

Introduction

Prof. Dr. Mark W. Tibbitt, 22. February 2022



- Overall learning objective: Students should be able to evaluate and design polymer networks and gels for industrial and biomedical applications based on macromolecular chemistry and structure.
- Instructor: Prof. Tibbitt – mtibbitt@ethz.ch
 - Office hours: Do 16:00–17:00 ML H 21
- Suggested book:
 - *Polymer Physics*, Rubinstein and Colby

History of polymer chemistry and soft matter

It all started in Mesoamerica!

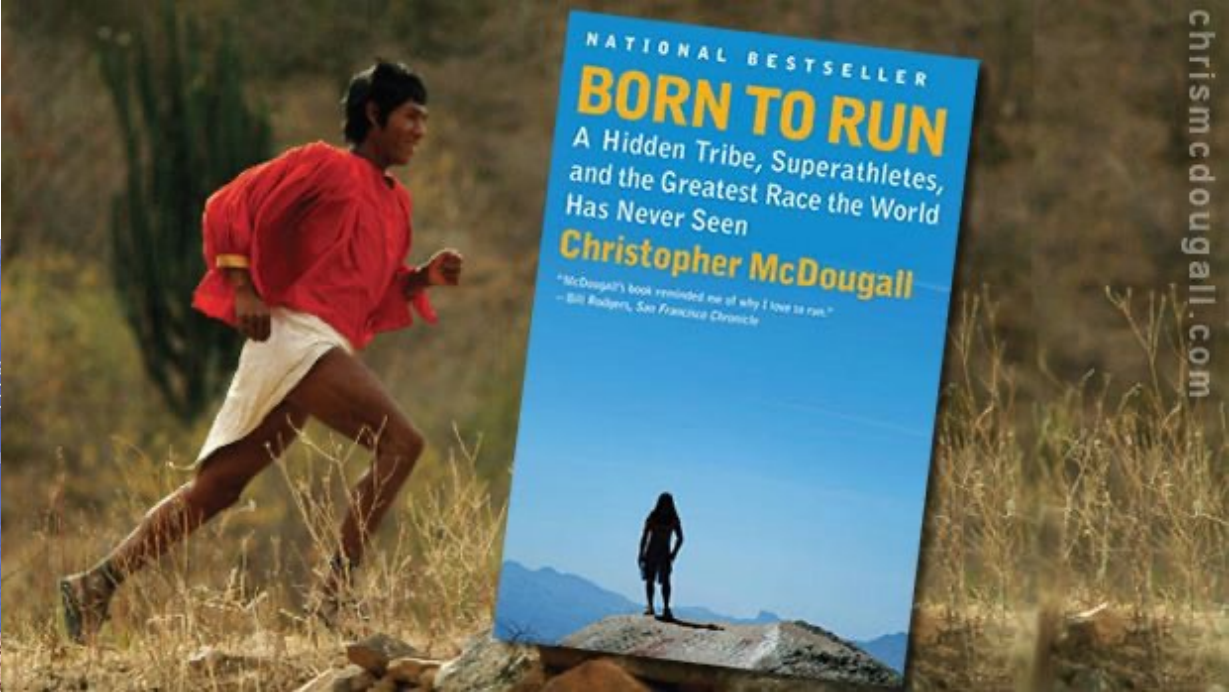
Natural latex



ca. 1600 BCE

The First Ballgame

A Maya player from Mexico's Yucatan where the game was invented nearly 3,000 years ago. Team sports and rubber ball games owe their origin to this indigenous American Olmec invention. Here the player tries to hit the dangerous, solid rubber ball with his hip through a carved stone circle protruding from one side of the stadium wall. The heavy ball could break bones or also cause body trauma and death to the player.



