

**BME 695K/IPPH 690W**

**Polymers in Biomedical  
& Pharmaceutical Systems**

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**Polymers in Everyday Life**

Tooth Brush  
Shaving blade  
Shampoo  
Lotions  
Sun screens  
Mascara  
Cosmetics  
Nail enamels

**1. Introduction to polymers**

**Polymer:** a substance whose molecules consist of many (poly-) parts (meros, greek) or units.

**Plastic:** a polymer-based material that can be molded, cast, extruded, drawn, or laminated into objects, films, or filaments.

**Oligomers and Polymers**

Monomer, Dimer, Trimer     ○ ● ○○ ○○○

Multimer     ○○○○○○ ○○○○○○

Oligomer  
(N = 30-200)

Polymer  
(N = >200)

Molecular weight: heterogeneous → average

**Synthetic Polymers**

**Linear polymers (1930's)**  
Homopolymer, block copolymer

**Crosslinked gel (1940's)**

**Branched polymers (1960's)**

**Dendrimers (1980's)**

**Polyhuman. Poly(red human)**

**One word. Just one word: Plastics. There's a great future in plastics.**

**2,000,000 PLASTIC BOTTLES**

**I HAVE JUST ONE WORD FOR YOU: BIOPLASTICS**

**One word. Just one word: Plastics. There's a great future in plastics.**

# Bioplastic Fantastic

Bugs that eat sugar and poop polymers could transform industry—and cut oil use too. by Stuart E. Brown

**Making plastic**

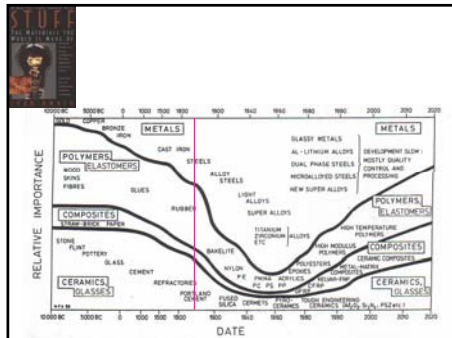
## Beginning of the Polymer History: Ivory replacement in 1866

### The stuff of history

- 1862** A mixture of collagen from animal cartilage and pyrene sulfonic acid at Eastman's Great International Exhibition. It is marketed as a replacement for rubber, but the material proves too costly to mass produce.
- 1876** After an investment of \$10,000 for a substitute for animal ivory, inventor John Wesley Hyatt creates celluloid with nitrocellulose (cellulose), the fully synthetic example in contact with cellulose in the photograph and film industry.
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- 1876** Du Pont engineers invent celluloid, the first mass-produced man-made plastic. The product causes cases of amputated limbs to disappear and gives rise to the modern toy industry.
- 1881** On May 15, dubbed "the day," 5 million pairs of nylon stockings become available to American women and men.
- 1902** A DuPont, Mich., company announces development of the first plastic hot tank system, which will enable users to eliminate bakelite emissions.
- 2001** Lucant Technologies researchers create the world's first plastic superconductor, paving the way for ultra-high-speed trains and a new era of quantum computing.

## A CENTURY OF SYNTHETICS

- 1902** First synthetic fiber, a rayon yarn.
- 1905** Bakelite patents, Bakelite
- 1915** Pyrex glass
- 1925** Cellulose
- 1926** PVC (chlorinated polyethylene)
- 1927** Scotch tape
- 1928** Sunray glass
- 1929** Latex from rubber
- 1930** Polystyrene
- 1932** Neoprene, the first synthetic rubber
- 1934** Carothers invents nylon
- 1935** Plexiglas
- 1939** Teflon
- 1940** Fabric mass-produced nylon stockings
- 1942** Polystyrene from, bakelite, acrylic
- 1946** Nylon papers, polyester
- 1950** Silly Putty
- 1952** Mylar recording tape
- 1958** Lycra spandex introduced
- 1963** Permanent press clothing
- 1965** Astronaut installed in Houston Astrohome
- 1975** Plastic soda bottles
- 1976** Kevlar bulletproof vests
- 1985** GO-stem carbon, buckminsterfullerene ("Buckyballs"), discovered



