

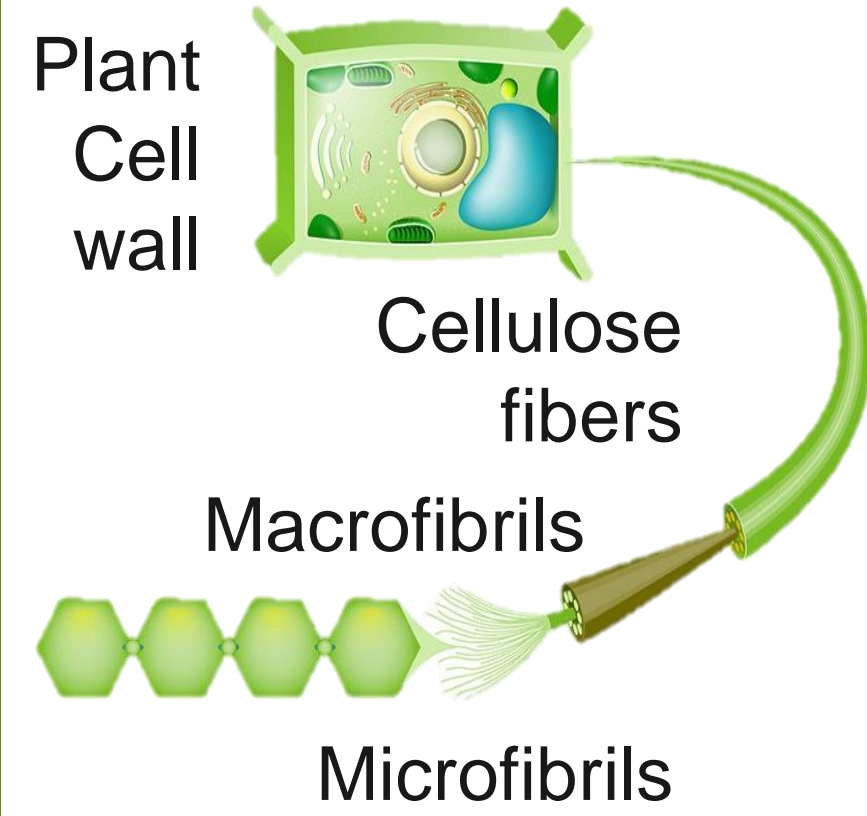
## Description of the synthesis tool

### Definition:

Natural polymers are macromolecules found in nature, composed of long chains of repeated subunits. They are synthesized by living organisms and include materials such as cellulose, proteins, and DNA.

