whether it be from boiling water or burning wood, just rub on raw Pantagruelion, just as it comes out of the earth, without doing anything else. But be careful to change the dressing, when you see it drying on the wound.." **(6)**

Hemp was a popular remedy in medieval Europe. In addition to the applications mentioned above, the herb was used to treat toothaches, to facilitate childbirth, to alleviate convulsions, fevers, inflammations, jaundice, and reduce swollen joints in arthritis and rheumatism. Cannabis was found worthy of honorable mention as a healing plant in several medieval herbals.

In the 18th century treatise *Hemp* by M. Marcandier, readers are reminded:

"Pliny tells us, the Hemp-seed is of a drying nature, that it weakens the generative powers in men when they eat it to excess. On the contrary, it promotes fruitfulness in fowls, for which reason it is purposely given them in winter time, and is a food to which birds are accustomed. It expels wind; is hard of digestion and disagrees with the stomach; it produces bad humour, and occasions headaches. It was formerly one of those legumes, which are fried for desserts: It was also made into little sweet cakes, to be eaten at collations, and to promote drinking; but at present, this unwholesome ragout is quite banished from our tables: It heats those that it too freely so much, that it occasions very dangerous vapours; so that those who prescribe a decoction of this seed to children that labour under epilepsies, far from procuring them relief, increase and irritate their disorder. The juice of it, squeezed out when it is green, draws insects to it, and brings out all the vermin that enter into the ears, and infest them. Taken in an emulsion, it is good against a cough and the jaundice, and also against the gonorrhea; its oil is recommended as an ingredient in pomatums for the small-pox; and it is laxative. Taken inwardly, or outwardly applied, it has not the dangerous qualities that are ascribed to the whole plant with its leaves; the powder of it mixt with drink, will make those who use it drunk, dull, and stupid: We are told that the Arabians make a sort of wine of it, which intoxicates, and poor people eat the oil of it in their soup.

"The grain and the leaves being squeezed, while they are green, and applied, by way of cataplasm, to painful tumors, are reckoned to have a great power of relaxing and stupefying... What Pliny assures us, of the great effect which an infusion of Hemp may have in coagulating water, will not appear surprising if we attend to the quality and quantity of the gum, which unites all the fibres of this plant together... It is, doubtless, for this reason, that it is given in drink to cattle to cure looseness. The decoction of green Hemp, with its seed, when well cleared of the dregs, causes the worms to come out of the ground on which it is poured, and the fishermen commonly make use of this expedient to catch them, when they have occasion...

"It abates inflammations, dissolves tumors and hard swellings upon the joints. Beat and pounded in a mortar, with butter, when it is still fresh, it is applied to burns, which it relieves greatly when it is often renewed. The juice and decoction of it, put into the fundaments of horses, brings out the vermin that infest them."

In his *Herbal*, Nicholas Culpepper (1616-1654) advised readers thus:

"An emulsion or decoction of the seed... eases the colic and always the troublesome humours in the bowels and stays bleeding at the mouth, nose, and other places."

Cannabis offers other mercies. In the 1830s, Dr. William O'Shaugnessy administered 2 grains of the resin to alleviate the suffering of a man dying of hydrophobia:

"In reviewing... this interesting case, it seems evident that at least one advantage was gained from the use of the remedy; the awful malady was stripped of its horrors; if not less fatal than before, it was reduced to less than the scale of suffering which precedes death from most ordinary diseases." **(7)**

Cannabis also was reported to be useful with varying degrees of success in the treatment of alcoholism, asthma, bronchitis, constipation, diarrhea, dysentery, dysmenorrhea and uterine hemorrhage, dropsy or edema, epilepsy, insanity, migraine, palsy, rheumatism, anthrax, beriberi, blood poisoning, incontinence, leprosy, malaria, snakebite, tonsillitis, parasites, and a legion of other maladies. **(8-11)**

In the late 19th century, cannabis was included in dozens of remedies available by prescription or over-the-counter. Reports of "cannabis poisoning" began to concern doctors. But V. Robinson noted in *An Essay on Hasheesh* (1912):

"An overdose has never produced death in man or the lower animals. Not one authenticated case is on record in which Cannabis or any of its preparations destroyed life... Cannabis does not seem capable of causing death by its chemical or physiological action." **(12)**

2.
Modern Medical Studies

After it was criminalized by the Marijuana Tax of 1937, cannabis was deleted from the British and US *Pharmacopoeia*, *Merck Index*, etc.. Despite governmental efforts to suppress the plant, people have continued to rediscover the medical benefits of cannabis, and thousands of scientific articles have been published to that effect. Dozens of therapeutic effects have been reported for the major cannabinoids, TetraHydroCannabinol (THC), Cannabinol (CBN), and Cannabidiol (CBD)**(Fig. 2)**

2a.
Glaucoma: --- Several million people worldwide are afflicted with glaucoma, in which the unchecked rise of intraocular pressure (IOP) causes irreparable damage of the retina and optic nerve, resulting in blindness. About 250,000 Americans suffer from glaucoma, and several thousand people go blind from the affliction each year in the USA. Glaucoma is somewhat controllable with medications, all of which are attended by dangerous side-effects -- with the exemption of cannabis.

In 1971, while conducting an experiment to determine whether cannabis dilated the pupils, R.S. Hepler and I.M. Frank chanced to notice that the smoking of marijuana reduced IOP by about 25% after 30 minutes. In addition, there was a 50% reduction in tear flow and in ocular pulse pressure. Subsequent studies confirmed this effect with THC and cannabis extracts administered orally, intravenously, or by topical application of THC in sesame oil. There is no development of tolerance. **(13-15)**

The mechanism of this effect is uncertain, but it is known that THC increases the outflow facility of the eyes and reduces the secretion of ocular fluid by constricting the blood vessels of the ciliary epithelium. CBD has no effect on IOP. Cannabis is known to produce tears and mild reddening of the conjunctiva, but these effects have little apparent clinical significance.

In a contrary finding, W. Daeson, *et al*., reported that chronic users in Costa Rica had increased IOP and an apparently incorrectable optical acuity deficit. A case of conjugate deviation of the eyes reportedly was caused by cannabis intoxication, according to Mohan and Sood. The effect lasted six weeks. **(16, 17)**

Dr. M.E. West confirmed the Jamaican folk belief that a run-extract of cannabis improves night-vision. Dr. West and Dr. Albert Lockhart eventually prepared a non-pyschoactive substance, called Canasol, which showed a marked improvement on IOP and "significant improvement in night vision." **(18, 19)**

The report by West and Lockhart prompted Keith Green, *et al*., to isolate and test water-soluble extracts of cannabis for IOP-reducing activity. Some compounds were found to reduce IOP by about 60% for up to 60 hours with doses as low as 1 microgram, administered intravenously. Other routes of administration are ineffective, due to the extremely large size of the glyco-protein molecules. **(20-22)**

2b.

Anti-Emetic --- In the 1970s, many patients undergoing chemotherapy for AIDS, Hodgkins disease and other cancers discovered that they suffered less nausea and vomiting if they smoked marijuana before receiving treatment. Subsequent tests by several oncologists showed THC to be superior to chlorperazine as an anti-emetic, but no more effective than metoclopramide or thiethylperazine. In other trials, no difference was found between the anti-emetic effects of THC. The emesis produced by methroxate, duxorubium, cyclophosphamide and flouracil are dramatically reduced by THC. It is less beneficial for patients receiving mustine, nitrosoureas, and cisplatin therapy. The synthetic cannabinoid Nabilone was found to be more effective than prochlorperazine as an anti-emetic in cisplatin treatment. The side-effects of being "high", dysphoric, sedated, etc., are tolerated better by young persons than by elders. The synthetic THC analog Levonantradol is known to possess anti-emetic activity while producing only mild side effects. Sallan, *et al*., found that nausea an vomiting was controlled by THC in 81% of patients. **(23-27)**

Chemotherapy patients who use cannabis as medicine generally prefer to smoke marijuana rather than ingest synthetic THC (Marinol) because they usually vomit before the pill can take effect (up to 3 hours later). Smoking allows the patient to titrate the dose puff by puff, and the drug takes effect within a few minutes. Synthetic THC loses its effectiveness after only a few treatments, and it is expensive. Alternatively, it is a simple matter to prepare an extract with clarified butter. This is administered in suppository capsules with pinholes poked in them.

Harvard University surveyed members of the American Society of Clinical Oncology in 1990, and found that 44% of the 1,035 respondents acknowledged that they had recommended the illegal use of marijuana to at least one patient undergoing chemotherapy. 48% agreed that they "would prescribe marijuana in smoked form to some of their patients if it were illegal." **(28)**

2c.
Asthma --- For the past 3,000 years or more, cannabis has provided welcome relief for countless numbers of asthmatics. It was widely used for that purpose in the 19th century. The inhalation of marijuana smoke causes bronchial dilation lasting up to 1 hour. The bronchodilator effect of orally-ingested THC lasts up to 6 hours, but it is not so powerful as smoking marijuana. THC aerosols are not so effective as smoking marijuana because aerosolized THC has an irritating effect on the air passages. **(29)**

L. Vachon, *et al*., reported that 0.7 mg. THC in a micro-aerosol proved to be up to 60% effective as a bronchodilator, with minimal mental effects and no parasympathetic effects. J. Hartley, *et al*., found that administration of minute doses (50-200 micrograms) of THC by inhalation increased the peak expiratory flow and forced expiratory volume in 1 second in a dose-related manner. The effects last 4 hours. D. Tashkin, *et al*., explored the anti-asthmatic effect of THC, and found it to be useful against the encroachment of emphysema. R. Gordon, *et al*., confirmed the anti-tussive effect. Cannabis also has been used with success in the treatment of whooping cough. In 1955, J. Sirek reported on the importance of hempseed in tuberculosis therapy, but the discovery has been largely ignored since then. **(30-34)**

2d.
Anti-Convulsant --- Cannabis' power to control spasticity and convulsions has been applied in folk medicine for thousands of years. The first European report of this effect was published in the 1830s by Dr. William O'Shaughnessy, who stated that "The [medical] profession has gained an anti-convulsive remedy of the greatest value." Dr. J. Russell Reynolds, who was Queen Victoria's personal physician for 30 years and administered cannabis to her, praised the anti-convulsive virtue of hemp. He wrote that "There are many cases of so-called epilepsy... in which India hemp is the most useful agent with which I am acquainted." **(35, 36)**

Many thousands of victims of all forms of convulsions, spasticity, and epilepsy, and of paralysis --- paraplegia, quadriplegia, Muscular Dystrophy (MD), Multiple Sclerosis (MS), and chorea, etc., and the associated neuralgias --- praise cannabis for its unique power of relaxation. Anecdotal reports of its efficacy prompted clinical studies which showed that Cannabidiol can help some patients to remain nearly free of convulsions without any toxicity or psychoactive side-effects. W.A. Check found a limited effect of smoking marijuana to alleviate the spasticity of MS. Experiments conducted by P. Consroe, *et al*., demonstrated a dose-related improvement of idiopathic dystonias by treatment with CBD. Other researchers have found THC to be useful in the treatment of MD. **(37-40)**

While testing THC for possible immunosuppressive effects, Lyman, *et al*., found that guinea pigs treated with THC developed few or no symptoms of experimental autoimmune encephalitis (EAE), which is used as a laboratory model of MS. 98% of untreated animals died, while 95% of the animals treated with THC survived and had much less inflammation of their brain tissue. **(41, 42)**

The 11-hydroxy metabolites of THC have been reported to be more effective against convulsions than the parent molecule. CBD also possesses anticonvulsant properties without producing behavioral impairment or tolerance, and it works where other drugs are refractory, or in combination with them. The CBD nucleus has been recommended as a template for the development of other anti-epileptic drugs. **(43, 44)**

In 1998, Gilson and Busalacchi reported a new medical use of cannabis, i.e., for the treatment of intractable hiccups. In their letter to *Lancet* (351: 267) the authors concluded:

"Because intractable hiccups is an uncommon condition, it is unlikely that the use of marijuana will ever be tested in a controlled clinical trial, and blinding would be difficult. Despite federal policy which forbids the use of marijuana therapeutically, this report should be considered for hiccups refractory to other measures."

2e.
Tumors--- L. Harris, *et al*., found anti-tumor effects of THC and CBN on Lewis Lung Tumor (LLT), but not in L-1210 Leukemia. THC and CBN inhibited primary tumor growth from 25% to 82% and increased the life expectancy of cancerous mice to the same extent. The anti-tumor activity of THC and CBN is very selective; it reduces tumor cells without damaging normal cells. CBD was ineffective. A. White, *et al*., found that THC slightly inhibited DNA replication, but CBD appeared to enhance the growth of LLT.

A 1975 study of "The Antineoplastic Activity of Cannabinoids" by the Department of Pharmacology and the Medical College of Virginia Commonwealth University Cancer Center reported:

"Lewis lung adenocarcinoma growth was retarded by the oral administration of delta-9-THC... and CBN, but not CBD. Animals treated for 10 consecutive days with delta-9-THC, beginning the day after tumor implantation, demonstrated a dose-dependent action of retarded tumor growth. Mice treated for 20 consecutive days with delta-8-THC and CBN had reduced primary tumor size."

M. Friedma reported that THC and CBD failed to inhibit tumor macromolecular biosynthesis in LLT. **(45-48)**

In 1994, the National Toxicology Program conducted a study which showed that THC protects against malignant tumors. The report was suppressed for three years. According to NTP deputy director John Bucher, the delay was due to a "personnel shortage".

2f.
Antibiotic --- The cannabinoid acids effectively inhibit and kill Gram(+) bacteria such as Staphylococcus and Streptococcus. An alcoholic extract of cannabis has been recommended as a topical application and for use in the treatment of penicillin-resistant

organisms. The preparations of cannabis can be applied to the skin or mucous membranes as a salve, poultice, or spray.

J. Kabelic, *et al*., reported a case in which a pathologist injured his thumb during a dissection. It became severely infected and was absolutely resistant to other antibiotics. Amputation was imminently necessary, but the infection was defeated by the last resort of cannabis extract.

Herpes labialis (acute viral inflammation of the skin), otitis media (inflammation of the middle ear), and second degree burns have been treated successfully in the same way.

Krejci, *et al.*, identified the active substance as 3-methyl-6-isopropyl-4'-n-pentyl-2',6'-dihydroxy-1,2,3,6-tetrahydrodiphenyl-3'carbonic acid. It was prepared as follows:

"The comminuted drug was extracted with petroleum ether, light benzene, or benzine, a water-soluble salt made by treatment with NaOH, acidified with Hcl, th precipitated resin extracted with ether, and this distilled off. Such a purified extract showed anti-bacterial activity against *Mycobacterium tuberculosis* even when the extract was diluted to 1:150,000. Gram-negative organisms of the coli-typhus group... were not affected... Blood, blood plasma, and serum partially inactivated the anti-bacterial substance, reducing the antibiotic effect... Sodium salts of the isolated amorphous substance showed increasing activity with increase of pH from 5 to 7.5; whereas crystallized acetyl derivatives (acids) showed increasing activity when pH decreased from 8 to 5..." **(49-52)**

Cannabidiolic Acid (CBDA) in a concentration of 1:200,000 in tomato juice inhibits the growth of *Leuconostoc mesenteroides* without changing the flavor of the drink. CBDA may be treated at 60° C. for 2 hours without affecting its antibiotic activity. CBDA also inhibits lactic acid bacteria which grow along with yeast in fruit juices. CBDA is ineffective in raw fruits. **(53)**

2g.
Arthritis--- Pliny the Elder recommended cannabis in the treatment of arthritis. In his *Treatise on Hemp*, M. Marcandier mentioned this:

"The root of it boiled in water, and applied in the form of a cataplasm, softens and restores the joints or fingers or toes that are dried or shrunk. It is very good against the gout, and other humours that fall upon the nervous, muscular, or tendinous parts."

