



There is more to carbohydrates than nutrition facts

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Early years...

- Primary and secondary education in Hamburg, Germany
- Chemistry teacher hit the spot
- Undergraduate studies in chemistry at Clausthal University of Technology
- Erasmus studies abroad
 - Italy
 - Scotland
 - France

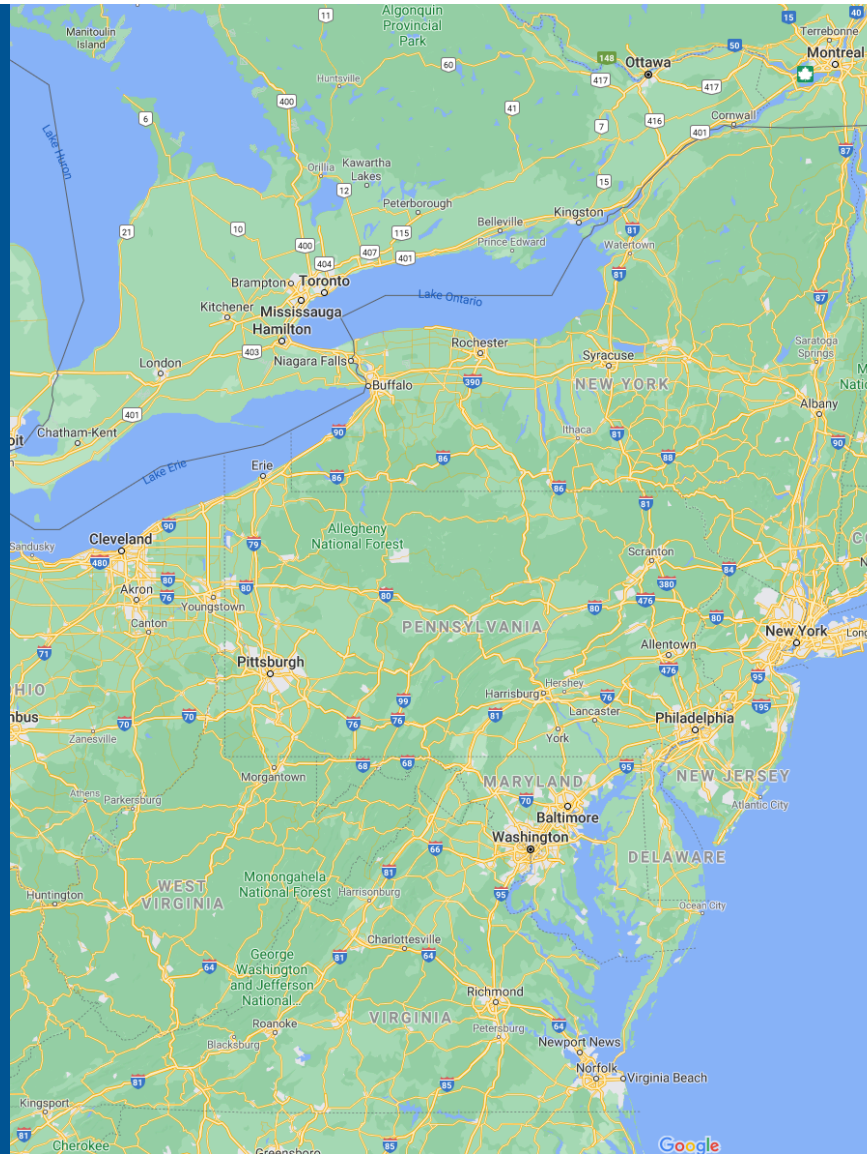


Reinhard Kraasch,
CC-BY-SA 3.0 DE /
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Foundert / CC BY-SA

North America, here I come...