1839 CE

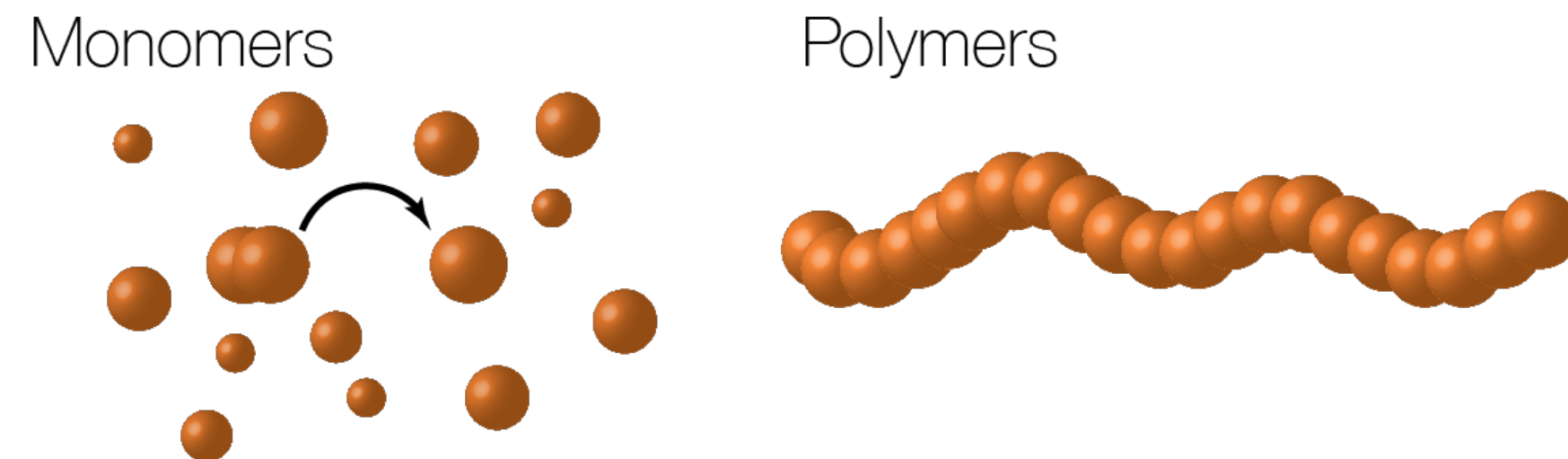


Hermann Staudinger



Nobel prize in Chemistry
1953

Proposed the concepts of **macromolecules** and **polymerization** reactions



“Dear colleague, drop the idea of large molecules; organic molecules with a molecular weight higher than 5000 do not exist. Purify your products, such as rubber, then they will crystallize and prove to be low molecular weight compounds!”

- Heinrich Wieland (Nobel Prize, 1927)

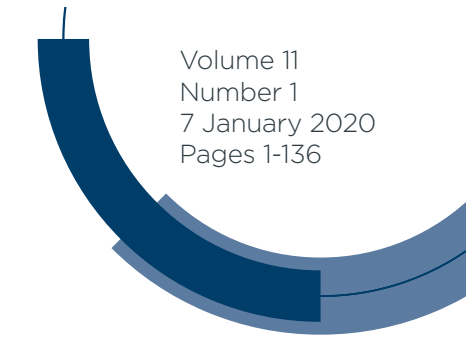
“My colleagues were very skeptical about this change, and those who knew my publications in the field of low molecular chemistry asked me why I was neglecting this interesting field and instead working on a very unpleasant field and poorly defined compounds, like rubber and synthetic polymers. At that time the chemistry of these compounds often was designated, in view of their properties, as **Schmierenchemie** (‘grease chemistry’).”