In 1994 *The Times of London* reported:

"The demand for marijuana among British pensioners has stunned doctors, police and suppliers... The old people use the drug to ease the pain of such ailments as arthritis and rheumatism. Many are running afoul of the law for the first time in their lives as they try to obtain supplies." **(54)**

2h.
Anxiety --- Most users of cannabis find that it produces calm, relaxed feelings, and some persons use it specifically to alleviate anxiety. Some inexperienced people become anxious

or panicky over the side-effects (dizziness, dissociation, etc.), which usually can be minimized by lying down and being reassured that there is no danger. Cannabis or THC does not provide consistent relief from anxiety for clinical purposes. Cannabis can precipitate psychotic episodes in clinical schizophrenics. L. Hollister, *et al*., have shown that oral administration of low doses of cannabis preparations have a sedative and tranquilizing effect without producing psychoactivity. THC alone has been shown to induce anxiety; the effect is blocked by CBD. **(55, 56)**

2i.
Depression--- As early as 1843, Jacques-J. Moreau de Tours extolled the value of hashish in the treatment of melancholy. In his *Observations on Hashish and Mental Illness*, Moreau wrote:

"One of the effects of hashish that struck me most forcibly and which generally gets the most attention is that manic excitement always accompanied by a feeling of gaiety and joy inconceivable to those who have not experienced it... It is really happiness that is produced." **(57, 58)**

In 1943, Dr. George Stockings reported on the synthetic cannabinoid Synhexyl as "A New Euphoriant for Depressive Mental States", particularly neurotic depression. This is the most common psychiatric condition encountered in clinical practice. Stocking concluded:

"The results... suggest that we have in this class of compounds a promising therapeutic agent for the treatment of chronic and intractable depressive states... Synhexyl... has the advantages of low toxicity, minimum of side effects, ease of administration, and chemical stability. Its use is not contra-indicated by the presence of coexisting organic disease, and it is suitable for out-patient practice. Its use does not interfere with other therapeutic measures, such as occupational therapy or psychotherapy. It is free from risks and disadvantages of the more drastic forms of treatment..." **(59)**

The results of more recent clinical studies with THC have been inconsistent. W. Regelson, *et al*., reported a significant reduction of depression in cancer patients with THC, but J. Kotin, *et al*., found no significant anti-depressant activity in several bipolar and unipolar depressed patients. Ablon and Goodwin obtained a positive response with bipolar (manic) depressives, but not with unipolar patients. Be that as it may, many depressed out-patients who do not respond well to standard treatments find respite in marijuana. **(60-62)**

A survey Richard Warner, *et al.* (*Amer. J. Orthopsychiatry,* Jan. 1994) of substance abuse among the mentally ill found that patients who used marijuana enjoyed greater relief from their symptoms (anxiety, depression, insomnia) and suffered fewer hospitalizations. Most patients who used alcohol reported that it worsened their problems.

2j.
Inflammation --- The soothing effect of hemp on inflammatory disorders has been known for centuries. In modern times, cannabis has received recognition from physicians after some patients began reporting that smoking marijuana gave them relief from conditions such as pruritis and atopic dermatitis, an allergic reaction distinguished by severe itching and patches of inflamed skin. The problem can become life-threatening and disfiguring

when it is complicated by infection. Conventional treatments have only limited effect.

R. Turner, *et al*., have shown that THC has an anti-histamine effect. Mishra and Sahai found that an alcoholic extract of cannabis potentiates the anti-pyretic action of aspirin. D. Kosersky, *et al*., showed that oral administration of THC is 20 times more powerful that aspirin and twice as potent as hydrocortisone in its power to inhibit edema. CBD was found to produce over 90% inhibition of erythema at a dose of only 100 micrograms, whereas THC produced only 10% inhibition. **(63-66)**

Another treatment of burns, bedsores, and other skin afflictions is described by B. Carty, *et al*., in US Patent 4,917,889, comprising an aqueous mixture of calcium hydroxide and hempseed oil. **(67)**

2k.
Analgesia --- From ancient times to date, cannabis preparations have been used to relieve pain. Several modern studies have shown analgesic effects of cannabis and its derivatives and analogues in animals, but the human model gives conflicting results. S. Miletin, *et al*., found that cannabis smokers have increased tolerance to experimental pain. To the contrary, Hill, *et al*., failed to detect analgesic action with another type of experimental pain. A study of cancer patients by R. Noyes, *et al*., found THC to be effective in reducing pain, while W. Regelson, *et al*., reportedly found no significant analgesia. The variable and non-specific analgesic effects of THC are accompanied by mental obfuscation, so it is unlikely to become clinically useful for this purpose. Research continues with synthetic analogues of THC. Fairbairn and Pickens showed that an ethanol extract of cannabis will potentiate the effects of pethidine and other analgesics. J. Barrett, *et al*., subsequently isolated two new flavenoids, called Canflavons, which exhibit potent analgesia due to their peripheral activity. **(68-72)**

More recent animal studies by several researchers (Univ. California SF., Univ. Michigan, Brown Univ., Univ. Minnesota) have shown that cannabinoids are effective analgesics which are not addictive, nor do they develop any tolerance. The cannabinoids alleviate several types of pain, particularly that of arthritis. Kennth Hargreaves (Univ. Texas) reported that injection of a THC-analog at an arthritic site relieves associated inflammation:

Local administration of the cannabinoid to the site of injury may be able to both prevent pain from occurring and reduce pain which has already occurred without producing side effects.

2l.
Anesthesia --- THC and CBN prolong ether anesthesia, while CBD reverses the effect. When administered in combination with THC and CBN, CBD reverses the effect of CBN, but not of THC. **(73, 74)**

2m.
Alcoholism --- Several women's temperance societies in the 1890s recommended the recreational use of hashish rather than alcohol, because liquor obviously led to wife-beating, while hashish did not. In fact, it was considered to be an aphrodisiac, and experts

recommended it for the purpose.

In 1891, Dr. J.B. Mattison recommended cannabis as "the best" treatment for delirium tremens. In 1953, Drs. Lloyd Thompson and Richard Proctor tested the synthetic cannabinoid Pyrahexyl in the treatment of alcohol withdrawal and obtained positive results:

We can report clinical alleviation of the symptoms in 59, or 84.28%. The 11 cases that did not show improvement (or 15.72%) did not differ a great deal clinically from the other 59... Perhaps an individual idiosyncrasy is the explanation, for it is known that individual reactions to other drugs do occur." **(75)**

In 1971, J. Scher proposed the use of cannabis as a substitute for alcohol in treatment of withdrawal and in delerium tremens. Rosenburg found no useful effect from cannabis alone. However, experiments conducted with marijuana as a reinforcer of disulfiram in the treatment of alcoholics did give positive results. **(76-78)**

During the rapid rise in popularity of marijuana among students in the 1960s, Dr. Halleck (Univ. Of Wisconsin) commented in the *New York Times*:

"Perhaps the one major positive effect of the drug is to cut down on the use of alcohol. In the last few years it is rare for our student infirmary to encounter a student who has become aggressive, disoriented, or physically ill because of excessive use of alcohol. Alcoholism has almost ceased to be a problem on our campuses. Many cannabists consider alcohol to be a debasing and degrading drug which they decline to use if marijuana is available."

2n.
Opiate Addiction --- In some cases, cannabis can serve to alleviate the symptoms of opiate withdrawal. As early as 1885, Dr. E. Birch reported the successful treatment of an opium addict and a chloral-hydrate addict by cannabis substitution and slow withdrawal. In 1891, Dr. J.B. Mattison held forth that "It has proved an efficient substitute for the poppy", and he described the case of "a naval surgeon, nine years a ten grains daily morphia taker... [who] recovered with less than a dozen doses. He recommended cannabis accordingly:

"[Cannabis is] a drug that has a special value in some morbid conditions, and the intrinsic merit and safety of which entitles it to a place it once held in therapeutics... Indian hemp is not here intended as a specific. It will, at times, fail. So do other drugs. But the many cases in which it acts well, entitle it to a large and lasting confidence." **(79-81)**

In a study of 49 cases of opiate withdrawal, conducted in 1942 by Drs. S. Allentuck and K. Bowman, cannabis was substituted for opium:

"The withdrawal symptoms were ameliorated or eliminated sooner, the patient was in a better frame of mind, his spirits were elevated, his physical condition was more rapidly rehabilitated, and he expressed a wish to resume his occupation sooner." **(82)**

Prof. Sandra Welch (Virginia Commonwealth Univ.) found that THC has a pronounced potentiating effect on morphine. At a low dose, THC increases the analgesic effect of morphine by 500%. At double the dose of THC, the effect is 10 times greater. The effect is not additive, and is relatively safe:

"One major advantage to a marijuana-morphine combination would be to reduce both the morphine component and a major morphine side-effect, depression of the respiratory system. It has already been confirmed that marijuana has no effect on the medulla, the center of the brain that controls respiration." **(164)**

This singular finding may lead to new methods of treating opiate addiction.

2o.
Diuretic --- H. Shirkey and J. Rodger reported a diuretic effect of cannabis roots; R. Sofia, *et al*., found that it disappears with increasing tolerance to the drug. **(83-85**)

2p.
Insomnia --- In 1890, the British physician J. Reynolds highly recommended cannabis indica for patients with "senile insomnia". The treatment remained effective for years without producing tolerance:

"In this class of cases I have found nothing comparable in utility to a moderate dose of Indian hemp."

CBD induces sleep in insomniacs, with fewer dreams and no side effects. Other conventional hypnotics produce undesirable consequences such as tolerance and addiction. Marijuana decreases slow-wave sleep but does not affect REM sleep. **(86)**

2q.
Herpes --- P. Morhan, *et al*., reported that THC reduces resistance to the herpes simplex virus. G. Lancz, *et al*., on the other hand, have shown that THC binds to the herpes virus and thus inactivates it. Topical application of an isopropyl alcohol extract of Cannabis has been used to provide symptomatic relief of herpes sores. It prevents blisters and makes sores disappear within a day. Cannabis also provided symptomatic relief from gonorrhea and syphilis. **(87, 88)**

2r.
Migraine --- In 1887, H. Hare gave medical testimony to the value of hemp in subduing and preventing attacks of migraine. In 1890, Dr. J. Reynolds stated:

"Very many victims of this malady have for years kept their suffering in abeyance by taking hemp at the moment of threatening, or onset of the attack."

In 1891, Dr. J.B. Mattison asserted that, of all the applications of cannabis, "Its most important use is in that opprobrium of the healing arts --- migraine." He concluded that the drug not only stopped migraine headaches, but also prevented the attacks. In *The Principles and Practice of Medicine* (1913), Dr. William Osler affirmed that "Cannabis is probably the most satisfactory remedy" for migraines. This fact is widely known amongst victims of migraine, but it has not been sufficiently explored by modern science. Z. Volfe, *et al*., reported that THC inhibits the release of serotonin from blood plasma platelets during migraine attacks, but the significance of the finding is unknown. **(89-93)**

2s.
Ulcers --- Stomach acid output decreases after the consumption of cannabis. This fact recommends it for the treatment of peptic ulcers, colitis, ileitis, spastic colon, and gastritis. Preparations of cannabis were used for that purpose in the 1890s. **(94, 95)**

2t.
Gynecology --- Cannabis has been used in the treatment of hyperemesis gravidum, a rare form of morning sickness in which the patient suffers from constant nausea and vomiting. When smoked or eaten during parturition, cannabis reduces pain and increases uterine contractions more quickly than ergot alkaloids. Native women in South Africa stupefy themselves with *dagga* to facilitate delivery. However, a heavily drugged baby might have a slow heartbeat and impaired ability to clear mucus from air passages. Dr. J. Grigor rediscovered the oxytocic properties of Indian hemp in 1852, and stated:

"It is capable of bringing the labor to a happy conclusion considerably within half the time that would otherwise have been required, thus saving protracted suffering to the patient, and the time of the practitioner."

Cannabis also has been used to treat mastitis, dysmenorrhea, and post-partum pain, and to increase lactation. **(96, 97)**

In 1883, Dr. John Brown recommended the use of cannabis in uterine dysfunctions, especially menorrhagia (excessive uterine bleeding):

"There is no medicine which has given such good results; for this reason it ought to take the first place as a remedy in menorrhagia... The failures are so few, that I venture to call it a specific in menorrhagia."

His contemporary colleague Dr. Robert Batho agreed:

"Considerable experience of its employment in menorrhagia has convinced me that it is... one of the most reliable means at our disposal... [Cannabis is] par excellence the remedy for that condition... It is so certain in its power of controlling menorrhagea, that it is a valuable aid to diagnosis in cases where it is uncertain whether an early abortion may or may not have occurred..." **(97)**

2u.
Anti-Oxidant ---Experiments conducted at the National Institute of Health (Bethesda MD) in 1998 showed Cannabidiol to be a potent anti-oxidant, even more effective than Vitamins C or E. The researchers induced ischemic strokes in rats, then treated them with CBD to neutralize free radicals which cause much of the damage associated with such strokes. The Israeli company Pharmos is conducting human clinical trials with the synthetic cannabinoid Dexnibinol to treat damage from strokes. CBD potentially offers an optional treatment (and possible prevention) of stroke, heart attacks, and neurodegenerative conditions such as Alzheimer's and Parkinson's diseases. **(98)**

3.

Hempseed & Nutrition

Legend says that Gautama Buddha ate only one hemp seed a day for six years while he waited for nirvana. Hempseed is eaten by many of India's poor people. A mixture called *bosa* consists of the seeds of Eleusine and hemp, and *mura* is made with parched wheat, amaranth or rice, and hempseed. The seeds are said to make all vegetables more palatable and complete foods. Sometimes it is an ingredient in chutney. *Bhang* and ripe hempseed also is used to flavor or strengthen the formulations of some alcohol beverages.

Hempseed has served as a primary famine food in China, Australia, and Europe as recently as World War Two. Medieval Christian monks ate hempseed gruel every day. Even in modern times, mothers of the Sotho tribe in South Africa are known to feed their babies with ground hempseed in pap. **(99)**

Hempseed now is an ingredient in food products, including flour, cheese, ice cream, yogurt, pudding, milk, spreads, candy, and meat substitutes. Prices are kept high by the cost of shipping, steam sterilization, repackaging, domestic shipping, and old equipment.

