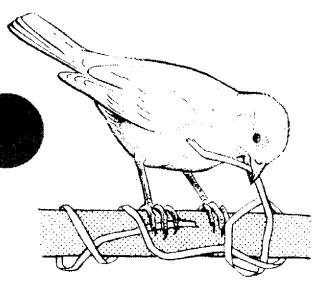
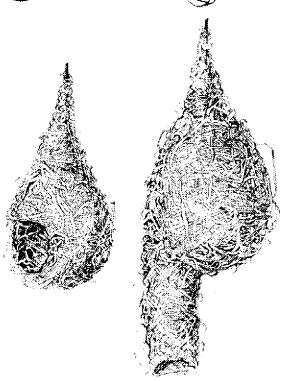
The Tensile & the Tantric

Animal, plant, and petrochemical; market, ecological, and moral. Animal, plant, and petrochemical; market, ecological, and moral. Animal, plant, and petrochemical; mar-

Choosing Fibers That Fit

Peter Warshall



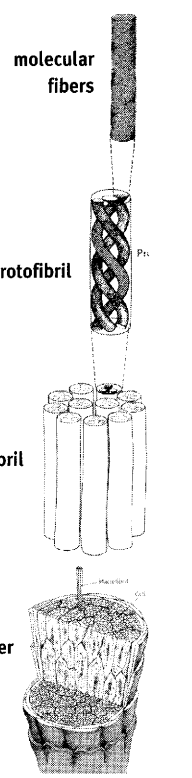


The next 15 pages were prepared with the generous assistance of Daniel Imhoff (ECO), Carolyn Moran (Living Tree), Sue Hall (Strategic Environmental Associates), Jim L. Boyer (University of Minnesota), John Roulac (HEMPTECH), and Whole Earth editorial staff.

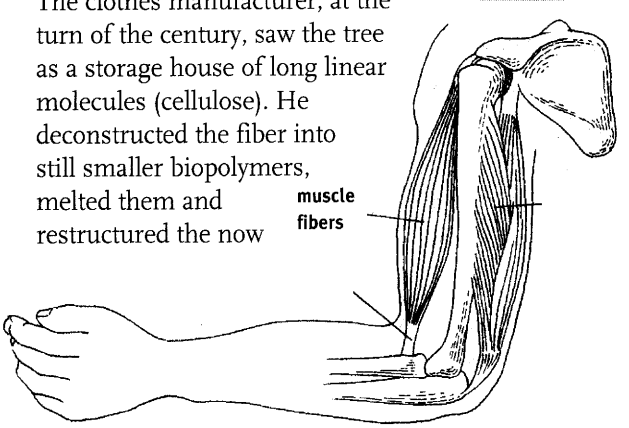
WE HAD NO INTENTION TO FEATURE FIBERS IN OUR revival issue. We intended to run a simple botanical on treefree paper. But our inventive (and humorous) contributors sent photos of "paper" made from cellulose fiber grown by bacteria; fiberglass bridges that helped save marbled murrelets; a futuristic horse blanket with fibers so sensitive they can adjust the blanket's insulation power to changing weather; hemp stone (a hemp-based plastic biopolymer) that can compete with petrolum-based fibers; and wallboard and trusses made from wastepaper pulps and soybean paste, urban wastewood, and agricultural waste straw. Fiber-thoughts flashed before us like draping silk, turned figurative, personal, almost obsessive. "What fibers are you wearing today?" "Oh, he needs moral fiber, not dietary." We were amazed that so little attention is paid to the longish, tough, and flexible filaments that connect nature to itself and to human life. Fiber frames the forms of all globular, amorphous protoplasm.

The wormy and spaghetti shapes of fibers provide a lot of surface area compared to their bulk. They can weave, knot, and twist to construct even stronger long-forms like braid, rope, and yarn. Tensile strength makes fibers ideal for nature's rigging. Sinew, tendons, and muscles hold our bodies together. Humanoids probably first rigged roots for burden baskets, and fibrous gut for slingshots. With agriculture, we humans converted sisal and hemp fiber to cordage. With petroleum, polyester fibers could be custom-designed for special uses like mountain climbing. No matter what the material, fibers equal rigging.

Fibers can also lie side-by-side or surround each other. Overlapping, fibers become "body shelters" like fur, fleece, and penguin feathers. With various glues, fibers form layers, plys, sheets, and cylinders of great tensile strength like insect exoskeletons, shells, lizard scales, tree trunks, paper, and bias-belted tires. A few species construct fiber artifacts which act as "extended body shelters" like cocoons, weaver bird nests, thatch, caulking, rugs, and plywood roofs. Fiber is the medium of most messages: the muscles of the handsome hunk; the canvas of painting; the papyrus of Egyptian art; the gold threads of tapestry; the beauty of shedding bark on ancient trees.



Industrial inventions modified and fragmented our senses of fiber. The word now sings different tunes to different folks, a kind of frame-of-reference blues. An older timberman sees trees, for instance, as a repository of naturally glued wood fibers that can be cut into boards and studs. The more modern timberman sees the trees as thinner sheets like veneer, and smaller pieces like wood chips for plywood and oriented strand board. The paperman sees the tree glue as a problem, deconstructs the tree into wood chips, unglues their fibers; and reconstructs them into sheets of paper. The clothes manufacturer, at the turn of the century, saw the tree as a storage house of long linear molecules (cellulose). He deconstructed the fiber into still smaller biopolymers, melted them and restructured the now



viscose tree into rayon and acetate thread.

To take off the commodity glasses — to see the forest for the polymers — has become increasingly a chore. Eyeball the ecostructure of trunks and branches that filigree the canopy, seeing in your mind's eye its fiber bundles. Visualize the leaf fibers supporting the weaker cells that gather light, breathe, and manufacture food, and the network of root fibers sucking up water in a corporate partnership with filamentous fungi, whose gossamer hyphal mesh extracts the soil nutrient. A dense and intricate mesh!

Fibers are also "strands of time," webbed together by repeated encounters. These "flextime" fibers have been the hardest to "see." We draw them as spaghetti-like connectors in nutrient cycles. These "lines of time" are mental fibers, concealed and revealed, and serve as a great analogy, model, story, or school for understanding the intertexture of human relations. A typical North American indigenous story tells how the soft-haired, blind mole carries dark earth messages to the surface, relaying them to the flashy-haired perky squirrel who runs up the fibrous-barked elder spruce to the perched power of the feathered eagle who, in turn, liberates the message into the relatively fiber-free sky. The "yarn" ties animated threads of morality, natural history, humor, and philosophy to The People. Spiritual fiber-lattices are the material most citizens yearn to know and exercise.

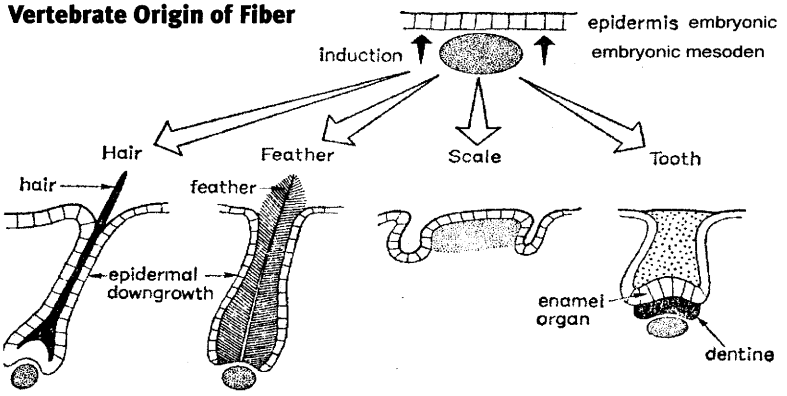
Unalienated Fibers

Juanita Ahil, an elderly O'odham (Papago) basket weaver taught me about unalienated fibers. She asked some Tucson friends for help. We piled into an old GMC, cruised the Sonoita hills until she pointed out a stand of vibrant yucca. Juanita would not harvest the leaves. She was too short and had too many memories of what happened to Indians "trespassing" onto ranches. I slipped under the four-strand barbed wire, wriggled my hand through the outer rosette of spiny leaves, gripped the sheath of young growth and popped out a fistful. Over the next two months, Juanita high-graded the leaves, peeled off the outer edges, then stripped out the interior leaf fibers, dried them, twisted them into threads, wove them with the black fibers of Devil's Claw vine, sold the small, elegant black and white basket to a trader who, in turn, doubled or tripled the price, and sold it to a collector.

Basket-making, slow and deliberate, blends handwork with long conversations and long contemplations. Juanita chatted about how this basket compared to earlier baskets; problems with yucca fibers harvested at the wrong season or wrong place; about a dozen other plants that could be combined with yucca for a dozen other purposes. We joked about stealing the rancher's yucca, and remembered relatives who had been caught. I learned the dignity of handcraft and of the moods woven into the basket while reconstructing the deconstructed leaves. ("See that wrong knot. John came over and complained about our cousin's drinking.")

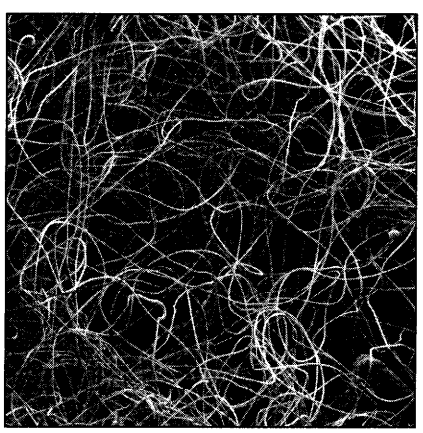
Juanita sweetly exposed my profound ignorance of the desert grasslands and my distance from the fingered feel, the sensual detail she honored in everyday life. I also lacked good origin stories: Where did the rubber, polyester and steel cords of the GMC's radials come from? Who was the rubber monster? The angel of steel? Who hated or had fun in their manufacture? What kind

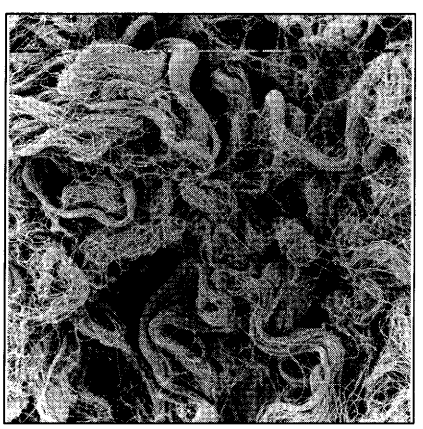
Vertebrate Origin of Fiber



Fiber Facts: We now consume five times more paper than in 1950.

Pulp will soon consume half the world's annual timber cut each year.





DAVID SCHARF

Left: Holofil (polyester fiber); Center: Human fibrin clotting blood, 3000x; Right: Paper towel fibers, 450X.

Fiber Facts: The US uses 65% virgin pulp. Less than 1% is treefree.

Treefree pulp supplies 9% of global paper pulp. Asia produces 88% of the planet's treefree paper.

20 million tons of urban wastewood enter municipal waste dumps each year.

of straw was my tattered cowboy hat? What farm and hat weaver? With gringo regret, I wondered why I hadn't bought her basket (Juanita died a few years after). Her gift was learning to say grace to the tough yucca and all other fibers for their gifts of cloth, rigging, shelter, woven beauty and information services. She helped set my editorial policy: always include the tantric loom.

