



The Harvey M. Krueger Family Center  
for Nanoscience and Nanotechnology

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# The Plant Age: Materials for the future



**The stone age didn't end for lack of stone.  
The oil age will end long before the world runs out  
of oil** "Sheik Ahmed Zaki Yamani"



**Biomaterials are better**



3 billion years of  
**evolution resulted in super  
performing materials and  
structures.**



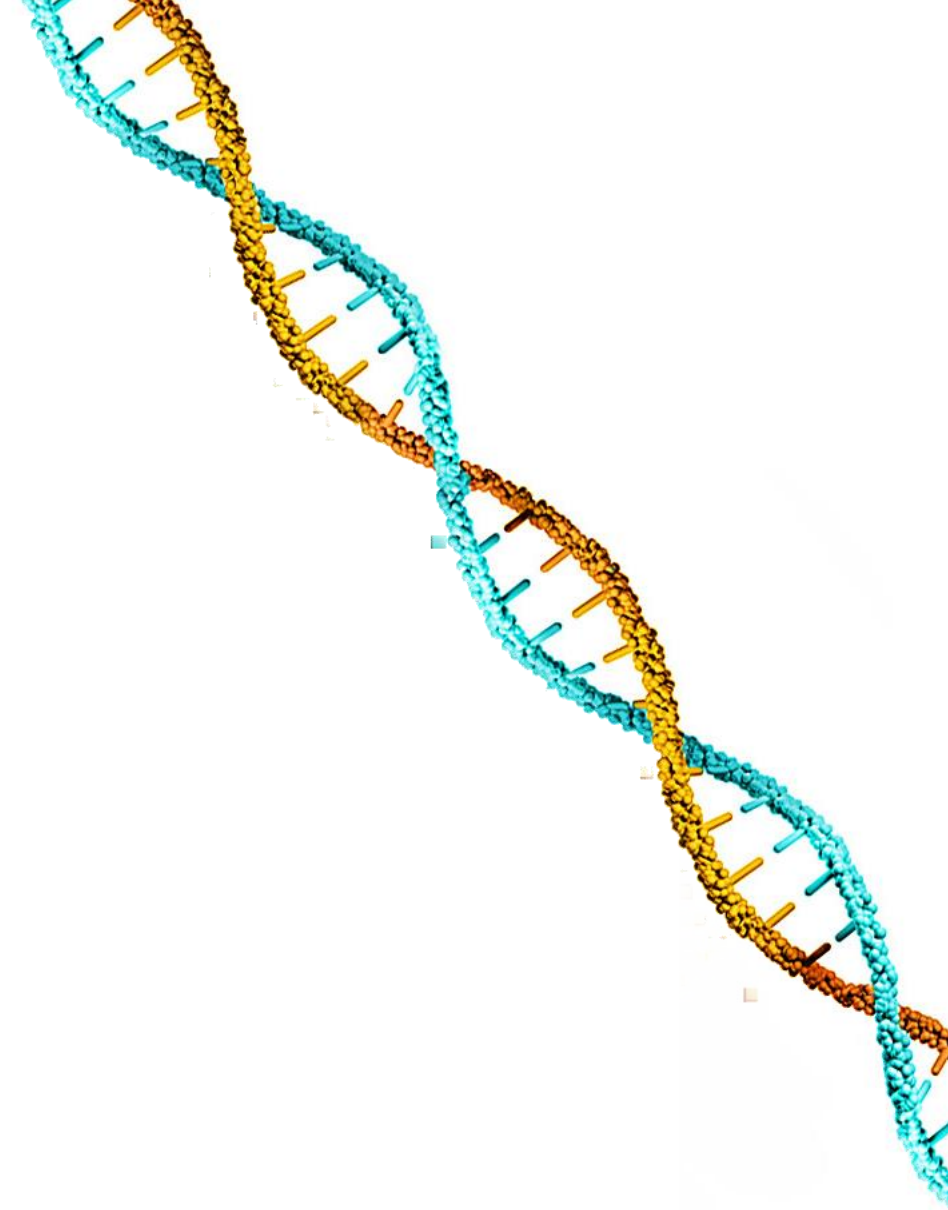
**Synthetic**  
medical implants  
“screw and glue”