Hempseed contains all the essential amino acids and fatty acids, and is considered to be a complete food. The seed or achene contains 26-31% crude protein, 65% of which is globular edestin and albumin that is about 84% digestible. Lysine (the limiting protein in edestin) and other components are destroyed by the heat generated when hempseed is pressed for its oil. Addition of 1% lysine hydrochloride will restore the nutritional balance of heat-treated edestin. The meal also contains about 6% carbohydrates, 5-10% fat, 12% crude fiber, 10% moisture, and 7% ash. **(100, 101)**

T.B. Osborne studied hemp edestin and reported on its isolation and purification in 1892. Until the passage of the infamous Marihuana Tax Act in 1937, edestin was regarded as a standard example of the seed globulins (the third most abundant protein after collagen and albumin). They are vital to the maintenance of a healthy immune system. **(102, 103)**

The globulin edestin in hempseed closely resembles that found in human blood plasma, and it is easily digested, absorbed, and utilized. Hemp edestin is so completely compatible with the human digestive system, that the Czechoslovakian Tubercular Nutrition Study (1955) found hempseed to be the only food that can successfully treat the consumptive disease tuberculosis, in which the nutritive processes are impaired. **(104)**

When hempseed is fed to poultry on a regular basis, the birds do not go "off feed", and they do not require hormones to fatten them. Egg production also is increased. Hempseed meal has an effect analogous to that of grit in chicken diets in as much as the gizzard linings are found to be free of corrugations and erosions. **(105-107)**

In *Systema Agriculturae* (1675), John Worlidge commented:

"Hemp seed is much commended for the feeding of poultry and other fowl, so that where plenty thereof may be had, and a good return for fowl, the use thereof must needs be advantageous..."

4.
Hempseed Oil

Hempseed oil is used in paints, varnishes, inks and lubricants. When exposed to air, the fatty acids in hempseed oil form a hard film which makes it very useful in the manufacture of paints. The cellulose and other organic chemicals in cannabis can serve as feedstock for the manufacture of plastics and other synthetic substances. The oil has excellent surfactant properties which are put to use in several new hygiene products such as soap, shampoo, cosmetics and balms. For example, the SATIVA Gmbh (Germany) manufactures a detergent from hempseed oil and ruptured yeast; it removes stains with high efficiency, due to its very low surface tension. The detergent is used as an industrial cleaner for engines, and to clean petroleum-contaminated soil. It is completely bio-compatible and uses no phosphates, enzymes, or bleaches.

30-35% of the weight of hempseed is oil containing 80% of the unsaturated essential fatty acids (EFA), Linoleic Acid (LA, 55%) and Linolenic Acid (LNA, 21-25%). These are not manufactured by the body and must be supplied by food. The oil also contains about 8% by volume of palmitic, stearic, oleic and arachidic acids. The 80% EFAs in hempseed oil is the highest total percentage amongst the common plants used by man. Flax oil ranks second with 72% EFAs. The EFAs are very sensitive to heat, light and oxygen. For this reason, hempseed oil must be processed and stored carefully (in the cold, dark, and under vacuum) to preserve the potency of the EFAs. The fatty acid composition (% of total oil) of hempseed oil is: 18:3w3 (20%), 18:2w6 (60%), 18:1w9 (12%), 18:0 (2%), and 16:0 (6%).

EFAs are precursors to the prostaglandin series (PGE 1,2, & 3). PGE 1 inhibits the production of cholesterol and dilates blood vessels, and it prevents the clotting of blood platelets in arteries. A. Kemmoku, *et al*., found that a diet of hempseed causes the serum levels of total cholesterol to drop dramatically. Blood pressure also decreases after several weeks of eating hempseed, due to the steady, adequate supply of EFAs. **(108-110)**

U. Erasmus, author of *Fats that Heal, Fats that Kill*, states that the proportions of Linoleic Acid (LA) and Linolenic Acid (LNA) in hempseed oil are perfectly balanced to meet human requirements for EFAs, including gamma-linoleic acid (GLA). Unlike flax oil and others, hempseed oil can be used continuously without developing a deficiency or other imbalance of EFAs. The peroxide value (PV, the degree of rancidity) of hempseed oil is only 0.1-0.5, which is very low and safe and does not spoil its taste. In comparison, the PV of virgin olive oil is about 20, and the PV of corn oil is about 40-60. **(111-116)**

A study conducted by Struempler and Nelson (Univ. of Utah) in 1997 indicates that legal hempseed oil contains enough cannabinoids to produce a positive result with standard urine drug test procedures. Samples continued to test positive for two days after the subject stopped ingesting hempseed oil. This effect has caused consternation in the drug-testing industry, and has led to lawsuits. The drug-testing industry is lobbying to ban hempseed oil. **(116)**

Table 1

Properties of Hempseed Oil

[Not available in the Internet Edition]

Table 2
Fatty Acid Analysis of Hemp Seed Oil

[Not available in the Internet Edition]

Table 3
General Analysis of Hemp Seed

[Not available in the Internet Edition]

Table 4
Typical Minera l Assay of Hemp Seed

[Not available in the Internet Edition]

Table 5
Typical Protein Analysis of Hemp Seed

[Not available in the Internet Edition]

5.
Public Health

The public health effects of cannabis consumption have been examined repeatedly by official panels, beginning with the Indian Hemp Drugs Commission in 1893. None of the studies have found reason to proscribe cannabis, and several have recommended that it be legalized.

5a.

The Indian Hemp Drugs Commission (1893-94) --- In the 1870s, it was common practice for government officials in India to blame ganja as a cause of insanity and crime, since users of ganja were poor, helpless, and convenient scapegoats. In 1871, the Indian Secretary of State directed all local administrators to inquire into the ganja problem. After reviewing the correspondence it received, the government duly announced that there was no proof that hemp drugs caused criminal behavior any more than any other drugs, such as opium or cocaine. The government also stated:

"There is no doubt that its habitual use does tend to produce insanity, the total number of cases of insanity is small in proportion to the population, and not large enough [to be of concern] even in proportion to the number of ganja smokers..."

Local officials were not convinced and continued to complain. Another commission was appointed in 1877 to study the issue. It was determined that the only way to reduce consumption was to make "the tax on this article as high as it can possibly bear":

"The policy of Government must be to limit its production and sale by a high rate of duty without placing the drug entirely beyond the reach of those who will insist upon having it."

Eventually the English bureaucrats also began to complain, until The Indian Hemp Drug Commission was established to study the issue. The commissioners did an excellent job, questioning the morality of hemp use, the possibility of controlling its cultivation, the grade of cannabis used (bhang, charas, or ganja), and the problem of admixtures of opium, datura, etc..

The Commission also studied the extent of use of hemp as a drug, its social and religious usage, its physical and psychological effects, and its relation to insanity and crime. When the Commission investigated the "very sketchy" records of insane asylums, they found that cannabis had been scapegoated:

"It is a common practice to enter hemp drugs as the cause of insanity where it has been shown that the patient used these drugs," and to change the reported "cause of insanity" from "unknown" to "ganja smoking"...

"It must be borne in mind that it is impossible to say that the use of hemp drugs was in all [61 of 222] cases the sole cause of insanity, or indeed any part of the cause... Taking these accepted cases as a whole, we have a number of instances where the hemp drug habit has been so established in relation to insanity that, admitting (as we must admit) that hemp drugs as intoxicants cause more or less of cerebral stimulation, it may be accepted as reasonably proved, in the absence of evidence of other causes, that hemp drugs do cause insanity...

"Summary of conclusions regarding effects... It has been clearly established that the occasional use of hemp in moderate doses may be beneficial; but this use may be regarded as medicinal in character. It is rather to the popular and common use of the drugs that the Commission will now confine their attention...

"In regard to the physical effects, the Commission have come to the conclusion that the moderate use of hemp drugs is practically attended by no evil results at all... The moderate use of hemp drug appears to cause no appreciable physical injury of any kind... As in the case of other intoxicants, excessive use tends to weaken the constitution and to render the consumer more susceptible to disease... It is but rarely that excessive indulgence in hemp drugs can be credited with inciting to crime or leading to homicidal frenzy...

"Total prohibition of the cultivation of the hemp plant for narcotics... is neither necessary nor expedient in consideration of their ascertained effects... When subjected to careful examination, the grounds on which the allegations [against hemp] are founded prove to be in the highest degree defective." **(117-119)**

5b.
The Canal Zone Studies --- The Republic of Panama prohibited the "cultivation, use and consumption of the herb Kan-Jac" (cannabis) in 1923. At the same time, reports of American soldiers smoking the drug prompted the provost marshal to prohibit its possession by military personnel in the Canal Zone. A formal committee was convened in April 1925 to investigate the issue. Col. J.F. Siler (chairman of the committee), *et al*., observed some soldiers, four doctors, and two police officers smoking marijuana without ill effect. Lt. Col. Chamberlain declared:

"I think we can safely say, based upon samples we have smoked here and upon the reports of individuals concerned, that there is nothing to indicate any habit forming tendency or any striking ill effects. All of the statements to the effect that two or three puffs produce remarkable effects are nonsense, judging from our experience."

In its report to the governor, the committee recommended:

"No steps [should] be taken by the Canal Zone authorities to prevent the sale or use of marihuana... There is no evidence that marihuana, as grown and used is a 'habit-forming' drug in the sense in which the term is applied to alcohol, opium, cocaine, etc., or that it has any appreciable deleterious influence on the individuals using it... The influence of the drug when used for smoking... apparently has been greatly exaggerated. Most of the reports appear to have little basis in fact. There is no medical evidence that it causes insanity... The British [Indian Hemp Drugs Commission] which investigated the effects of Cannabis sativa... came to the conclusion that... most of the effects attributed to it were due to other substances (opium, datura, stramonium, cantharides, etc.) added to the preparations which were used...."

Repeated investigations in 1929 and 1931 produced the same results. Col. Siler's summary of the Canal Zone investigations was published in *Military Surgeon* (November 1933):

"The Committee reached the following conclusions:

"There is no evidence that marijuana as grown here is a 'habit-forming' drug in the sense in which the term is applied to alcohol, opium, cocaine, etc., or that it has any appreciable deleterious influence on the individual using it...

"Delinquencies due to marijuana smoking... are negligible in number when compared with delinquencies resulting from the use of alcoholic drinks which also may be classed as stimulants and intoxicants. **" (120, 121)**

Years later during the Vietnam War, the drug problem certainly did exist for the military, and it was severely complicated by the easy availability of opiates and by the CIA's trafficking of heroin. It was estimated that about 60% of the US soldiers in Vietnam used marijuana to make their situation tolerable.

5c.
The LaGuardia Committee Report --- In 1938, while Frank H. LaGuardia was mayor of New York, he requested that the N. Y. Academy of Medicine appoint a special subcommittee "to make a survey of existing knowledge on this subject [marijuana] and carry out any observation required to determine the pertinent facts regarding this form of drug addiction and the necessity for its control." In 1944, Mayor LaGuardia's Committee on Marihuana published its report, *The Marihuana Problem in the City of New York*. The study was comprised of sociological, clinical, and pharmacological studies. The clinical study considered medical aspects (symptoms, behavior, and organic and systemic functions, addiction, tolerance, and possible therapeutic applications), psychological and intellectual functioning, emotional reactions, general personality structure, and family and community ideologies.

In its final report, the Committee drew the following conclusions (among others):

"The practice of smoking marijuana does not lead to addiction in the medical sense of the word... The use of marihuana does not lead to morphine or heroin or cocaine addiction and no effort is made to create a market for these narcotics by stimulating the practice of marihuana smoking. Marihuana is not the determining factor in the commission of major crimes... Juvenile delinquency is not associated with the practice of smoking of marihuana. The publicity concerning the catastrophic effects of marihuana smoking in New York City is unfounded...

"Indulgence in marihuana does not appear to result in mental deterioration... Under the influence of marihuana the basic personality structure of the individual does not change, but some of the more superficial aspects of his behavior show alteration... [A comparison between users and non-users] accustomed to daily smoking for a period of from two and a half to sixteen years, showed no abnormal system functioning which would differentiate them from the non-users. There is definite evidence in this study that marihuana smokers were not inferior in intelligence to the general population and that they suffered no mental or physical deterioration as a result of their use of the drug."

When subjects were tested for their family values and ideologies while under the influence of marihuana, it was found:

"The only very definite change as a result of the ingestion of marihuana was in their attitude toward the drug itself. Without marihuana only 4 out of 14 subjects said they would tolerate the sale of marihuana while after ingestion 8 of them were in favor of this." **(122)**

5d.
The Wooton Report --- The British Advisory Committee on Drug Dependence appointed the Hallucinogens Sub-Committee, chaired by Baroness Barbara Wooton of Abinger, to review the literary evidence about cannabis. The *Wooton Report on Cannabis*, issued in 1968, confirmed earlier studies:

"Having reviewed all the material available to us we find ourselves in agreement with the conclusion reached by the Indian Hemp Drugs Commission appointed by the Government of India (1893-1894) and the New York Mayor's Committee on Marihuana (1944) that the long-term consumption of cannabis in moderate doses has no harmful effects." **(123, 124)**

5e.
The Shafer Commission --- The Comprehensive Drug Abuse Prevention and Control Act of 1970 also established the national Commission on Marijuana and Drug Abuse, chaired by former Pennsylvania Governor Raymond Shafer. In summary, the commission concluded:

"WHO USES THE DRUG? At least 24 million Americans over the age of 12 have used marihuana at least once, and at least 8.3 million are current users. Two percent (500,000) of the 'ever-users' can be classified as heavy users and use the drug more than once a day.

"EFFECTS OF MARIHUANA ON THE INDIVIDUAL: There is no evidence that experimental or intermittent use of marihuana causes physical or psychological harm...

"The immediate effects of marihuana intoxication on the individual's organs or bodily functions are transient and have little or no permanent effect. However, there is a definite loss of some psychomotor control and a temporary impairment of time and space perception.

"No brain damage has been documented relating to marihuana use.

"There is no reported case of a single human fatality in the United States proven to have resulted solely from the use of marihuana.

"No reliable evidence exists to indicate that marihuana causes genetic defects in man.

"Psychosis resulting from marihuana use is extremely rare and such reactions tend to occur in predisposed individuals.

"MARIHUANA & PUBLIC SAFETY: The evidence indicates that marihuana does not cause violent or aggressive behavior or crime.

"Recent research has not proven that marihuana use significantly impairs driving ability...

"MARIHUANA & THE PUBLIC HEALTH & WELFARE: The present level of marihuana use in American society does not constitute a threat to the public health.

"Although some segments of society fear that marihuana use leads to idleness and "dropping out", little likelihood exists that the introduction of a single element such as marihuana would significantly change the basic personality of any person; rather, an individual is more likely to "drop out" when circumstances join to produce psychological pressures which he cannot handle effectively.

"Except for some individuals for whom drug-taking, perhaps including marihuana use, has become a central figure of their lifestyles, the marihuana user is not "sick" or in need of "treatment".

"MARIHUANA & OTHER DRUGS: The overwhelming majority of marihuana users do not progress to drugs other than alcohol, although statistically marihuana users are more likely to experiment with other drugs than non-users. In general, a person willing to experiment with one drug is more likely to experiment with another drug than a person not predisposed to experiment to begin with...