Fiber Futures

The market system for fibers is now global with petrochemical fibers (hydrocarbons) supplying the majority of textile, upholstery, and industrial cloth, cordage, and related products. Only paper and, in some places, building materials, remain somewhat immune from hydrocarbon competition. On the other hand, plant-based fibers (carbohydrates) may be having a comeback. A small group of committed citizens and businesses and a great creative spirit have rejuvenated fiber agriculture and forestry. New crops like kenaf, waste straw, sugar cane and industrial hemp; new cultivation techniques like organic cotton; and new products such as strawboard and treefree paper have found small but solid markets. Their promoters see treefree crops as more efficient, less harmful to both workers and the environment, supporting rural

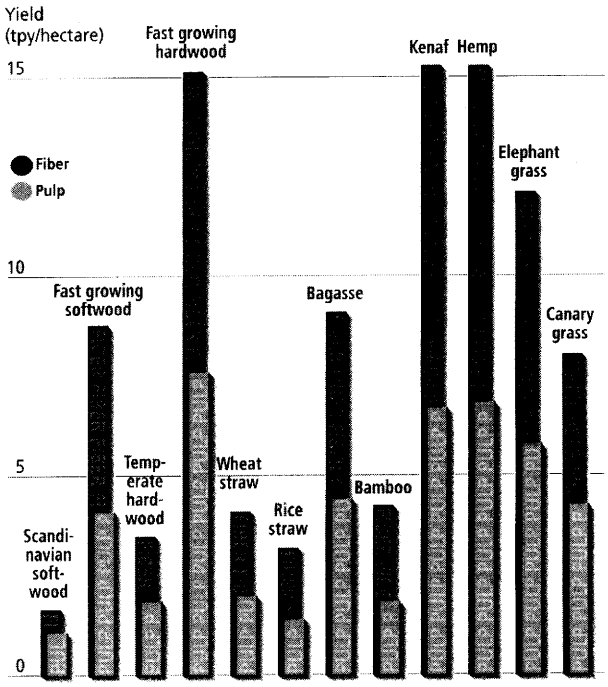


Chart shows the average annual yields* per year for papermaking fibers.

*tonnes/hectares

The US produces 65% of its pulp from timber harvesting. Worldwide, paper pulp comes from conifers (about 67%); plantations (about 25 to 35%); and tropical hardwoods (1%). Pulp demand will soon be responsible for half the world's annual timber cut each year. The Northern industrialized nations produce 83% of all paper products. They also consume ten times more paper per person (by weight) than the less industrialzied South, and five times more paper per person.

Natural (Carbohydrate) Fibers

Forest	*Agriculture*	*Livestock*	*Mineral*	*Ocean & Tidal Zones*
Tree fibers **Fruit fibers** (kapok, coconut husks)	**Bast fibers** (flax, hemp,ramie,shrubs) **Vascular fibers** (cereal straws, bagasse, bamboo, esparto, reeds, pine needles **Leaf fibers** (abaca, sisal, etc.)	**Wools** (sheep, goats, camels, angora rabbits) **Skins** **Silk**	**Asbestos** **Glass** **Aluminum**	**Chitin** (crabs, lobsters)

Cellulose pulps & fibers

Paper & cardboard products *(endless list)*

Engineered woodfiber products: Particle boards, Blended bricks

Biopolymer resins: Shelters
Regenerated natural fibers: Rayon, Acetates, Vegetable plastics, Apparel, Home furnishings, Medical, Tire cord, Fabrics, Fiberfill, Cigarette filters

Natural Fibers

Textiles, Ropes, Rugs, Velum skins

Fiberglass, Fireproof fabrics, Optical, metallic fibers

Chitosan
Filter fabrics
Wound-healing fabrics
Drug medium

BLENDS WITH SYNTHETICS

economies and communities, decreasing the greenhouse impact of petrochemicals, and reducing the flight of farmers to the urban jungles. Moral fiber has rejoined the material.

Arbokem, for instance, is a producer of straw fiber pulp and paper in Oregon. Al Wong, its founder, with persistent entrepreneurial spirit, organized farmers' coops to manage the waste straw supply chain. Each coop owns part of Arbokem to encourage community and loyalty. Farmers no longer burn the waste straw (reducing greenhouse gases) but leave 90% to prevent soil erosion and protect soil quality. Selling the remaining straw to Arbokem increases profit per acre by 25 to 50%. Al's patented agripulping process reduces the amount of capital needed for small mill pollution management. The effluent can be sold as fertilizer and the pulp is chlorine-free with minimal water use. He now competes with wood pulps and should soon undercut their price.

Fiber fact: A 300 acre petrochemical plant equals 600,000 acres of cotton in terms of fiber production.

The spirited advocates of the new bio-economy have a complex and heroic path ahead. Phase One of Earth Day succeeded and is now over. The world is fully aware of the environment and its problems. Enviro issues are mainstream. Phase Two — the fusing of ecological knowledge into the market system — has just begun. The market system remains amoral and unforgiving. The feedback loops to help save legacy forests or regenerate sheep-grazed grasslands have yet to be constructed.

Sally Fox had a perfect offering. She patented a cotton with green and brown bolls and she grew her cotton organically — avoiding all the soil erosion, toxic harms from both planting and dying colors, and water waste. But cotton gins refused her cotton, afraid her seed would contaminate ag biz seeds. Israel challenged her market share with its own green and brown cotton and she has had to sue to protect her patent. Sally found expert cloth makers and marketers. But her green and brown textiles lasted only a few years in a market that loves changes in color with each season. She will attempt to switch to sheets and towels which have less fickle color demands. Despite help from Esprit, Patagonia, and Ikea, she hovers near bankruptcy.

FoxFibre, her company, cobbled together just about as perfect an ag ecosystem as possible. Yet, the take home lessons are brutal: an enterprise can fail simply because cultural tastes glamorize variety in color. Consumers who want to buy feel-good offerings remain ill-informed about the ecological consequences of their choices. How does a consumer know that all green t-shirts or white

Fiber Facts: 50% of textile fibers are cotton, and 25% of all petrochemicals are used to grow it.

The US landfills one million pounds of textiles per day (mostly synthetic carpets and upholstery), and 200 million pounds of denim each year.

Synthetic (Hydrocarbon) Fibers

Petroleum, Natural Gas & Asphalt

Fiber fact: About 95% of all US carpets and 45% of all home furnishings (sheets, drapes, upholstery and carpets) are petro-based fibers. 30% of all clothing are synthetics. A car needs 25 pounds of petrobased fiber in the tires and the inside trim and fabric.

Non cellulosic polymers
(by chemical synthesis)

Step-growth polymers

Polyamides: Nylon, Tire cord, Seat belts, Parachutes, Ropes, Strings, Nets, Sleeping bags, Tents, Doll hair

Polyesters: Easy-care fabrics, Pet containers, Polartec®fabrics, x-ray film, home furnishings, Fiberfill

Polyurethane: Spandex® & Lycra®fabrics, Thermal insulation, Soundproofing, Adhesives, Coatings

Olefin: Sportswear, Insulation, Roadbeds, Upholstery, Automotive interiors, Cordage, Cl-free medical items (extruded)

Chain-growth polymers

Polyacrylonitrilles: Acryllic fabrics, Home furnishings, Simulated furs, Automotive fabrics,

Exotic Synthetics:

PBI: Flame-resistant fabrics Concrete reinforcement

Sulfar: Reverse osmosis filter fabrics

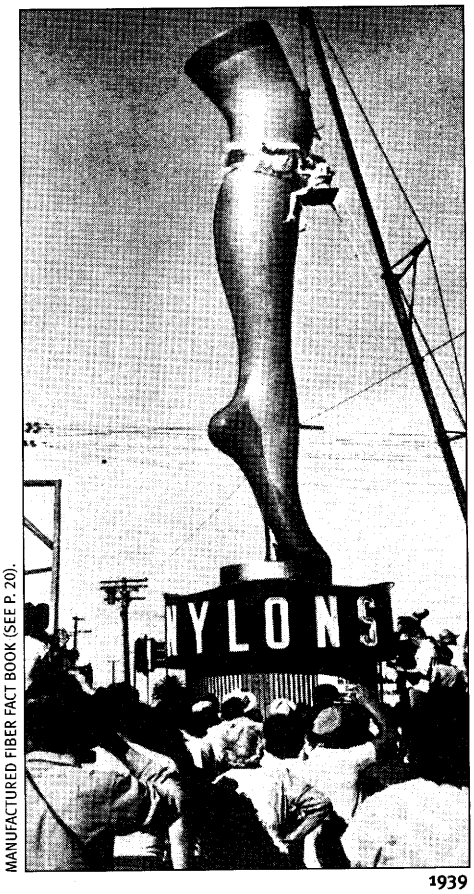
Aramid©: Gun-shot resistant fabrics, helmets, tires, sailcloth, ropes, marine & sports products

cotton sheets are not the same? How can FoxFibre and her distributors change consumer decisions when the consequences occur in very distant places and in complicated economic and ecological networks?

FoxFibre is breaking the new paths that face all fiber lovers. The challenge of harmonizing market and ecosystem. Rayon gulps exorbitant process water gallonage and produces exorbitant effluents. Which manufactured fiber does least harm? Certain synthetic fibers release petro-based toxins during manufacture and disposal. Without a new frame for choice, the consumer wanders exhausted among ads and info-glut unable to find a simple, clear path to a new market of caring. We hope this magazine will help overcome some info-gaps and double-speak.

The paper products business is in worse shape. No one knows which forest was cut for the paper pulp that became your writing pad. Maybe the pulp came from a plantation or maybe from an old-growth temperate forest. No one knows if the tree cutting diced the forest into such small patches that a species could no longer survive. Did the cutting cause an irreversible change? There is hope (and we need lots of hope) that substituting for tree pulp will help save legacy forests. Kenaf, bagasse, hemp or waste straw could, in theory, reduce demand for tree pulp or other tree products. Treefree fiber crops can, in theory, be grown with less harmful, equally productive techniques, and some of the longer fibers in kenaf and hemp can greatly increase the tensile strength of recycled paper pulps. These crops can, in theory, revive rural economies in places like Kentucky, which is weaning itself from tobacco, or Thailand, where farmers look for more stable incomes.

Beyond theory is the harsh fact: harvesting, manufacturing, and consuming treefree products does not automatically protect old-growth or other forests. The cybernetics aren't there yet. The economic and societal fiber is wimpy. The forest products industry doesn't stop harvesting just because treefree products enter the market. It finds other markets for trees such as building and construction, or it exports tree pulp to China, whose thirst is huge and growing. Or, it plays with the market system: begging more subsidies to lower its prices or underselling pulp to out-compete treefree growers during start-up. For the moment, the only simple feedback loop I can conjure is: to take profits from the sales of treefree products and buy a forest to remove it from market predation.



MANUFACTURED FIBER FACT BOOK (SEE P. 20).
1939

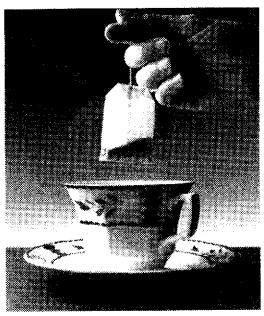
Phase Two — the harmonizing and conjoining of market system to ecosystem — needs help. Like unwrapping a silk cocoon, there are miles of tough questions demanding to be yanked. The bottom line for ecosystems is biodiversity protection; for market systems it's financial profit; for rural communities it's income security (vs. income maximization). The "rules" for accounting, intergenerational equity, and discounting within a bio-economy are embryonic. The rules to change rules (without extraordinary hardship or even bloodshed) reel wildy. Locked-in market constraints — rules to prevent harm to workers and consumers, or rules to prevent extinction — have yet to achieve moral, robust support within the business arena. We will try to use our pages to update and imagine the futures of the ecosystem/market system dialog.

