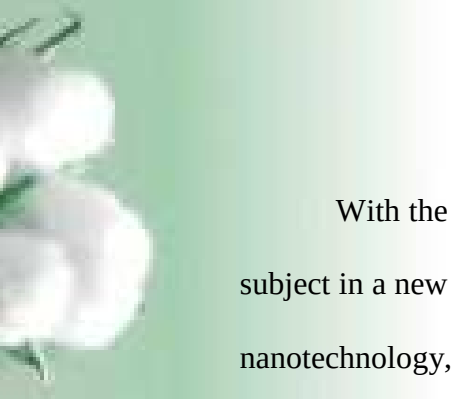
No More Ironing?

(or bleaching, or starch, or deodorants, or lint rollers, or…)

All right, wrinkle-free and stain resistant clothing are still a work in progress, so the ironing board will remain a household fixture. But with new advancements in cotton and cotton treatments, it might not be that far off. Between liquid-proof shirts that can keep cool or warm up depending on body temperature and odor fighting socks, the possibilities seem endless. And with the latest genetically engineered cotton, it can be produced cheaper than ever, and with less harm on the environment. Cotton certainly has changed since the time of Eli Whitney and his revolutionary gin.

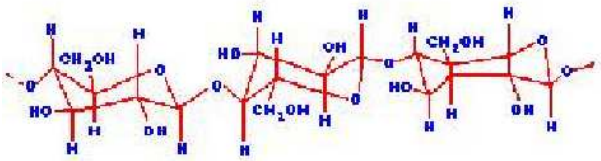


With the latest revolutions in the clothing industry, cotton has become the leading subject in a new chemistry-textile industry. Everything from bioengineering to the newest nanotechnology, micro-encapsulation and even NASA developed treatments have been employed to ease the work and care put into keeping clothing looking the best it can. But how do these innovations work?

Wrinkle Free and Stain Resistant: the new fads of the textile industry

Almost everything in today's world is made for the sole purpose of lightening the workload, for making life a little easier. From portable GPS systems that tell when to turn and where (no more looking up maps and directions) to robotic vacuum cleaners that do entire rooms without any outside assistance (no more pushing and pulling heavy uprights) - all of the latest easy-care technology fills busy (or just lazy) people's dreams. Some of the most popular breakthroughs, wrinkle-free pants and shirts promise that consumers can simply "wash-and-wear."

Wrinkle-free clothing makes up around 25% of clothing on the racks today (Kantor). Intrinsically wrinkle-resistant, cotton wrinkles only when it gets wet, which proves a problem for keeping clothes clean. Water is a polar molecule, which has both positively-charged and negatively-charged sections instead of charged evenly throughout the molecule. Water's polarity makes it form hydrogen bonds, weak bonds between the positively-charged hydrogen end of one molecule and the negatively-charged oxygen end of another molecule. Cotton is composed mainly of cellulose, a relatively strong



Molecular Structure of Cellulose

molecule; the cellulose molecules bind together with “cross-linked hydrogen bonds” (Kantor), which form between hydrogen and hydroxyl (OH) groups at the end of each molecule. The polarity of water causes it to mess with the hydrogen bonds in cellulose, just enough to weaken the cotton - leaving it wrinkled when it comes out of the wash. The bonds easily restore their former shape when ironed; the steam from the iron weakens the bonds just enough to press in place.

So, to make cotton garments “wrinkle-free,” they just have to be made waterproof. Research has found that most chemicals related to formaldehyde bind well to cellulose, making it water-resistant. But formaldehyde has the unfortunate quality of being toxic - its fumes cause tiredness, headaches, coughing, and respiration problems. This might be an issue for people planning to actually wear the newly wrinkle-free clothing. An inexpensive relative of formaldehyde, called dihydroxy dimethylol ethylene urea, though still toxic, can be treated with chemical buffers and catalysts to make it safe. This finish gets applied to the clothing either before or after the garment is constructed from cotton fabric, using a variety of spraying, soaking, and drying techniques. Though very effective for the first 40 or so washes, this treatment wears out over a period of time, so do not throw the irons out just yet. Research is being conducted to improve this condition - or else consumers could just buy another pair of pants.