"The weakest link between marihuana use and use of other drugs is between marihuana and heroin; about 4% of those who have tried marihuana have also tried heroin."

In its summary, the Commission noted:

"Once existing policy was cast into the realm of public debate, partisans on both sides of the issue over-simplified the question of the effects of the drug on the individual. Proponents of the prohibitory legal system contended that marihuana was a dangerous drug, while opponents insisted that it was a harmless drug or was less harmful than alcohol or tobacco.

"Any psychoactive drug is potentially harmful to the individual, depending on the intensity, frequency, and duration of use. Marihuana is no exception. Because the particular hazards of use differ for different drugs, it makes no sense to compare the harmfulness of different drugs. One may compare the harmfulness of different drugs. One may compare, insofar as the individual is concerned, only the harmfulness of specific effects. Is heroin less harmful than alcohol because, unlike alcohol, it directly causes no physical injury? Or is heroin more harmful than alcohol because at normal doses its use is more incapacitating in a behavioral sense?

"Assessment of the relative dangers of particular drugs is meaningful only in a wider context which weighs the possible benefits of the drugs, the comparative scope of their use, and their relative impact on society at large...

"Looking only at the effects on the individual, there is little proven danger of physical or psychological harm from experimental or intermittent use of the natural preparations of cannabis, including the resinous mixtures commonly used in this country. The risk of harm lies instead in the heavy, long-term use of the drug, particularly of the most potent preparations.

"The experimenter and the intermittent users develop little or no psychological dependence on the drug. No
organ injury is demonstrable...

"Total prohibition is functionally inappropriate. Apart from the philosophical and constitutional constraints... a total prohibition scheme carries with it significant institutional costs. yet it constributes very little to the achievement of our social policy. In some ways it actually inhibits the success of that policy.

"The primary goals of a prudent marihuana social control policy include preventing irresponsible use of the drug, attending to the consequences of such use, and deemphasizing use in general. Yet an absolute prohibition of possession and use inhibits the ability of other institutions to contribute actively to these objectives. For example... the illegality of possession and use creates difficulties in achieving an open, honest educational program, both in the schools and in the home." **(125)**

The Commission recommended changes in the Federal law, thus:

"Possession of marihuana for personal use would no longer be an offense, but marihuana possessed in public would remain contraband subject to summary seizure and forfeiture. Casual distribution of small amounts of marihuana for no renumeration, or insignificant renumeration not involving profit would no longer be an offense."

Instead of heeding the sage advise of the Shafer Commission, President Nixon declared "war on drugs" in a message to Congress on June 17, 1971, and we now suffer accordingly.

5f.
The Jamaica Study --- In 1970, the National Institute of Mental Health (NIMH) Center for Studies of Narcotic and Drug Abuse sponsored the Jamaica Study, "the first project in medical anthropology to be undertaken and... the first intensive, multi-disciplinary study of marijuana use and users to be published." **(126-129)**

The Jamaica project staff studied the legislation, ethnohistory, and social complex of ganja, and the acute effects of smoking in a natural setting. Clinical studies were conducted, and examinations made of respiratory function and hematology, electroencephalography, and psychiatric evaluations and psychological assessments ere made of the 70 subjects. The complex ganja culture from which the subjects were drawn pervades and greatly influences the working-class community. In some communities, 50% of the males over 15 smoked ganja regularly, and only 20% were non-smokers.

In his forewords to Vera Rubin and L. Comitas' *Ganja in Jamaica* (1975), Raymond Shafer (Chairman of the Shafer Commission, v.i.) stated:

"While Americans are concerned with the alleged 'amotivational' and drug escalation effects of marihuana, ganja in Jamaica serves to fulfill values of the work ethic; for example, the primary use of ganja by working class males is as an energizer. Furthermore, there is no problem of drug escalation in the Jamaican working class; as a multipurpose plant, ganja is used medicinally, even by non-smokers, and is taken in teas by women and children for prophylactic and therapeutic purposes. For such users, there is no reliance even on potent medicines, amphetamines or barbiturates, let alone heroin and LSD. Further, the use of ganja appears to be a "benevolent alternative" to heavy consumption of alcohol by the working class. Admissions to the mental hospital in Jamaica for alcoholism accounts for less than 1% annually, in contrast to other Caribbean areas where ganja use is not pervasive and admission rates for alcoholism are as high as 55%.

"This study indicates that there is little correlation between use of ganja and crime, except insofar as the possession and cultivation of ganja are technically crimes. There were no indications of organic brain damage or chromosome damage among the subjects and no significant clinical (psychiatric, psychological or medical) differences between the smokers and controls. The single medical finding of interest, and this is a trend, is the indication of functional hypoxia among heavy, long-term chronic users. Ganja is customarily mixed with tobacco, and ganja smokers are also heavy cigarette smokers... It was impossible to distinguish between clinical effects of ganja and tobacco smoking and cigarette smoking; it is, consequently suggested that smoking per se may be a factor in this finding.

"Despite its illegality, ganja use is pervasive, and duration and frequency are very high; it is smoked over a longer period in greater quantities with greater THC potency than in the United States, without deleterious social or psychological consequences. The major difference is that both ganja use and expected behaviors are culturally conditioned and controlled by well-established tradition. The findings throw new light on the cannabis question, particularly that the relationship between man and marihuana is not simply pharmaceutical, and indicate the need for new approaches."

The Jamaica Study also afforded due respect to the Rastafari religion, in which ganja is regarded as a sacrament and a gift of God:

"In addition, ganja, unlike alcohol, has special symbolic attributes. Rastafarian metaphysics, for example, emphasizes and brings into focus general concepts derived from working-class views of ganja. For them, it is "the wisdom weed" of divine origin, an elixir vitae, documented by Biblical chapter and verse which over-rides man-made proscriptions. Religious authority thus validates and fortifies commitment to its use; there is no need to invoke religious validations of alcohol consumption, which is legally and socially accepted. While drinking in the local bar may enhance feelings of sociability, the sacred ganja permits a sense of religious communication, marked by meditation and contemplation."

Melanie Dreher, an anthropologist at the University of Miami, was a key member of the Jamaica team. In her study, entitled *Working Men and Ganja*, she found that the drinking of ganja tea or tonic extracts is widespread, even by non-smokers and children:

"The health-rendering effects of these preparations are reported for a wide variety of general and specific disorders including the alleviation of symptoms specific to arthritis, rheumatism, gonorrhea, hypertension, asthma, bronchitis, urinary retention, recurrent malaria, impotence, vision problems, dermatological eruptions, pneumonia, colds, and various intestinal complaints. Ganja teas and tonics are particularly recommended for children... The preparations are administered to children to cure marasmus and infant diarrhea, relieve the pain of teething, and in general provide an all-purpose medicine for the young..."

5g.

The Costa Rica Study ---In 1971, the University of Florida and National Institute of Health (NIH) cooperated in a study led by William Carter, *et al*., of *Chronic Cannabis Use in Costa Rica*. 84 cannabis smokers and 156 controls who had never smoked ganja were subjected to a battery of sophisticated medical and psychological examinations. The results were equivalent to those of the Jamaica study, with few notable differences: the similarities outweighed the differences between users and non-users, and ganja smokers generally enjoyed longer-lasting relationships with their mates. The Costa Rica project also examined testosterone levels and immunology as affected by cannabis. No relation was found between cannabis use and testosterone levels, nor were the subjects' immune functions impaired. The neurophysiological functions, intelligence and personality of the subjects did not differ significantly from the matched controls. Chronic cannabis consumption did not impair intelligence or cause any apparent brain damage. In short, the Costa Rica study found no significant health consequences to chronic cannabis smokers.

The NIH refused to accept the report for publication, demanding that it be rewritten three times. Still not satisfied, the NIH then had it rewritten by another editor, and then printed only 300 copies. Fortunately, a copy of the original version was leaked to NORML, which made it public. **(130-132)**

5h.
***The Greek Study* ---** In their study of hashish-smokers in Greece, conducted in 1975, C.N. Stefanis and M.R. Issodorides presented microphotographs of damaged human sperm and suggested that the low arginine content in the sperm nuclei indicated "deviant maturation". However, it was later revealed that the photographs had been retouched; the study was fraudulent. Stefanis and Issodorides were obliged to issue a "correction of misinformation" in the journal *Science*. **(133-136)**

5i.
The Coptic Study --- This 1981 study by two UCLA psychologists, Drs. J. Thomas and Jeffrey Schaeffer tested the physical and mental health of 10 members of the Ethiopian Zion Coptic Church, whose members believe that the use of ganja is a spiritual act. The church has been given official recognition as an organized religion by the governments of Jamaica and Florida. The Coptic Study showed that the IQs of these people actually increased since they began to use ganja. **(137)**

5j.
The Expert Group --- In 1982, the British Advisory Council on the Misuse of Drugs released its *Report of the Expert Group on the Effects of Cannabis Use*, in which it offered the following conclusions:

"1. There is insufficient evidence to enable us to reach incontestable conclusions as to the effects on the human body on the use of cannabis;
"2. But that much of the research undertaken so far has failed to demonstrate positive and significant harmful effect in man is attributable solely to cannabis;

"3. Nevertheless in a number of areas there is evidence to suggest that deleterious effects may result in certain circumstances;
"4. There is a continuing need for further research, particularly of the epidemiological characteristics of cannabis use and on the effects of its long-term use by humans;

"5. There is evidence to suggest that the therapeutic use of cannabis or of substances derived from it for the treatment of certain medical conditions may, after further research, prove to be beneficial." **(138)**

5k.

The Relman Committee --- In 1982, the Institute of Medicine (IOM) of the National Academy of Sciences issued its comprehensive report on *Marihuana and Health* after a 15-month study of the chemistry and pharmacology of cannabis, its effects on the respiratory and cardiovascular systems, brain, and other biological systems, plus the behavioral and psychological effects and cannabis' therapeutic potential. Their specific conclusions are included in the sections following. **(139)**

5l.

***The LeDain Commission* ---**The Canadian government a Commission of Inquiry into the Non-Medical Use of Drugs in May 1969. It was popularly called the LeDain Commission after its chairman, Gerald LeDain (Dean of Osgoode Hall Law School, York University, Toronto). In its 320-page *Interim Report* (April 1970), the commission described the need to legalize the simple possession of cannabis (and other psychoactive drugs) in terms of the cost of prohibition:

"Its enforcement would appear to cost far too much, in individual and social terms, for any utility which it may be shown to have... The present cost of its enforcement, and the individual and social harm caused by it, are in our opinion, one of the major problems involved in the non-medical use of drugs... Insofar as cannabis, and possibly the stronger hallucinogens like LSD, are concerned, the present law against simple possession would appear to be unenforceable, except in a very selective and discriminatory kind of way. This results necessarily from the extent of use and the kinds of individual involved. It is obvious that the police cannot make a serious attempt at full enforcement of the law against simple possession...

"The Commission is of the opinion that no one should be liable for imprisonment for simple posssession of a psychotropic drug for non-medical purposes...

"Many of the young people who have appeared before us have been critical of the drug education to which they have been exposed. In particular, they have said that the attempts to use 'scare tactics' have 'backfired' and destroyed the credibility of sound information...

"The conclusion we draw from the testimony we have heard is that it is a grave error to indulge in deliberate distortion or exagerration concerning the alleged dangers of a perticular drug, or to base a program of drug education upon a strategy of fear. It is no use playing 'chicken' with young people; in nine cases out of ten they will accept the challenge...

"1. The use of marijuana is increasing in popularity among all age groups of the population, and particularly among the young;

"2. This increase indicates that the attempt to suppress, or even to control its use, is failing and will continue to fail --- that people are not deterred by the criminal law prohibition against its use;

"3. The present legislative policy has not been justified by clear and unequivocal evidence of short term or long term harm caused by cannabis;

"4. The individual and social harm (including the destruction of young lives and growing disrespect for law) caused by the present use of the criminal law to suppress cannabis far outweighs any potential for harm which cannabis could conceivably possess, having regard to the long history of its use and the present lack of evidence;

"5. The illicit status of cannabis invites exploitation by criminal elements, and other abuses such as adulteration; it also brings cannabis users into contact with such criminal elements and with other drugs, such heroin, which they might not otherwise be induced to consider.

"For all of these reasons, it is said, cannabis should be made available under government-controlled conditions of quality and availability."

6.
Physical Effects

Many reports written in the 1970s about the physical effects of THC and cannabis smoke were grossly biased for political purposes, no thanks to the infamous Gabriel Nahas and his coterie of propagandists. Their corruption of the scientific process severely retarded the progress of cannabis medical research at that time and since then. The Nahas scandal is discussed in Section 10 (Propaganda).

6a.
Smoking --- THC is not a respiratory depressant. However, heavy smoking of marijuana (several times daily) causes mild constriction of airways. Smoking can produce inflammation and aggravate existing sinusitis, pharyngitis, bronchitis, or coughing. Antibiotics do not provide relief, but a decrease of consumption does. Light smoking of marijuana has little effect on breathing, except for bronchodilation. Many asthmatics are thankful for this. Ventilatory mechanics and gas exchange remain normal, except for a transient stimulatory effect on oxygen consumption and CO_2 ventilation. Marijuana decreases the salivary flow in the maxillary gland, resulting in a dry mouth. **(140-142)**

Alveolar macrophages, the antibacterial mechanisms of the lung, are slightly affected by water-soluble cytotoxins found in marijuana smoke, but the reported experimental results are conflicting and inconclusive. The heat of the smoke depresses the activity of the ciliated esophageal cells. There is scant evidence of a direct carcinogenic effect of smoke or tar. Some experiments with marijuana tar have produced mutations in several strains of bacteria, and rats which have been painted with the tar have developed benign skin tumors. Marijuana smoke has been found to contain many of the same carcinogenic compounds as tobacco, but to date there have been no cases of cancer attributed to smoking cannabis. The effect of marijuana seems to accelerate (rather than initiate) malignant changes. The traditional water-pipe (hookah or bong) serves well to mitigate the irritating effects of the smoke. **(143, 144)**

Dr. Paul Donald has presented preliminary circumstantial evidence of 20 cases of upper aerodigestive tract malignancy (squamous cell carcinomas of the tongue, lips, neck, tonsils, etc.) in 20 young patients (average age: 26.2 years) who smoked marijuana. Only four of the group did not also use tobacco, alcohol and other drugs. A few of the cases had used cannabis only occasionally in high school and college. It is questionable if their use of marijuana was the etiological cause of the malignancies. Many of the same irritants in tobacco smoke are found in marijuana smoke, some of them (such as napthalene and benzopyrene) in greater amounts than in tobacco. Biopsies of chronic hashish smokers conducted by Tennant and others have shown cellular abnormalities such as proliferating basal epithelial cells and atypical cells, but no malignancies. **(145-148)**

Vitamin C and cysteine have been found to reverse or protect hamster lung tissue cultures against the atypical growth induced by exposure to marijuana smoke. **(149)**