- Hermann Staudinger

Polymer Chemistry

Anniversary issue: 100 years of polymer science

rsc.li/polymers



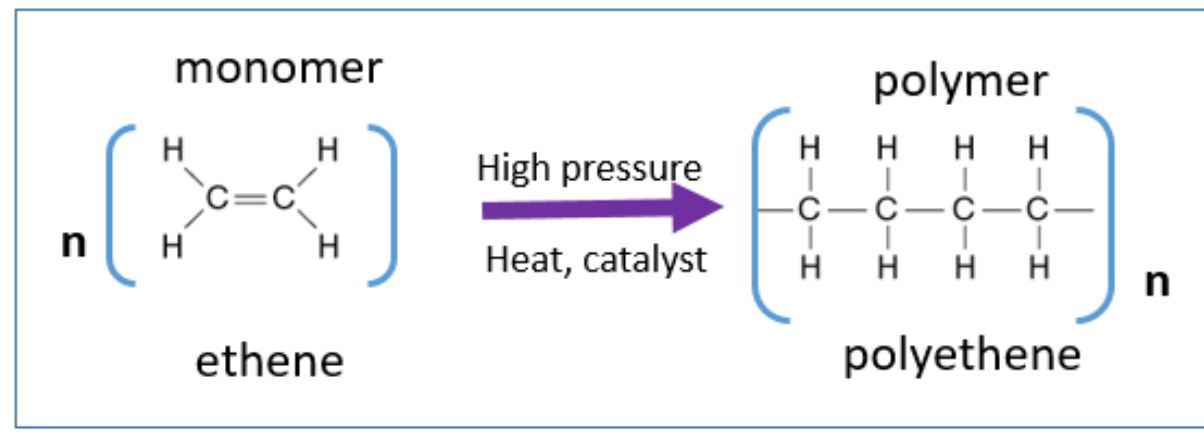
ISSN 1759-9962