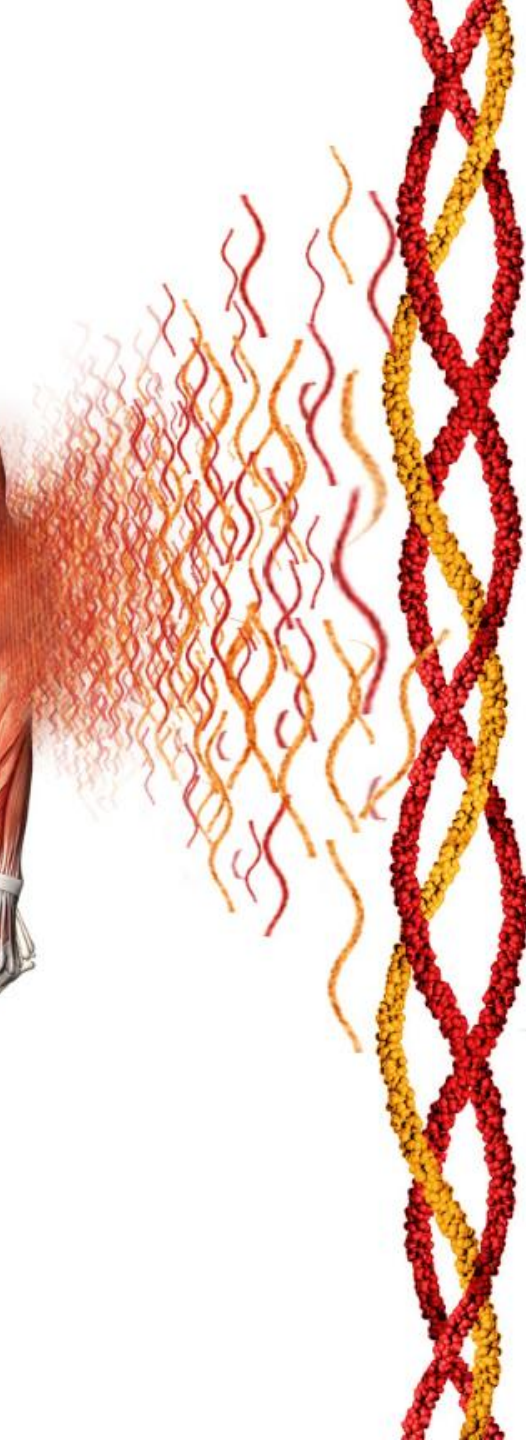


Synthetic materials  
**fail to perform**



In nature  
organisms  
**are self  
assembled**





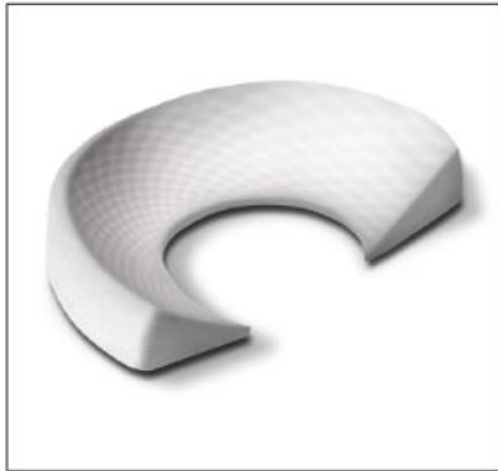
Our body  
is made of  
**collagen**

TRIPLE COLLAGEN HELIX





### ARTIFICIAL MENISCUS



### AUTOGENOUS BLOCK GRAFT



"Autogenous block graft" by Dental Specialty Group - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:Autogenous\\_block\\_graft.jpg#mediaviewer/File:Autogenous\\_block\\_graft.jpg](http://commons.wikimedia.org/wiki/File:Autogenous_block_graft.jpg#mediaviewer/File:Autogenous_block_graft.jpg)

### BIOLOGICAL HEART VALVE



"Carpentier-Edwards biological heart valve" by Stif Komar - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:Carpentier-Edwards\\_biological\\_heart\\_valve.jpg#mediaviewer/File:Carpentier-Edwards\\_biological\\_heart\\_valve.jpg](http://commons.wikimedia.org/wiki/File:Carpentier-Edwards_biological_heart_valve.jpg#mediaviewer/File:Carpentier-Edwards_biological_heart_valve.jpg)