Wrinkle-free pants: a new industry favorite

The process of making cotton fabric wrinkle-free tends to leave the clothing susceptible to grease and oil stains. This caused the need for the application of stain-resistant technology as well. Cotton is naturally absorbent because of cellulose’s

negatively-charged hydroxyl groups that bind with water's hydrogen bonds, soaking the molecules up. Because of cellulose's outer affinity for water, it is hydrophilic, or "water-tolerant." To make the cellulose water (and other liquid)-proof, something needs to make the cellulose hydrophobic, or "water-intolerant." Nano-Tex LLC, a textile company in North Carolina, invented an ingenious process using nanotechnology. They created tiny whisker-like cylinders, measuring 10 nanometers long, which would wrap around the cellulose fibers. Carbon-based and nonpolar, the cylinders do not readily bind with water molecules and do not form hydrogen bonds, and so create a hydrophobic barrier around the cotton. To attach them, the cotton cloth is immersed in a solution of water and the cylinders, and then heated so that the water evaporates leaving the cylinders to spread out and naturally bind to the individual cellulose fibers.

Now virtually liquid-proof, the fabric can't absorb any liquids, and so they bead up and roll right off without staining. Because the whiskery cylinders are so small, they leave the fabric looking and feeling the same as normal cotton clothing. After the addition of the cylinders, the wrinkle-resistant resin treatment is applied, and manufacturers have new wrinkle- and stain-free clothing lines hot out of the chemistry lab.

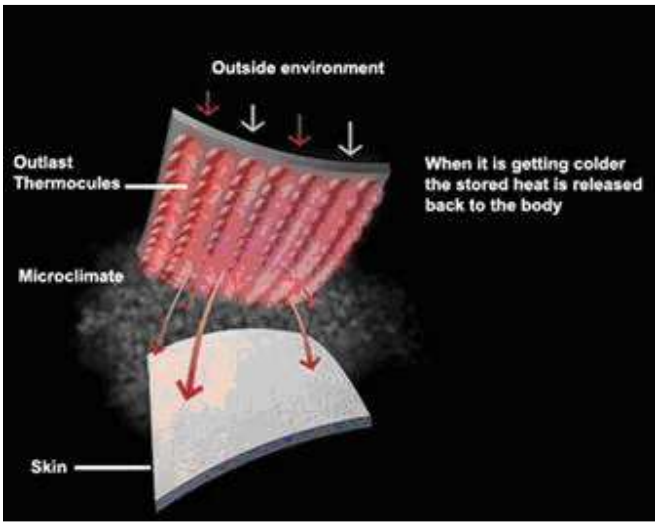
Clothing can't absorb the stain-causing liquid

Climate Control and other Commodities

If NASA made a pair of pants, what would they be like? Well, they certainly would have the latest comfort advancement originally designed for astronaut clothing. Up in space, the astronauts have to deal with extreme temperatures, both freezing cold and

sweltering heat. So, NASA developed a system where the clothing actually sensed the body heat of the astronauts to protect them. Now the treatment is being applied to everyday clothing so the average person can enjoy temperature-controlled comfort.

Micro-encapsulation makes climate control possible; tiny particles filled with an active ingredient are bound to the fabric and release over time. In the case of climate control, these particles, or “thermocules,” are filled with phase change materials, which have the ability to store large amounts of energy. When the body heats up, the phase change materials liquify, absorbing the energy that causes heat and cools the body down.



When the body gets colder, the phase change materials solidify and release the heat energy to warm the body up. It’s like a personal thermostat; whether the person feels too hot or too cold, the thermocules in the clothing respond to keep a comfortable temperature.