- Doctoral studies in Syracuse, NY (cold!)
- Postdoctoral studies in Montreal, QC (colder...)
- Summer internship at Eastman Chemical Company in Kingsport, TN (hot!!!)
- Joined Virginia Tech faculty in 2004 (just right)



State University of New York College of
Environmental Science and Forestry



VIRGINIA TECH™

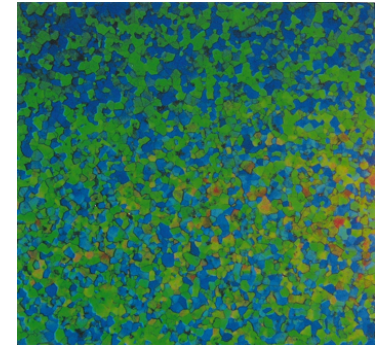
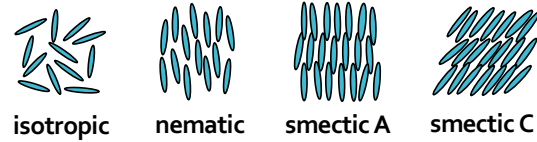
EASTMAN

Scientific journey

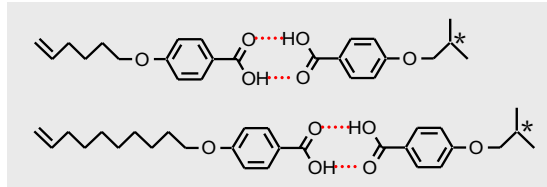
- OChem? Maybe not...
- PChem it is
- M.S. concentration in liquid crystals
- Ph.D. research
 - Polymer composites
 - Cellulose nanocrystals
- Postdoctoral research
 - Liquid crystalline behavior of cellulose nanocrystals



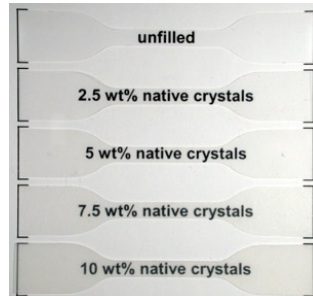
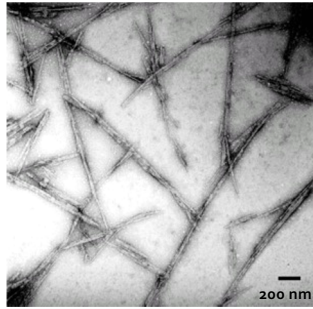
Encarna Sáez Goñalons & Víctor Martínez Moll (User:Puput) / CC BY-SA



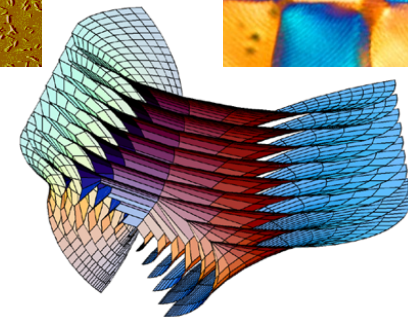
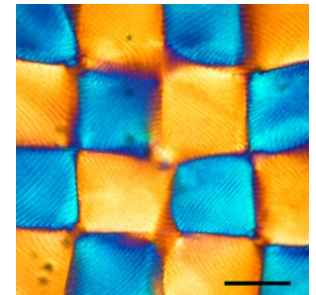
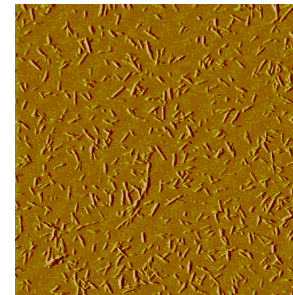
Grunert, M., & Winter, W. T. (2002). *Journal of Polymers and the Environment*, 10, 27.



Grunert, M., Howie, R. A., Kaeding, A., & Imrie, C. T. (1997). *Journal of Materials Chemistry*, 7, 211.