## 1839 POLYISOPRENE

### THE MADMAN WHO MADE RUBBER USEFUL

With no real knowledge of chemistry or any other field of science, Goodyear set out to answer his own question: How can you make a better type of rubber?

$$\left( \begin{array}{c} \text{H} \\ | \\ \text{---} \text{C} \text{---} \\ | \\ \text{H} \end{array} \right)_n \text{---} \left( \begin{array}{c} \text{H} \\ | \\ \text{---} \text{C} \text{---} \\ | \\ \text{H} \end{array} \right)_m \text{---} \left( \begin{array}{c} \text{H} \\ | \\ \text{---} \text{C} \text{---} \\ | \\ \text{Cl} \end{array} \right)_p \text{---} \left( \begin{array}{c} \text{H} \\ | \\ \text{---} \text{C} \text{---} \\ | \\ \text{H} \end{array} \right)_q$$

**Polychloroprene = Poly(2-chloro-1,3-butadiene)** **1931**  
(Trade name: Neoprene)

**1868. CELLULOSE, THE FIRST THERMOPLASTIC. THE FIRST FLEXIBLE PHOTOGRAPHIC FILMS FOR STILL AND MOTION PICTURES**

**THE IDENTIFICATION OF CELLULOSE**

It is known that naturally produced cellulose cellulose occurs in 1868 when it was first used as a material for photographic films. The first cellulose film was made by Nicéphore Niépce and Louis J. M. Niepce in 1816. The first cellulose film was made by Nicéphore Niépce and Louis J. M. Niepce in 1816. The first cellulose film was made by Nicéphore Niépce and Louis J. M. Niepce in 1816.


**GIANT MOLECULES, ESSENTIAL MATERIALS FOR EVERYDAY LIVING AND PROBLEM SOLVING. RAYMOND B. SEYMOUR & CHARLES A. CARPENTER. JOHN WILEY & SONS, INC., 1981. PP. 117-119.**

**1891. Rayon: artificial silk.**

**Regenerated man-made fibers of cellulose from cuprammonium cellulose, viscose (cellulose xanthate), or cellulose acetate.**

**Study on silkworm by Louis Marie Hilaire Bernigault, Paris: Silkworm secretes a liquid from a narrow orifice that hardens upon exposure to air (silk).**

**Idea: Pass a liquid that has similar characteristics to silk before being secreted through a man-made apparatus to form fibers that can spun and feel like silk.**



Natural strength. Proteins in strands of silk emerging from a spider's spinneret combine resistance with extreme toughness.

**Beginning of Polymers**

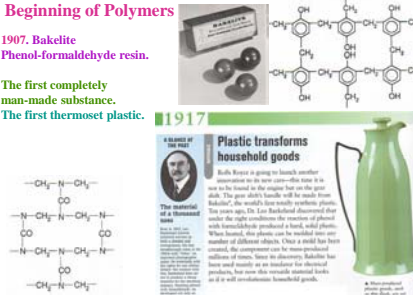
**1907. Bakelite**  
**Phenol-formaldehyde resin.**