### CELLULOSE

Plant Cell wall

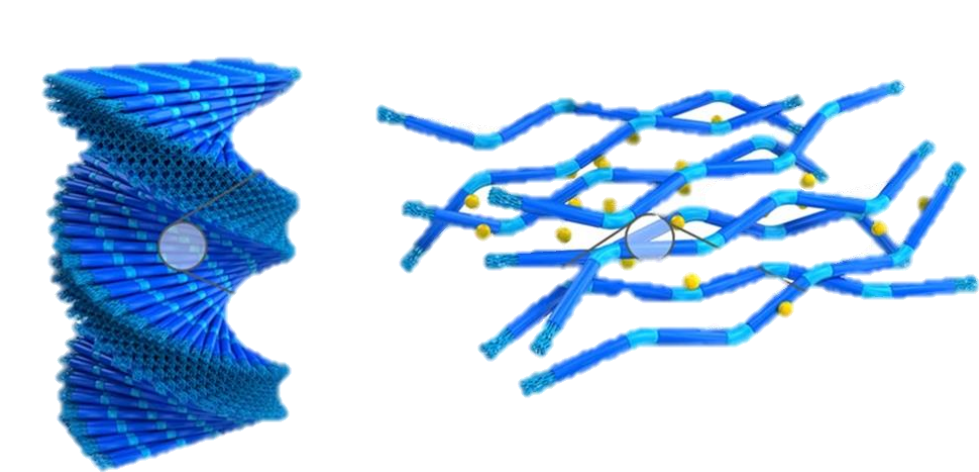


### Examples:

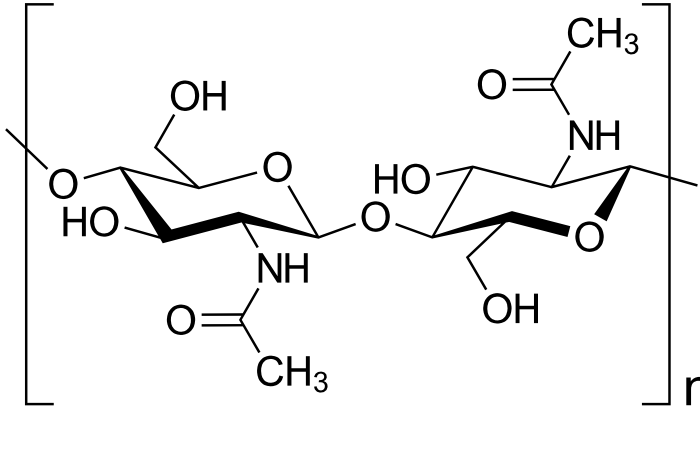
Cellulose (plant cell walls), Chitin (exoskeletons of arthropods), Silk (produced by silkworms), Natural Rubber (latex from rubber trees), Starch (corn, potatoes), Pectin (fruits), and Agar (red algae).



Crustacean



Chitin Nanofibrils



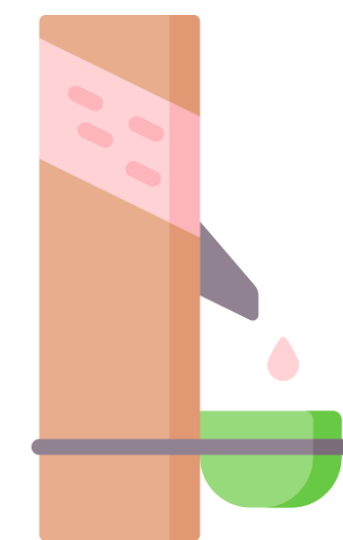
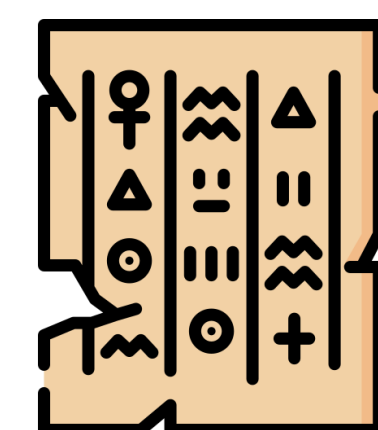
Chitin

## History, Development and Applications

### 19th Century

1839 - Vulcanization of Rubber: Charles Goodyear discovered the vulcanization process.

1856 - Development of Celluloid: Alexander Parkes developed Parkesine, the first synthetic plastic, derived from cellulose.

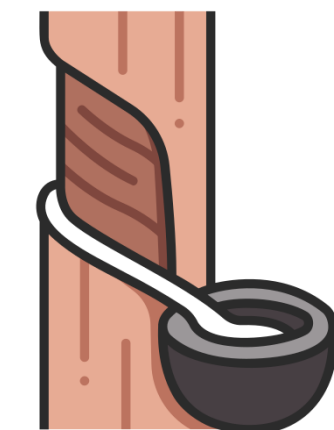


### Modern Innovations

1990s - Advances in Biotechnology enabled the production of natural polymers through microbial fermentation.  
2000s - Nanocellulose and Chitosan Research into nanocellulose (derived from cellulose) and chitosan (derived from chitin).

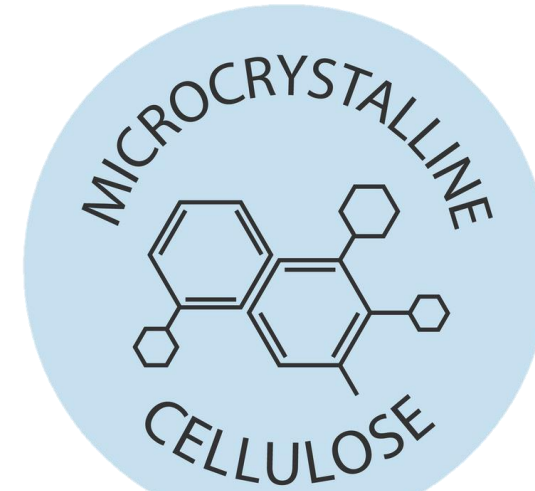
### Ancient times

Natural polymers such as cellulose (from plant fibers) and proteins (from animal sources) were used in making textiles, paper, and other essential materials. For example, Egyptians used papyrus, made from the pith of the papyrus plant, as early as 3000 BC.



### 20th Century

1930s - Natural Rubber Demand with the expansion of the automotive industry.  
1950s - Introduction of Biodegradable Polymers: Research into biodegradable polymers began, aiming to develop materials that could decompose naturally.