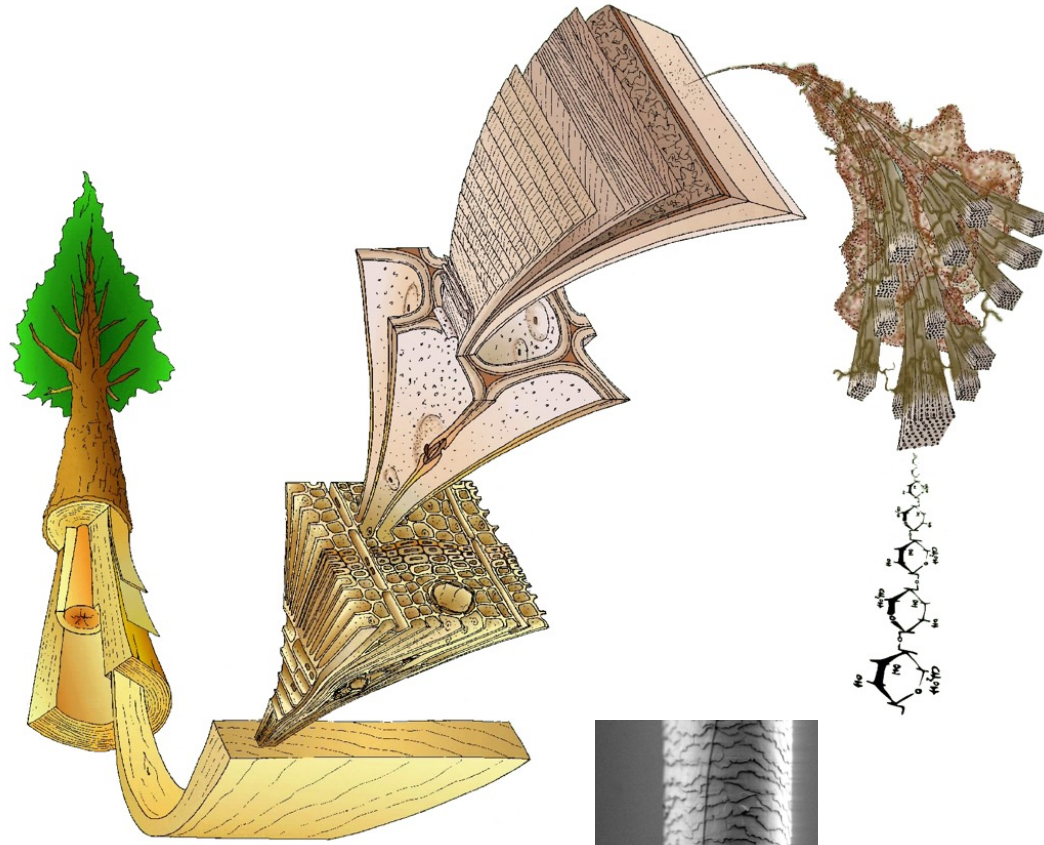
Roman, M., & Winter, W. T. (2006). In *Cellulose Nanocomposites: Processing, Characterization, and Properties* (pp. 99–113). Washington: American Chemical Society



What are cellulose nanocrystals?

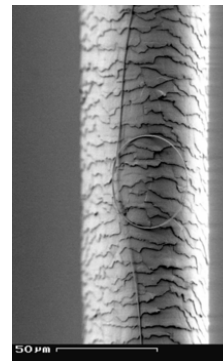
- Cellulose molecules are long strings of glucose
- In nature, cellulose form highly crystalline fibrils
- Cellulose fibrils are what makes trees strong
- Cellulose fibrils can be "chopped up" with acid
- Cellulose nanocrystals are stiff nano-needles

Wood Technology Research Center, University of Canterbury

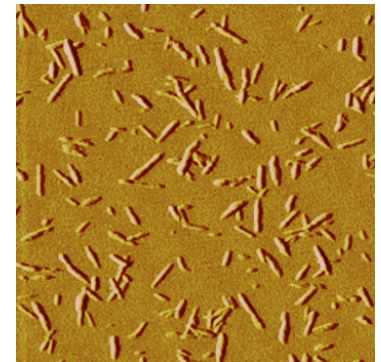
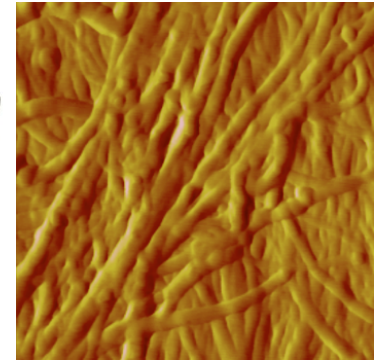