Safety is a  
**big issue**





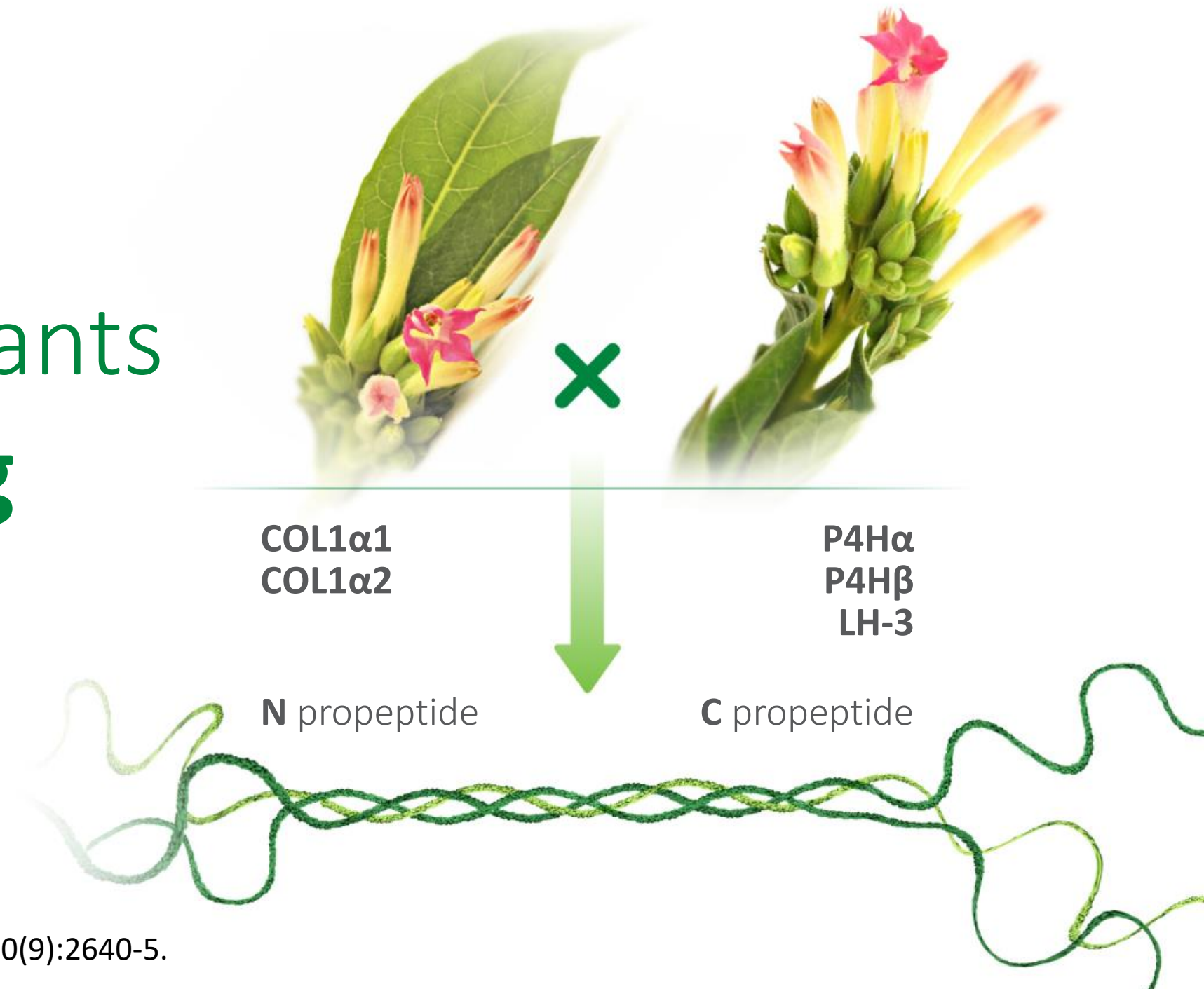
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Federal Register  
January 12, 2007:

**The FDA is proposing  
to prohibit the use of  
certain cattle material  
in drugs, biologics and  
medical devices  
intended for use  
in humans**

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Transgenic tobacco plants  
expressing  
**5 human  
genes**





# Large scale Human collagen produced in tobacco plants



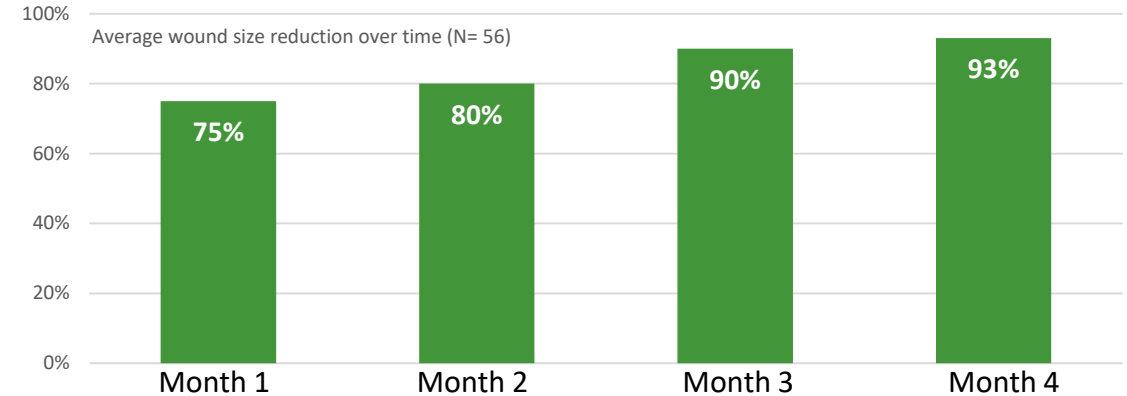
Diabetes affect more than 400 million people  
DFU a major cause of lower extremity amputation.  
1million amputations per year (1 every 30 seconds)