**The first completely man-made substance.**  
**The first thermoset plastic.**

**1917**

**Plastic transforms household goods**

**Urea-formaldehyde Resin (1926)**



**1907**

**LEO BAEKELAND**

**I just want to see new stuff for you just one word, plastics. There's a great future in plastics.**

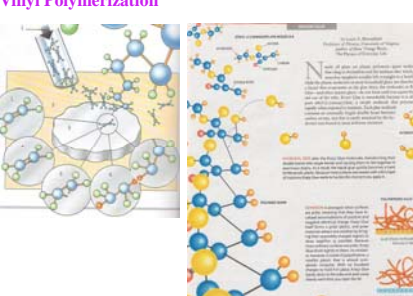


**Table 2.1 Chemical Development of Commercial Polymers**

Year	Material	Chemical Development	Typical Application
1862	Natural Rubber	Latex	Shoes, tires, hoses, etc.
1869	Cellulose Nitrate	Nitrocellulose	Explosives, lacquers, films
1872	Cellulose Acetate	Cellulose acetate	Explosives, lacquers, films
1873	Cellulose Sulfonate	Cellulose sulfonate	Explosives, lacquers, films
1874	Cellulose Phosphate	Cellulose phosphate	Explosives, lacquers, films
1875	Cellulose Oxide	Cellulose oxide	Explosives, lacquers, films
1876	Cellulose Ether	Cellulose ether	Explosives, lacquers, films
1877	Cellulose Ester	Cellulose ester	Explosives, lacquers, films
1878	Cellulose Derivative	Cellulose derivative	Explosives, lacquers, films
1879	Cellulose Compound	Cellulose compound	Explosives, lacquers, films
1880	Cellulose Polymer	Cellulose polymer	Explosives, lacquers, films
1881	Cellulose Resin	Cellulose resin	Explosives, lacquers, films
1882	Cellulose Plastic	Cellulose plastic	Explosives, lacquers, films
1883	Cellulose Fiber	Cellulose fiber	Explosives, lacquers, films
1884	Cellulose Paper	Cellulose paper	Explosives, lacquers, films
1885	Cellulose Cloth	Cellulose cloth	Explosives, lacquers, films
1886	Cellulose Fabric	Cellulose fabric	Explosives, lacquers, films
1887	Cellulose Textile	Cellulose textile	Explosives, lacquers, films
1888	Cellulose Yarn	Cellulose yarn	Explosives, lacquers, films
1889	Cellulose Thread	Cellulose thread	Explosives, lacquers, films
1890	Cellulose Cord	Cellulose cord	Explosives, lacquers, films
1891	Cellulose Rope	Cellulose rope	Explosives, lacquers, films
1892	Cellulose Cable	Cellulose cable	Explosives, lacquers, films
1893	Cellulose Wire	Cellulose wire	Explosives, lacquers, films
1894	Cellulose Tape	Cellulose tape	Explosives, lacquers, films
1895	Cellulose Bandage	Cellulose bandage	Explosives, lacquers, films
1896	Cellulose Dressing	Cellulose dressing	Explosives, lacquers, films
1897	Cellulose Bandage	Cellulose bandage	Explosives, lacquers, films
1898	Cellulose Bandage	Cellulose bandage	Explosives, lacquers, films
1899	Cellulose Bandage	Cellulose bandage	Explosives, lacquers, films
1900	Cellulose Bandage	Cellulose bandage	Explosives, lacquers, films

**GIANT MOLECULES, ESSENTIAL MATERIALS FOR EVERYDAY LIVING AND PROBLEM SOLVING. RAYMOND B. SEYMOUR & CHARLES A. CARPENTER. JOHN WILEY & SONS, INC., 1981. PP. 117-119.**

**Vinyl Polymerization**




**Condensation Polymerization (Step-reaction Polymerization)**

**STIR UP SOME NYLON**

**Nylon 6-10**

$$n \text{ H}_2\text{N(CH}_2\text{)}_6\text{NH}_2 + n \text{ HOOC(CH}_2\text{)}_{10}\text{COOH} \rightarrow \text{[NH(CH}_2\text{)}_6\text{NHCO(CH}_2\text{)}_{10}\text{CO}]_n\text{ + } 2n \text{ H}_2\text{O}$$

**Schools should be in the stores**



**WALLACE HUME CAROTHERS: THE FATHER OF NYLON**

**HIS SYNTHETIC RUBBER WAS A HIT, BUT NYLON SET OFF ROOTS IN THE STORES**

**Wallace Hume Carothers: The Father of Nylon**

Carothers would not be as kind to the century's other great plastics pioneer, Wallace Hume Carothers. A brilliant chemist but a troubled soul, Carothers was hired by DuPont in 1928 from his position at Harvard to run the company's newly minted Purdy Hall. Executives in charge of DuPont's diversification from gunpowder into synthetics made a bet—unusual at the time—that an investment in "silk" science would pay off.