The most evident and immediate effect of smoking or ingesting cannabis is a rapid increase in heart rate (up to 90 beats/minute) which diminishes within an hour and poses no threat to a healthy individual. Blood pressure rises slightly, and postural hypotension can occur. Premature ventricular contractions have been reported. Chronic use of cannabis produces a consistent gain in plasma volume caused by sodium retention. After a few weeks, smokers develop a tolerance to the cardiac and psychotropic effects of THC. However, people with atherosclerosis or other coronary disease are at risk and should not compromise themselves with cannabis. In a case reported in 1979, a 25 year old man developed an acute subendocardial infarction after smoking marijuana. **(150)**

6b.
Hypothermia --- THC produces hypothermia (lower body temperature) in animals, but experiments with humans have shown little or no such effect except at high doses. Instead, skin temperature, metabolic rate, and heart rate are increased, but core temperature remains unchanged. Marijuana also inhibits sweating. **(151, 152)**

6c.
Chrono-Pharmacology --- E.L. Abel found a chrono-pharmacological effect of THC in conjunction with hypothermia in mice injected with THC in DMSO, morning, noon and night. The greatest change in body temperature occurs in the afternoon, and the least change in the morning and at night. **(153)**

6d.
Toxicity --- Cannabis is non-toxic. No deaths from an overdose of cannabis have ever been verified. A few poorly documented reports have listed cannabis as the cause of death, but closer examination has shown the accusations to be untenable. **(154-15)**

A few near-fatal intravenous injections of a water extract of marijuana have been reported. In 1970, one such foolish person suffered reversible anuritic acute renal failure, hypotension, tachycardia, transient leukopena, fever, pulmonary venous congestion, and an enlarged liver. **(157)**

It has been estimated that it would be necessary to chain-smoke about 800 marijuana cigarettes to kill a human, and even then one would probably receive a lethal dose of carbon monoxide first. In comparison, only 60 mg of nicotine or 300 ml of alcohol can kill a person. The LD_{50} for THC in animals is between 20-40 mg/kg/iv, or 800-1400 mg/kg orally depending on the species. **(158, 159)**

6e.
Driving --- Experimental studies of driving conducted on test courses have shown that performance is impaired by marijuana. Judgment, concentration, and car handling skills are affected, and the influence may persist for a full day afterward. The determination of marijuana intoxication requires a blood or urine sample; this has made it difficult to study role in driving violations and accidents. Furthermore, the detrimental effects on motor skills may persist for several hours after the subjective euphoria has passed. Comparison of several studies indicates that about 15% of road accidents involve marijuana. Soderstrom, *et al*., found that up to 34.7% of vehicular trauma patients they examined were under the influence of marijuana. **(160)**

In 1993, police in Memphis TN outfitted an ambulance as a "drug van" with a toilet, interview area, and videotaping equipment . They proceeded to make on-the-spot tests of the urine of any reckless drivers who appeared not to be drunk. 150 drivers were sampled; 89 (59%) tested positive for marijuana or cocaine.

Marijuana was implicated in the 1987 crash of a freight train and a Metroliner, resulting in 16 dead and 48 injured persons. Cannabinoids were detected in the blood of the conductor of the freight train, which had run through 3 red signals before the crash. In 1988, a switchman whose error caused a derailment and a train crash was found to have smoked marijuana sometime before the accident.

In 1994, the National Highway Transportation Safety Administration (NHTSA) released a study made by K.W. Terhune, *et al.*, in 1992 on "The Incidence and Role of Drugs in Fatally Injured Drivers" (DOT-HS-808-065). The release of the report was delayed because it apparently contradicted the official federal propaganda that illicit drugs constitute a major danger to drivers. Alcohol was found in 51.5% of 1882 dead drivers. Only 17% showed traces of other drugs. THC was present in 6.7%; cocaine in 5.3%, amphetamine in 1.9%, and tranquilizers in 2.9%, etc. Two-thirds of the drug-using drivers also tested positive for alcohol.

6f.
Antidotes --- Chinese herbalists use the mung bean (*Phaseoli radix*) as an antidote to cannabis intoxication. Hindu Ayurvedic practitioners treat the effects of ganja with purgations, head baths with cold water, unction with sandalwood paste, with fragrant and cooling flowers. Drinks are prepared with sugar, milk and butter, or with lemonade or other sour drinks. Patients are made to ingest betel leaves, camphor, and cloves. Silk clothing should be worn, and sleep is recommended. More recently, it has been found that Magnesium Pemoline (Cylert) neutralizes the mental effects of cannabis. **(161)**

6g.
Potentiation --- The Indian Hemp Drugs Commission reported that the root of *juar* (sorghum) is employed to increase the potency of *bhang* preparations, but is considered to be too powerful to use by itself. The unknown chemical in sorghum reportedly is found only in cold-weather *ringhi* and *shialu* varieties raised in the area of Bombay and in the Central Provinces, and it occurs and disappears "within certain fixed limits of time and locality." More recently, it was claimed that the "aversive odor stimulus" of burning hair added to marijuana increased the "subjective high" and decreased the heart rate in subjects. **(162)**

6h.
Interactions --- The cannabinoids bind to plasma proteins and may interact with other drugs thus bound. Cannabinoids are metabolized by hepatic enzymes and may interact with other drugs (i.e., alcohol, barbiturates, and theophyllin) by competing for the enzyme substrate. **(163)**

Prof. Sandra Welch (Virginia Commonwealth Univ.) found that THC has a pronounced potentiating effect on morphine. At a low dose, THC increases the analgesic effect of morphine by 500%. At double the dose of THC, the effect is 10 times greater. The effect is not additive. Prof. Welch noted:

"One major advantage to a marijuana-morphine combination would be to reduce both the morphine component and a major morphine side-effect, depression of the respiratory system. It has already been confirmed that marijuana has no effect on the medulla, the center of the brain that controls respiration." **(164)**

THC enhances the depressive effects and prolongs the sleeping time of barbiturates. It also produces a significant decrease in heart rate. **(165)**

THC significantly potentiates PCP in a dose-related manner. The LD_{50} values are not affected. THC and PCP interact by potentiating the depressant effects and antagonizing the stimulating effects of each other. The combined effects also are attenuated. PCP sometimes is found as a contaminant of street marijuana, having been added to increase the apparent potency, and hence the sales value, at a low cost. **(166, 167)**

THC and CBD prolong the sleep time with Quaalude. Reportedly, on rare occasions, Quaalude has been smoked with marijuana. **(168)**

Marijuana, tobacco, and alcohol often are consumed together, and their effects are additive, increasing the impairment of psychomotor performance. Nicotine uniformly augments the bradycardia and hypothermia effects of THC . **(169-171)**

The mental and cardio-vascular effects of THC and amphetamines are additive and related to aggregation, not to metabolic process interactions. At lower doses, THC enhances amphetamine stimulation; in high doses it blocks the stimulant action. **(172, 173)**

6i.
Contra-Indications --- Marijuana has been a complicating factor in the emergency treatment of diabetes. In one case, ingestion of marijuana was followed by severe diabetic ketoacidosis. Another patient developed diabetes mellitus following the ingestion of marijuana over a 3-day period. Plasma glucose and insulin levels increase after marijuana use. THC has been shown to impair glucose tolerance in rats, to inhibit the action of exogenous insulin, and to antagonize the release of endogenous insulin. CBD antagonizes the action of insulin. **(174, 175)**

The administration of cannabis smoke to dogs receiving penicillin-G reportedly caused coarse tremors and eleptiform episodes in 90% of chronically-dosed dogs. Humans are advised to avoid this combination.

In summary, marijuana should not be used by children or pubescent youths, pregnant or nursing women, people with chronic heart, lung, or liver disease or who are diabetic, epileptic, or psychotic. Nor should anyone operate motor vehicles or other dangerous machinery while under the influence of cannabis.

6j.

Contaminants --- *Aspergillus niger*, *Salmonella*, *Chaetomium globosum*, and other fungi have been found to contaminate cannabis. *Penicillium chrysogonum* also has been found on hemp; it is pathogenic to hemp seeds and leaves. M. Chusid, *et al*., reported that a 17-year old male was debilitated by pulmonary aspergillosis acquired from smoking marijuana. Outbreaks of salmonellosis in Ohio and Michigan were linked to marijuana use in 1981. The symptoms include diarrhea, fever, and abdominal pain. **(176)**

Some samples of marijuana have been found to be adulterated with other drugs, particularly PCP, which can produce severe psychotic reactions. In one reported case, marijuana was soaked in a solution of scopolomine, dried, and smoked. The result was an acute though brief psychotic episode. **(177)**

The dust inhaled by soft hemp workers (hacklers and scutchers) can cause byssinosis or cannabosis, and otherwise causes more chronic lung disease and lower forced expiratory volume (FEV) than controls of the same age. Chronic respiratory symptoms (cough, phlegm, and dyspnea) develop even after exposure to hemp dust. It is also a mild hemolytic. The degree of hemolysis increases with the pH. Tracheobronchial lymph nodes develop immunoblasts and become swollen with increased lymphocytes. A study of 100 Spanish hemp hacklers showed the average age of death to be 39,6 years, compared to regular farm workers hose average lifespan was 67.6 years. **(178-181)**

The oral administration of diadril (25 mg) and 500 mg ascorbic acid (vitamin C) prevented or restored breathing functions due to byssinosis.

D. Drachler found that several soldiers who shared a hashish-pipe contracted Hepatitis-B. Saliva is a vehicle for transmitting the virus. It is also possible to transmit other diseases in this manner, making it a dangerous practice. **(182)**

6k

Immunology --- THC or marijuana has a mild, transient suppressive effect on the immune system, but hashish has been shown to have a temporary stimulating effect on the immune system. The reason is unknown. Some persons develop antibodies in response to marijuana, sometimes including allergic reactions. Many AIDS patients consume marijuana to stimulate their appetites and to suppress vomiting, but the practice might weaken the immune system in some cases and introduce salmonella, etc.. **(183-186)**

6l.

Male Reproduction --- THC inhibits the synthesis of testosterone in Leydig cells by blocking the cleavage of cholesterol ester. THC produces a mild, reversible effect on sperm production, but does not seem to have a negative effect on male fertility. Various animal and human studies have measured reduced weights of the testes and prostate gland, lower levels of testosterone in blood plasma, and suppressed spermatogenesis after acute or chronic administration of THC or cannabis. **(187)**

A few cases of "pubertal arrest" have been reported, i.e., a 17-year old male who had smoked marijuana several times daily since age 11, yet still had not attained puberty. After a few months of abstinence, his growth accelerated, his sex organ enlarged, and his levels of testosterone and luteinizing hormone (LH) rose to normal levels.

In 1974, R. Kolodny, *et al*., reported that the levels of LH, plasma testosterone, follicle-stimulating hormone, prolactin, and sperm counts of 20 men who regularly smoked marijuana were significantly lower than controls. The report sparked a controversy that has smoldered for years since then. J. Mendelson, *et al*., J. Coggins, *et al*., and other researchers obtained other results, attributed to differences in study designs, routes of administration, the potency and purity of the drug, and bias. Because the hormonal suppression of spermatogenesis takes more than 4 weeks to develop, W. Hembree, *et al*., concluded that the observed short-term effects are caused by direct action upon the seminiferous tubular epithelium. Possibly this could lead to the development of a new type of male contraceptive. **(188-191)**

In the Jamaica project study of subjects' chromosomes, the researchers reported:

"No abnormal configurations, exchanges or dicentrics were seen... Chronic cannabis smoking appears to have no significant effect on the mitotic chromosomes of human peripheral blood lymphocytes in the Jamaican male. The incidence of mild chromatid breakage... was no higher than that found randomly in other studies...

"These findings lend no support to the recent allegation that chromosome damage... even in those who use cannabis "moderately" is roughly the same type and degree of damage as in persons surviving atom bombing..."

A study by Dr. Donald Tashkin, *et al.* (UCLA), published in 1997, found that habitual smokers of marijuana do not suffer a greater annual rate of decline in their lung function than do non-smokers. Their report concluded:

"Findings from the present long-term, follow-up study of heavy, habitual marijuana smokers argue against the concept that continuing heavy use of marijuana is a significant risk factor for the development of [chronic lung didease]... Neither the continuing nor the intermittent marijuana smokers exhibited any significantly different rates of decline... No differences were noted between even quite heavy marijuana smoking and nonsmoking of marijuana."

In contrast, tobacco-only smokers suffered a significant rate of decline in their lung functions. It was noted that regular marijuana-smokers are more likely to suffer mild bronchitis or wheezing than non-smokers.

6m.

Gynecomysteia --- The enlargement of breast glands in males is a common transient occurrence among adolescents. Gynecomysteia also is caused by cirrhosis of the liver, by testicular, adrenal and pituitary tumors, and by steroids, amphetamines, and other drugs. In

1972, J. Harmon and M. Aliapoulios presented 14 cases of breast development in young men who had smoked marijuana for several years. Other causes were excluded. Three patients enjoyed a decrease in breast development after abstaining from marijuana. A controlled study of 11 gynecomastic US soldiers in Germany found only "a non-association between idiopathic gynecomysteia and chronic cannabis use." Experiments with rats showed that THC stimulated male breast development, possibly by affecting the release of pituitary prolactin. Human studies found a transient increase in serum prolactin concentration. If cannabis does induce gynecomysteia, it may depend on the dosage, potency, frequency of use, and the endocrinology of the individual. **(192-195)**

6n.
Female Reproduction --- Experiments with rats have demonstrated some teratogenic effects (malformations) and decreased conception caused by cannabis, but the results are considered to be of marginal relevance to humans. The route of administration, solvent medium, concentration and high doses used in the experiments were extremely unnatural and unrealistic. Insulin, penicillin, cortisone and aspirin produce the same effects. The Relman Committee report on *Marijuana and Health* concluded:

"Although there is widespread use of marijuana in young women of reproductive age, there is no evidence yet of any teratogenic effects of high frequency or consistent association with the drug. There are isolated reports of congenital anomalies in the offspring of marijuana users, but there is no evidence that they occurred more often in users than in nonusers..." **(196)**

In any case, pregnant women probably should not smoke marijuana.

Jonathan Buckley studied *in utero* exposure to marijuana:

"Maternal use of mind altering drugs prior to and during pregnancy was found to be associated with an 11-fold increased risk (p=0.003) of ANLL [Acute Non-Lymphatic Leukemia] in offspring when compared to offspring of controls... We conclude that, although the association of marijuana exposure *in utero* and subsequent development of ANLL has not been firmly established, the evidence is strong enough to justify further study."