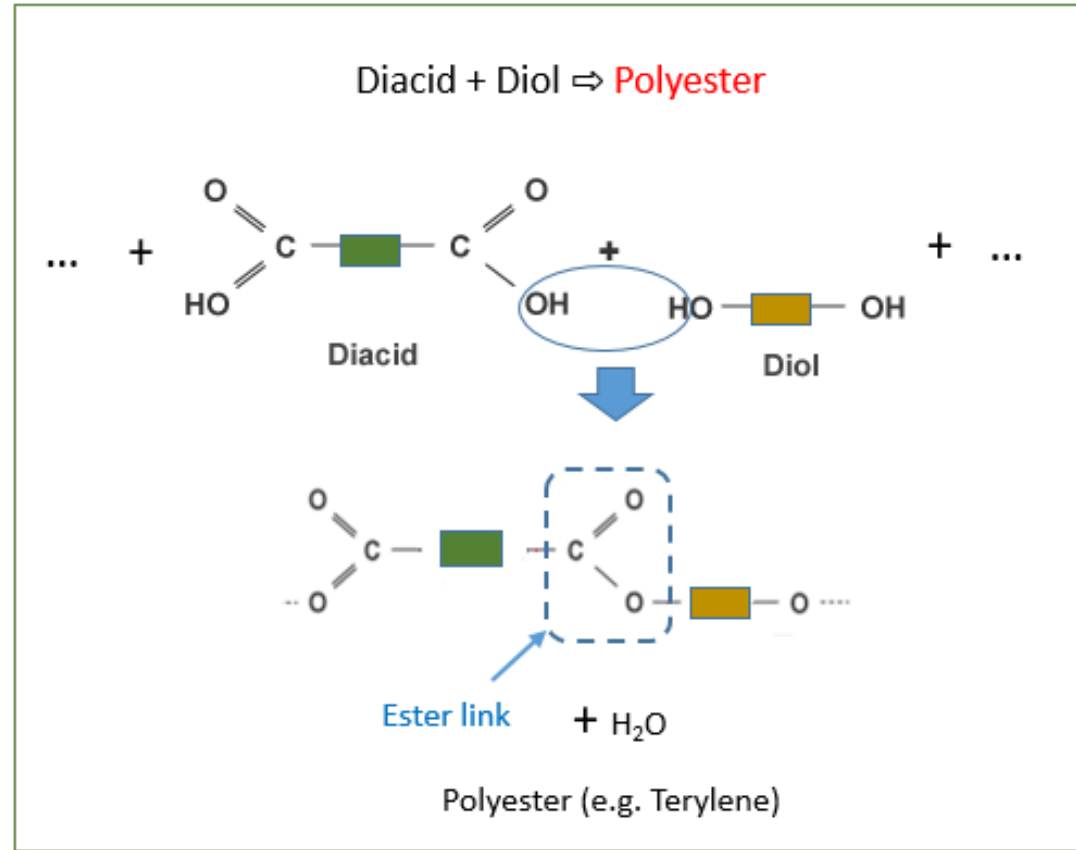
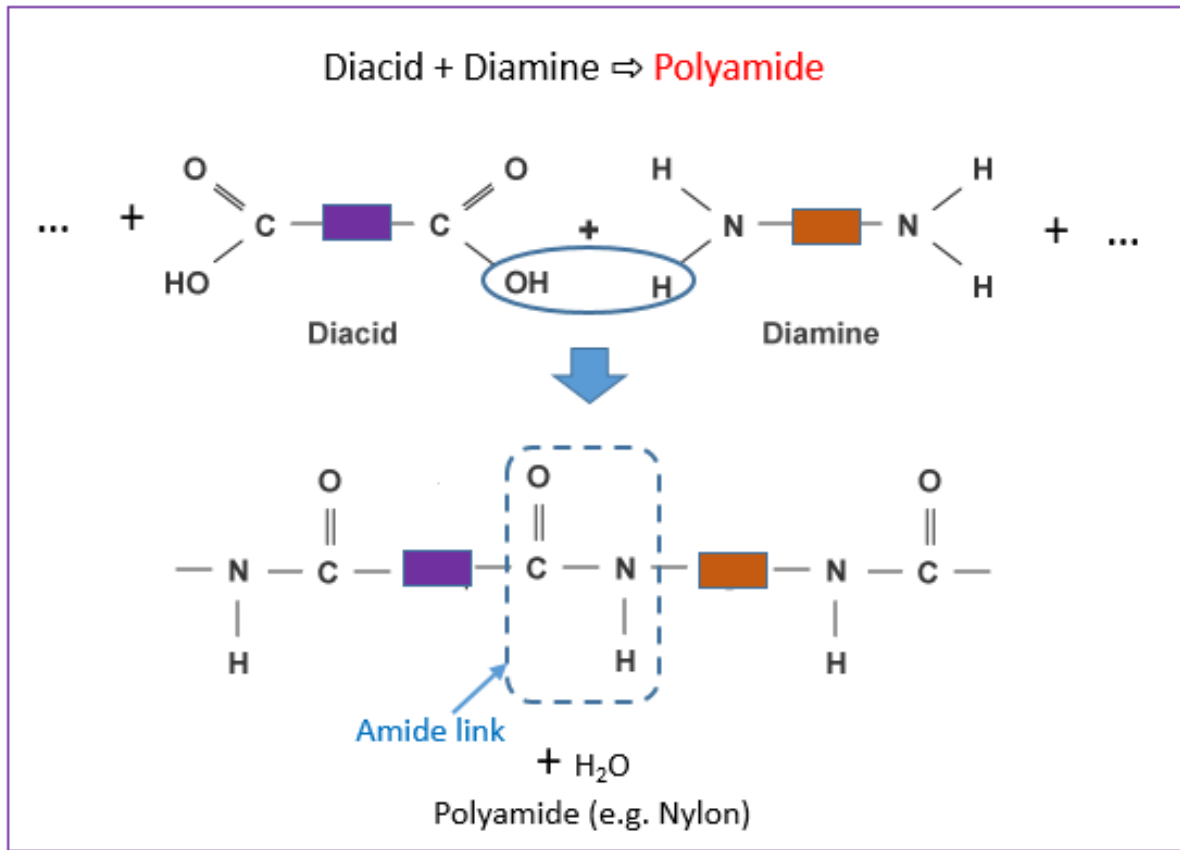
EDITORIAL
Holger Frey and Tobias Johann
Celebrating 100 years of "polymer science":
Hermann Staudinger's 1920 manifesto