They were right. Carothers was given a state-of-the-art lab, a bright young research staff and instructions to do basic research on polymers like bakelite, cellulose and silk, whose molecular structure was a matter of intense debate. Carothers, applying the new ideas of quantum mechanics to some novel theories about the structure of polymers, correctly deduced that they were long chains of enormous numbers of small molecules chemically linked together.

Once he knew how natural polymers worked, making synthetic ones was relatively easy. Carothers' first success was nitrone, a rubber-like substance that DuPont started selling in 1932. His four de force, however, was an artificial silk that Carothers called 66 polyamide but that DuPont dubbed nylon.

Nylon was an instant hit when first introduced at the 1939 World's Fair. DuPont promoted it with fervor, giving 30 ft.-long mannequin legs to show it off. Public demand for the silk-like material was overwhelming. Women bought more than 4 million pairs in one day; newspapers reported "nylon riots" in the department stores. During World War II, when all DuPont's nylon production went into the war effort (for parachutes, tire cords, tank vests and ropes), "a pair of nylon stockings could buy you anything," as one Navy researcher quipped.

Carothers, however, saw none of this. A chronic depressive, he killed himself by drinking cyanide in a Philadelphia hotel room in 1937, two years before nylon hit the market.

**By Bob Amels**

**1939**

**DuPont begins to market nylon**

**Nylon mania looks set to sweep the nation with the unprecedented demand for clothes made from the world's first synthetic fiber.**

People caught their first glimpse of nylon at this year's World's Fair in New York. The chemical giant DuPont has also begun to manufacture nylon commercially. Initially developed five years ago by a research team led by Wallace Carothers, nylon is produced in a reaction between an acid and an amine. Through varying the reaction components, it is possible to change the properties of the fiber from hard and tough to soft and rubbery.

**Need For New Tough Plastic.**

**Synthesis of nylon based on Staudinger's theory on polymeric nature of plastics.**



**1942**

**A GLANCE AT THE PAST**

### Nylon is used for parachutes

The American military has adapted the synthetic fiber nylon to use for making parachutes. Parachutes have become an essential part of modern warfare, used by pilots for escaping from damaged aircraft, dropping spies behind enemy lines, and landing supplies and troops. Until now all parachutes have been made from silk spun by silk worms. Silk production is slow and costly; Nylon parachutes can be manufactured cheaply and on a massive scale to aid the Allied war effort.

**The history of the parachute**

Parachutes are used for a variety of purposes. They are used to land troops, supplies, and equipment. They are also used for rescue operations. The history of the parachute dates back to the 15th century. Leonardo da Vinci is credited with the first parachute design. However, it was not until the 19th century that parachutes became practical. In 1825, Louis Blanchard made the first successful parachute jump. Since then, parachutes have become an essential part of modern warfare.

**New Velcro® fastener patented**

A Swiss engineer, George de Mestral, has patented a new fastener called Velcro®. The patent covers the use of hook and loop fasteners. These fasteners are made of two different materials. One material has small hooks or loops, and the other has small loops or hooks. When the two materials are pressed together, the hooks or loops catch on each other, creating a strong bond. Velcro® fasteners are used in a wide variety of applications, from clothing to medical devices.

**1955**

The chemical structure of the nylon is shown below:

$$\left[ \text{NH} - (\text{CH}_2)_6 - \text{NH} - \text{CO} - (\text{CH}_2)_4 - \text{CO} \right]_n$$

**1955**

**The Hard and the Soft**

French engineer Jean Guillet has come up with a material for the future. It is called the Hard and the Soft. This material is made of two different materials. One material is hard and the other is soft. When the two materials are pressed together, they create a strong bond. This material is used in a wide variety of applications, from clothing to medical devices.