# Vergen<sup>x</sup>™FG Clinical outcomes

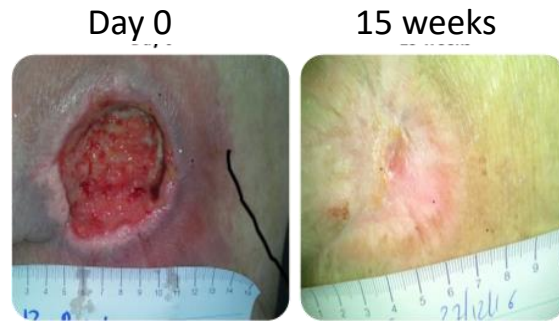


**75% average wound closure after 1 month (single treatment);  
93% average wound closure after 4 months**



**History:** Female, 86 years old with large pressure ulcer in sacral area

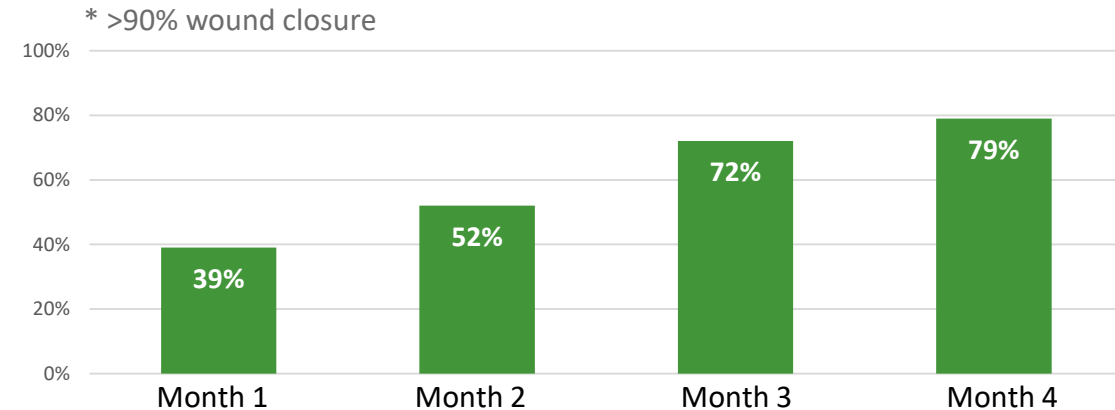
**Results:** Patient achieved complete wound closure within 15 weeks post treatment



**History:** Male, 64 years old with neuropathic leg ulcer with history of ischemia, angioplasty and infection. Patient did not respond to any other wound treatment/materials.

**Results:** Wound fully healed within 3 months.

**79% clinically significant wound closure\* after 4 months**

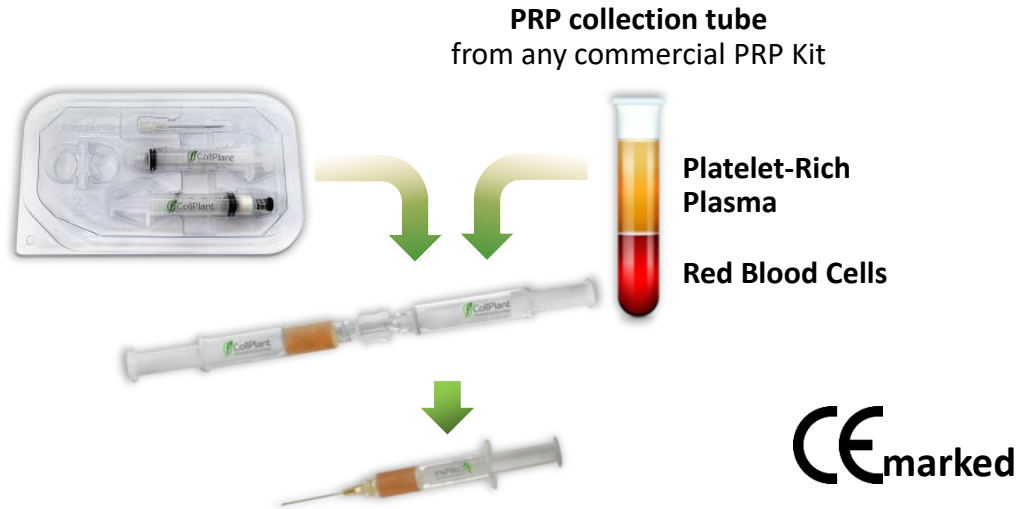


Source: Data on file at Collplant



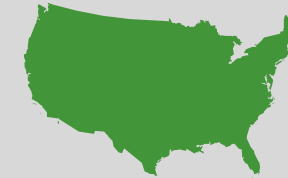
# Vergen<sup>x</sup>™ STR Orthobiologics