### Medical and Healthcare



### Tissue engineering



### Drug Delivery Systems



### Biodegradable Sutures



### Packaging



### Biodegradable Films



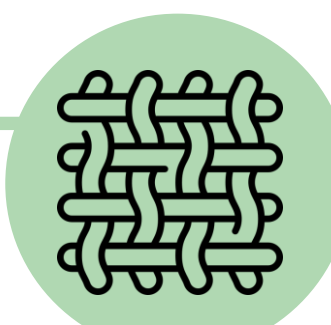
### Edible Packaging



### Compostable Bags



### Textiles and Apparel



### Sustainable Fabrics



### Smart Textiles

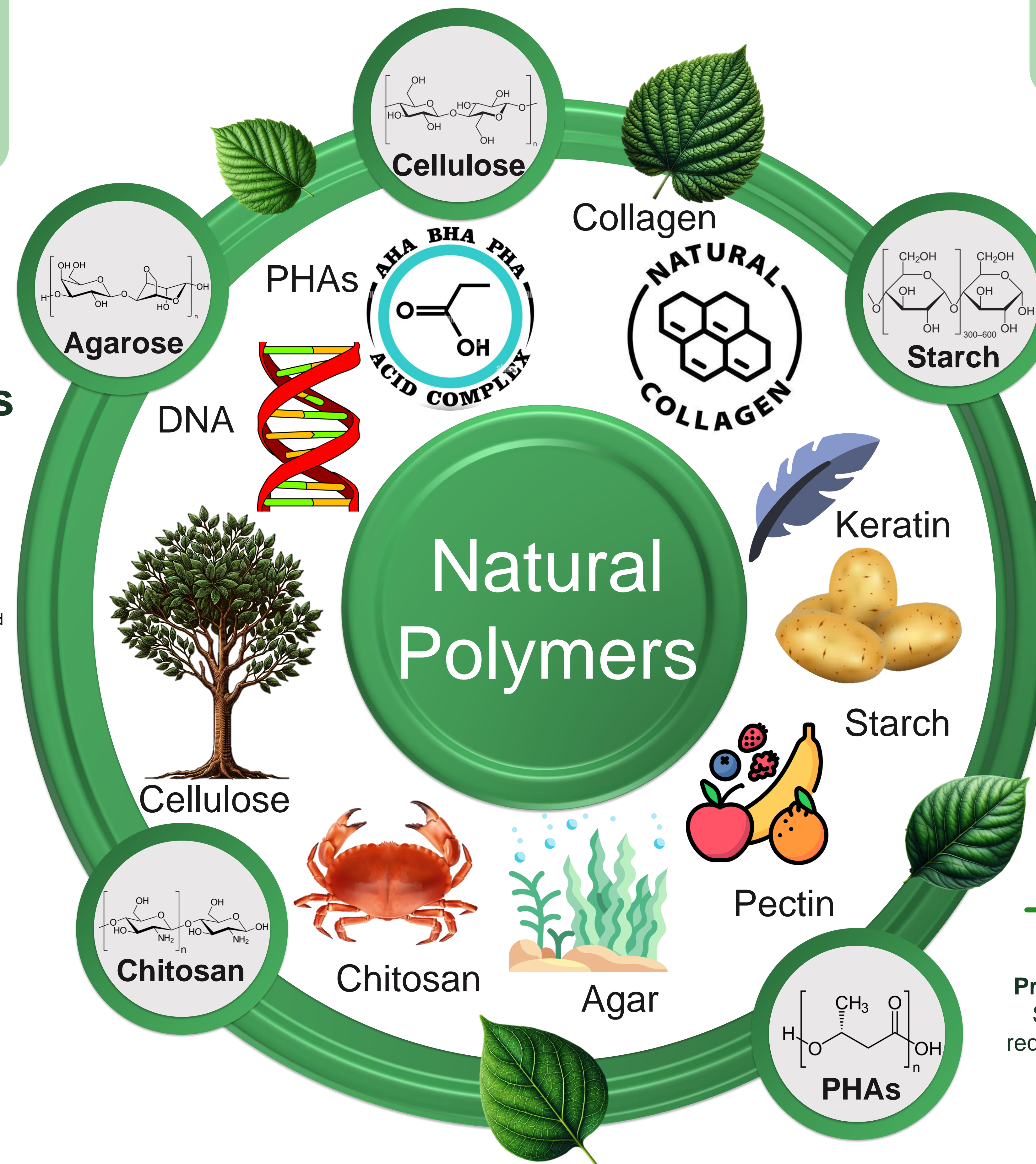


# Natural Polymers

## 2024 ACS Summer School for Green Chemistry & Sustainable Energy

Author: Nelson Barrios

North Carolina State University



## How/why does the tool relate to Green and Sustainable Chemistry?

### Sustainability

Natural polymers are renewable, biodegradable, and often have lower environmental impacts compared to synthetic polymers.