**Poly(methyl Methacrylate)**

$$\left[ \text{C} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{H} \end{array} \begin{array}{c} \text{CH}_3 \\ | \\ \text{C} \\ | \\ \text{O} \\ | \\ \text{OCH}_3 \end{array} \right]_n$$

**Poly(hydroxyethyl Methacrylate)**

$$\left[ \text{C} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{H} \end{array} \begin{array}{c} \text{CH}_3 \\ | \\ \text{C} \\ | \\ \text{O} \\ | \\ \text{OCH}_2\text{CH}_2\text{OH} \end{array} \right]_n$$

**Silicone Rubber**

$$\left[ \text{Si} \begin{array}{c} \text{CH}_3 \\ | \\ \text{O} \\ | \\ \text{CH}_3 \end{array} \right]_n$$

**Bouncing putty: new uses for an old idea**

Scientists have discovered a new use for an old idea. Bouncing putty, a material that has been used for centuries, is now being used in a variety of applications. This material is made of two different materials. One material is hard and the other is soft. When the two materials are pressed together, they create a strong bond. This material is used in a wide variety of applications, from clothing to medical devices.

**Poly(vinyl Chloride)**

$$\left[ \text{C} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{H} \end{array} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{Cl} \end{array} \right]_n$$

**Nonstick (Teflon®-coated) pans introduced**

French engineer Marcel Grignani has come up with a material for the future. It is called Teflon®. This material is made of two different materials. One material is hard and the other is soft. When the two materials are pressed together, they create a strong bond. This material is used in a wide variety of applications, from clothing to medical devices.

**Poly(tetrafluoro ethylene)**

$$\left[ \text{C} \begin{array}{c} \text{F} \\ | \\ \text{C} \\ | \\ \text{F} \end{array} \begin{array}{c} \text{F} \\ | \\ \text{C} \\ | \\ \text{F} \end{array} \right]_n$$

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**Polyurethane**

**PLASTICS**

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$$\left[ \text{C} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{H} \end{array} \begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{Cl} \end{array} \right]_n + \text{OCN}-\text{R}-\text{NCO} \rightarrow \left[ \text{O}-\text{C} \begin{array}{c} \text{H} \\ | \\ \text{N} \\ | \\ \text{H} \end{array} \text{O}-\text{C} \begin{array}{c} \text{H} \\ | \\ \text{N} \\ | \\ \text{H} \end{array} \text{O}-\text{R}-\text{N} \right]_n$$

**Make new products happen with Hypoc**

Scientists have discovered a new use for an old idea. Bouncing putty, a material that has been used for centuries, is now being used in a variety of applications. This material is made of two different materials. One material is hard and the other is soft. When the two materials are pressed together, they create a strong bond. This material is used in a wide variety of applications, from clothing to medical devices.

**bowling balls**

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**Emergence of Synthetic Polymers**

**Year 1960 - present**

1. Large scale operations.
2. Applications in daily lives, transportation, communications, education, & leisure.
3. Polymer composites
4. Polymers as biomaterials.
5. Functional polymers  
Polymers with bioactivity
6. Smart polymers and hydrogels
7. Biodegradable polymers

**1960**

**First successful artificial heart valve**

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**Heart surgery developments**

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**Silicone Rubber**

Cohesive silicone gel implants, such as this one made by McGhan, a division of Inamed, are used for breast reconstruction.

**Poly(acrylic acid)**

Superabsorbents

$$\begin{array}{c} \text{H} & \text{H} \\ | & | \\ -\text{C}- & \text{C}- \\ | & | \\ \text{H} & \text{COOH} \end{array}$$

$$\left( \text{CH}_2-\text{CH} \begin{array}{l} | \\ \text{OH} \end{array} \right)_n$$

27.4 billion

**More Problems With Plastics**

**news of the week**

**MOMENTUM BUILDS AGAINST BISPHENOL A**

**MOISTURE PROOF** Crystal-clear fluoropolymer films in blister packaging protect blockbuster drugs.

Businesses that were once "pioneered to the stars" are now "basic building blocks" for the company's future.