Micro-encapsulation can also save stinky feet. Particles embedded in cotton socks can slowly release their active ingredients (deodorants or cover-up fragrances) as the person wears them. Empty particles, called cyclodextrins, can even absorb smelly sweat molecules and trap them until washed - the molecules just rinse away. Adding an antibiotic finish can also eliminate smells because it kills the bacteria that cause odor: no bacteria, no smells.

Besides climate and odor control, there has also been research into static resistance. This would keep pesky pet hair and lint from sticking to clothing by reducing the static charge that causes the cling. Also, manufacturers have started adding

moisturizers that release during wear, keeping skin from drying out during those cold winter months. Everything from insect repellent to therapeutic fragrances is being added to clothing, whether for comfort, aesthetics, or just plain luxury. Consumers nowadays want everything they buy to be the most current product with the most innovative commodities, so manufacturers have to come up with more and more creative ideas.

With all of these new innovations in textiles, concerns rise about the effect of farming such large quantities of cotton. Acres upon acres of land are used for the sole purpose of commercial cotton consumption, and all of this land gets sprayed with harmful toxins so that insects don't eat the entire crop. This spraying proves harmful to the environment and has lasting consequences, plus it costs more for the farmers. New technology in genetic engineering promises to ease these problems by reducing chemical spraying, while increasing the crop yield. Exciting developments such as cotton that can produce its own pesticide or that can resist chemical herbicides are some of the latest talk amongst agronomists.

The bollworm, a common antagonist of the cotton plant

Bt Franken-Cotton

Genetic engineers have created a super-plant, a veritable Frankenstein of cotton. This cotton, called Bt cotton, can fight off attacking insects all on its own, but not by throwing punches. Bt cotton contains a pesticide-producing gene from the bacterium *bacillus thuringiensis*. The insects unwittingly eat the plant, ingesting the poison at the

same time. This Frankenstein, though a strange combination of DNA, is not a monster, but a superhero that reduces chemical spraying by 75% while increasing cotton yield by about 20% (“Bt Cotton”).

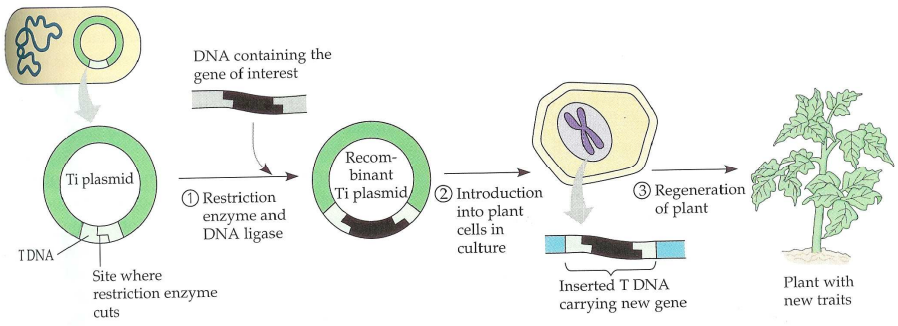
Though a Franken-cotton, Bt cotton wasn’t made by sewing together parts and flipping a large power switch. Before genetic engineering, sexual barriers restricted breeders to crossing existing cotton varieties and hoping for useful mutations. Now geneticists can select what gene they want a new plant to express, insert it into the original plant DNA, and get exactly the traits they wanted. This produces a transgenic species, or an organism with genes from two or more different sources. But the process is not quite as simple as it sounds. First, they have to find an easily-isolated, useful gene. Usually these come from bacteria or viruses, relatively simple organisms with fewer numbers of genes to sift through to find the right one.

With the Bt gene **Without the Bt gene**

Once geneticists locate the correct gene, such as the toxin-producing gene from the bacteria *bacillus thuringiensis*, they take it out of the bacterial DNA using restriction enzymes. Restriction enzymes cut at specific codes in the DNA; the same enzyme both cuts out the desired gene and cuts the receiving DNA, so that the new gene binds smoothly with the host. Sometimes the gene pieces get inserted directly into the DNA of the original plant. In the case of Bt cotton, however, geneticists used another bacterium to do the work for them.