### Green Chemistry

Their use aligns with green chemistry principles by reducing reliance on fossil fuels, minimizing waste, and promoting the use of sustainable resources.

## Advantages of the tool



### Biodegradability

Break down naturally, reducing environmental pollution.



### Renewability

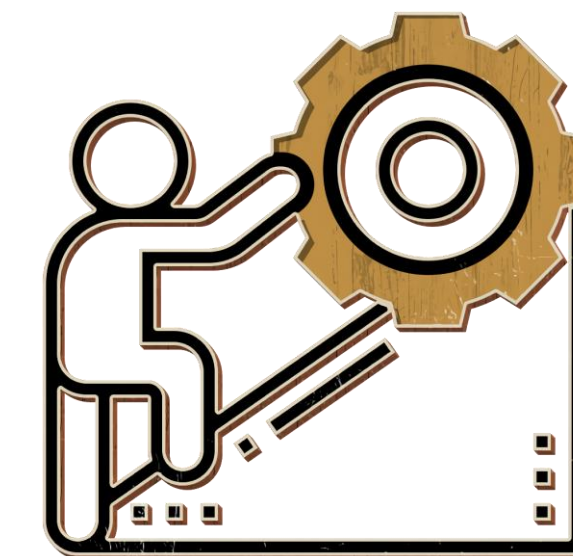
Derived from renewable resources.



### Non-toxicity

Often safer for humans and wildlife.