Writing and writing paper comes to my hand with the whine of the computer printer and the fast pick-up of shiny sheets of sleek laser-paper. A larger connectivity has been temporarily lost and a larger connectivity is being reborn. The fingers that ignore the clay coating, the white wash, the fibrillation of treeflesh, also encourage the mind to ignore, in Paul Hawken's bons mots, the ecology of commerce. The ignorant hand and mind also forego the occasion to reconstruct a worthwhile and elegant tapestry called planet home. ⊕

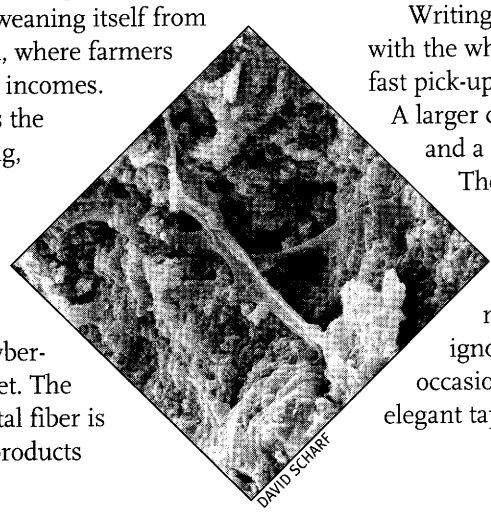
Driving Forces in the Bio-Economy

⊕ **Substitutions** of carbohydrates for hydrocarbons (e.g., ethanol for methanol, soy inks for dyes; treefree paper for wood pulp).
⊕ **Intensification** of carbohydrate farming of trees or treefree crops.
⊕ **Increased efficiency:** a goal of 50 to 75% increased efficiency in fiber lifecycle use.
⊕ **Recycling and re-use of biowastes** (e.g., leftover straw, construction wood).
⊕ **Deconsumption,** especially when the product is junkmail and frivolous packaging.
⊕ **Molecular re-engineering:** Turning petro-based fibers into a renewable resource.
⊕ **The price of oil.**

Below: Is your teabag petrochemical plant fiber? Abaca, flax, kenaf? This is vinyon, a polyvinyl-chloride that softens in hot water.



Right: Murchison meteorite "fiber" from Mars.


DAVID SCHARF

The Briefest History of Fibers

Evolution of Fibrous Living

Biopolymers, Filaments, and Fibers.

It all started with the origin of life (maybe 3.5 billion years ago). Much remains mysterious. Natural fibers come from highly evolved biochemical "building blocks" called monomers. Cellular engineering strung them together in simple or twisted ways to form linked chains (polymers) which, in turn, arranged themselves into baroque molecular nets, coils, braids, and yarns called fibrils. The fibrils took on the long cylindrical shape we call fibers.

Amino acids are the building blocks for fibrous proteins (silk, hair, wool, feathers, nails, scales, tendons, skin, hooves, and horns). Sugars are the building blocks for fibrous carbohydrates (the cellulose that structures plant walls, stems, trunks, leaves, husks, and cottons; the chitin that forms the bio-fabric of lobster, crab, insect, and spider exoskeletons). Ultimately, solar-powered fibers hold the planet's living flesh together.

Phase 1, Deconstruction: The human hand unhinges tendons, pulls apart plant fibers, gathers lost wool.

Probably over 2 million years ago, we humanoids began breaking off, shredding, and peeling plant parts for shelter (frames and thatch), plaiting and rough weaving them into bags and burden baskets with headbands, tying them together as brushes and brooms, knotting fish and bird nets, and twisting threads. We unhinged tendons and shaped fibrous bones and antlers for awls and points. Skins with fur became early apparel. Over 8,000 years ago, we harvested wild goat and sheep wool caught in thorny bushes, and began the fabrication of felt. Early mobile communication media were on fibrous sheets from tanned skins (vellum) and bark.

Phase 2, Deconstruction: Fleecing the Sheep; Pulping the Woody Stems.

About 12,000 years ago, we began to take a more manipulative interest in reliable fiber production. As early as 7,000 years ago, we ingeniously cultivated and deconstructed cotton bolls and started tight weaving. We domesticated wild goats and sheep and, rather than killing them for skins, began to harvest their wool annually by shearing. Increasingly, we reconstructed these fibers into felt, yarns, textiles, and carpets. With domestication, the skin of unborn lambs became a prized writing surface. Peat and moss caulked northern shelters, became adobe bricks in the south. The first fiberfill may have been domesticated goose down for pillows. A period of handiwork and treasured crafts ensued.

By 5,000 BC, early "papermakers" sliced, mashed, and pounded flat the soft innards of plants like papyrus or the outer barks of trees. About 100 AD, the Chinese deconstructed mulberry bark, bamboo, flax, and other grass stems. Floating the separated fibers in water and reassembling them in sheets, true paper entered the communication arena. Recycling and substitution of materials began with old linens re-used as an ingredient of paper pulp.

From top: Fibrous old growth forest; Pomo burden basket with headband; Replica of early Anglo-Saxon thatch hut; Wood pulp mill.

Phase 3, More Deconstruction: Pulping the Super-Stem; Trees = Paper.

Hemp, esparto grass, rags, and other plant fibers could not keep up with the demand for paper. In 1840, after 200 years of whimsical gazing at those great fiber storage houses called trees, British papermakers began mechanically scraping tree flesh for paper pulp. Tree glues (lignin) gummed up the works. By the 1890s, a chemical method for dissolving the glues and separating tree fibers became economical. The European, and then American, paper industry transformed the old-growth temperate forests to chips. Clearcuts, the popular novel, and a paper-based administrative techno-bureaucracy blossomed. Non-wood fibers and linen/cotton rag recycling declined with short revivals during the world wars for rope and uniforms. Only two natural fibers — kapok and goose down — grew in the market as fiberfill for lifesavers and sleeping bags.

Phase 4, and More Deconstruction: Biopolymers from Pulps.

Not long after chemical engineers unglued wood chips into fibers, the fibers themselves were deconstructed. In a kind of industrial devolution, plant fiber cellulose, the building block of all plant fibers, was extracted and then melted into a resin. The resin,

forced through a showerhead with tiny holes (spinneret) and hardened into long filaments, could be cut into staple and used as yarn. Trees were now "biopolymer storage units." By 1910, the cellulosic resins of cotton and wood pulp became "viscose rayon." Rayon rapidly became the middle-class "silk" for blouses, "silk" stockings, and coat linings. Cellulose resins manufactured the celluloid of movies, the cellophane for kitchen wraps, and the rayon/rubber blend for car tires. The use of all other natural fibers, especially for textiles, began its long decline. Paper remained, and remains, strongly tree-based.

Phase 5, New Deconstruction: Cracking Petroleum for Fibers.

Viscose rayon prepared the way for petro-based synthetic fibers. Deconstructing plant matter to cellulose was not too many chemical engineering steps from "cracking" fossil fuels. (Cracking breaks raw petroleum's big molecules into small ones.) By the first World War, petroleum, natural gas, and coal could be cracked down to small molecules (monomers) and then reconstructed into long filaments or sheets (the polymers). The filaments could be cut into staple and used like yarn.

In 1939, nylon became the rage, with every shapely leg in Hollywood showing it on screen. Plant- and wool-based fibers reeled under competition from acrylic, nylon, and polyester fiber carpets, sports shirts, slacks, sweaters, home furnishings, curtains, tires, hose, and rope. Sleeping bags and tents discovered synthetic fiberfills. Deck chairs and shingles took a piece of the furniture and building markets. Tree-based paper products remained immune from petrochemical attack.

Fibrous Crises: Paradigm Deconstruction.

Petrochemical fibers undoubtedly postponed the cutting of huge acreage of trees, as well as the clearing of land for cotton. By the mid-1960s, fibrous confusion entered the minds of citizens trying to balance ecosystems and market systems. The prophets of a paper-free electronic communications workplace have been false prophets; paper use per person increases with downloading, faxes, and photocopiers. How to de-consume? More and more legacy forests turn to paper pulp. How to protect the intact forests, clean our rivers, and still have paper fiber? Which fiber does least harm? The economic geogaphy of fibers has been spun. Textiles, once a basic economic indicator in the North, flee South. Southern nations with petroleum can produce petro-fertilizers and pesticides for cotton and synthetic fibers and fabric blends. The fickle price of petroleum is now the wild card for both cotton and synthetic fiber production. Labor increasingly loses its importance to total technology. How to handle the globalized, petro-based, low-human-input industry?

From top, left to right: Spinneret showing synthetic fiber formation; Girl in rayon acetate dress; Cormorant chicks deformed by petrochemical effluents; Tree pulp plantations replacing forests; WW II ad promoting industrial hemp; Horse blanket with heat-sensitive fibers.

Fiber Futures: Regenerating the Planet.

The petro- and the bio- will vie for market share in the next twenty years. New niches for "forgotten fibers" (kenaf, hemp, bagasse, cereal straws) may emerge to supplement wood chips in paper, textile, and building products. Organic cotton may have a comeback.

Further deconstruction, rearranging fiber-plant genes, seems inevitable. In twenty years, cellulose may be grown by bacteria. Paper would become an aquatic resource. Plants like rape seed have already been re-engineered to grow bio-plastic within their tissues. Paper industries may employ fungi to unglue plant pulp fibers, replacing chemicals. New short-fiber papers could replace the need for longer fibers from trees, hemp, and kenaf. New defibrillation techniques may make treefree fibers competitive with wood chips for low grade paper like newspapers. Membrane filtration will enable bio-plastics to compete with polyester.

Petrochemicals will hardly disappear within the next fifty years. Polymer re-engineering will make more petro-plastics recyclable. Petro-based fibers and extruded sheets will act like a renewable resource. Toxic fibers will drop from the market. Erasable plastic paper is a possibility. Read the paper, drop it in a bin where its washed of print, and recoat it with the new news. Mix-and-match blends of synthetics and natural fibers in textiles, tires, buildings, and paper will confuse our sense of clear-and-distinct categories. If all goes spectacularly well, a future Nobel Prize winner will figure out how pulp-based plant products, petro-based products, efficiency, recycling, new grazing practices, and deconsumption can outstrip population growth and increased demand, AND actually save our last legacy landscapes. ⊕

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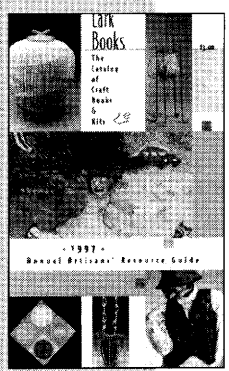
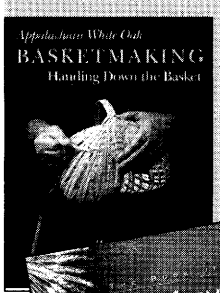
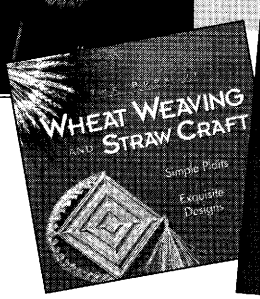
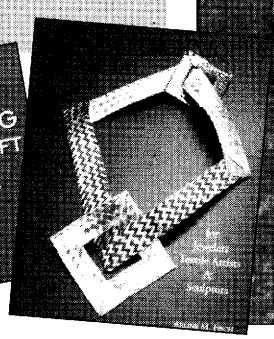
Lark Books
(The Catalog of Craft Books & Kits)
Brenda Sconyers, Director. 1997; 80 pp. $3. P.O. Box 2580, Asheville, NC 28802-2580; 800/284-3388.

The art of craft — who knew how big a part the mastery of fibers played? Fortunately for us, the folks at **Lark Books** have a grasp on it all. There are probably two dozen books and kits in their *Annual Artisans' Resource Guide* we wanted to review in this issue alone: *Pine Needle Basketry, The Fine Art of the Tin Can, Textile Techniques in Metal, Fiberarts* magazine, the *Make Paper, Make Art Kit* . . . Here is a wealth of really good material selected by Oregon College of Art and Craft faculty, written by pros for novices as well as masters, with the basic how-to and so much more. It's inspiration for the bookbinder, the basketweaver, the candlestick maker, and for those whose craft yens have yet to be discovered. —ET



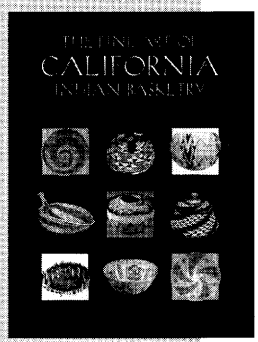






The Fine Art of California Indian Basketry
Brian Bibby. Crocker Art Museum/Heyday Books, 1996; 114 pp. $20.