Other investigators have reported that babies born of marijuana-smoking mothers are shorter, weigh less, and have smaller heads, and cry less at birth. **(197)**

A study by M.C. Dreher, *et al.*, published in the journal *Pediatrics* tested 24 Jamaican newborns who had been exposed to cannabis prenatally, plus 20 non-exposed babies from socially and economically matched mother. The infants were compared at day one, three, and thirty by a trained examiner who was unaware of which babies' mothers smoked. No differences were found on day 1 or 3, but at day 30 the children of the cannabist mothers scored much higher in tests of their reflexes, autonomic stability, and general irritability. The children of heavy smokers (at least 21 times a week) scored significantly higher in 10 of the 14 measured characteristics (alertness, orientation, robustness, regulatory capacity, etc.). No negative effects were observed. The researchers also offered a speculation:

"It is possible... that the outcomes at one month are related to neonatal exposure to marijuana constituents via breast milk. Nineteen of the mothers reported that cannabis increased their appetites and relieved their nausea during pregnancy." **(198)**

6o.
Mutagenesis & Cytogenesis --- THC is not carcinogenic, but the tar from marijuana smoke has been shown to produce mutations in bacteria, and skin tumors on rats painted with the tar. Extensive testing by H. Glatt, *et al*., A. Zimmerman, *et al*., and others failed to demonstrate any mutagenic effect or any inhibition of DNA repair. Despite the worst efforts of Gabriel Nahas and his colleagues, other researchers and peer reviews have determined that marijuana and THC do not cause chromosome damage. However, it may affect chromosome segregation during the course of cell division, resulting in daughter cells with abnormal numbers of chromosomes. **(199-201)**

After examining the available evidence, the Relman Committee concluded:

"A variety of effects on cellular processes have been reported, usually based on studies of *in vitro* systems. The low water solubility of the cannabinoids and the need to add solvents and emulsifiers, along with the tendency to use higher *in vitro* concentrations than occurs in living animals, makes interpretation of such experiments difficult... The weight of the evidence from *in vitro* cultures of human cells and from *in vivo* animal and human studies is that neither marijuana nor THC causes chromosome breaks." **(202-204)**

6p.
Cerebral Atrophy --- In the 1970s, considerable controversy was generated by sensational reports by R. Heath, *et al*., alleging that smoking marijuana caused "brain damage." The animals were forced to smoke large amounts of marijuana in a few minutes through a smoking machine, without any opportunity to breathe normally: the animals were suffocated with the smoke. Any brain damage was certainly caused by oxygen starvation, not by the drug. Other experiments with rats have demonstrated severe damage to the hippocampus using huge doses (10-60 mg/kg/day for 60 days), but such experiments bear no relation to real-life conditions and are not relevant to humans except for purposes of prohibitionist propaganda. **(205-207)**

The Relman Committee summarized the issue thus in their report on *Marijuana and Health*:

"There is substantial controversy about whether marijuana causes changes in brain structure or in brain cells. Two studies have reported that marijuana produces changes in brain morphology. Both suffer sufficiently from methodological and interpretational defects that their conclusions cannot be accepted. Furthermore, other studies have not found changes in morphology...

"There is no persuasive evidence that marijuana causes morphological changes in brain structure. Electron micrographic studies of monkey brains indicating morphologic changes are methodologically flawed and cannot be used as evidence for an effect of marijuana on brain cell morphology..."

7.
Mental Effects

Cannabis' mental effects are notorious. They are generally characterized by euphoria, but that is a simplistic description. The clinical effects are much more complex, and sometimes frightening, but apparently benign:

7a.
Perception --- Marijuana produces a wide spectrum of perceptual effects. These include mood changes, facilitation of interpersonal behavior, and reduction of aggressive behavior. In other words, marijuana usually makes people feel happy, sociable, and peaceful. A variety of perceptual phenomena have been recorded by Charles Tart, who made a psychological study of marijuana intoxication. Characteristic visual perceptions include patterns, vivid imagery, and improved peripheral vision. Hallucinations, auras, and dimensional changes occur less often. The senses of taste, smell, touch and hearing are augmented with new qualities and greater intensity. Usually there is a craving for sweets. The sense of time is consistently distorted by marijuana; events seem to last much longer than they really do. Another common effect is a strong sense of being here-now. The phenomenon of *deja vu* occurs more often. In some subjects, time becomes non-linear. This can be problematic if the person is not aware of techniques for manipulating the effect to advantage. Paranormal phenomena such as empathy, intuition, or telepathy, and mystical experiences often are reported. Marijuana often is considered to be an aphrodisiac in that it can enhance sexual experiences. Emotions are felt more strongly. People often report that they feel more childlike and open to new experiences. **(208-212)**

Reese Jones repeatedly tested marijuana and placebos containing no THC, and found that the placebo produced about 60% subjective "high" responses. Average quality marijuana gave about 70% high response. Much of the high results from "set and setting" (the subject's expectations and surroundings). Cannabis is unique among drugs in that the user can develop so-called "reverse tolerance", requiring less and less to get high.

Dr. Andrew Weil elaborated on the concept of a placebo-effect by marijuana and reverse tolerance in *The Natural Mind* (1972):

"If all of the so-called psychological effects of marihuana are really not attributable to marihuana, and if the physical effects that are attributable to it are so unimpressive, what, then, is marihuana? Certainly it is about as far from being a drug as it can be and still merit the name drug rather than herb. In fact, nutmeg, which we are used to thinking of as a spice, has far more pharmacologic power than hemp. To my mind, the best term for marihuana is active placebo -- that is, a substance whose apparent effects on the mind are actually placebo effects in response to minimal physiological action... all psychoactive drugs are really active placebos since the psychic effect arise from consciousness, elicited by set and setting, in response to physiological clues... Not surprisingly, regular marijuana users often find themselves becoming high spontaneously... The user who correctly interprets the significance of his spontaneous highs take the first step away from dependence on the drug to achieve the desired state of consciousness and the first step toward freer use of his nervous system..." **(213)**

7b.
Adverse Effects --- Cannabis sometimes evokes a panic reaction from naive smokers (and

from prohibitionists). As many as a third of regular users occasionally experience paranoid or panic reactions, hallucinations, confusion, and other adverse reactions, especially in unfavorable settings and at high doses. The problem occurs most often when cannabis is ingested, apparently because the dose cannot be controlled as it can with smoking. Medical treatment is rarely sought because the situation is easily self-controlled in most cases. Chinese herbalists recommend mung bean as an antidote.

Perhaps the most extreme case on record involved an episode of "koro" following cannabis-smoking. Koro is a state of acute anxiety characterized by retraction of the penis into the abdomen. In this instance, a Hindu man who smoked ganja for the first time experienced extreme depersonalization and could not feel his legs:

"He then tried to feel the presence of his legs by deep pressure with his fingers, and to his utter surprise and horror he discovered that is penis had seemingly gone inside the abdomen beyond grasping or holding. At this feeling of "penis loss" he shouted for help... His friends came hurriedly and "dragged out" the receded penis manually. He was in a state of acute psychogenic shock... He was taken to a nearby pond with his penis held by one of his friends and he was put into the water... Eventually the victim perceived that the retracting penis had become stable and regained its usual morphology." **(214)**

The so-called "acute brain syndrome" or delirium attributed to cannabis abuse is distinguished by mental clouding, perceptual disturbances, disorientation, impaired goal-directed thinking and behavior, memory disorders, disruptions of sleep patterns, and changes in psychomotor control. The symptoms develop quickly and fluctuate rapidly. The syndrome manifests during drug use and soon disappears with abstinence. Most of the reported cases have come from India and the Middle East, where the potency of cannabis products is generally higher and consumption is more widespread than in Europe and America. Cases have been reported among American soldiers in Vietnam and in Europe; the men recovered in 3 to 11 days and returned to duty. **(215-218)**

A sufficient number of reports have accumulated to indicate a temporal association between the use of marijuana and the return of preexisting symptoms of mental illness such as hypomanic behavior. Schizophrenics may be particularly susceptible to such relapse. Depressive patients treated with THC have shown a high incidence of dysphoria reactions. Nonetheless, many psychotic persons smoke marijuana to relieve their symptoms; this indicates that negative or positive reactions are highly individualized. **(219-221)**

7c.
Learning--- In state-dependent learning, information is learned while intoxicated and is best recalled while intoxicated with the same drug. State-dependent learning is performed more slowly with marijuana. Recall usually is impaired, apparently because of poor concentration causing a deficit in the attention-storage phase of memory. **(222)**

Numerous tests have shown that marijuana has adverse effects on short-term memory, persisting for 2-3 hours. Some researchers contend that the effects persist for at least 6 weeks. Some have gone so far as to claim that marijuana causes brain damage. On the other hand, Arthur Leccese (Prof. of Psychology, Kenyon College, OH), has researched the effects of drugs on memory, and offers a second opinion:

"There is really no evidence that any of the recreational compounds --- cocaine, marijuana, LSD --- are capable of causing significant or prolonged brain damage that would have any effect on anybody's ability to function adequately in a cognitive way. That is, unless you overdosed. If you're not sure whether you ever overdosed, then you didn't. I teach a course where we talk about memory loss as a consequence of brain damage, and if you scour that literature, you'll find that --- short of overdose --- the only drugs we know do it are alcohol and other organic solvents, glue sniffing, stuff like that. The only that is demonstrated to be certainly associated with brain damage... to areas involving memory is alcohol." **(223, 224)**

7d.
Dependence --- *The Merck Manual of Diagnosis and Therapy* (15th edition, 1987) states:

"Chronic or periodic administration of cannabis or cannabis substances produces some psychic dependence because of the desired subjective effects, but no physical dependence; there is no abstinence syndrome when the drug is discontinued.

"Cannabis can be used on an episodic but continual basis without evidence of social or psychic dysfunction. In many users the term dependence with its obvious connotations probably is misapplied.

"Many of the claims regarding severe biologic impact are still uncertain, but some are not. Despite the acceptance of the "new" dangers of marijuana, there is still little evidence of biologic damage even among relatively heavy users. This is true even in the areas intensively investigated, such as pulmonary, immunologic, and reproductive function... The chief opposition to the drug rests on moral and political, and not a toxicologic, foundation". **(225, 226)**

7e.
Amotivational Syndrome --- Some chronic users of marijuana exhibit a group of personality changes which clinicians are wont to call "amotivational syndrome". The changes include: apathy, loss of ambition and energy, poor concentration, and a decline in work or scholastic performance. This group of symptoms also is found in nonsmokers, and it is not always associated with regular use of marijuana. Since many troubled individuals seek relief or "escape" in drugs, frequent use of marijuana can be counter-productive behavior for such people, and for adolescents in particular. **(227, 228)**

The issue of "amotivational syndrome" largely began in 1971, when the *Journal of the American Medical Association* published an article entitled "Effects of Marihuana on Adolescents and Young Adults", written by Harold Kolansky and William Moore. It was accompanied by an editorial proclaimation:

"[This study is] the first real evidence based on good research of the harmful effects of marihuana. Heretofore, medicine has been able to say only that there was no good evidence of harm from smoking pot. Now we have some evidence."

Kolansky and Moore described 38 marijuana smokers, 13 to 24 years old:

"[They]showed an onset of psychiatric problems shortly after the beginning of marihuana smoking; these individuals had either no premorbid psychiatric history or had premorbid psychiatric symptoms shortly after the beginning of marihuana smoking; these individuals had either no premorbid psychiatric history or had premorbid psychiatric symptoms which were extremely mild or almost unnoticeable in contrast to the serious symptomatology which followed the known onset of marihuana smoking... It is our impression that our study demonstrates the possibility that moderate-to-heavy use of marihuana by persons with a predisposition to psychiatric illnesses may lead to ego decompensation ranging from mild ego disturbance to psychosis..."

Although the authors showed an association between smoking marihuana and mental problems, they did not demonstrate causal relationship, nor did they explain the mechanism of "ego decompensation", which they repeatedly stated was due to the "toxic" effect of marihuana. Thus, the damage as done to the truth, if not the marihuana smokers.

The unqualified report generated a storm of controversy. The eminent Dr. Lester Grinspoon offered this observation:

"All in all this paper is, from a scientific point of view, so unsound as to be all but meaningless. Unfortunately, from a social point of view it will have a great significance in that it confirms for those people who have a hyperemotional bias against marijuana all the things they would like to believe happen as a consequence of the use of marijuana and in turn it will enlarge the credibility gap which exists between young people and the medical profession. I am convinced that if the American Medical Association were less interested in the imposition of a moral hegemony with respect to this issue and more concerned with the scientific aspects of this drug this paper would not have accepted for publication."

In 1990, J. Shedler and J. Block published the results of a rigorous longitudinal study of 101 youths whom they followed from age 3 to 23, examining their psychological health in relation to drug use. The researchers found that adolescents who had experimented occasionally with drugs, particularly, were well adjusted. Abusers and non-users were not so happy:

"Adolescents who used drugs frequently were maladjusted, showing a distinct personality syndrome marked by interpersonal alienation, poor impulse control, and manifest emotional distress. Adolescents who had never experimented with any drug were relatively anxious, emotionally constricted, and lacking in social skills. Psychological differences between frequent drug users, experimenters, and abstainers could be traced to the earliest years of childhood and related to the quality of their parenting. The findings indicate that (a) problem drug use is a symptom, not a cause, of personal and social maladjustment, and (b) the meaning of drug use can be understood only in the context of an individual's personality structure and developmental history...

"The most effective drug prevention programs might not deal with drugs at all... Current efforts at drug 'education' seem flawed on two counts. First, they are alarmist, pathologizing normative adolescent experimentation... and perhaps frightening parents and educators unnecessarily. Second, and of far greater concern, they trivialize the factors underlying drug abuse, implicitly denying their depth and pervasiveness." **(229)**

Johnathan Shedler said:

"It's absolutely not the case that experimentation leads to abuse... The few youths who did become addicts shared three psychologic factors that made them susceptible: poor impulse control; unhappiness --- they were anxious, distressed or depressed; and alienation --- they had few friends, they weren't invested in anything like sports or family relations."

Psychologist Judith Brook concluded from her similar studies that "parental support, warmth, responsiveness, affection and the child's identification with the parent" were fundamental to prevention of drug abuse in later years, Mellinger, *et al*., also refuted the association of marijuana with amotivation; instead, they found that poly-drug use (alcohol, amphetamines, cocaine, etc.) is associated with the syndrome. **(230)**

A comparison of marijuana users and non-users revealed that individuals who did not smoke marijuana scored slightly higher on psychological tests for sociability, communality, responsibility, and achievement by conformity, perhaps because they were "too deferential to external authority, narrow in their interests and over-controlled." Marijuana smokers scored higher for empathy and independent achievement, and had better social perception and more sensitivity to the feelings and needs of other persons. The researchers concluded that marijuana smokers possess all the "achievement motivation necessary for success in graduate school."

Interviews conducted in 1970 by N. Zinberg and A.Weil with regular and heavy smokers of marijuana revealed that they felt "bitter about society's attitude toward marijuana... Being defined as a deviant and law breaker, for something they could not accept as criminal, had driven them into increasingly negative attitudes toward the larger society." C. Davis reported in the *Drug Journal Forum* (1977) that the psychological health of young marijuana smokers did not appreciably differ from that of non-users or psychedelic users. **(231, 232)**

Scientific American magazine reviewed and evaluated the many studies claiming to show that drug use in the workplace is counter-productive or dangerous. It was found that all but one of the studies were poorly designed or had been misinterpreted. The single valid study, published in the *Journal of General Internal Medicine*, found "no difference between drug-positive and drug-negative employees" in terms of job performance or evaluations by their supervisors, except for the fact that 11 persons out of the 158 who passed their drug tests were fired within a year, while none of those who tested positive after being hired were dismissed. **(233)**

Contrary to Kolansky and Moore, the Jamaica Study found otherwise:

"Almost unanimously, informants categorically stated that ganja, particularly in spliff form, enabled them to work harder, faster and longer. For energy, ganja is taken in the morning, during breaks in the work routine, or immediately before particularly onerous work... The effects of small doses of ganja in the natural setting are negligible, while concentration on the work task itself increases markedly after smoking...