**POLY(ETHYLENE TEREPHTHALATE)**

$$\left[ \text{OCH}_2\text{CH}_2\text{OOC}-\text{C}_6\text{H}_4-\text{CO} \right]$$

**TRADENAMES:**  
 DACRON  
 VYCRON (FIBERS)  
 MYLAR (FILMS)

**APPLICATIONS:**  
 BIOMATERIALS  
 FILM  
 RECORDING TAPES  
 BOTTLES

**Fantastic Plastic**

**Carbon Fiber** How Are Carbon Fibers Used?

Carbon fiber used to strengthen components

**Teach your SUNGLASSES to read**

**Peel And Stick Lenses**

SIMPLE YET eminently clever: Optix 20/20 lenses transform any eyewear into reading glasses. The flexible lenses peel and adhere like oil-change stickers on a windshield—by molecular attraction. Stick them onto your regular glasses, and you effectively create bifocals. They come in 10 strength levels. In test markets, the lenses sell for about \$25; they could be in drugstore chains by early next year. Slightly larger versions for safety glasses and scuba masks are in the works. [www.optix.com](http://www.optix.com)

**STICKY STUFF**

A tribute to those products that hold our daily lives together.

**Result of a failure of making high strength polymeric adhesive**

**STRONG HOLD**

**Surlyn®**

$$\left( \text{CH}_2-\text{CH} \begin{array}{l} | \\ \text{C}_6\text{H}_4 \end{array} \right)_x \left( \text{CH}_2-\text{CH} \begin{array}{l} | \\ \text{CO}_2\text{R} \end{array} \right)_y$$

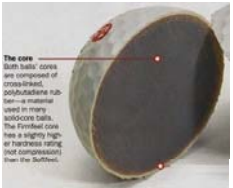
Surlyn® is the random copolymer poly(ethylene-co-methacrylic acid). The incorporation of methacrylic acid is typically low (< 15mol. %). Some or all of the methacrylic acid units can be neutralized with a suitable cation, commonly Na<sup>+</sup> or Zn<sup>2+</sup>.

**Surlyn®: Distance Polyurethane: Spin**


**Polybutadiene**

$$\left( \begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} \\ | & | & | & | \\ \text{---C---C---C---C---} \\ | & | & | & | \\ \text{H} & & & \text{H} \end{array} \right)_n$$

The core  
Both butadiene units  
are composed of  
cross-linked,  
polybutadiene sub-  
units—a material  
used in many  
industrial parts.  
The finished core  
has a slightly high-  
or hardness rating  
(not compressible)  
than the surface.



**Polyisoprene  
(Natural Rubber)**

$$\left( \begin{array}{c} \text{H} & & \text{H} & \text{H} \\ | & & | & | \\ \text{---C---C---C---C---} \\ | & \text{CH}_3 & & | \\ \text{H} & & & \text{H} \end{array} \right)_n$$


**Kevlar (Poly(p-phenylene terephthalamide))**



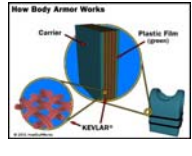
**Stephanie Kwolek**

"Consumer Albatross" crossed the English Channel in 1979. It was constructed from a variety of plastics, including Kevlar film, Teflon, Delrin, acetal resin, carbon fiber, Kevlar screens, and carbon-reinforced polymer.

**Hydrogen-bonded sheet**      **Sheets stack together**



**How Body Armor Works**



**WARRIOR OF THE FUTURE**

**DATA QUALITY: NEW FEDERAL GUIDELINES SPARK CONCERN**


**CHEMICAL**  
An American Science Series

**MATERIALS IN SPORTS**  
High performance from basic science



**WORKINGKNOWLEDGE**

**At the Moment**



**WORKINGKNOWLEDGE**

**Cool Shirt**



**Polyethylene**

Workers cover the ski slopes on the Pitztal Glacier in Austria with an innovative white fleece in an effort to protect the mountain from glacier melting.