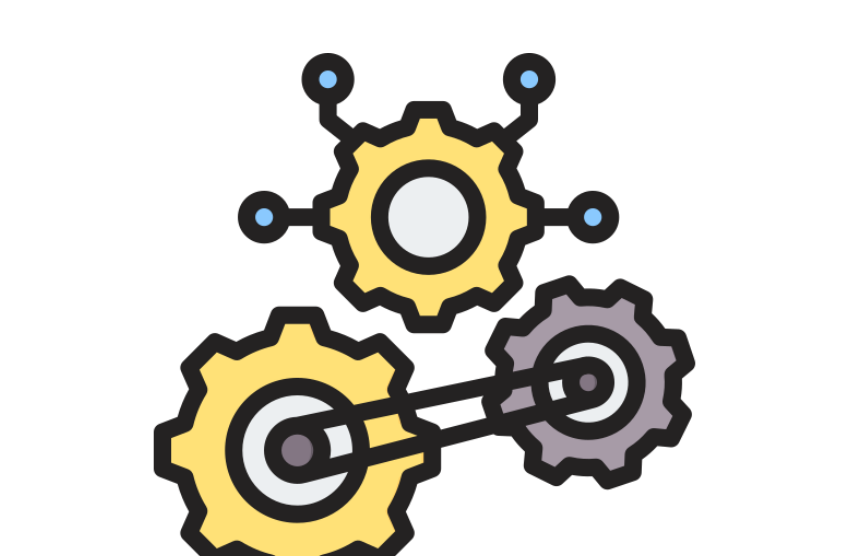
## Disadvantages/challenges of the tool



**Processing Complexities**  
Some natural polymers require complex processing.



**Economic Challenges**  
Higher production costs compared to synthetic alternatives.



**Performance**  
May have inferior mechanical properties and durability.

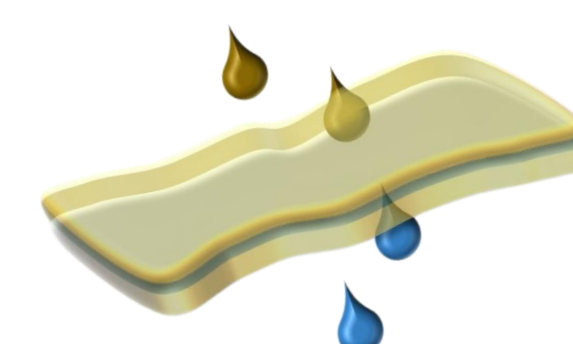
## Examples of successful applications

## ADVANCED APPLICATIONS

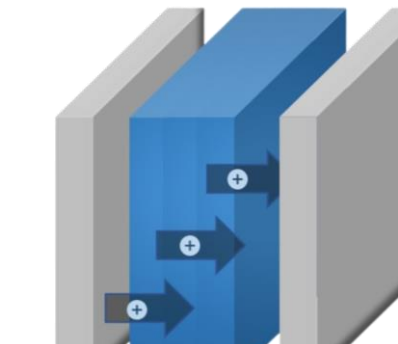
### Coatings



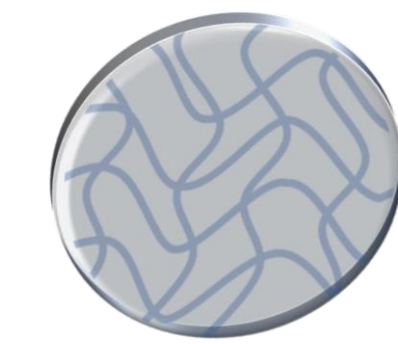
### Water remediation



### Active food packaging



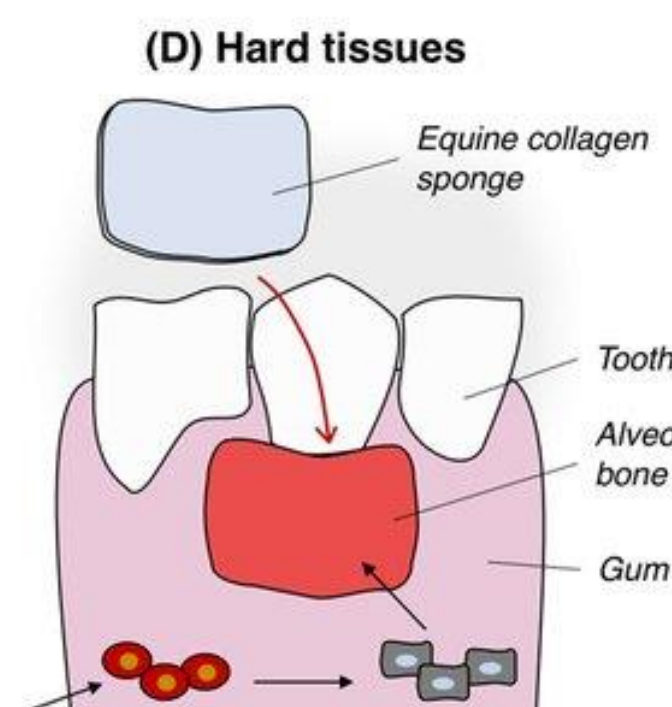
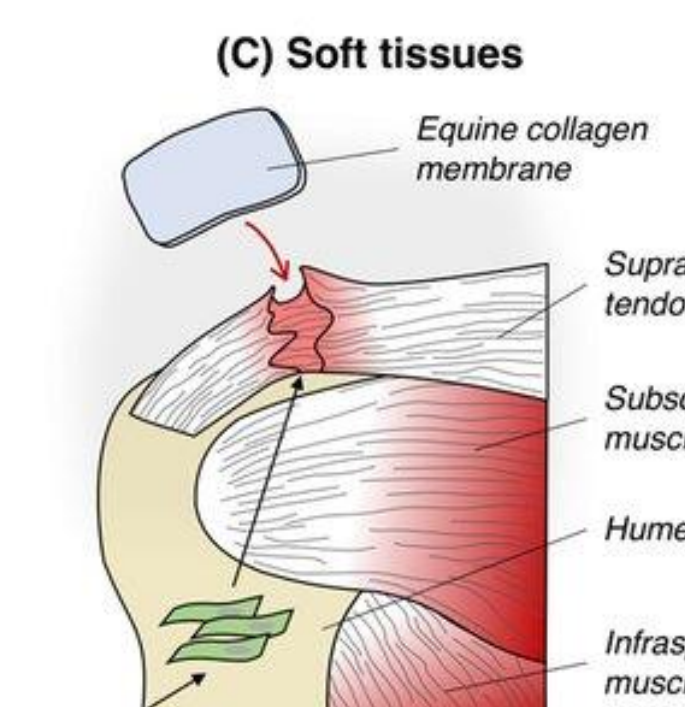
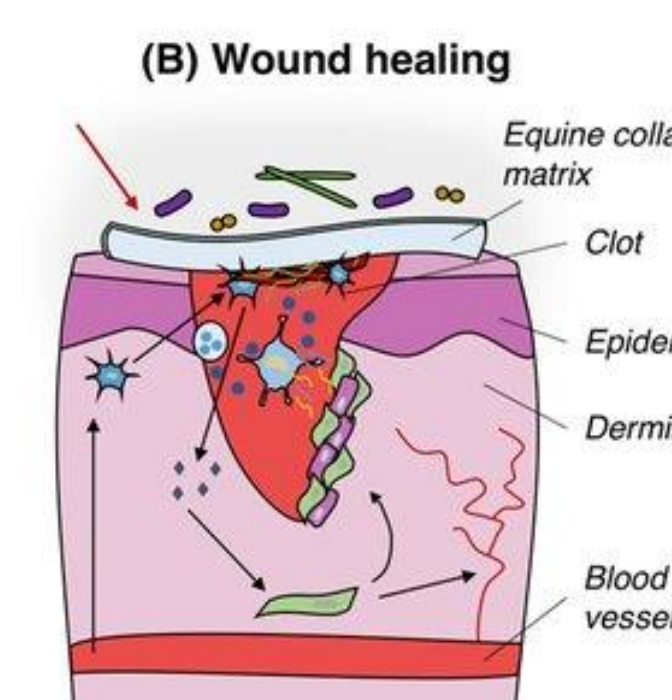
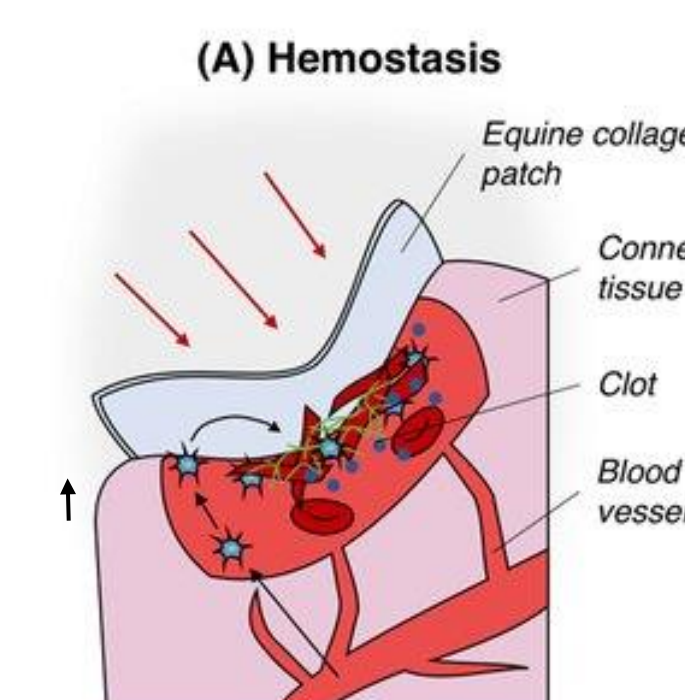
### Fuel cells