Micrometer: $\mu\text{m} = 10^{-6} \text{ m}$
Nanometer: $\text{nm} = 10^{-9} \text{ m}$

NSF Press Release 03-147, December 17, 2003,
Eric Mazur and Limin Tong et al., Harvard
University and Zhejiang University in China

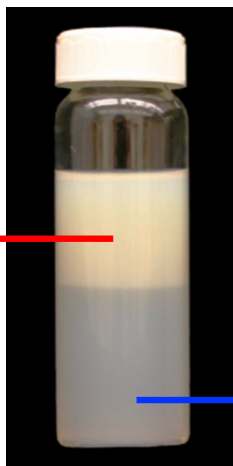


M. Roman, unpublished data



My research at Virginia Tech

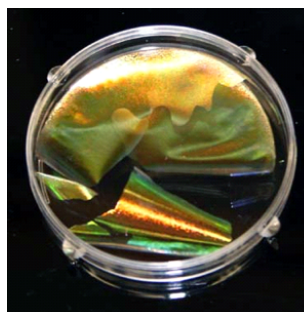
- Focused on cellulose nanocrystals and related materials
- Physicochemical properties
- Potential applications
 - Oral drug delivery
 - Targeted delivery of anticancer drugs
 - Nanocomposites for 3D printed bone scaffolds



10 wt%



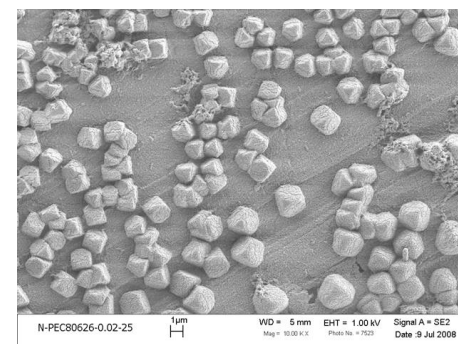
M. Roman, unpublished data



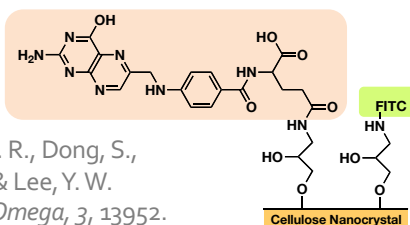
Drawing by Kevin Yager

http://csacs.mcgill.ca/francais/docs/CHEM634/LC_Gray.pdf

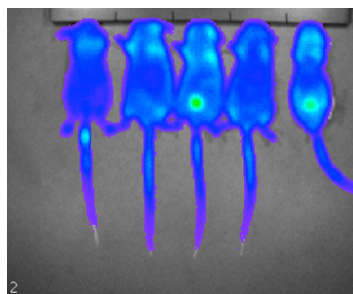
Microparticles formed upon mixing with chitosan



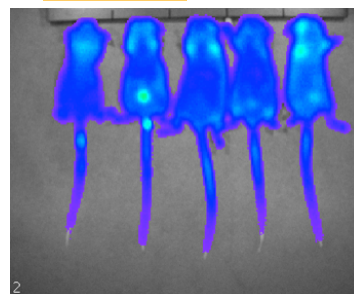
M. Roman, unpublished data



Bittleman, K. R., Dong, S., Roman, M., & Lee, Y. W. (2018). *ACS Omega*, 3, 13952.

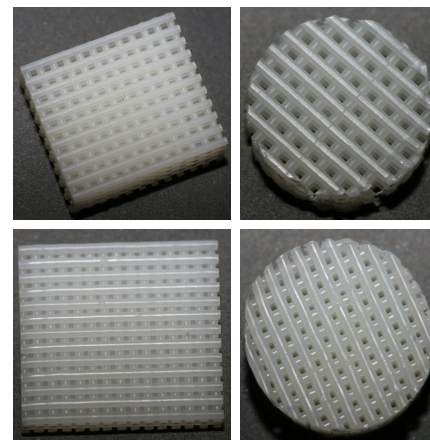


4 h post injection



8 h post injection

3D printed bone scaffolds



M. Roman, unpublished data

How I became the director of a \$23M NSF center

- 2016 & 2017: Program Chair of the Cellulose and Renewable Materials Division of the American Chemical Society
- 2018: Annual perform. review panel for \$100M DOE research center
- NSF solicits proposals for “Materials Innovation Platforms” that focus on the convergence of materials research with biological sciences
- Passion, vision, boldness and naiveté