Soft Tissue Repair



- Intended for treatment of tendinopathy
- Provides:
  - Localization of platelets at the injury site
  - Extended therapeutic effect of growth factors
- A single application is all that is required to initiate the healing process
- Distributed in Europe by Arthrex under the brand ACP® Tendo
- Pre-Sub meeting with FDA in Q4, 2018

Orthopedic clinics,  
US\*:



16.4M

individuals seeking  
intervention for tendon and  
ligament injuries

Current Global Tendinitis  
served market:



0.5B\$

(mostly steroids)



# Vergenix™ STR Clinical outcomes

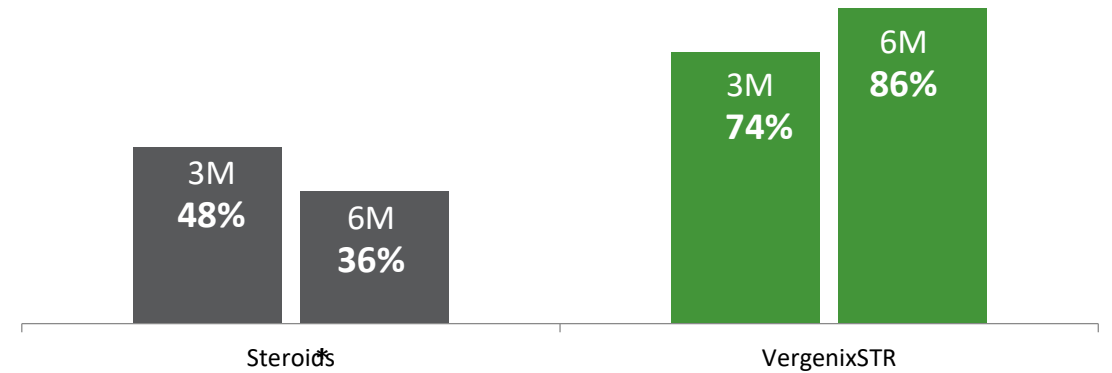
Significant advantages over standard of care

Clinical study

**74%** of patients show clinical success at 3M

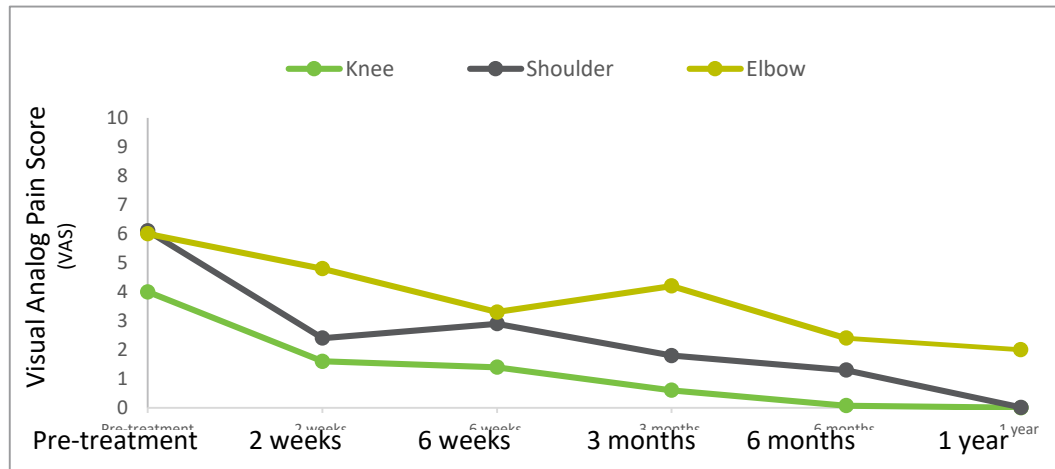
**86%** of patients show clinical success at 6M

- 40 patients, single arm, single treatment, 3 & 6 month f/u
- End points – Safety; recovery in pain and motion as measured through PRTEE, Quality of Life questionnaire and grip strength test