The First Californians fused art with function in the making of baskets, and the beauty and complexity of these everyday objects is a joy to behold. This is not your average art book, but rather a window into the culture of Native Californians, ancient and modern. Stories of the artists, their tribes, and their gathering grounds accompany each brilliant photograph. You will not believe these baskets! The colors are so rich, the shapes so deep, you'll want to give gifts, gratitude, and high praises to the hands that made them. —Joanna Davis



❝ The Kumeyaay, formerly known as Diegueño, and later as Ipai-Tipai, maintain communities on both sides of the U.S.-Mexico border. Many still speak Kumeyaay as a first language and Spanish as a second. The traditional Kumeyaay homeland included both interior desert and coastal environments. People migrated throughout the year, moving from the valley floor or canyon bottom to work their way gradually into the higher elevations of the mountains, following the ripening of various plant foods. Six varieties of acorns, as well as a variety of other plants, could be collected within the Kumeyaay habitat. The Kumeyaay used pottery for cooking and storage, as well as baskets for collecting and processing foods.

❝ Bertha Wright Mitchell was born in the old village of *tlet* in Colusa County. A significant portion of her childhood and adolescence was spent around her grandparents who spoke only the old Wintun language. Bertha's grandmother, Lyda Buck, and mother, Mollie Wright, were basketmakers. By the age of nine Bertha was making her own baskets. Her method of learning was observation. Bertha stated that she wasn't taught to weave but learned how by watching her mother. Bertha recalled, "I thought it was boring." But eventually she "just felt like doing it. I just had it in me to do it."

Fiber Society
161 Sirrine Hall, School of Textiles, Clemson University, Clemson, SC 29634; 803/656-5957, fax 803/656-5973.

Scientific research in fibers, fiber products, and fibrous materials.

Jenny Miller (1842-1932), Pomo basket weaver.

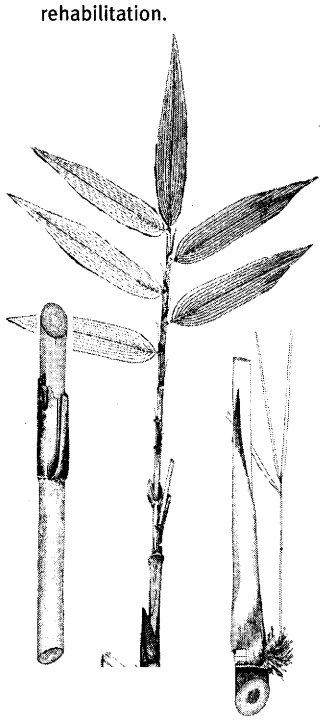
Whole Earth Treefree Botanical of

Carolyn Moran & Peter Warshall with the generous assistance of Dan Imhoff

Bamboo (*Bambusa* species) is a grass. It is the second most widely used non-wood fiber on the planet (six percent of global plant fiber production), whose bio-attributes just about equal those of pine. Bamboo has become the main non-wood fiber in India, Thailand, and China. (In Brazil the main one is sisal and in Argentina it is bagasse.) Like hemp, bamboo is easy to cultivate and is well known to farmers. Its wondrous versatility in building construction forces bamboo paper lovers to compete with builders for the stems. Not all bamboos are equal. Some have a low fiber content and low yield rate, but there are both warm temperate and tropical species that can become paper yielders.

The Environmental Bamboo Foundation: *Ubud, Bali, Indonesia; 62-361/974-02, fax 62-361/974-029; ebfbali@denpasar.wasantara.net.id.*

Design and marketing of bamboo products; education and training in all aspects of bamboo production, from planting to marketing; and bamboo based agroforestry and watershed rehabilitation.



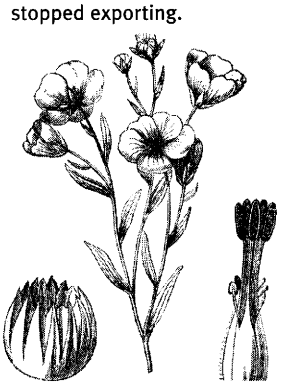
Esparto grass (*Stipa tanacissima*). From southern Spain and northern Africa, esparto grass is used for book papers and by specialty papermakers. The paper has premium formation, smoothness, and ink gloss. Best known for its porosity, the esparto leaf is a cylindrical, rolled-sheath leaf with strong dimensional stability.

With a finer fiber density of 15 million fibers per gram — the highest of any paper pulp, and twenty percent more dense than eucalyptus — a little esparto grass can go a long way. Its short fibers can best be extracted by chemically dissolving the lignin (the glue that must be "dissolved" to free up the individual fibers) and removing the silica.

Groups of nomadic Bedouin women harvest esparto grass, while the men bundle the grassy stalks. The rootstock remains. The grass could be harvested yearly but it isn't, because the tribes are nomadic and there's so much of it. Camels transport the grass across the desert to a collection area. It is left to dry in the intense sun for six months. This labor-intensive process provides much-needed jobs, supplemental income, and high retail prices.

Flax (*Linum usitatissium*). The bast fiber (the outer layers of the stem) of textile flax is the source of elegant linen. Linen rags, cuttings, and threads have been used as the feedstock for papermaking for two thousand (or more) years. More recently the straw (whole stem) from linseed oil flax (flax cultivated for its seed) has been used for the manufacture of cigarette and other high-quality papers. Its high tear and tensile strength is superior to wood pulps. Like hemp and bamboo, flax yields multiple products. Paper has been a lower-value end product.

Fiber flax does best in temperate climates. It is more fickle than oilseed flax, and originally grew in areas with cool, moist springs, moderate summers, and rich soil (Belgium and Ireland). In 1843, Sarah Damon Owen brought flax seed west by ox cart from Kentucky, and was amazed that the fiber flax did so well. The flax industry boomed in Oregon, especially during World War II, when European nations stopped exporting.



International Linen Association: *c/o Gerli & Co., New York, NY; 212/685-0424.* Western European linen weavers and flax processors. Quarterly newsletter: *Linen Today.*

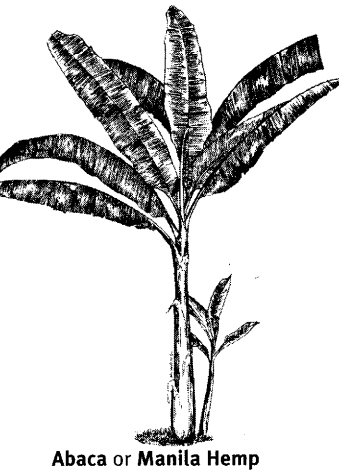
Hemp (*Cannabis sativa*). Ah! Infamous hemp. To be grown for THC or good fiber for textiles and ropes and maybe, in the future, plastic and hundreds of other co-products. They say it's hard to breed for both fiber and fun. Male plants are best for fiber, the virgin females for psychoactivity. Marijuana is cosmopolitan, but fiber hemp grows mostly in Europe (Hungary, Ukraine, and smaller amounts in France, Spain, and the UK) and south Asia. Despite rekindled interest, fiber hemp cultivation has been in long decline with shorter-term peaks during the world wars.

Easy to cultivate, the high-yield bast fiber is one of the longest of the non-wood fibers. It is superior to wood pulps and makes an ideal additive to recycled paper pulps to improve strength. Hemp paper is tough and durable and can be finished to a creamy, desirable sheet with the addition of some shorter, softer fiber such as esparto or cotton. About 0.005 percent of the world's paper (by volume) is hemp. Hemp fiber forms the sheeting for the Gutenberg Bible and the Declaration of Independence. In 1575, in the New World, at the first paper mill outside Mexico City, a composite of hemp and cotton rags was the pulp of choice. US hemp paper production began in 1690. It was against the law for Colonial American farmers *not* to grow fiber hemp. Hemp was extracted by retting (soaking to separate the fiber). During the American Colonial period, masters forced slaves to enter retting basins (even in winter) as the humanoid mechanical separators. So many died of pneumonia that slave-retting became illegal. The whole stalk (bast plus the shorter inner fibers) cannot compete with wood pulp under present market conditions: hemp costs two-and-a-half times more per ton. A new chemi-mechanical process that replaces older, purely chemical processes, may lower costs and help hemp grab a share of the higher-quality printing- and writing-grade paper market.

Most "modern" nations prohibit fiber hemp cultivation. The DEA requires high fences with concertina wire and all-night lighting which penalizes hemp growers. Legal repression has given hemp fiber glamour and a larger market niche. Wearing hemp is also a bumper sticker saying, "Question Authority." Two hundred firms sell hemp products with a projected legal market of $15 to $30 billion per year. Kentucky (looking for tobacco substitutes), Canada, Ukraine, Germany, and the Netherlands are all investigating markets. So far hemp has been labor-intensive. Mechanization of this unfamiliar (yet so familiar) crop needs research and development funds.

Hemp Industries Association: *Chandler Heights, AZ; 602/988-9355.* Best American access.

Plant Fibers

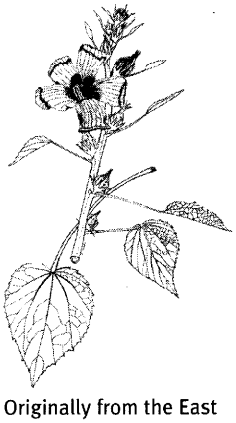


Abaca or **Manila Hemp** (*Musa textilis*). This leaf fiber, a member of the banana family, makes an extremely strong pulp with a high tear and tensile strength. Abaca is used for marine cordage, Japanese shoji screens, abrasive backing papers, and tea bags. It has potential for paper currency, Bibles, and cigarette papers. No fiber of equal strength and pliancy has been found. Grown in the Philippines by small landholders, its present drawbacks are low yield, high costs, and limited potential for a wider market as a low-end paper product. All manila hemp ropes should be recycled into paper.

Kenaf (*Hibiscus cannabis*) is considered the latest plant fiber to enter the treefree paper competition. The long bast fibers (similar to flax and hemp, and equivalent to pine) produce porous, high-strength paper with increased opacity and lowered sheet thickness. Definitely superior to wood fibers, kenaf can help reinforce the broken and short fibers of multiply-recycled waste paper. Kenaf yields many products and has been used as fuel, animal bedding, oil absorbent, and particle board for wall paneling.

The USDA started kenaf research thirty years ago. In 1981, the US International Paper Mill carried out a commercial-scale newsprint run that demonstrated the feasibility of a kenaf-based publication. But the wood pulp industry has resisted retooling the mills. For a planned 35,000-acre kenaf operation in Texas that could significantly wedge into the paper market, $360 million had to be raised for a new mill and harvesting equipment. Australia seriously considered kenaf for newsprint but could not arrange the financing and the income security that farmers required before they dared switch to another crop. A similar attempt failed in Thailand.

Less vulnerable to climatic whims and pests, kenaf needs lower inputs and management compared to other bioregional crops. This cotton/okra relative zooms from seed to fifteen feet in as little as five months, with low resins and silica — both favorable price considerations. Kenaf's drawback is its seasonality, requiring storage. Storage can lead to losses from fungi and rot, and complicates milling. Mills want an even flow of material for maximum efficiency.



Originally from the East Indies, kenaf (an annual) is now grown for paper fiber in Texas, Thailand, and China. Kenaf can be used to fabricate tissue paper, paperboard, or roofing felt. Texas produces kenaf interior moldings for cars. Start-up processing plants in California, Louisiana, and New Mexico will make a major attempt to enter the paper market. Prices remain ten to fifteen percent higher than premium recycled papers.

International Kenaf Association: *Ladonia, TX; 903/367-7216.*

Cotton (*gossypium* species), the premier textile fiber, enters the paper market as rags, textile scraps, and linters. Linters are a residue, the short fibers that adhere to the seed after ginning. These fibers can be cut from the seed in a series of passes through cutting blades ("first-cut linters," "mill run," "second-cut linters," etc.). Scraps are the major source of non-wood fibers for paper in the United States (about

0.3 percent of all paper pulp). Cotton produces a very high-quality paper, but has high production costs. It has a well-established market niche.