"The belief that ganja acts as a work stimulant and the behavior that this induces casts considerable doubt on the universality of what has been described in the literature as 'the amotivational syndrome', or a 'loss of desire to work', to compete, to face challenges. Interests and major concerns of the individual become centered around marijuana and drug use becomes compulsive... In Jamaica, and one would suspect in other cannabis-using, agricultural countries, ganja is central to a 'motivational syndrome', at least on the ideational level. Ganja... rather than hindering, permits its users to face, start and carry through the most difficult and distasteful manual labor..."

[Dr. Andrew] Weil suggests that in the United States 'amotivation' is a cause of heavy marihuana smoking rather than the reverse.

Melanie Dreher, a member of the Jamaica Study, made a similar finding:

"[There was] no impairment of the ability to work, no apathy. In fact, the opposite seemed to be true... But anthropological findings have been disappointingly underutilized in the forming of national policy."

Dreher said that members of a presidential commission told her they weren't interested in the results of her work if it failed to show negative effects of marijuana use. **(234)**

8.
Neurology

In 1984, Miles Herkenham and his colleagues at NIMH mapped the brain receptors for THC, using radioactive analogs of THC developed by Pfizer Central Research. They found the most receptors in the hippocampus, where memory consolidation occurs. There we translate the external world into a cognitive and spatial "map". Receptors also exist in the cortex, where higher cognition is performed. Very few receptors are found in the limbic brainstem, where the automatic life-support systems are controlled. This may explain why it is so difficult to die from an overdose of cannabis. The presence of THC receptors in the nasal ganglia --- an area of the brain involved in the coordination of movement --- may enable the cannabinoids to relieve spasticity. Some receptors are located in the spinal cord, and may be the site of the analgesic activity of cannabis. A few receptors are found in the testes. These may account for the effects of THC on spermatogenesis and its alleged aphrodisiacal properties.

S. Munro, *et al*., located a peripheral CX5 receptor for cannabinoids in the marginal zone of the spleen. The Anandamide/cannabinoid receptor site, a protein on the cell surface, activates G-proteins inside the cell and leads to a cascade of other biochemical reactions which generate euphoria. **(235-240)**

CBD antagonizes THC and competes with THC to fill the cannabinoid receptor site. THC also exerts an inhibitory effect on acetylcholine activity through a GABA-ergic mechanism. It significantly increases the intersynaptic levels of serotonin by blocking its reuptake of into the presynaptic neuron. THC also elevates the brain level of 5-hydroxy-tryptamine (5-HT) while antagonizing the peripheral actions of 5-HT. **(241-243)**

In 1990, Patricia Reggio, *et al*., developed a molecular reactivity template for the design of cannabinoid analgesics with minimal psychoactivity. The analgesic activity of the template molecule (9-nor-9b-OH-HHC) is attributed to the presence and positions of two regions of negative potential on top of the molecule. The template places all cannabinoid analgesics on a common map, no matter how dissimilar their structures.

The brain produces Anandamide (Arachidonylethanolamide), which is the endogenous ligand of the cannabinoid receptor. It was first identified by William Devane and Raphael Mechoulam, *et al*., in 1992. Anandamide has biological and behavioral effects similar to THC. Devane named the substance after the Sanskrit word *Ananda* (Bliss). The discovery of Anandamide and its receptor site has unlocked the door to the world of cannabinoid pharmacology. **(245-248)**

9.
Compassionate Cannabis

Robert C. Randall, a glaucoma patient, was arrested in 1975 for cultivating cannabis. He sustained a defense of "medical necessity": THC is proven to reduce Intra-Ocular Pressure (IOP) in glaucoma with negligible side-effects (to wit, euphoria or anxiety), when other conventional treatments have failed. Over 7,000 Americans go blind from glaucoma each year. More than 250,000 people in the USA suffer from the incurable disease, and so do millions more worldwide. Being obliged to supply Randall with legal medical marijuana, the federal government created the Compassionate Investigative New Drug program, through which qualified patient could obtain their supply. The application involved a ludicrous amount of paperwork, and few doctors were willing to take on the task. The Public Health Service has suspended the program in 1993. Assistant Health Secretary Philip Lee wrote: "Sound scientific studies supporting these claims are lacking despite anecdotal claims that smoked marijuana is beneficial", but suggested that the PHS may allow privately funded experiments to determine if cannabis has any health benefits.

A review of the extant literature on Cannabis shows many conflicting claims. The results obtained by one researcher or group often cannot be duplicated by others, and sometimes are inconsistent in themselves. The problem may be due to any of several causes, such as purity of materials, small numbers of test subjects, different external conditions, routes of administration, and differences in protocols. The problem has also been complicated by politically bias pseudo-scientific studies conducted by such as Gabriel Nahas, *et al*.

Since New Mexico first allowed the medical use of marijuana in 1978, some 40 states have passed similar legislation, but their programs have been suppressed by federal prohibition, despite official protests from the states.

9a.
NORML vs. DEA ---The obnoxious recidivism posed by the various federal agencies which are concerned with cannabis, is well-illustrated by the example set by NORML vs. DEA. The Controlled Substances Act (CSA) of 1970 placed marijuana under Schedule I, the most restrictive classification, thus making it unavailable for medical use. The provisions of the CSA allow individuals and organizations to petition for rescheduling. Accordingly, the

National Organization for the Reform of Marijuana Laws (NORML) filed a petition with the Bureau of Narcotics and Dangerous Drugs (BNDD) in May 1972, urging the BNDD to reclassify cannabis to Schedule II so doctors could prescribe it as a medicine. The petition was summarily rejected without holding public hearings as required by the CSA, and it was falsely claimed that reclassification would violate the obligations of the United Nations Single Convention on Narcotic Substances.

NORML filed suit in the US Court of Appeals, which issued its decision in January 1974, ordering the BNDD to reconsider the matter. The BNDD and its successor, the Drug Enforcement Administration (DEA), did not take action until September 1975, when the DEA denied NORML's petition "in all respects." NORML again appealed to the US Court of Appeals, which decided against the DEA in April 1977 and ordered the agency and the Department of Health, Education & Welfare (DHEW) to undertake a scientific and medical evaluation of the petition. Despite repeated court orders to review the petition, the DEA only continued to delay and divert the issue. On October 16, 1980, the Court again ordered the DEA to review the petition "in its entirety", but the DEA ignored the judgment.

In March 1982, The Food & Drug Administration (FDA) published a recommendation that pure THC be reclassified to Schedule II of the CSA. The DEA reclassified THC under Schedule II in April 1982. The FDA approved synthetic THC for medical use in June 1985 under the chemical name Marinol.

NORML was joined by the Alliance for Cannabis Therapeutics (ACT), which also filed 13 "patient petitions" with the DEA. Again and again, NORML and ACT appealed for a review of their joint petition. After still more delaying action, the DEA saw fit to conduct hearing, only 15 years after the initial court order to that effect. The hearings were held from Summer 1986 until Summer 1988 (Docket No. 86-22).

Administrative law judge Francis Young reviewed the documentary evidence and the testimonies of the many patients and doctors who appeared as witnesses, and issued his 69-page ruling on September 6, 1988. He wrote, in part:

"Marijuana, in its natural form, is one of the safest therapeutically active substances known... The provisions of the [Controlled Substances] Act permit and require the transfer of marijuana from Schedule I to Schedule II... The cannabis plant considered as a whole has a currently accepted medical use in treatment in the United States. There is no lack of accepted safety for use under medical supervision and it may lawfully be transferred from Schedule I to Schedule II. The judge recommends the Administrator transfer cannabis. Based upon the facts established in this record and set out above, one must reasonably conclude that there is accepted safety for use of marijuana under medical supervision... The evidence in this record clearly shows that marijuana has been accepted as capable of relieving the distress of great numbers of very ill people, and doing so with safety under medical supervision. It would be unreasonable, arbitrary and capricious for the DEA to continue to stand between those sufferers and the benefits of this substance in light of the evidence in this record."

While he concluded that the perceived dangers of marijuana do not outweigh its medical benefits, Judge Young noted that "In strict medical terms, marijuana is far safer than many foods we commonly consume."

DEA administrator John Lawn summarily rejected the court's decision and made his own arbitrary judgment:

"Accounts of these individuals' suffering and illnesses are very moving and tragic. They are not, however, reliable scientific evidence... These stories of individuals who treat themselves with a mind-altering drug, such as marijuana, must be viewed with great skepticism. There is no scientific merit to any of these accounts."

In 1989, Lawn charged that advocates of medical cannabis have a "Dark Ages" mentality and have "attempted to perpetrate a dangerous and cruel hoax on the American public."

In April 1991, the Appeals Court decided that Lawn "had acted with a vengeance" to reject Judge Young's recommendation, and ordered the DEA to restudy its opposition to marijuana. The DEA then demanded that cannabis must meet a new set of standards for accepted medical use, based on the Food, Drug & Cosmetic Act. The DEA required: an acceptable scientific determination and knowledge of cannabinoid chemistry and its toxicology and pharmacology in animals, designed on scientific clinical trials of its effectiveness in humans, general availability, information about the use of marijuana, general recognition of cannabis' clinical use in medical journals, texts, and pharmacopoeia and by physicians associations and other organizations, and its recognition and use by a majority of practitioners.

The plaintiffs appealed once more, and on April 1971, a three-judge panel of the US Courts of Appeal (DC Circuit) ordered the DEA to reconsider its opposition to marijuana as medicine and to reevaluate its criteria, which were illogical and impossible to satisfy. Again, the DEA refused to act, and in March 1992 issued its final rejection of any petitions to reschedule cannabis. On February 8, 1994, the US Court of Appeals upheld the DEA decision to keep marijuana classified as a Schedule I substance.

Meanwhile, in May 1991, the United Nations deigned to reassign THC from Schedule I (as established by the 1971 Convention on Psychotropic Substances) to Schedule II, because the pure substance has been proven useful for several medical purposes, and it is "not widely used outside legitimate medical channels." The Cannabis plant remained in Schedule I, because it is "used illegally by millions of people worldwide."

In June 1991, Herbert Kleber, the Deputy Director of National Drug Control Policy, assured the public that anyone with a legitimate medical need for cannabis would be able to receive a Compassionate IND. Yet, only about 50 persons ever were approved for the program. Nonetheless, NIDA processed and distributed more than 160,000 marijuana cigarettes for human use between 1979 and 1990. James Mason, chief of the Public Health Service (PHS), canceled the program in March 1992 after a surge of new applications from AIDS patients. The increase in applications was prompted by a 1990 court decision supporting the medical necessity defense posed by Kenneth and Barbara Jenks, a young Florida couple who contracted AIDS from a tainted blood transfusion received by the husband, a hemophiliac. They smoked home-grown marijuana to relieve the nausea and loss of appetite caused by AIDS and their AZT treatments. Mason said the free-marijuana program ended because "If it is perceived that the Public Health Service is going around giving marijuana to folks, there would be a perception that this stuff can't be so bad. It gives a bad signal. I don't mind doing that if there is no other way of helping these people... But there is not a shred of evidence that smoking marijuana assists a person with AIDS." He also claimed that inhalation of marijuana smoke could aggravate the lung ailment known as pneumocystitis carinii pneumonia, which afflicts some people with AIDS. Mason said he also feared that AIDS patients, crazed on marijuana, would be more likely to practice unsafe sex." A PHS spokesman denied charges that the move was politically motivated, saying that Mason made the decision because doctors at the NIMH said patients who used marijuana could be treated with other drugs instead. The decision was also influenced by the "apparent inconsistency of the government manufacturing and distributing marijuana while it is waging a war on drugs."

DEA Administrator Robert Bonner said, "Claims of marihuana's medical benefits are a cruel hoax to offer false hope to desperate people," and he compared the modern movement to support the medical use of cannabis to when, "a century ago, many Americans relied on snake oil salesmen to pick their medicines."

9b.
***The RAP Report* ---** In 1990, the office of California Attorney General John Van de Kamp tried to censor the 20th annual report issued by its Research Advisory Panel (RAP. The office had been mandated to research "the nature and effects" of marijuana and to provide "compassionate medical access" to cannabis. The RAP was required to report yearly to the governor and the Legislature on its research projects. RAP chairman Edward O'Brien, Jr., strictly limited research and failed to provide cannabis for qualified patients. Instead, he insisted on foisting synthetic THC (Nabinol, Marinol, etc.) onto applicants. The program expired in September 1989 after the staff members decided that "not enough people had been treated to justify its extension."

The RAP recommended that the state legislature "immediately modify" the state's anti-drug policy and permit the cultivation of cannabis for personal use. Instead, the report was censored and published with this disclaimer:

"The executive summary and commentary sections of this annual report have been deleted at the direction of the attorney general."

Vice Chairman Frederick Meyers, MD, and other panel members decided to publish the report themselves, an did so. In its commentary section, the group wrote:

"Our 'War on Drugs' for the past fifty years has been based on the principle of prohibition and has been manifestly unsuccessful in that we are now using more and a greater variety of drugs, legal and illegal...

"Legislation aiming at regulation and decriminalization (not 'legalization') should be formulated as novel efforts that could be quickly modified if unsuccessful.

"The first suggestions for demonstration legislation, rationalized and detailed herein are: 1) Permit the possession of syringes and needles. 2) Permit the cultivation of marijuana. 3) As a first step in projecting an attitude of disapproval by all citizens toward drug use, take a token action in forbidding sale or consumption of alcohol in state-supported institutions devoted in part or whole to patient care and educational activity...

"As Prohibition failed to stop people from consuming alcohol, so too have today's drug laws failed to halt drug abuse and may actually be exacerbating some of the problems associated with it. We are currently at a similar point in our history where much of the leadership and a considerable fraction of the public are coming to question whether prohibition is not equally unproductive in coping with the drug problems. Clearly the marijuana laws are unenforceable in the face of the attitudes and practices of a significant fraction of the population."

10.
Propaganda

During the 1970s, a spate of research reports were published claiming that marijuana causes damage to the brain, to chromosomes, the immune system and the lungs, etc.. Although those studies have been discredited since then, they continue to be mongered as facts by prohibitionists will say anything and stop at nothing to prevent cannabis from coming into its own. Much of the injury to truth was caused by Gabriel Nahas of Columbia University. Nahas was appointed to the UN Narcotic Control Board in by Secretary General Kurt Waldheim in 1971. Earlier that same year, Nahas (who was an anesthesiologist) was involved in a scandal over a fraudulent report of a death attributed to cannabis in Belgium. In his new position with the UN, Nahas dispensed generous grants to a clique of colleagues who proceeded to generate numerous biased and misinterpreted studies alleging to reveal terrible bodily and mental damage resulting from marijuana use.