Materials Innovation Platforms (MIP)

PROGRAM SOLICITATION
NSF 19-526

REPLACES DOCUMENT(S):
NSF 15-522



National Science Foundation

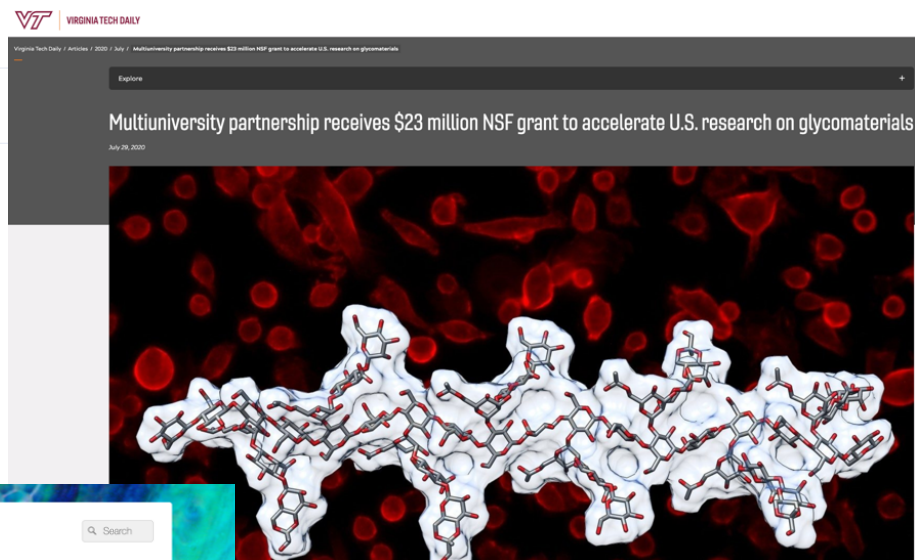
Directorate for Mathematical & Physical Sciences
Division of Materials Research

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

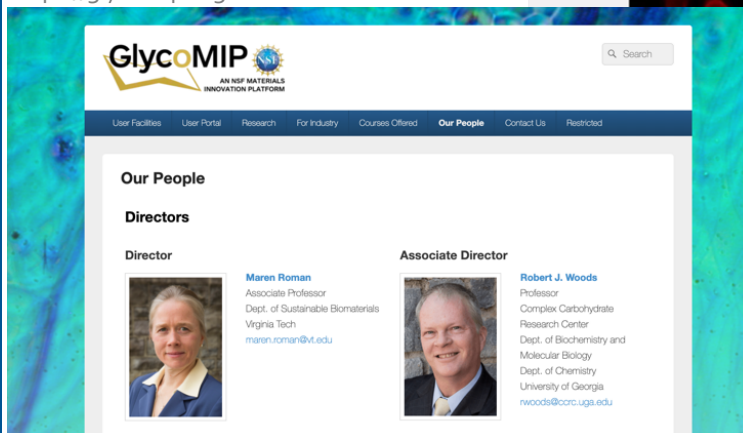
April 26, 2019

<https://www.nsf.gov>

<https://glycomip.org>



<https://vtnews.vt.edu/>

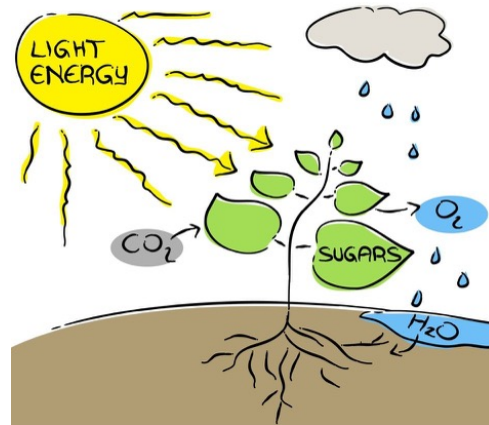


GlycoMIP is funded by the National Science Foundation through cooperative agreement DMR-1933525.