Cotton does best in warm temperate or tropical climates. The soft, fleecy fiber has been cultivated for 5,000 years. It is loved for, among other qualities, its washability— tougher than rayon, stronger wet than dry. Cotton is also moth-free, has great wickability, and a porous coolness. Synthetics stole part of the cotton market because cotton has low drapeability, wrinkles easily, shrinks, mildews, stains with sweat, and bleaches in sunlight.

Bagasse (*Saccharum officinarum*), another agricultural residue, is the crushed stalks of sugarcane after the sugar has been extracted. Sugarcane is a grass with high fiber yield, but its short fibers (closer to hardwoods or eucalyptus) and high lignin and silica content increase pulping costs. But India, Mexico, Indonesia, Thailand, Colombia, Brazil, Argentina, and South Africa all use bagasse for pulp production because of its fine newsprint qualities. Forty-five percent of all Mexican pulp comes from bagasse. Bagasse accounts for 12 percent of world production of non-wood fibers.

In the 1950s, the US led the world in designing the tools for bagasse pulping. Now, Cuba leads the way. The Cuba-9 Experimental Center studies the application of high-yield bagasse to small-scale pulp mills. The Cubans search for maximum efficiency: a more energy-efficient sugar mill that uses surplus bagasse for fuel; a pulp/paper mill with a low-cost pulping process; animal feed from "waste," and other by-products. Bagasse-based paper pulp competes with other uses such as hardboard and insulation board. Since sugarcane waste is also used for a fuel at sugar mills, a balance must be struck between energy and pulp. In India, sugar mills must be linked to paper mills by law which, at times, stimulates exports of coal to compensate for fuel losses.

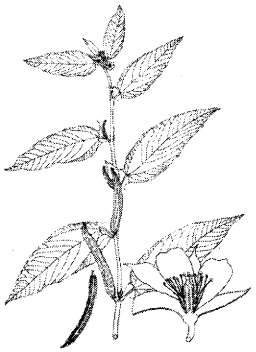
Cereal crop straw is the leading non-wood fiber on the planet (forty-seven percent of global non-wood production). Wheat, rye, barley, oats, and rice offer a large straw supply and supplemental income for farmers in the production of low grade paper. China and India are leading recyclers. Straw has good printing qualities despite its short fiber length, which resembles hardwoods more than pines. Drawbacks include high silica content, low cellulose, weak fibers, and high transport costs compared to value. Straw pulps are always mixed with other fibers.

Straw as paper pulp competes with straw as a feedstock in other industries, e.g., straw-bale houses, agriboards, feed supplements, compost, "log" pellets, and chemicals manufacturing. Farmers cannot harvest all their straw without risking lowered soil fertility or erosion. In the US, Ninety percent remains to be plowed back into the soil and to control erosion.

In other regions, where straw is burned to clear the fields, the straw pulp alternative both increases income and lowers greenhouse gas emissions. New genetic short-stemmed wheat varieties have hurt the market for straw pulps and agriboard.

Ramie (*Boehmeria nivea*). Also called China Grass or filasse, ramie is a member of the nettle family. It is the plant that saves the princess condemned to weave nettles into coats

of mail in "The Swan," a Hans Christian Andersen fairy tale. This lustrous and super-smooth fiber is difficult to extract and clean. Used for high-class underwear and special threads as well as fancy papers, ramie awaits a techno-breakthrough, cheap labor, or more princesses to lower costs. Native to tropical Asia.



Jute (*Corchorus* species) has very long, pale yellow fibers that are not particularly strong but important as a recycled paper fiber. Jute is widely employed for gunny sacks, burlap, twine, carpet, curtains, and more. The butt ends and waste scraps from jute rope and sacking join other fibers in paper production.

Burlap and Jute Association: *c/o Malcolm E. Martin; New York, NY; 212/408-1040; fax 212/541-5369.* Importers and brokers.

Other fibers

Not yet for the big time, other paper fibers have special importance.

Reeds of all types enter the paper market in China, and to a smaller extent in Europe. They offer a free by-product for constructed wetland sewage treatment.

Cornstalks, which comprise thirty percent of all US

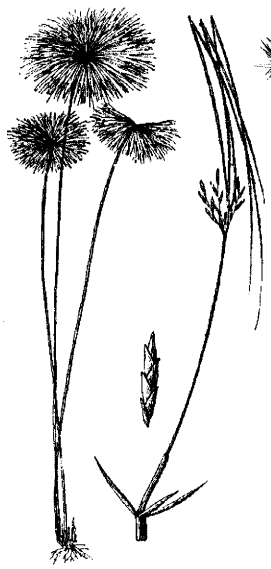
plant waste fiber, have not been incorporated into paper.

China jute or **Indian Mallow** (*Abutilon Theophrasti*) is a lot like jute and now grows weed-like in the US. Adding it to paper would generate revenues from weed-control.

Paper mulberry bark with its soft, lustrous fibers has been used in Japan for paper lanterns, umbrellas, and writing paper.

So-called **rice paper** comes from other plants, not rice: *Tetrapanax payriferum*, *Edgeworthia tomentosa*, and *Wickstroemia canescens* all transform into elegant fibrous sheets.

Papyrus, the root word of "paper," is the flattened interior of the plant's stem. India and Africa still produce small amounts.

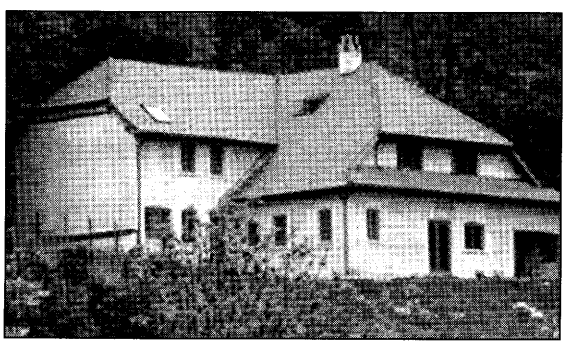


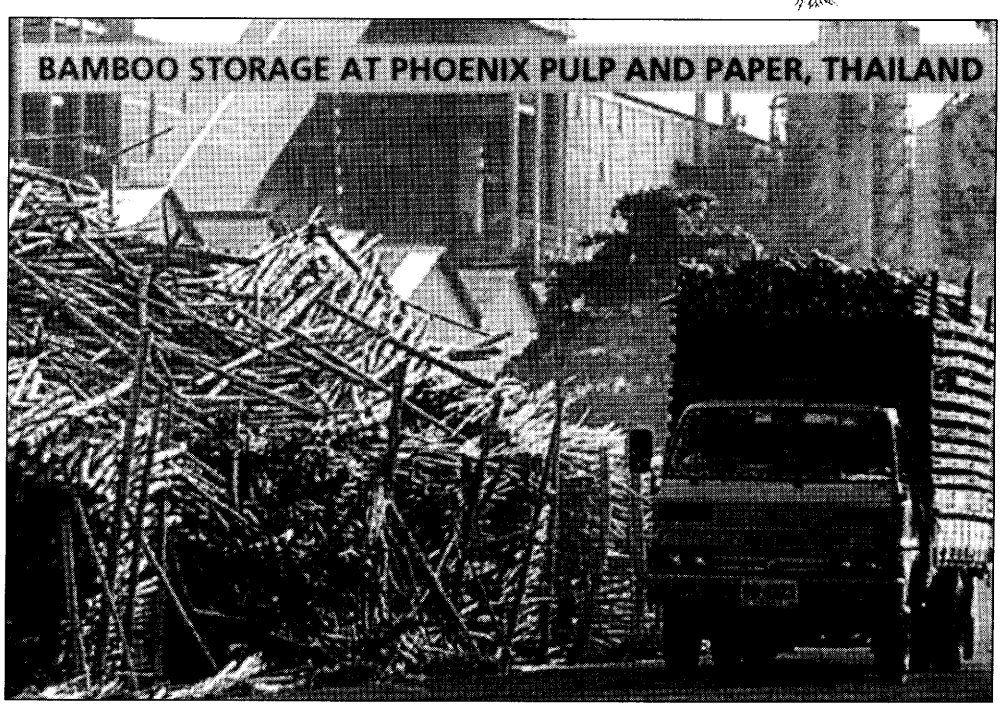
Papyrus paper is not what we call paper today (separated fibers reconstituted as sheets).

Sisal hemp or **maguey** (*Agave cantala*) grows on arid soils worldwide, with superior tear and tensile strength compared to wood. Because it does not displace important crops and can switch from paper to hard fiber cordage depending on price, its bright white sheets (requiring little bleach) make it a prime candidate for a pine/sisal combo paper. ⊕

Carolyn Moran runs Living Tree Paper Company (see Treefree Yellow Pages p.15), a leading manufacturer and wholesaler of alternative fiber papers with hemp content. Living Tree has recently launched a new paper line called "Vanguard Hemp" with twenty-five percent hemp, twenty-five percent cotton, and fifty percent process chlorine free post-consumer waste content. This is the first company to commercially manufacture hemp paper in North America. Dedicated to bioregional and local community participation, Carolyn refuses to make a distinction between economic and spiritual enlightenment. Read all about it in Talking Leaves, *the magazine of her Deep Ecology and Education Project (DEEP, 541/342-2974).*

Illustrations by Terry Bell and M. Wong. Special thanks for locating art go to Dennis Breedlove and to Karren Elsbernd at the California Academy of Sciences Special Collections Library.





Above: A house in France built from compressed hemp. Right: Photo from *The World of Fiber Processing* (see p. 17).

Treefree Paper

Major Activists

Conservatree
San Francisco, CA; 415/433-1000; fax 415/391-7890. *Greenline* is the most up-front newsletter tracking demand reduction, de-inking mills, peroxide bleaching, hypocrisy, laws and the latest news on paper-saving. Our favorite gadfly to lazy enviros, and sweet mom to corporations needing A's for effort. Membership for private sector is $59; for nonprofits, $39.

ReThink Paper
Earth Island Institute, San Francisco, CA; 415/788 3666; fax 414/788-7324; rtpinfo@igc.apc.org; www.earthisland.org/ei/paper/rtp.html. Publishes fact-sheets on ecological paper alternatives and economic constraints (performance standards, printing schedules, budget constraints). They're activist, from pulp to garbage pail to pulp to . . .

Rainforest Action Network
San Francisco CA; 415/398-4404; fax 415/398-2732; lesswood@igc.apc.org. RAN remains the Paul Revere for environmentally sound paper practices, pushing Mitsubishi to think harder and kids to study harder. Publishes *Cut Waste, Not Trees* — 70 pages of resources, articles, and action tips on alternative papers, building materials, and designs, as well as wood-use reduction. For kids, their *Tree-Free Action Guide* includes making paper, organizing your school and enviro clubs, and writing letters to decision makers. Both pubs are printed on 100 percent kenaf paper. Connected to **Wood Reduction Clearing House:** *Washington, DC; 202/387-803; fax 202/234-5176; ned@tap.org.*

Treefree Paper Suppliers:

Mostly rolls, printing sheets, and/or stationery

Arbokem, Inc.
Vancouver, BC, Canada; 604/322-1317; fax 604/322-5865. Specialty is agricultural waste (i.e., wheat and rice straw).

Dancing Tree Recycled Paper and Printing
Berkeley, CA; 510/486-1616. Hemp, kenaf, garlic, bamboo, and high post-consumer waste.

Fox River Paper Company
Appleton, WI; 800/558-8327. Premium recycled and bamboo.

The Friendly Chameleon
Philadelphia, PA; 800/717-8242; fax 215/508-1699; chameleon@igc.apc.org. Wide range of treefree hemp content papers.

Green Field Paper Co.
San Diego, CA; 619/338-9432. Organic cotton, hemp, junk mail, and agricultural residues. Printing and writing paper.

Living Tree Paper Company
Eugene, OR; 800/309-2974; fax 541/687-7744, talkleaves@igc.apc.org. North American-milled premium hemp content papers in printing and writing grades.