The *Journal of the American Medical Association* published a critical review of Nahas' "essentially moralistic" book, *Marihuana: Deceptive Weed* (1973), and noted:

"Biased selection and interpretation of studies and omissions of facts abound in every chapter... So much of the volume is distorted that one must know the marijuana literature in order to judge the accuracy of each statement." **(249-251)**

Columbia University held a press conference in 1975 to publicly dissociate itself from Nahas' embarrassing pseudo-science. In 1976, the National Institute of Health refused to give Nahas any more money for cannabis research, and in 1983, the National Institute of Drug Abuse (NIDA) repudiated his work and cut off any further funding to him. Nahas left America and moved to Paris, where he established a prohibitionist organization called Europe Against Drugs (EurAD) in 1992. Meanwhile, the DEA and various prohibitionist groups in the USA continue to tout his phony publications as scientific gospel.

Richard Cowan, then head of NORML, pointed out the dangers of anti-drug propaganda in the *National Review*:

"The fact is that the "narcotics" bureaucrats had been making a variety of wild claims about the perils of pot for decades, making it virtually impossible to do research on the subject. Today, since they can no longer block all research on the drug, the narcocrats simply sponsor ideologically reliable researchers who can be counted on to produce politically useful results. And conservatives generally swallow it whole, because they do not apply to marijuana the same high intellectual standards with which they analyze other subjects, nor do they apply the same standards to the laws against it that they apply to other laws...

"In general, the politicization of drug research undermines the credibility of valid drug information. In the short run, untrue but frightening reports about the dire effects of pot may result in reduced consumption. In the long run, these reports will be seen to be false, and users will, in reaction, disbelieve even the reports that are true. Even worse, warnings about the effects of other drugs also lose credibility, with most unfortunate consequences. Statements such as "marijuana is the most dangerous drug" are not just harmless hyperbole --- they necessarily imply that angel dust, speed and heroin are "safer"...

"Consider the implications of what I am saying, if I am correct. The narcotics police are an enormous, corrupt international bureaucracy with billion-dollar budgets, and multi-billion graft opportunities. They have lied to us for fifty years about the effects of marijuana and now fund a coterie of researchers who provide them with "scientific" support. Some of these people are fanatics who distort the legitimate truth of others for propaganda purposes.

"I realize that this is much more extreme than saying that marijuana is harmless, which, again, it is not. If I am right, then the anti-marijuana propaganda campaign is a cancerous tissue of lies undermining law enforcement, aggravating the drug problem, depriving the sick of needed help, and suckering in well-intentioned conservatives... and countless frightened parents..."

In testimony at hearings before the DEA in 1987 on the medical use of marijuana, Dr. Tod Mikuriya, who had worked with the National Institute of Mental Health (NIMH) in 1967, said:

"When I served at NIMH, in my responsibility in setting up the first legitimate research on cannabis, I saw first-hand the government's bias in examining marijuana. The government seemed only to want to justify the total prohibition of cannabis, including it prohibition as a medicine, rather than to honestly research this plant. This political motivation for government research was a principle reason for my leaving NIMH."

11.
Cannabis & Crime

Beginning with the Indian Hemp Drugs Commission (1983-94), several distinguished governmental and scientific bodies have investigated the possible association of marijuana with crime. All such studies have reached similar conclusions: marijuana does not usually incite users to commit violent or sexual crimes. Instead, marijuana tends to reduce aggression in most people. Laboratory and clinical studies have shown that although some persons do commit crimes while under the influence of cannabis, such abuse is under-represented in studies of violent offenders, especially in comparison with users of alcohol and amphetamines. Studies also indicate that while some marijuana users commit crimes against property, non-drug variables probably are more influential than are drug effects on deviant behavior.

Drug effects are highly individualized by multiple factors, such as: pharmacological properties of the drug, poly-drug interactions, adulterants, dosage, mode of administration, cumulative effects, and pre-drug personality conflicts, mindset, and setting. Sophisticated analyses by several researchers indicate that pre-drug personality disorders are closely associated with assaults that occur during marijuana intoxication. Only an indirect relation exists between marijuana and crime. While all studies suffer from methodological limitations, it is nonetheless apparent that other than the crime of buying and possessing marijuana, there is no reliable evidence that the plant is a "cause" of crime. **(252-255)**

The Indian Hemp Drugs Commission found that, "For all practical purposes, it may be laid down that there is little or no connection between the use of hemp drugs and crime."

William Bromberg and associates reviewed the criminal records of 16,854 offenders in the psychiatric clinic of New York County from 1932-37, and found only 67 users of marijuana. Six were charged with crimes of sex and violence, and the rest were charged with crimes against property. **(256, 257)**

The LaGuardia Commission of New York City (1944) concluded that "Marijuana is not the determining factor is the commission of major crimes."

In the Wooton Report, it was pointed out that, "In the United Kingdom, the taking of cannabis has not so far been regarded, even by the severest critics, as a direct cause of serious crime."
After conducting a thorough review of the available research in 1972, the Shafer Commission reported these conclusions:

"The use of marijuana did not cause or lead to the commission of aggressive or violent acts by the large majority of psychologically and socially mature individuals in the general population... In fact, only a small proportion of marijuana users among any group of criminals or delinquents known to the authorities and appearing in study samples had ever been arrested or convicted for such violent crimes as murder, forcible rape, aggravated assault or armed robbery. When these marijuana-using offenders were compared with offenders who did not use marijuana, the former were generally found to have committed less aggresive behavior than the latter...

"Further, no findings indicate that marijuana was generally or frequently used immediately prior to the commission of offenses in the very small number of instances in which these offenses did occur. In contrast, however, the aggressive and violent offenders in this sample did report with significantly greater frequency the use of alcohol within 24 hours of the offense in question.

"These findings should be considered in the light of an earlier West Coast study of disadvantaged minority-group youthful marijuana users, many of whm were raised in a combative and aggressive social milieu... the data show that marijuana users were much less likely to commit aggressive or violent acts than were those who preferred amphetamines or alcohol. They also show that most marijuana users were able to condition themselves to avoid aggressive behavior even in the face of provocation. In fact, marijuana was found to play a significant role in youth's transition from a "rowdy" to a "cool", non-violent style."

In the book *Legalize It?* (1993), co-authored with James Inciardi, Arnold Trebach stated:

"[Before the passage of the Harrison Act in 1914] massive crime was not caused by wide drug avilablility. It is quite possible that prohibition was the leading cause of the huge increases in crime evident in the last 100 years. However, I do not attempt to make that argument here because so many other social and environmental factors --- urbanization, economic dislocations, class conflicts, the breakdown of old family values and controls, to name only a few -- have emerged over the last several decades that help explain crime... Nevertheless, I believe the data [police records]... seriously undercut the modern argument that legalizing drugs would certainly lead legions of citizens into lives of crime... Virtually all of the data support my central thesis: the absence of national prohibition and the generally easy availability of drugs cannot be shown to have pushed significant numbers of people into crime. Under prohibition, crime rates have risen dramatically." **(258)**

12.
Polemics Against Prohibition

America has been fighting the so-called Drug War ever since President Nixon cursed the nation with his
declaration in 1971. It has been to little avail, because the Drug War cannot be won. Instead, the institutionalized national psychosis known as the Drug Enforcement Administration (DEA) has turned the USA into a police state.

Intoxication is a basic drive in the animal world. It cannot be suppressed without generating psychotic consequences. The eminent psychopharmacologist Ronald K. Siegal, Jr. (UCLA) presented the case for natural drug use in his study of *Intoxication: Life in Pursuit of Paradise* (1989):

"Recent ethological and laboratory studies with colonies of rodents and islands of primates, and analyses of social and biological history, suggest that the pursuit of intoxication with drugs is a primary motivational force in the behavior of organisms. Our nervous system, like those of rodents and primates, is arranged to respond to chemical intoxicants in much the same way it responds to rewards of food, drink, and sex. Throughout our entire history as a species, intoxication has functioned like the basic drives of hunger, thirst or sex, sometimes overshadowing all other activities in life. Intoxication is the fourth drive. We have become the most eager and reckless explorers of intoxication."

It behooves us to cultivate our abilities and realize our potential, but not necessarily without drugs, as prohibitionists would have it. However, that lesson cannot be learned by denying ourselves freedom of choice. Our dysfunctional drug laws punish natural exploratory behavior and forbid us from testing our character in the mirror of psychedelic molecules. Prohibition is ineffective and unconstitutional. Illicit drugs are readily available to almost anyone who wants them, especially among youths, and even in prison, where guards are dealers.

Laws against drugs are predicated on the false assumption that all drug use is harmful. Actually, few drugs are truly addictive when used in moderation, and most people simply will not allow themselves to become addicted. Instead, they use other forms of compulsive behavior (religion, sex, love, politics, money, work, sports, TV, gambling, etc.) to produce altered states of consciousness; some claim to be happy.

Prohibitionists take the process several steps farther, getting their kicks by trampling on the rights of others. Indeed, as the British M.P. Walter Elliot observed in 1920, Americans are "the barbarians of the West" because of their "extraordinary savage idea of stamping out all people who happen to disagree... with their social theories" about alcohol and other intoxicants.

People use and abuse any and all substances in their search for reality or fantasy. Most societies and individuals choose their poisons (alcohol, tobacco, cannabis, coffee, cocaine, opium, Prozac, etc.) for arbitrary moral or traditional reasons. Thus they determine what is a "good", "bad", legal or illicit drug. Otherwise, as Dr. Andrew Weil put it, "There are no good or bad drugs; there are only good or bad relationships with drugs".

The distinctions between legal and illicit drugs are purely ritualistic, magical attributes with little or no basis in pharmacology. Dogmatic Christians (and religionists of almost all other brands) especially fear magic and drugs, so they cannot be very realistic about drugs (let alone magic). There's just no arguing with taste. Indeed, as Fred Nietzsche observed, "Alcohol and Christianity are the two great European narcotics". Karl Marx expressed the same general idea in a similar aphorism: "Religion is the opium of the people".

The entire sad spectacle is mere superstitious scapegoating. The scapegoat is a sacrificial victim (animal or human), heaped upon with the sins and other failures of the people. The wretched creature is banned into the wilderness, or condemned to death. In ancient Greece, the sacrificial human was called *pharmakoi* (remedy), from which are derived the terms pharmacology, pharmacy, etc.. The Greeks abandoned the practice ca. 600 BC, after which *pharmakoi* assumed its modern meaning. However, the collective subconscious mind appears to have retained its primitive magical character; today we exercise the custom of *pharmakoi* in the form of draconian anti-drug laws by which users and dealers are ostracized or quarantined as if they were diseased. Through the skillful abuse of language, prohibition propagandists portray drugs as a virus; no one is immune to the plague of pleasure and self-destruction, and there is no cure.

Fortunately, education is a powerful prophylactic against such quackery. Plato warned us: "Complacent ignorance is the most lethal sickness of the soul". Truly, knowledge is the only therapy for the deadly stupidity caused by anti-drug propaganda. With knowledge and self-control we can meet the challenge and carefully explore the dimensions revealed by psychoactive substances.

Thomas Jefferson and Dr. Benjamin Rush (who was George Washington’s personal physician and a signer of the Declaration of Independence) both foresaw that the federal government might someday attempt to control medicine. Dr. Rush warned:

"Unless we put medical freedom into the Constitution, the time will come when medicine will organize into an underground dictatorship... To restrict the art of healing to one class of men and deny equal privileges to others will constitute the Bastille of medical science. All such laws are un-American and despotic and have no place in a republic... The Constitution of this republic should make special privilege for medical freedom as well as religious freedom."

Thomas Jefferson also declared this in no uncertain terms:

"If people let the government decide what foods they eat and what medicines they take, their bodies will soon be in as sorry a state as are the souls who live under tyranny."

The foresight of Jefferson and Rush has proven true, and the problem appears to be terminally cancerous. Medical tyranny pervades modern society in such various forms as national health care programs, the FDA and DEA, and the heinous Drug War.

Prohibition is a complete failure. The Drug War actually is controlled chaos, serving the interests of an "underground dictatorship" while it forbids us from the pursuit of happiness --- particularly in the form of Cannabis.

Using the phony Drug War as its primary excuse for "necessary" abridgements of our rights, the federal government of the USA has abandoned the Constitution and surrendered to the Communist model of suppression by imposing pre-trial detention without bail, mandatory minimum prison sentences, and capitol punishment for drug crimes, plus increased fines, forfeitures and asset seizures, "good faith" exceptions to the exclusionary rule, and other aberrant violations of justice. Stoned military forces are used to enforce civilian law and to interdict suspected smugglers at sea and in the air. Intelligence agencies smuggle huge quantities of cocaine and heroin from Asia and South America into the USA, and operate clandestine laboratories to finance their crimes. Entire governments have been toppled by cocaine (Bolivia, Panama, Bahamas, etc.). Civilians are required to submit to unreliable drug tests to gain employment. Obnoxious currency controls supposedly prevent the laundering of drug money, and so on. In short, America has become a police state because of its insane drug laws and cowardly citizens.

The Drug War is a coup d’etat. The Drug War is not being fought against molecules, but against ourselves and freedom. The Drug War is conquering America law by law, right by right, until nothing will remain but to fight the Second Civil War foreseen by George Washington and several other American prophets. The Drug War is a fraud that has cost Americans their civil rights, over 150 billion tax dollars, and at least 100 million man-years spent in prisons, in futile, corrupt law enforcement, and other associated costs including countless deaths at home, in the streets, and abroad. We have been rendered dumb and stupid by an open conspiracy that suckles on us like a vampire, eats our children, and aborts our birthrights.

Abraham Lincoln is attributed with having stated (8 December 1840):

"Prohibition... goes beyond the bounds of reason in that it attempts to control a man’s appetite by legislation and makes a crime out of things that are not crimes... A prohibition law strikes a blow at the very principles upon which our government was founded."

There are several legal precedents which support the many Americans who refuse to obey drug laws. The decision in Maybury vs. Madison (1803) is clear enough:

"All laws which are repugnant to the Constitution are null and void."

According to 16 Am Jur. 2d. Sec. 177 & 178, the general rule is:

"An unconstitutional statute, having the form and name of law, is in reality no law, but is wholy void and ineffective for any purpose. It imposes no duty, confers no rights, creates no office, bestows no power or authority on anyone, affords no protection and justifies no acts performed under it. No one is bound to obey an unconstitutional statute and no courts are bound to enforce it... If any person acts under an unconstitutional statute, he does so at his peril and must take the consequences."

Cannabis must be made legal. This is the first step toward the only viable resolution of the drug problem: legalize all drugs (with regulatory control of quality, dosage, etc.). Cannabis does not need to be controlled, but only to be regulated and cultivated for all the values of its fiber, seeds and resin. Yet, instead of enjoying the benefits of Cannabis, we suffer for tiny Pyrrhic victories in a perpetual civil war. We have been convinced by propaganda to repudiate the principles of freedom upon which our former rights were founded. The continued suppression of Cannabis only aggravates a grave injury to society that probably will not be healed by legalization in time to prevent disaster from other quarters. God forbid that this burning issue should become the funeral pyre of freedom! Hemp is sure to survive and thrive, whether it is in the victory gardens or in the ruins of the USA.

Legalize it!

13.
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14.
Index