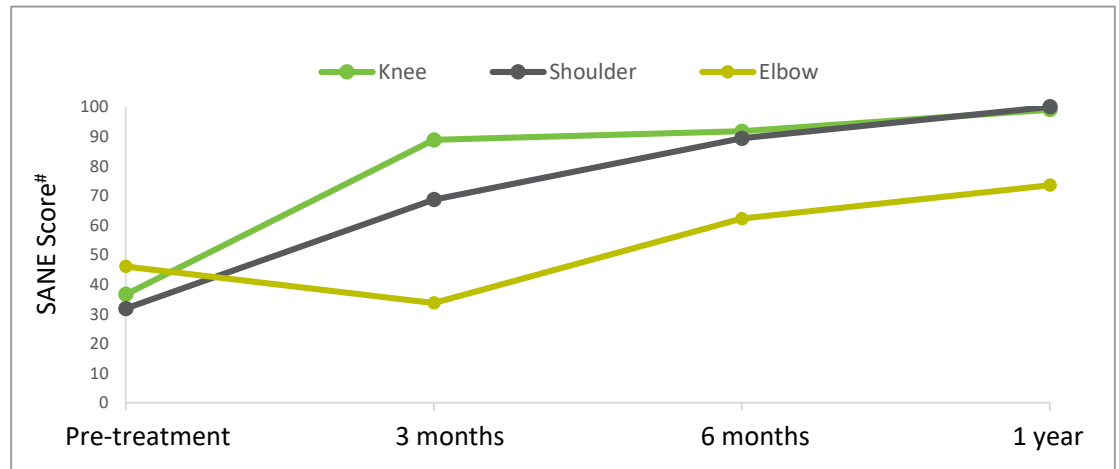


PMS\*\*

Pain reduction



Improved patient functionality



#Single Assessment Numerical Assessment

# BILOGIC DRUGS



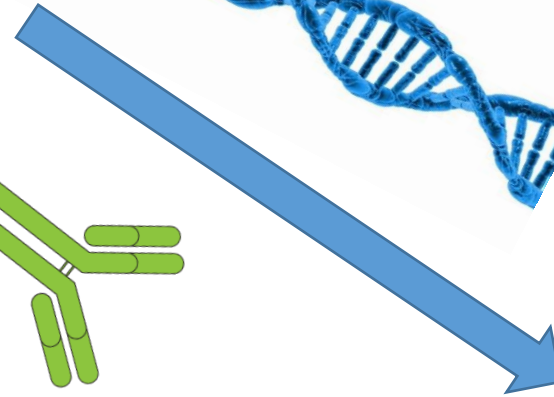
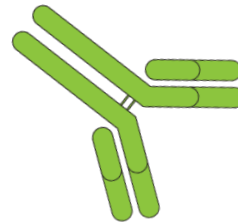
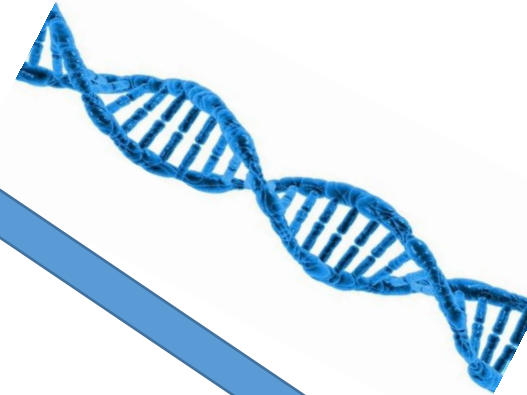
- ✓ Humira cost 35,000 USD/year (100 USD/day)
- ✓ Only 1 out of 1000 people in the world can afford Humira.

**BioBetter**™

*Making modern medicines affordable*

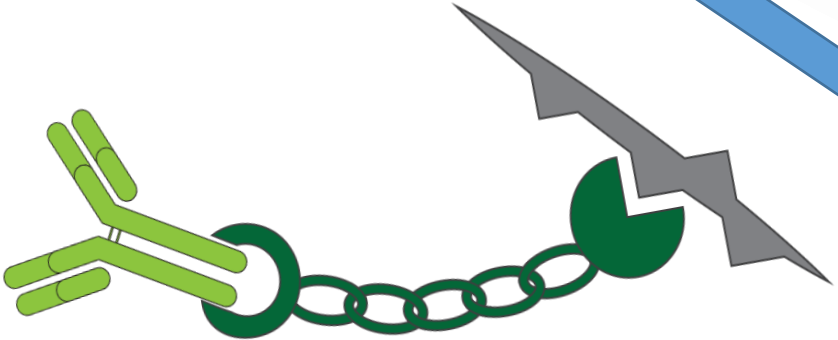
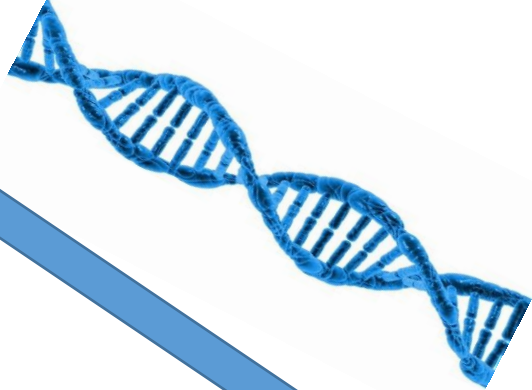
# Expensive reactors and media