Neenah Printing.
Roswell, GA; 770/587-8754; fax 770/587-8709. 50 percent bagasse and 50 percent pre- or post-consumer wastepaper. Up to 120 lb. rolls and writing papers and envelopes.

PCW100
Port Washington, NY; 516/767-8021; pcw100@pcw100.com. Hemp, kenaf, high pcw blends.

Peacetree Paper and Printing
Portland, OR; 503/233-5821, fax 503/233 5821, www.teleport.com/~ptree. Kenaf, bamboo and recycled.

Vision Paper
Albuquerque, NM; 505/294-0293. A division of KP Products, Inc., it's the nation's largest supplier of kenaf paper.

NY Recycled Paper
New York, NY; 212/645 2300. Agricultural byproducts and post-consumer waste.

Mostly cut papers and stationery

Arbour
Ottawa, ONT, Canada; 613/567-3168. Flax, cotton, hemp ,wheat pulp, and post-consumer.

Bandelier
Santa Fe, NM; 505/474-0900. Rice paper, plus more.

Dieu Donne Press & Paper
New York, NY; 212/226-0573. High archival quality handmade papers for artistic use. They also have a retail shop.

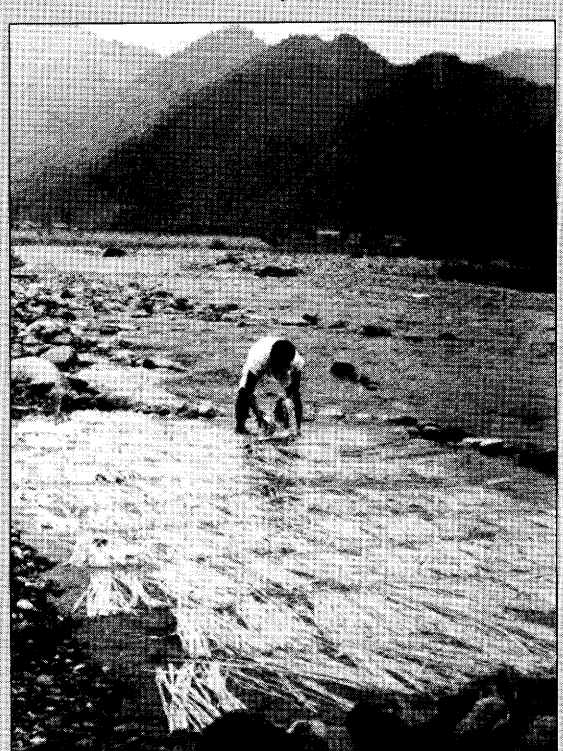
Ecolution
Merryfield, VA; 800/769-HEMP. Hemp stationery.

Four Corners Paper Company
Scottsdale, AZ; 602/991-2320. Seaweed papers, and more.

Non-Paper Paper

Internet
Remember, the Internet is tree-free! If you don't download and print a hard copy too many times. Order from online directories. Use the paperless catalogs and phonebooks. Read virtual newspapers.

Nalgene Plastic Paper
Forestry Suppliers Inc., Jackson, MS; 800/647-5368. Almost indestructible — water-, rot-, light-, tear-, fray-, curl-resistant. ⊕



Checking the bark laid out to wash and bleach in a weir in the hills of Mino, Japan. From *Washi: The World of Japanese Paper*, Sukey Hughes, Kodansha International.

Deconsume! Recycle!

American Reusable Textile Association
Largo, FL; 813/531-6698. Members include fiber producers and mills, fabricators, distributors and processors, laundry equipment and supplies manufacturers. Geared toward hospitals and industrial users. Reusable textile products are environmentally safer and less expensive than disposables. Brochure: *The Responsible Choice*.

Materials for the Future Foundation
San Francisco, CA; 415/561-6530. Mining biowaste as a material for community development. Job creation and waste diversion, not necessarily paper.

Stop Junk Mail Forever
Good Advice Press, Elizaville, NY; 914/758-1400. Tells exactly how to get off, and stay off, every unwanted direct mail and telemarketing list. Your family receives thirty pounds of unsolicited mail each year. Direct mailers gobble sixty-eight million trees per year and swallow up twenty-eight million gallons of ink. Half the received envelopes are never opened. We pay $320 million incinerating, landfilling, and recycling. Read this, drop out of junk mail.

National Resources Defense Council
New York, NY; 212/727-2700; nrdcinfo@nrdc.org, www.nrdc.org. Best community development project to recycle urban waste wood.

Sheppard Envelope Company
Worcester, MA; 800/325-6622. "Boomerang" mailing system with sixty to seventy percent paper reduction.

Tension Envelope Company
Kansas City, MO; 816/471-3800. FedEx's Send-n-Return supplier.

Stu Heinecke Creative Services
Seattle, WA; 206/286-8668. Total use, no waste direct mailing.

Environmental Defense Fund Paper Task Force
New York, NY; 212/505-2100, 800/684-3322. Corporate paper recycling for beginners.

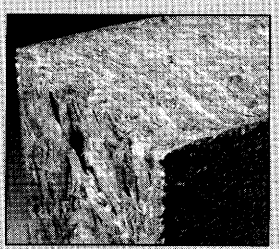
The Recycled Paper Coalition
Palo Alto, CA; 415/985-5568, rpc@igc.apc.org. Orienting offices and businesses toward politically correct enviro paper use.

WoodWise Consumer Initiative
Co-op America, San Francisco, CA; 415/896-1580. Exposing the link between consumption and deforestation, and providing practical tactics and alternative sources that reduce wood consumption.

National Recycling Coalition
Washington, DC; 202/625-6406.

New Building and Construction Materials

Straw and Other Fibers



Center: EnviroPanel, from baked straw compressed between kraft paper.

WheatBoard
PrimeBoard, Inc., Wahpeton, ND; 701/642-6026; fax 701/642-1352. Industrial grade particle board made from wheat straw. seven to ten percent lighter than traditional particle board, sixty percent more moisture resistant. Targeted for use in furniture, cabinets, store fixtures, etc.

Agriboard Building System
Agriboard Industries, Fairfield, IA; 515/472-0363; fax 515/472-0018. Heat-compressed wheat and rice straw panels — no toxic chemicals used in manufacture. Framing lumber for building construction reduced by up to ninety percent.

Easiboard/Easiwall
Pierce International, Inc. (US distributors for Stramit Industries), Englewood, CO; 303/792-0719, fax 303/799-6469. Single component, non-loadbearing domestic partitioning system (o.k., think drywall), made from highly compressed wheat, rye, rice, and barley straw with no synthetic additives. High acoustic and thermal insulation and high fire resistance.

Out on Bale
Tucson, AZ; 520/624-1673. Promotes development of straw bale construction.

Plyboo
Smith & Fong Company, San Francisco, CA; 415/285-8230. Laminated flooring, wall paneling, and countertop material made of two thin layers of bamboo.

Eco Timber International
San Francisco, CA; 415/864-4900.

Sea Star Trading Co.
Newport, OR; 503/265-9616. Both are suppliers of high density lumber board made from coconut palm, for flooring, columns, and furniture.

Composites

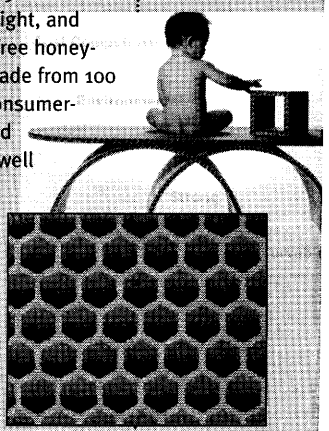
Environ
Phenix Biocomposites, Inc., St. Peter, MN; 800/324-8187. Decorative surface material comprised of bio-based resin, cellulose fiber from recycled paper products, and color additives. Looks like natural stone when finished but cuts and fabricates like wood; twice as hard as red oak, half the weight of granite with better abrasion resistance. For interior, non-structural use only.

Resincore
Rodman Industries, Marinette, WI; 715/735-9500. A formaldehyde-free particleboard composed of sawdust, phenolic resin, and wax, used for general interior construction.

Recycled Waste Wood and Other Products

Evanite Fiber Corporation
Corvallis, OR; 41/753-1211. Manufacturer of 1/8-1/4" panels (hardboard, pegboard) made from recycled urban waste, pallets, shelves, and industrial spools.

Gridcore Panel Products
Gridcore Systems International, Long Beach, CA; 562/901-1492, fax 562/901-1499. Strong, lightweight, and formaldehyde-free honeycomb panels made from 100 percent post-consumer-waste paper and card-board, as well as various agricultural fibers. Really cool stuff. Used for furniture, cabinets, stage sets, store fixtures, product exhibits, etc.



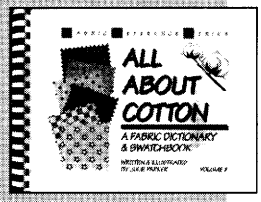
Homasote Co.
West Trenton, NJ; 609/883-3300. They take 250 to 350 tons of old newspaper a day and turn it into panels. That's about 70,000 tons of wastepaper a year. Uses range from carpet underlayment to structural roofing.

Re-Fiber Products
Wood Recycling, Inc., Woburn, MA; 617/937-0855. Various combinations of wood fiber and recycled newsprint paper mulch for use in hydraulic seeding.

Thermo-ply
Simplex Products, Adrian, MI; 517/263-8881. Fiberboards from 100 percent recycled cardboard boxes, office and mill waste, manufacturing scrap, etc. ⊕

Cotton and Other Textiles

All About Cotton
(A Fabric Dictionary & Swatchbook)
Julie Parker. 1993; 120 pp. $17.95, $29.95 with samples. Rain City Publishing, P.O. Box 15378, Seattle, WA 98115, 202/527-8778.



All about cotton? Close enough for me. Like Julie Parker's other Fabric Reference books (see pp. 18-19), this one explores the fiber's transformation to fabric, its properties, uses, history, assets, and limitations. The author has woven in enough trivia to satisfy the most ardent fiber-fact junkie (poplin was named for Avignon, the fourteenth-century "papal city"; Oxford cloth came from a Scottish mill whose other fabrics were named Cambridge, Harvard, and Yale). The book reviews forty-two different fabrics for individual characteristics, cost, wearability, and care. Best of all, the book can be ordered with swatches of the forty-two fabrics, to attach to the pages where they're discussed. A treat for the eyes, fingers, and understanding. —MKS

Organic Cotton

Natural Cotton Colors, Inc.
Wickenburg, AZ; 520/684-7199; fax 520/684-7299. Brokers for Sally Fox's patented FoxFibre — organically grown cotton from cotton varieties that are genetically white, green, and brown. No dyes needed.

Cotton Plus, Ltd.
O' Donnell, TX; 806/439-6646, fax 888/439-6647. LaRhea Pepper is an organic cotton farmer and represents 20 other farmers in the Texas Organic Cotton Marketing Cooperative. Their bales are sold for use in clothes, home furnishings, personal hygiene products, even the little tufts of fluff inside the tops of medicine bottles. She will sell smaller quantities to individuals with a credit card.

Coyuchi
Point Reyes Station, CA; 415/663-8077; fax 415/663-8104; coyuchcn@nbn.com. Wholesale textile manufacturer selling fabric woven with certified organic cotton fibers. Also produces smaller product line of hats, throws, napkins, and kitchen towels, available for wholesale or retail.

Other Textiles

American Textile Manufacturers Institute
Washington, DC; 202/862-0500; fax 202/862-0570. Represents mills manufacturing and processing cotton, man-made, wool, and silk textile products. Has 1200 volume textile library. Periodicals: *Textile Hi-Lights* (quarterly) and *Textile Trends* (weekly).

Industrial Fabrics Association International
St. Paul, MN; 800/225-432;, fax 612/222-8215. Fiber producers, weavers, coaters, laminators, and finishers. Manufacturers of canvas and industrial fabrics in thirty-six countries. Publications: *Fabrics and Architecture* ($21/year for 12 issues), *Geotechnical Fabrics Report* ($35/year for 9 issues), *IFAI Bookstore Directory, Industrial Fabric Products Review* ($30/year for 12 issues).