Common reactions to synthesize polymers:

Addition Polymerisation

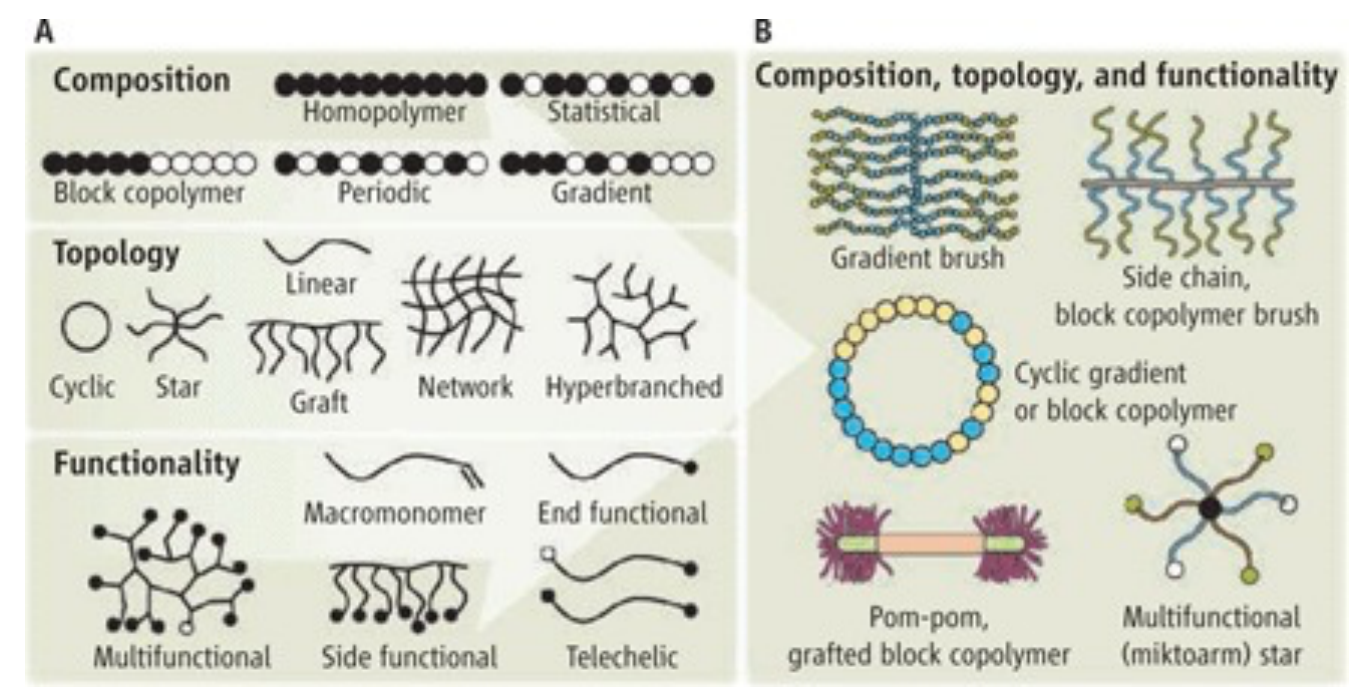


Condensation Polymerisation



onlinemathlearning.com

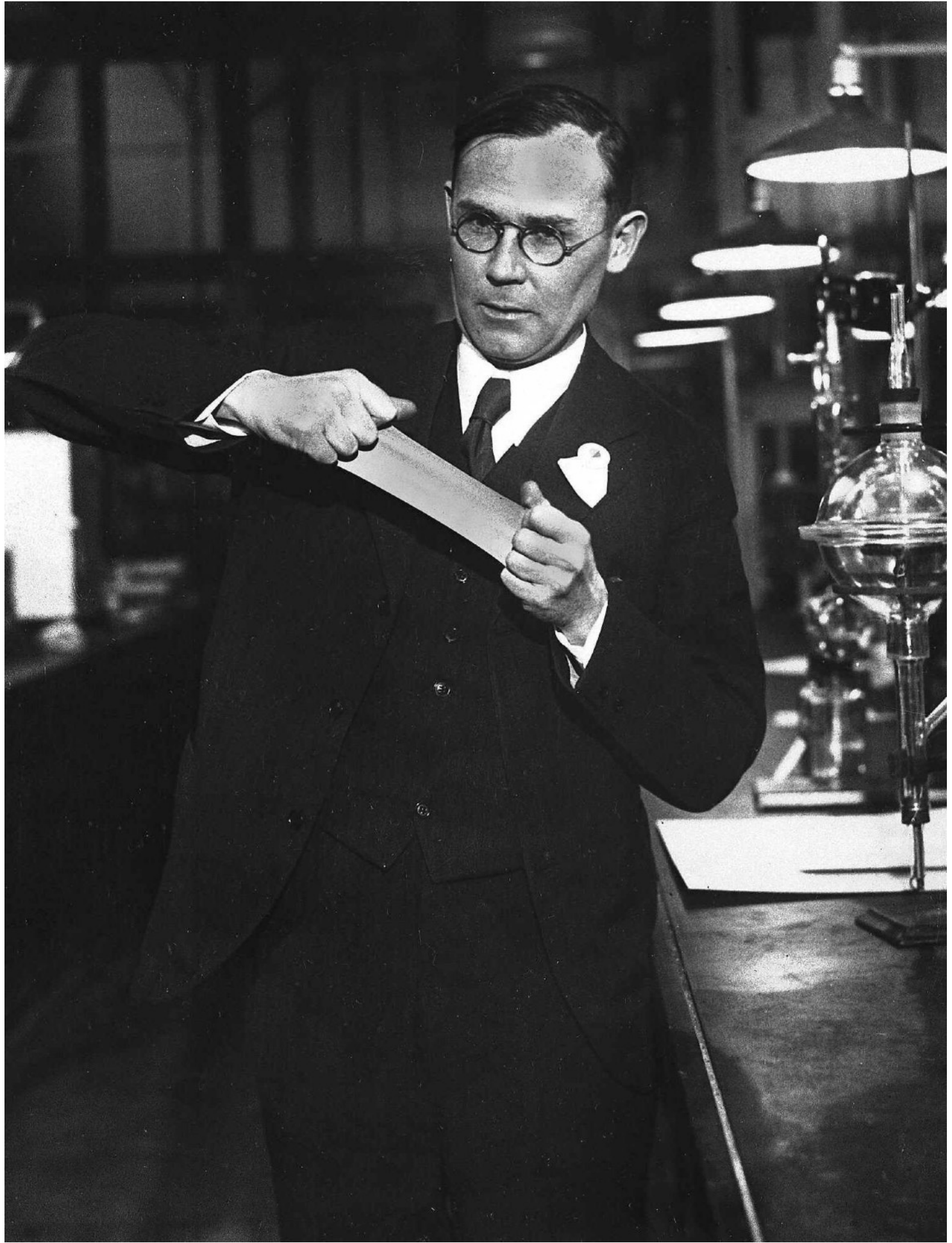
Polymer architectures:



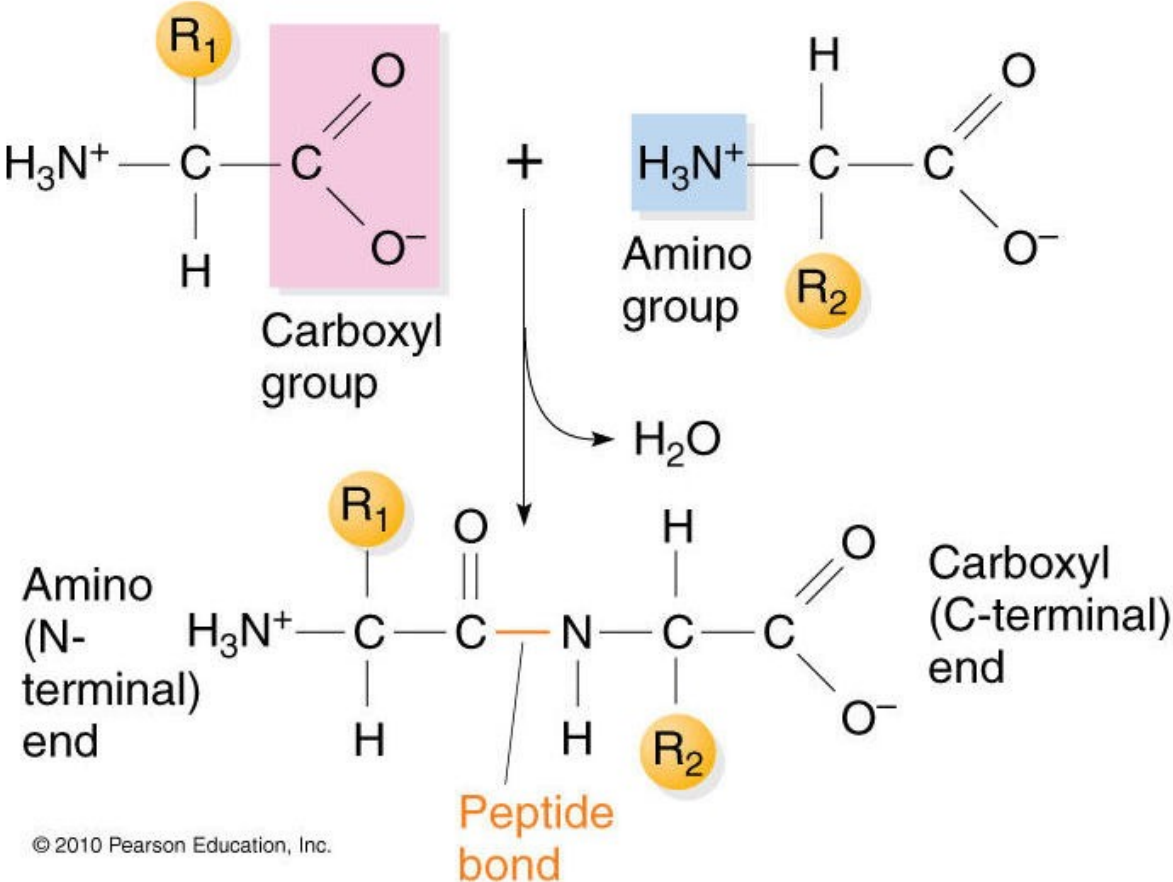
AAAS

Proteins to polymers – Carothers (Dupont) and Nylon

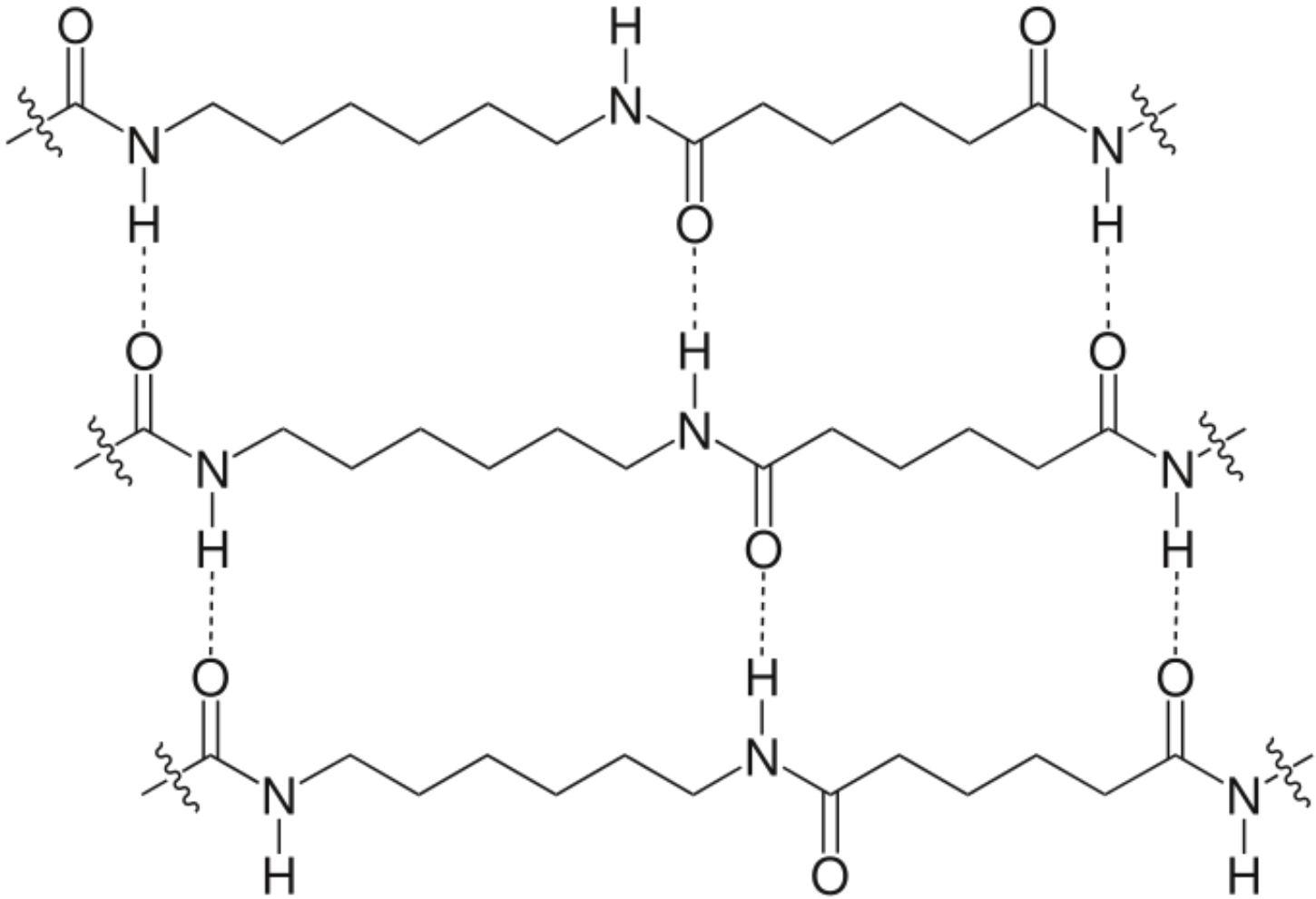
Wallace H. Carothers



Peptide chemistry:



Nylon 6,6:



Proteins to polymers – Carothers (Dupont) and Nylon

In the name of beauty

Dr. West's presents 2 great brushes

Dr. West's *Miracle-Tuft* MADE WITH EXTON 50¢

Dr. West's "25" MADE WITH NYLON 25¢

Dr. West's Two Great Brushes Compared

MIRACLE-TUFT	"25"
• Exton bristles— heavier texture, stronger, last longer	• Nylon— lighter than Exton, stronger than natural bristle
• Sealed in glass—the only surgically-sterile brush	• Sanitary-sealed carton, cellophane wrapped
• Finest handles	• Lighter handles

THE SEALED-IN-GLASS QUALITY LEADER OF THE WORLD—The only basic improvements ever made in a toothbrush are perfected in this finest of all tooth-cleansing instruments: *Exton bristle*, the unique bristle-like filament developed by Du Pont, and today offered only by Dr. West's; and *Dr. West's exclusive glass package*, making *Miracle-Tuft* the one brush to reach you surgically sterile, 100% germ-free.

One brushing with a *Miracle-Tuft* will convince you that here is the way to more attractive smiles, healthier gums, sparkling, brilliantly clean teeth. Even Dr. West's new "25", sensational achievement that it is, must bow to *Miracle-Tuft's* outstanding superiority. Available in a choice of shapes and textures.

FIRST TOOTHBRUSH EVER MADE WITH THRILLING NEW NYLON—Now—Dr. West's presents another wonder brush: A brush made possible by the development of the new Du Pont Nylon bristle. Though lighter in weight than Exton, used only in *Miracle-Tuft*, the bristles of the "25" are superior to any natural bristle.

Offering a host of Dr. West's famous quality features, Dr. West's "25" like the *Miracle-Tuft* is non-porous, water repellent, anti-soggy. It will definitely *outlast* any and all natural-bristle brushes!

At this amazing low price, anyone can afford a *fine* toothbrush. But—for the *finest* brush you can buy now or ever...it's still Dr. West's *Miracle-Tuft*, 50¢! Choice of Regular, Professional and new Oro shapes.

Copyright 1949 by West Products Co.

October 16, 1948

PACK IT—washable, quick-drying nylon man's robe! So light it takes up little room—so long-wearing you'll be packing it for many trips to come! Because nylon can be "heatset" wrinkles and creases are no worry.

WORK WITH IT! In the water—out again—commercial laundry bags must be strong, light, extra long-wearing. And they are—made with nylon! Tough, elastic nylon fibers have a high tensile strength when wet, are unaffected by detergents.

WASH IT! Hang it up! Your nylon blouse is almost ready to wear again. For nylon is that fast-drying fiber! Needs oh so little ironing; can be set to hold its shape. Your blouse will keep its fresh, crisp and feminine look—wear and WEAR!

news about **NYLON**

it all started with a stocking

... a sheerer, lovelier, longer-wearing stocking than women had ever dreamed of!

Today you're choosing filmy nylon hose in fashion-right, costume-bright colors—sheer, resilient, surprisingly strong for their weight.

You're finding nylon nicer in sweaters, panties, slips, lace, gloves—you're benefiting from nylon's toughness and elasticity in countless industrial uses.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

TO MANUFACTURERS: Are there textile fibers in your product? Then you'll want to read "Nylon Textile Fibers in Industry." Write for this important book now!

NEW! FREE book for women, teachers, students—
"About Du Pont Nylon." Write to Nylon Division, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Del.