The disease-carrying bacterium *Agrobacterium tumefaciens* causes its disease in plants by inserting some of its DNA into the genetic material of plant cells it infects. By replacing the harmful genes with the useful one from *bacillus thuringiensis* using the same restriction enzyme, geneticists created an easily-reproduced, transgenic plant-making machine. This new super-bacterium inserts the pesticide gene into plant DNA, making genetic engineers' job easy (sort of).

Because not all of the plant cells in culture become infected with the Bt gene, geneticists had to include an anti-biotic resistant gene in the *Agrobacterium tumefaciens* transfer bacterium. When the culture is treated with the anti-biotic, only the cells that received the Bt gene survive because they also have anti-biotic resistance. This leaves the culture filled with all cells having the pesticide-producing gene, which then grow slowly into a whole cotton plant capable of producing its own transgenic seeds.



These new transgenic Bt cotton plants produce poisonous protein in their flower, or "boll". Insects such as the bollworm start to eat the boll, ingesting the crystalline protein as well. Once the insect eats eight or nine of these crystals, they bind together and bore holes in the membranes of nutrient-absorbing cells. The insects quickly stop eating and starve to death within 24 hours because it cannot absorb the necessary energy to live. The great thing about the Bt crystal proteins is their specificity; the crystals can only break cell membranes of certain organisms because of the variety of different receptor

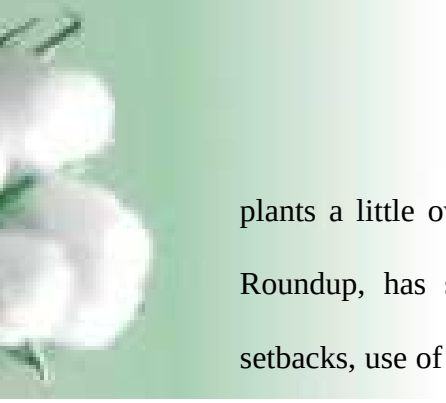
proteins on the outside of cells. The pesticide stays completely harmless to other plants and animals in the environment, as well as, of course, humans. So, the transgenic Bt cotton plants yield more cotton, because insects can't eat as much, and are safer for the environment, because of the reduction in toxic chemical spraying and the relative harmlessness of its own pesticide (which also makes it cheaper).

Bt crystalline protein

A Roundup-Ready Reality

Bt cotton is not the only transgenic cotton plant making a splash in the industry. Herbicide-tolerant breeds such as BXN and Roundup-Ready have the ability to resist certain toxic chemical weed killers. That way, farmers can spray the entire field, but only kill the weeds. This should reduce herbicide use because only small amounts of a strong herbicide are used, compared with the large amounts of herbicide that's gentler on normal cotton. BXN cotton tolerates spraying with bromoxynil, while Roundup-Ready tolerates glyphosate. Herbicide tolerant transgenics are created using the same process as the Bt cotton. Sometimes, the genes for herbicide tolerance are packaged with the Bt gene, making the cotton impervious both to weed killers and insects.

Though great in theory, herbicide tolerant cotton plants have proven problematic. Bromoxynil is a possible carcinogen in humans, while Roundup is very toxic to most animals and humans. Also, some farmers reported the bolls falling off Roundup-Ready



plants a little over halfway through the season. Monsanto, the company that produces Roundup, has since fixed this problem and reimbursed the farmers. Despite these setbacks, use of herbicide tolerant cotton has resulted in the decrease in number of sprays and kinds of herbicides used. Hopefully, through more genetic and experimental research, scientists can develop a safer way to repress weed growth than chemical spraying, though they certainly are getting closer. Maybe one day they will engineer a cotton plant that is inherently stain and wrinkle resistant, can fight off bugs all on its own, and maybe even weed itself. Who knows, it could happen.

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