Hemp Textiles International
Bellingham, WA; 360/650-1684; fax 360/650-0523. Wholesaler and manufacturer of hemp textiles, yarns, etc. made from fibers imported directly from China. This company is reintroducing hemp to the mainstream textile market in the US with their own brands of fiber blends (hemp/organic cotton, hemp/recycled wool, hemp/recycled pop bottles).

The Navajo-Churro Sheep Association
Ojo Caliente, NM. Formed to preserve and promote this breed, whose wool is still prized by hand spinners for the open locks in an unsurpassed range of color. ⊕

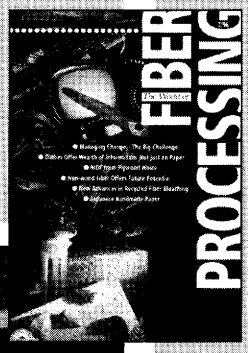
❝ Cotton linters are short fibers that remain stuck to the seed after the cotton is ginned. The seeds are ginned a second time to remove the linters. They are used to make rayon and acetate fabrics, plastics, paper, shatterproof glass, film, high-gloss lacquers, liquid cement, twine, wicks, carpets, surgical gauze and stuffing for mattresses and furniture.

The seeds are separated into hulls and meat. The hulls are used to make paper, plastics and explosives, and as fertilizer and cattle feed.

Levi Strauss & Co. uses denim scraps to make the company's stationery, which has a faint blue tint that reminds you of, well, . . .

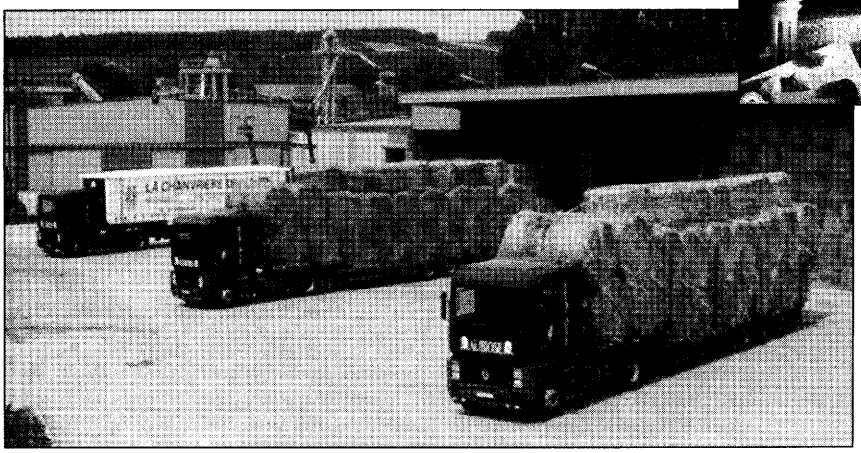
The World of Fiber Processing
Hans Ahrnberg, Editor. Sunds Defibrator Industries AB, S-851 94 Sundsvall, Sweden; 46 60-16 50 00; fax 46 60-16 55 00; www.sundsdefibrator.com.

A bi-annual magazine that overviews fiber processing developments in a number of industries.



Industrial Hemp
(Practical Products — Paper to Fabric to Cosmetics)
John W. Roulac, Editor. 1995; 49 pp. $4.95 ($6.95 postpaid). HEMPTECH: The Industrial Hemp Information Network, P.O. Box 1716, Sebastopol, CA 95473-1716; 805/646-4367, fax 805/646-7404, info@hemptech.com.

This fifty-page booklet will fit into your pocket even though it's crammed full of interesting facts about the world's most controversial fiber. Surprising factoids: the fenders on early Fords were made of hemp; hemp can be made into various food products for humans and domestic animals; in 1942, the US government made a film, entitled *Hemp for Victory*, to stimulate the wartime hemp industry. —Dana Harmon



Far left: Bales of industrial hemp find a large market in France.

A Bestiary of Useful Fibers

Merino Sheep

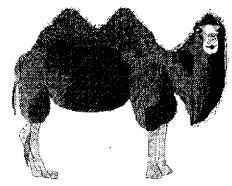
Domesticated for 12,000 years, sheep wools, depending on the breed, either become apparels or carpets. Apparel wool is the most absorbent natural fiber, with great breathability, resistance to dirt, ability to hold dyes, wrinkle resistance, and warmth without weight. Great Britain, as a result of the Roman conquest, developed sixty breeds and still grazes thirty million sheep. With its former colonies, the United King-dom became the center of sheep diversity and high quality apparel wools. Shrinkage, pilling, moths, weight when wet, and modern detergents present inconveniences compared to layering with some specialty petrochemical-based fabrics. Acrylics have replaced wool sweaters, carpets, blankets, and men's hosiery in many markets.

Mohair Goat

The long, extraordinarily lustrous fiber is stronger and more resilient than sheep wool, dyes the best of all fibers, and doesn't shrink. To improve fluffiness, it is blended with sheep wool or synthetics. A favorite of moths. One of the oldest textile fibers, Mohair goat domestication is believed to have centered in Turkey. Mohair goat herds have shaped the vegetative landscape and eroded hillslopes of many a watershed in Turkey, Arizona, New Mexico, Texas, South Africa, etc. Automobile upholstery was largely mohair until the end of World War II when petrochemical fibers stole the market. One of the few natural fibers with multiple end-uses, it can be blended into either apparel, upholstery, drapery, or rugs.

Cashmere Goat

From the Kashmir province of northern India, the cashmere goat remains quasi-domesticated, its supply subject to political troubles. A major eco-transformer of the high plateaus of India, Tibet, Mongolia, China, Iran, and Afghanistan. To complicate fleece gathering, the best fleeces come from the highest elevations (12,000 to 15,000 feet), with reduced quality as one descends. Isolated herders comb about four ounces per year from each goat. Cashmere fiber is a high altitude adaptation; ounce for ounce, it has more insulating power than any other natural fiber. Shawls, dressing gowns, sweaters, dresses, and long underwear have luxurious, silky, soft, and pliant texture, beautiful drape, and rare wrinkles.



Bactrian Camel

Softer, lighter in weight, warmer, more fragile, and more water repellent than sheep wool, the two-humped camel's hair is usually blended with wool for strength. Never wrinkles but does pill. The "llama analog" of Asia: part pack-animal, part fiber-giver. Beard hair becomes rugs and paint brushes. Soft undercoat becomes clothing. The coarser hairs are blended with wool to become poor man's cashmere. Rarely shorn, the wool is gathered during shedding season. Beware: Camel coats can be all sheep wool with camel-colored fibers. Camel coats should be camel fibers or you're being conned. The **Cashmere and Camel Hair Manufacturers Institute** (*Boston, MA; 617/542-7481, fax 617/542-2199*) promotes cashmere and camel hair products.

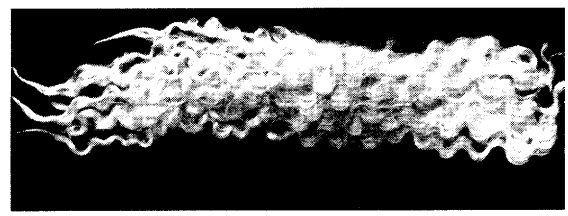
Alpaca & Llama

The two popular cameloid wools from South America: Alpaca is high-grade — softer, finer, stronger and more lustrous than sheep wool. Alpacas coevolved with high Andes grasses, limiting globalization compared to sheep. Their slippery fibers resist dying and weaving. They can be sheared only once every two years. But, alpaca fleece contains no waste wool ("kemp") as do other wool providers. The llama is larger (sometimes twice the weight). A multi-purpose cameloid, locals love them as pack animals with the perk of harvesting a coarser, weaker wool with lots of kemp. Not a high Andes specialist, llamas have begun to spread to the mountains of the United States.

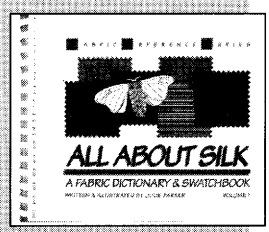
Blue-faced Leicester fleece—long, lustrous, curly locks, for strong smooth fabrics.

Sheep and goats have impacted vast areas of the planet. In Australia, they compete with some kangaroos. In the US, they encourage predator control of coyotes, eagles, and wolves. The shrublands of parts of California, Great Britain, Spain, Australia, Afghanistan, Iran, Turkey and others can best be viewed as sheep (goat) resistant landscapes with significant ecosystem degradation.

*The **American Wool Council** (c/o American Sheep Industry Association, Englewood, CO; 303/771-3500, fax 303/771-8200) promotes use of wool and wool products. The **Wool Bureau** (New York, NY; 800/986-WOOL, fax 212/557-5985) is the US branch of the International Wool Secretariat. It is a promotional and technical group sponsored by wool growers of the Southern Hemisphere.*



All About Silk
(A Fabric Dictionary & Swatchbook)
Julie Parker. 1992; 92 pp. $14.95, $29.95 with samples. Rain City Publishing, P.O. Box 15378, Seattle, WA 98115, 202/527-8778.



See *All About Cotton (p. 17).*
This volume offers thirty-two silky samples. —MKS

❝ A single, unbroken cocoon yields from 1,600 feet to more than a mile of continuous filament, in contrast to the short fibers of cotton, wool, linen and other natural fibers.

Felt
(New Directions for an Ancient Craft)
New York, NY; 212/505-2100, 800/684-3322.

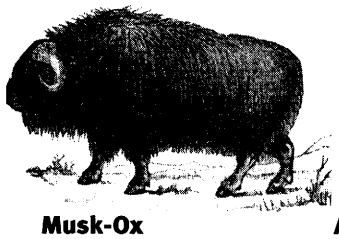
Not those colored craft squares but the thick, dense fabric that has kept humanity protected for the last 8000 years. Color photos, sketches, and lucid text tell of felt's history, traditions, and creation with directions for felted jewelry, clothing, carpets, and yurts. I want this book. Thanks to my hair and large (some say "swelled") head, I can't find hats. Sjöberg's hat-making instructions should solve that problem. —Wendy Chatley Green

❝ Agitation, i.e., pressure and movement, is required for felting to oocur. Pressure forces the air out of the fleece so that the fibers can come into contact with one another. Movement, which in the beginning consists of careful massage and circular motions, allows the fibers to migrate to produce a thin, stretchable fabric.

❝ Jewelry that will be worn against the skin should be made from soft fiber such as the lamb's wool of fine-wool breeds. Jewelry can be shaped around the plastic-coated wire that is sold in spools in garden supply or hardware stores.

Vicuna

Very soft, very luxurious, twice as fine as Merino wool, and very rare 'cause the vicuna won't domesticate nor turn sheepish. They must be killed to be fleeced. Populations dropped from 400,000 to 15,000 before Peru protected them. The smallest South American cameloid (three feet at the shoulder), the vicuna yields only a few ounces of fleece per lifetime. The alluring chestnut to cinnamon fleece makes vicuna the most coveted apparel fiber on the planet. Beware of fakes!



Musk-Ox

Musk-ox are scarce and the wool comes from shedding in spring. Domesticated musk-ox are now combed or massaged to obtain more of the downy, soft, itch-free, shrink-free undercoat. Each musk-ox yields about five pounds a year. (It takes only a few ounces to make a scarf or hat.) Extremely durable and eight times warmer than most wools, qiviut is so clean that it needs no carding before spinning. Qiviut products are essentially value-added only (no raw musk-ox wool enters the market) from Oomingmak, Inc., an Eskimo cooperative in Anchorage and a few other locales. It is the dream bioregional fiber product.

Angora Rabbit

Probably bred near Ankara (Turkey), this specialty hair rabbit has been a French source of fiber since the early 1700s. (The angora rabbit should not be confused with "angora" from the angora goat, also bred near Ankara.) The softest and finest of all specialty fibers, the rabbit's fur is plucked (or clipped) every few months. It is up to eight times warmer than wool for its weight. Usually blended with sheep wool or nylon because angora rabbits' short fibers are weak and slippery to spin. Its static electric crackling once made it a long underwear and blanket favorite to treat aches and pains from arthritis. China produces the most blendable grade. France remains the leader in gourmet angora.