Photosynthesis and respiration

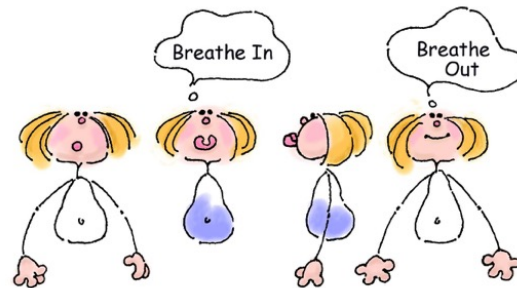
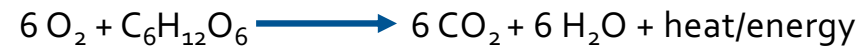
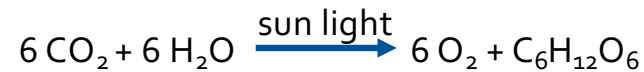
- carbohydrates are synthesized in plants by photosynthesis and sugar interconversion
- sugars are stored for energy and used for structural support
- humans and animals derive energy from eating plants
- carbohydrates are converted to CO_2 , H_2O , and energy through
 - respiration
 - aerobic biodegradation
 - combustion



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There is more to carbohydrates than nutrition facts

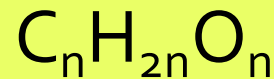
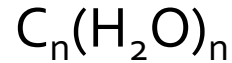
- Carbohydrates are “hydrates of carbon”
- Simple carbohydrates are “monosaccharides”
- We frequently eat chains of carbohydrates
 - table sugar, milk sugar (disaccharides)
 - fructo oligosaccharides
 - starch (polysaccharide)
- Carbohydrates in foods:
 - simple (sugars)
 - complex
 - metabolized
 - soluble fiber
 - insoluble fiber

Nutrition Facts	
8 servings per container	
Serving size 2/3 cup (55g)	
Amount per serving	
Calories	230
% Daily Value*	
Total Fat 8g	10%
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 160mg	7%
Total Carbohydrate 37g	13%
Dietary Fiber 4g	14%
Total Sugars 12g	
Includes 10g Added Sugars	20%
Protein 3g	
Vitamin D 2mcg	10%
Calcium 260mg	20%
Iron 8mg	45%
Potassium 235mg	6%

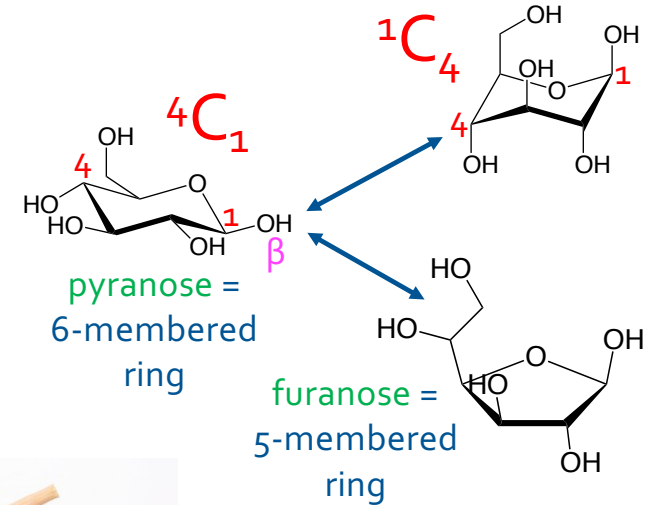
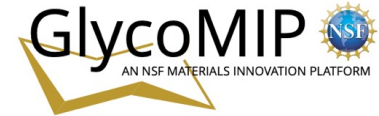
* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

U.S. Food and Drug Administration / Public domain

“Hydrates of carbon”

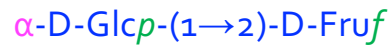


where $n \geq 3$



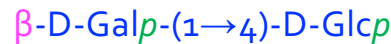
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Sucrose