**ELECTRIFYING PLASTICS**

**Plastic Fantastic**



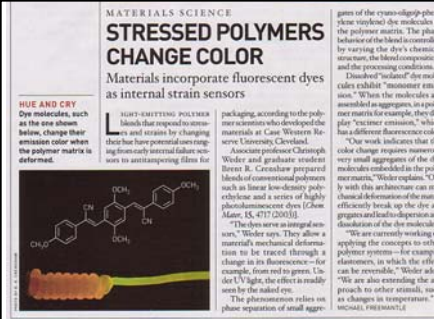
**A Plastic with Hues You Can Use**



**MATERIALS SCIENCE**

**STRESSED POLYMERS CHANGE COLOR**

Materials incorporate fluorescent dyes as internal strain sensors



**NEWS OF THE WEEK**

**NOVEL MOLECULAR THERMOMETERS**  
Thermometer polymers begin to glow above a threshold temperature

**CRYSTALLINITY**  
**Sea Snails Shed With Iron Sulfide Scales**

**HOW 3-D CHIPS ARE MADE**

**SOFT LITHOGRAPHY**

**HOW 3-D CHIPS ARE MADE**

**SOFT LITHOGRAPHY**

**GENERALIZED** New technology works

**DVD Burners**

**DVD BURNERS**

**DVD BURNERS**

**Science & Technology Electronics**

**Just Two Words: Plastic Chips**

They can endow just about anything with computer smarts—and they'll be cheap

**Self Healing Plastics**

**Plastic, heal thyself**

Researchers at the University of Illinois have created a self-healing plastic. Add its repair kit and cracks disappear.

**PLASTIC**

**PLASTIC**

**PLASTIC**

**Polyacrylamid**

**Swedish researchers report acrylamide found in starchy foods**

Researchers at Sweden's National Food Administration (NFA) and Stockholm University announced on April 23 that high concentrations of acrylamide are found in some starchy foods, such as potatoes, are fried or baked. However, when the same foods are analyzed in their raw state or after boiling, no traces of acrylamide are found.

**Agarose**

**DNA evidence convicts criminal**

**Biodegradable Polymers**

**how green are green plastics?**

It is now technologically possible to make plastics using green plants rather than nonrenewable fossil fuels. But are these new plastics the environmental answer researchers have hoped for?

**PRODUCTION AND ENERGY DEMANDS**

Plant-derived plastics require more energy to produce—and thus result in higher emissions of greenhouse gases associated with burning fossil fuels—than do many of their petrochemical counterparts.

**PLANT-BASED PLASTICS**

**PLANT-BASED PLASTICS**

**PLANT-BASED PLASTICS**

**Natural Polymers**

Nucleic acids  
 Proteins  
 Polysaccharides

Are natural polymers safe?

**DNA**

**DNA**

Shining a Light on the 'Dark Lady of DNA'

**Protein**

When the temperature reaches 60° C, or 140° F, the protein units join together in helix-like bundles. These are held together by hydrogen bonds, which are broken when the protein is heated, softening the egg.

**How Is Yogurt Made?**

**Gelatin**

Our National Dessert

Peptide bond

$$\left( \begin{array}{c} \text{H} \\ | \\ \text{---N---C---C---} \\ | \quad | \quad || \\ \text{H} \quad \text{R} \quad \text{O} \end{array} \right)_n$$

**Protein Folding**

Figure 3-3 Two adjacent  $\alpha$  helices are usually arranged antiparallel to each other. They pack closely together by interacting hydrophobic side chains in the interaction area between them. Two such units are frequently arranged in a four-helix bundle, where hydrophobic side chains from all four  $\alpha$  helices pack into a hydrophobic core in the center of the bundle. In the polypeptide chain of the RNA-binding protein RBP, helix forms two antiparallel helices joined by a short loop region. The main chain is represented as a ribbon, side chains as magenta circles. In the RBP molecule consists of two polypeptide chains, where the two  $\alpha$  helices of each chain are arranged into a four-helix bundle.