Spider & Silkworm

Fiber-lovers suffer from arthropod envy. No one has made a fiber like spider silk: most stretchable before bursting, greatest tensile strength, and with the greatest resilience to strain. The less tough silk of the domestic silkworm is still lustrous, catching reflected light; strongest for its weight, stretchy, and resilient (a body clinger); breathing and warm. Imitated by nylon for strength and rayon for sheen, silk is unique in beauty and mystique. But, too much sunlight, sweat, or carpet beetle munching damages silken fabrics. Though rich in co-products (face powder additive, wigs, fishing line, surgical sutures), silk's price has narrowed its market niche to high-end items. The **International Silk Association** (*c/o Gerli & Co., New York, NY; 212/213-1919, fax 212/683-2370*) promotes use of silk in all forms.

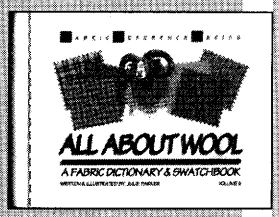
Crab & Lobster

Chitin is the fiber of lobsters, crabs, and the hard exoskeleton of most insects. The frame of butterfly wings, chitin is a kind of long-chain sugar closely related to cellulose. During the "teneral" period, when the outer layers are shed so the arthropods can grow, the softer fabric-like qualities of chitin are more apparent.

Currently used for bandages and burn dressings, it reduces scars and infection and improves healing. It's great for drug capsules. Cosmetic futures are bright because chitin clings non-allergenically to skin. It can be used to help clarify wastewater, and, perhaps even increases rice harvests when used to coat seeds. An abundant recyclable material culled from the wastes of the shellfish industry, chitin (and its modified form, chitosan) needs improved processing and a method to insure a secure supply to compete in the fiber markets.

All About Wool
(A Fabric Dictionary & Swatchbook)

Julie Parker. 1996; 144 pp. $25, $45 with samples. Rain City Publishing, P.O. Box 15378, Seattle, WA 98115, 202/527-8778.

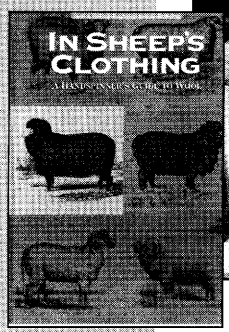


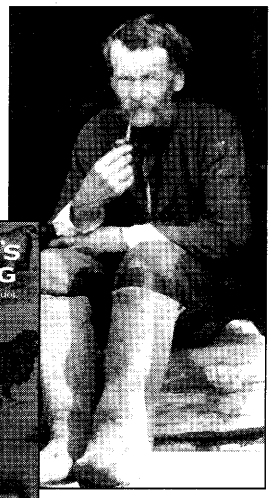
Same format as *All about Cotton* (p. 17), with thirty-five samples, from boiled wool to whipcord. —MKS

In Sheep's Clothing
(A Handspinner's Guide to Wool)

Nola Fournier & Jane Fournier. Interweave Press, 1995; 223 pp. $24.95

A field guide to fleece: photos and descriptions of breeds of sheep and their wool. The book also untangles the physics of wool and yarn production — how fiber type and preparation determine the yarn produced, why breed, health, nutrition, and weather affect a fleece, and how to chose and handle fleece. Even the glossary taught me something: "suint" means "sheep perspiration." —Wendy Chatley Green





Felt boots from Koskenpään in Jämsä.

❝ Each part of the fiber contributes to the characteristics that make wool so versatile. For example, the tiny overlapping scales behave just like shingles on a roof. The scales repel liquid, causing it to bead up and roll off the surface of the fabric. The inside of the fiber acts more like a sponge. The porous membrane allows wool to absorb moisture in the form of vapor, such as humidity or perspiration, which it stores in the hollow cells of the inner fiber.

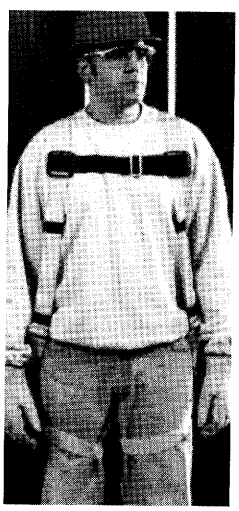
❝ Each fiber is coated with a layer of wool wax or grease. Most wool grease melts at between 110° and 120° F (43° and 49° C), so if your washing liquid is cooler, the grease will not be removed.

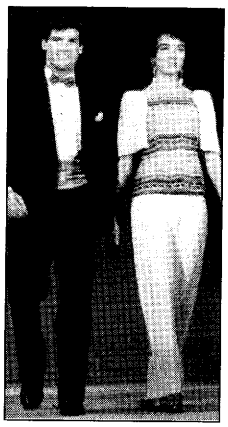
❝ The fleece should fall freely, with adjacent locks loosely connected but moving independently. The fleece should not feel stiff. The natural groupings or locks of fibers, called staples, should separate easily. Avoid fleece that is matted (cotted) requiring that you wrench the staples apart.

Inventory of Synthetic Fibers

Rayon (1910)
Acetate (1924)
The grand quest to outdo the silkworm lead to rayon, Count Hilaire de Chardonnet's Paris sensation. These earliest synthetic fibers were still based on cotton or tree pulp cellulose ("biopolymers"). The pulp was deconstructed into a fluffy white cellulose, then turned into a viscose resin which was squeezed through spinnerets that resembled a shower head, and hardened as a "manufactured fiber from natural plants." Because of the Great War and other more profitable uses such as dope for airplane wings and celluloid for motion pictures, it took until 1924 for "artificial silk" to grab significant market share of hosiery, blouses, and linings. These "cellulosic fibers" have passed their peak as cheap petro-based fibers (nylon and polyester) and have displaced regenerated pulp fibers. Rayon manufacture requires large volumes of water, generating water pollution and waste treatment expenses. But, its high absorbency keeps it available for diapers, feminine hygiene products, cigarette filters, and surgical products.

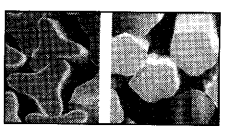
Nylon (1939)
was the first non-cellulose fiber made directly from petrochemicals and/or coal. Its petro-family of polymers is called polyamides; its source petro-molecule is toluene. In 1931, Wallace Carothers presented his finding on long chains of small molecules. The miracle fiber (no more moths! no more mildew! exceptionally strong!) replaced silk parachutes, silk stockings, and sewing thread. Nylon entered the carpet and men's sport shirt markets. In World War II, nylon was an ingredient of paper money, tires, ropes, and tents. Now, nylon seat belts, windbreakers, sleeping bags, tarpaulins, curtains, etc. are everywhere.





Polyester (1953)
Its source monomers are xylene and ethylene which become the polymers polypropylene and polyethylene. Polyester fibers are lightweight and wash-and-wear, with longer fibers than nylon. As electric dryers saved women from clothesline drudgery, polyester wrinkle-free fabrics further freed them from ironing. Polyester replaced rayon and nylon in many tire fabrics, and further reduced the percentage of textiles made from cotton. (At times, polyester is used in cotton blends.) Seatbelt safety rules sparked further production. A favorite for ropes and nets, floppy disk liners, and fiberfill for sleeping bags. Some of the polyesters contain chlorine, and these have become sources of harm to wildlife and humans during production, use, and disposal of the end product.

Acrylic (1950)
Modacrylic (1950)
Entering the market as "wash-and-wear," polypropylene acrylics are best in blends with cotton. Acrylic was a major leap in time-saving for homemakers and washer women. Its uneven fiber surface is unique, with outstanding wickability and resistance to sunlight. Modacrylics took over the "furry" textile market, including teddy bears, wigs, deep-pile coats, paint rollers, and fake sheep fleece. Acrylics ate away at the markets for wool carpets and blankets as well as sweaters.



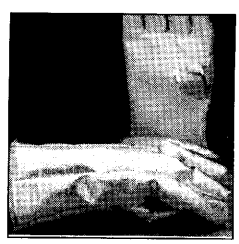
Olefin (1959)
is a by-product of the breakdown ("cracking") of the large molecules of raw petroleum into smaller ones (propylene and ethylene gases). The most lightweight of synthetic fibers, olefin is super-comfortable, with exceptional wickability. Olefins are the best replacement for the chlorinated synthetic fibers and plastics used in medical paraphernalia. You'll also find them in sportswear, thermal underwear, cars, fabrics, carpets, and geotextiles.

Specialty fibers

Vinyon (1939)
is a polyvinyl chloride with all the health problems associated with chlorinated polymers. It can bind non-woven fibers and fabrics. Vinyon has been a substitute for plant-based filters in tea bags!

Saran (1941)
is another polyvinyl chloride. Its heavy fibers encourage use in public transport upholstery, deck chairs, and garden furniture.

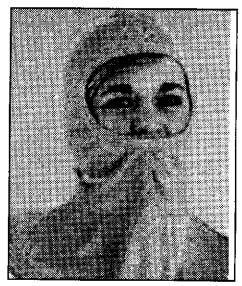
Metallic (1946)
fibers are simply to look cool in swim suits or

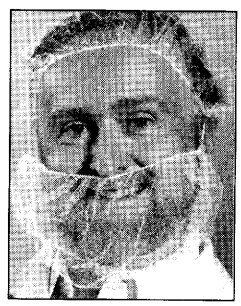


hot pants — made with plastic and metal foils.

Spandex (1959)
the stretchable fiber of bathing suits and sports clothes, is stronger and more durable than rubber, its major plant competitor.

Aramid (1961)
the fire-resistant polyamide, is a favorite for aerospace and military; bullet-proof protective "armor" fabric, as well as an asbestos substitute.



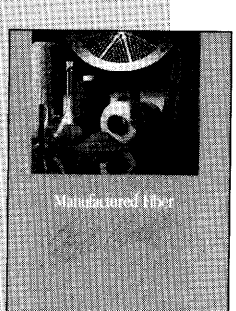


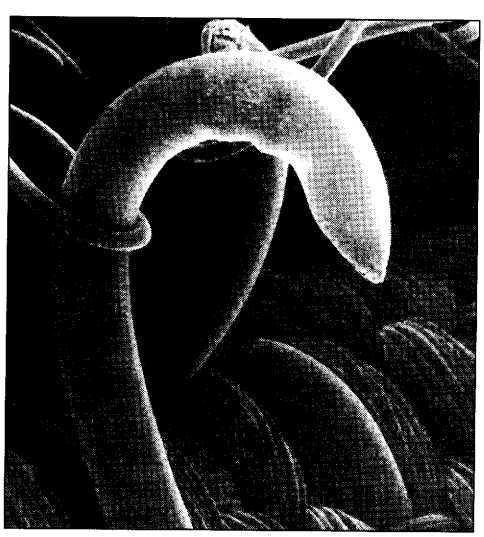
PBI (1983)
also has no melting point and will not ignite; it is the love of astronauts and fire departments.

Sulfar (1983)
has special resistance to chemical and thermal attack; it has changed industry with filter fabrics for coal boilers, papermaker felts, electrical insulation, specialty membranes, gaskets, and packings. ⊕

American Fiber Manufacturers Association
Washington, DC;
202/296-6508, fax
202/296-3052.

Distributes video depicting production and end uses of manufactured fibers. Book: *Manufactured Fiber Fact Book*, Periodical: *Manufactured Fiber Guide.*





**Second column: Weather-resistant, lightweight nylon harness.
Third column: Polyester apparel.
Fourth column: Specially constructed synthetic fibers. Triangular is for carpets.
Fifth column: Silica/aluminum fabric gloves with wool lining.
Sixth column: PBI/rayon blend protective hood (top). Flame resistant, 100 percent nylon hairnet and beard cover for bakers (bottom).
Left: Velcro.**