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Lactose



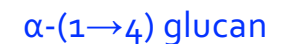
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Fructo oligosaccharides



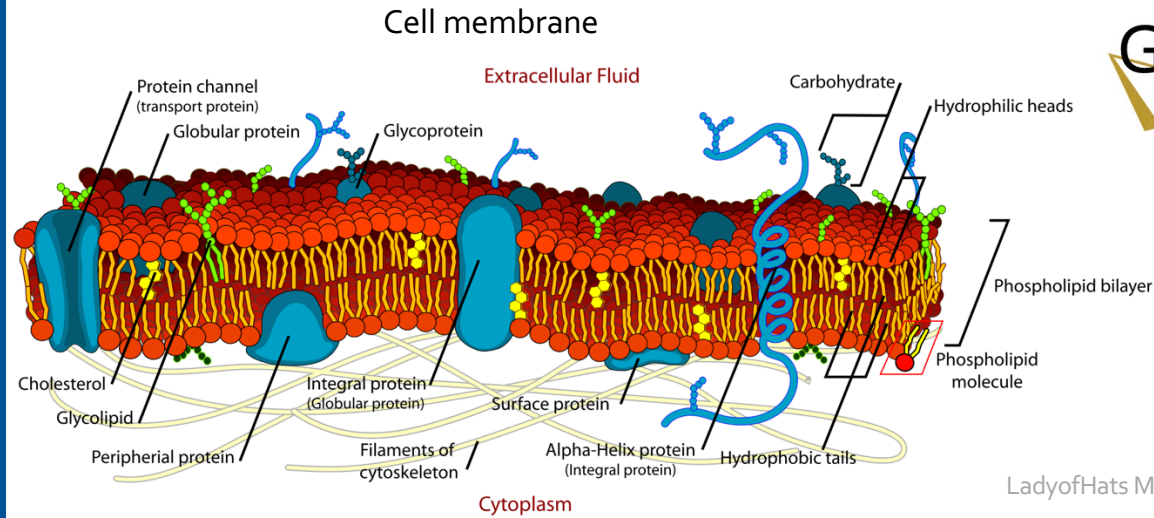
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Starch

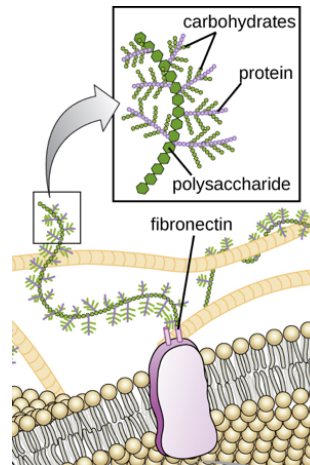


What are glycomaterials?

- Glycomaterials are materials that contain or are made of carbohydrates
- Chains of carbohydrates are called 'glycans'
- Glycans are often attached to proteins, lipids, even some RNA
- Glycans are the least understood building block of cells

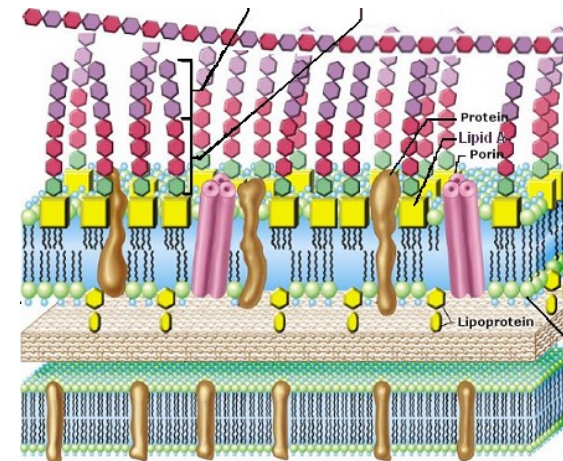


Proteoglycans in the extracellular matrix



Wikimedia Commons

Bacterial capsular polysaccharides



Poinsot, V, Carpena, MA, Couderc, F. In: The Complex World of Polysaccharides, Karunarathne, DN, IntechOpen, 2012.