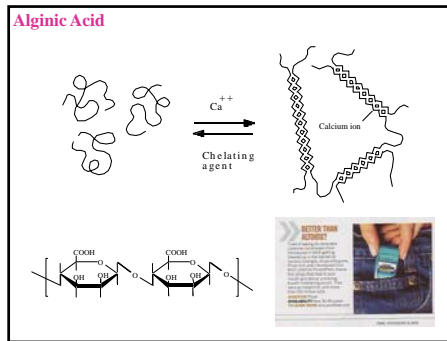
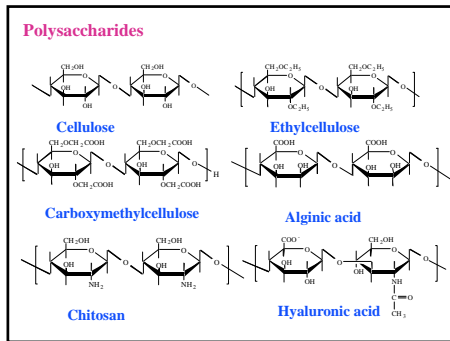
Introduction To Protein Structure  
 Carl Branden & John Tooze, 1991

**Introduction To Protein Structure**

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**Microtubules, Microfilaments**

NERVE CELL has long extensions, called neurites, that connect electrically with neighboring nerve cells. Labels: Left and top right, Neurites extend from the cell (center of right), for example, during the repair of an injury, by elongating neuronal neurites that are known as microtubules (microt). Contractile microfilaments (actin) surround the microtubules, compressing them and restricting their growth. The same microfilaments, however, are connected to other ones (orange) that extend forward to the growth where the cell anchors to an underlying substrate (orange). When the microfilaments pull themselves forward against these adhesions, they push the microtubules to elongate, and the neurite extends further.



**Chitosan**

**Chitosan and DIETARY FIBERS**

Research supports dietary fiber's role in weight control. A unique fiber from a shellfish source offers special attraction.

Chitosan is a natural polysaccharide found in the shells of crustaceans. It is a linear polymer of N-acetylglucosamine units. It is known for its ability to form a gel in the presence of calcium ions, which is why it is used in various biomedical and pharmaceutical applications.

**Hemorrhage-Control Bandages**

Since the Civil War, battlefield medics have used hemostatics and sponges to stop the bleeding caused by combat injuries. During the war in Iraq, medics were equipped with a new innovation: Hemorrhage control bandages made by HemCon, an Oregon-based startup. What has long been known for its air-industry properties—the material is treated with a coat to increase its porous structure and lighter to bond with negatively charged blood cells, HemCon is meeting Peace and Drug administration approval to use the bandages in surgical settings, but in the meantime, they have already found a place in the first aid kit that travels with President Bush. It's just a matter of time before they also find a place in your medicine cabinet. — *Scott Branson*

Market size: 5000 U.S. Billion, Market Size: 2000 U.S. Billion (Projected)

Supplier: 3M, HemCon, HemCon, Johnson & Johnson, Procter & Gamble

**Blood Is Thicker with Seawater**

RESEARCHERS PROPOSE THAT the reason the ERYTHROcyte aggregation is enhanced in seawater is due to the presence of divalent cations, such as calcium and magnesium. The technology will help save lives of the 10,000 American who die each year from hemorrhage. The bandages will allow an individual and emergency responders, like the military, police, fire, and other first responders, to stop the bleeding.

**Starch**

**Bread: Soft Hard**

**Guar Gum, Xanthan Gum**

**Ingredients in Use: Guar & Xanthan Gums**

**Guar and Xanthan Gums**

Guar gum is a natural polysaccharide extracted from the guar bean. It is used as a thickener and stabilizer in various food products. Xanthan gum is a polysaccharide produced by the fermentation of glucose and sucrose by the bacterium Xanthomonas campestris. It is used as a thickener and stabilizer in various food products.

**Pectin**

**PECTIN Overpowers Plaque**

Research & White, 2003

**Without Pectin**

**With Pectin**

**Polymers:**

**They are indispensable in our daily life and in the biomedical and pharmaceutical systems.**