FOR NYLON... FOR RAYON... FOR FIBERS TO COME... LOOK TO DU PONT

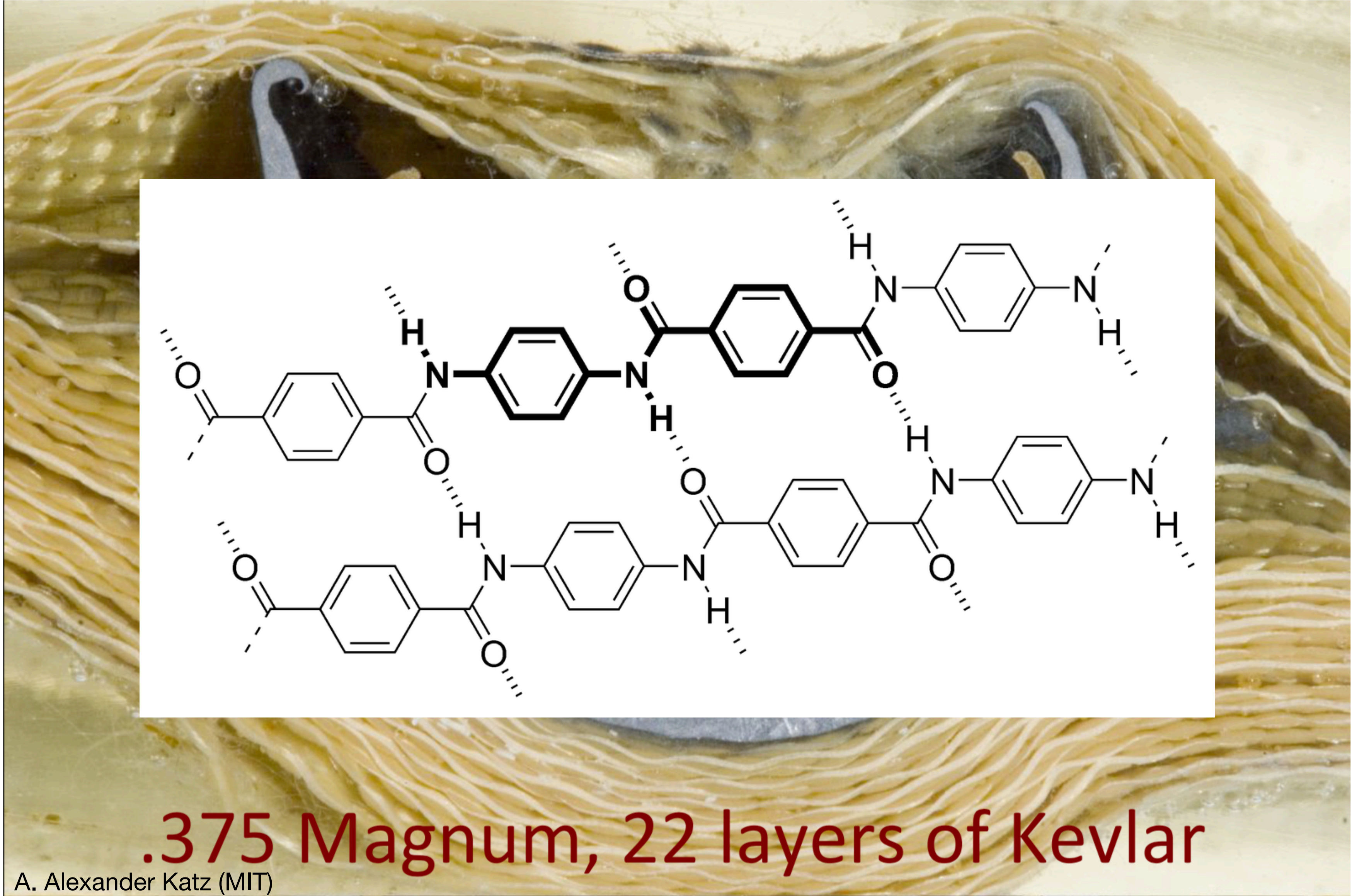
Ultra-strong polymer fibers - Kevlar



.375 Magnum, 22 layers of Kevlar

A. Alexander Katz (MIT)

Ultra-strong polymer fibers - Kevlar

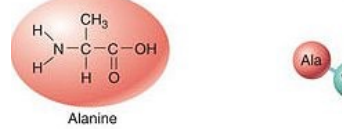


The major building blocks of life are macromolecules

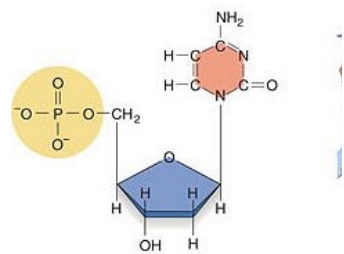


TABLE 4.1 MACROMOLECULES

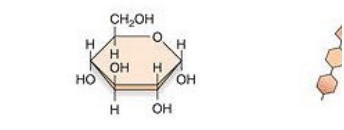
Monomer
Amino Acid



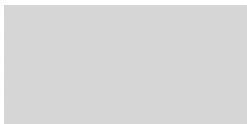
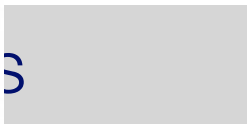
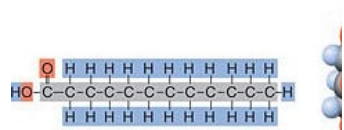
Nucleotide



Monosaccharide



Fatty acid



Essential Cell Biology, Garland Science 2010

freepik.com

Soft contact lenses



shutterstock

Controlled release devices



NIH, USA

Degradable sutures



Ethicon

- Wide range of structure and properties:
 - Insulating or conducting
 - Soft elastic to very stiff plastic
 - Large reversible deformations
 - Low to high crystallinity
 - Photovoltaic, piezoelectric
 - Temperature dependent properties

- Tunable properties:
 - Weak intermolecular interactions allow chains to readily reorganize in response to external stimuli.