Glycomaterials underpin many technologies

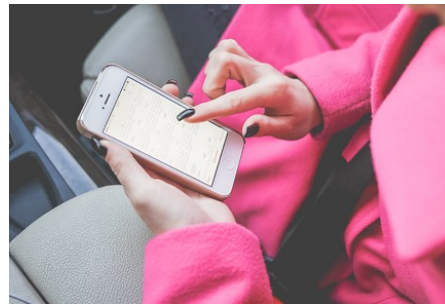
- Jams and jellies
- Vaccines and therapeutics
- Digital displays
- Organ printing
- Oil drilling fluid
- Food stabilizer



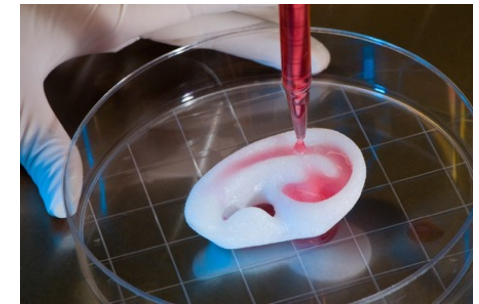
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FotoosVanRobin / CC BY-SA



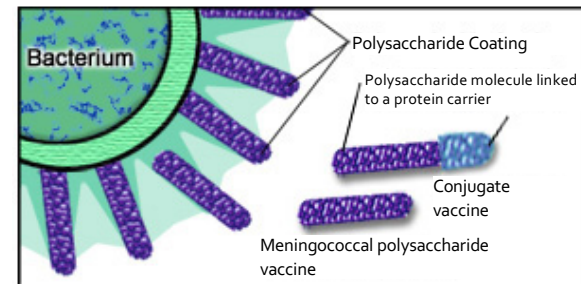
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Army Medicine / CC BY



wikimedia.org



ndhealth.gov

Resources for Teachers

- “Carbohydrate Builder” on <http://glycam.org>
- VT Fralin Life Sciences Institute:
 - Biotech-in-a-Box
 - Virus Tracker in a Box

GLYCAM

HOME ABOUT US NEWS LEGACY TOOLS HELP DOWNLOADS

GLYCAM-Web will be upgraded soon. This version will still be available! Problems? glycam@gmail.com

3D Structure Prediction Tools 3D Structure Libraries Other Tools Force Field Documentation Report a Problem

All builders at GLYCAM-Web generate molecular structure files that can be used in visualization programs or as input for simulations. For the builders that generate 3D structures from a primary sequence (e.g., DManpb1-6DGlcpNAcb1-OH), we offer the interfaces listed below for setting the primary sequence.

cb Carbohydrate Builder A point-and-click interface for building monosaccharides through oligosaccharides

glycam.org



FRALIN LIFE SCIENCES INSTITUTE
VIRGINIA TECH.

Biotech-in-a-Box program

- kits for bringing biotechnology to Virginia high school and community college classrooms
- Institute pays round-trip shipping between Virginia Tech and the school

Virus Tracker in a Box

- game for use in middle and high school classrooms
- bar-coded wristbands represent infection with a particular virus

<https://fralinlifesci.vt.edu/education-and-outreach.html>

Outreach Programs

- Programs of the Fralin Life Sciences Institute (see right-hand side)
- College of Engineering: Pathways for Future Engineers
 - two-week summer program for rising 10th, 11th, or 12th graders
- College of Natural Resources and Environment: Inside Trees
 - 3-day summer camp
 - targeted at women and minority high school students from rural regions



FRALIN LIFE SCIENCES INSTITUTE
VIRGINIA TECH.

Kids' Tech University: Graduate School

- designed to spark high schoolers' interest in the growing fields of science, technology, engineering, and math
- day-long learning experience
- access to resources and expertise at Virginia Tech

Class Tours

- tour of the facilities at Virginia Tech
- participation in hands-on activities centered around DNA

Fralin Research Experience for High Schoolers

- educational program open to aspiring scientists
- grades 9 to 12
- prepares students to pursue highly competitive STEM majors
- offering hands-on training in college-level research activities
- non-paid internship positions, available year-round.

<https://fralinlifesci.vt.edu/education-and-outreach.html>