### Composites, films and membranes

### References

- [1] Silva, A. C., Silvestre, A. J., Vilela, C., & Freire, C. S. (2021). Natural polymers-based materials: A contribution to a greener future. *Molecules*, 27(1), 94.
- [2] Gallo, N., Natali, M. L., Sannino, A., & Salvatore, L. (2020). An overview of the use of equine collagen as emerging material for biomedical applications. *J. of Functional Biomaterials*, 11(4), 79.



### Collagen-based wound dressings

Hemostatic agent (A), wound dressing (B), matrix for soft (C) and hard (D) tissues regeneration.

### Why Bamboo?

- Antibacterial:** Anti-fungal qualities of bamboo naturally keep bacteria away, significantly reducing odor.
- Thermo Control:** Bamboo has a hollow micro-fiber structure, allowing it to be naturally warm yet breathable.
- Moisture Wicking:** Bamboo absorbs moisture and wicks it away, keeping you drier and more comfortable.
- Hypoallergenic:** Anti-allergy and anti-fungal qualities of bamboo make it perfect solution for active people with sensitive skin.
- UV Protection:** Our bamboo fabrics are naturally treated with UPF 40 to cut out 97.5% of harmful UV rays.
- Super Soft:** Our fabrics optimize the fine molecules and natural weave of bamboo to make it super soft.
- Eco-Friendly:** Bamboo is a sustainable, renewable, vegan, and plant-based material that helps us stay true to our earth-friendly priorities.
- Fitness & Health:** All of these qualities make bamboo the perfect material to keep you operating at peak performance.

### Textiles

Bamboo fibers are processed to create sustainable fabrics used in clothing such as t-shirts, socks, and underwear.