**BioBetter™**  
*Making modern medicines affordable*



# Drug purification process is expensive

**BioBetter™**  
*Making modern medicines affordable*





Humira for 70 cent/day

**BioBetter™**

*Making modern medicines affordable*



**Sequoia trees;  
hundreds of tons for hundreds of years**



**in the sun and UV light**



it is made of



it is made of



**Sugar!!!**

# 10

times  
stronger  
than steel !!!



# CNC; The future of the Industry



Google™



Alibaba.com™

ebay™



Pulp & Paper Industry Waste,  
**a Perfect Source for CNC**



Pulp & Paper Industry Waste,  
**a Perfect Source for CNC**

**11M ton  
waste  
annually**  
in Europe alone





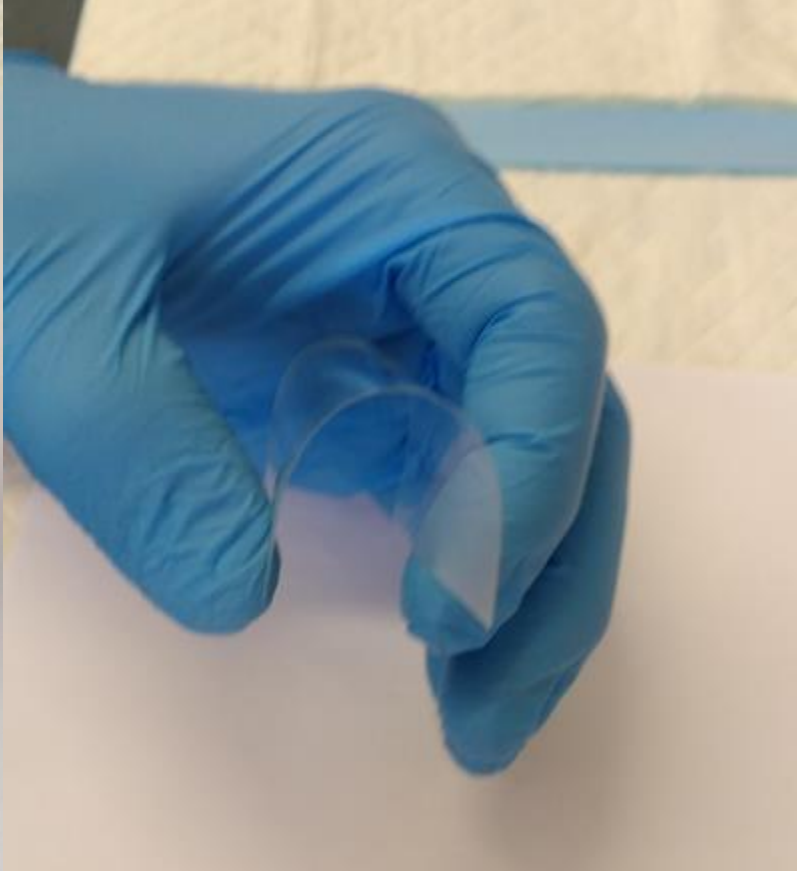
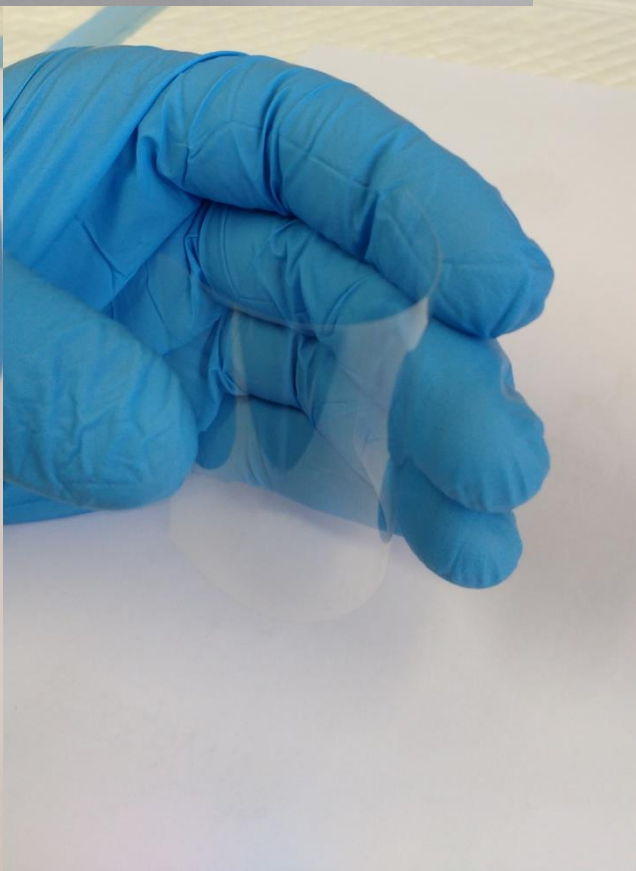
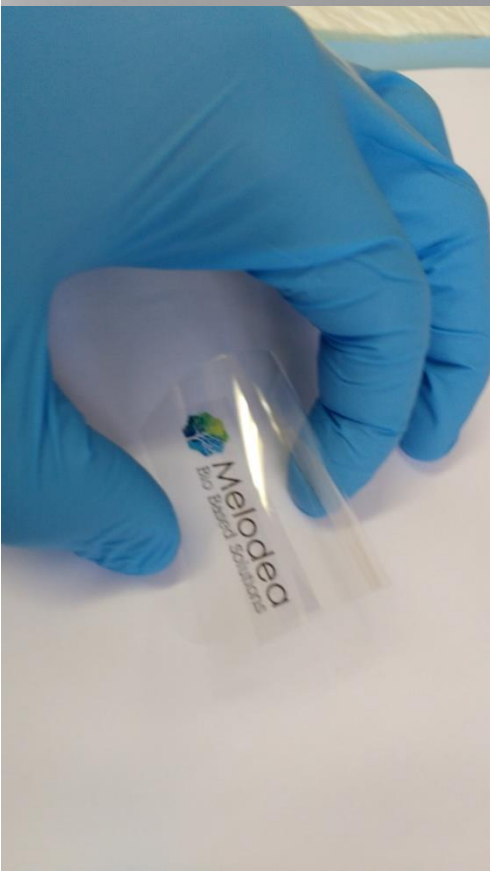
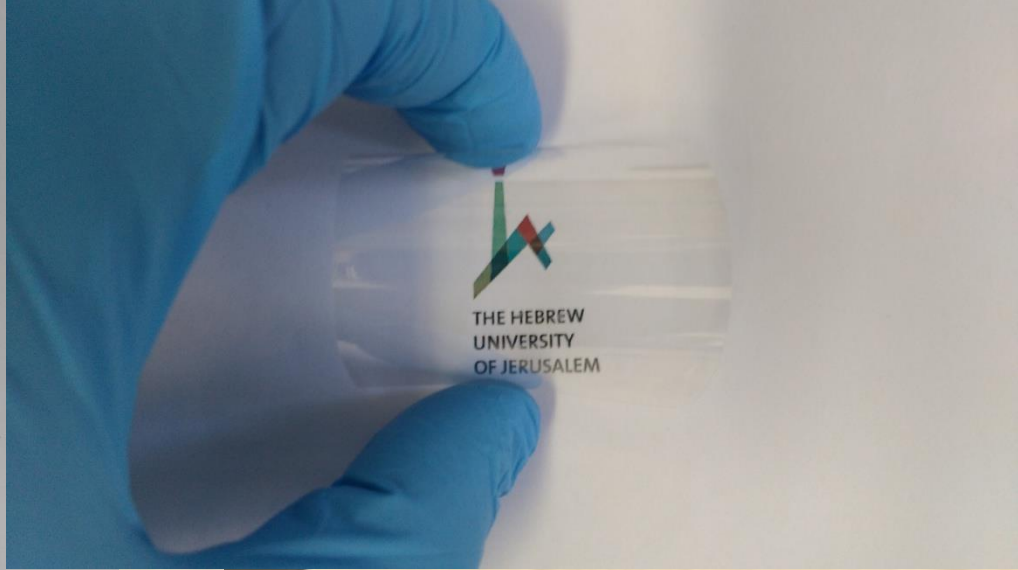


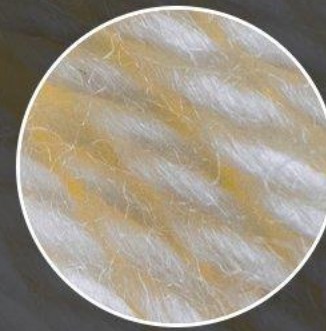
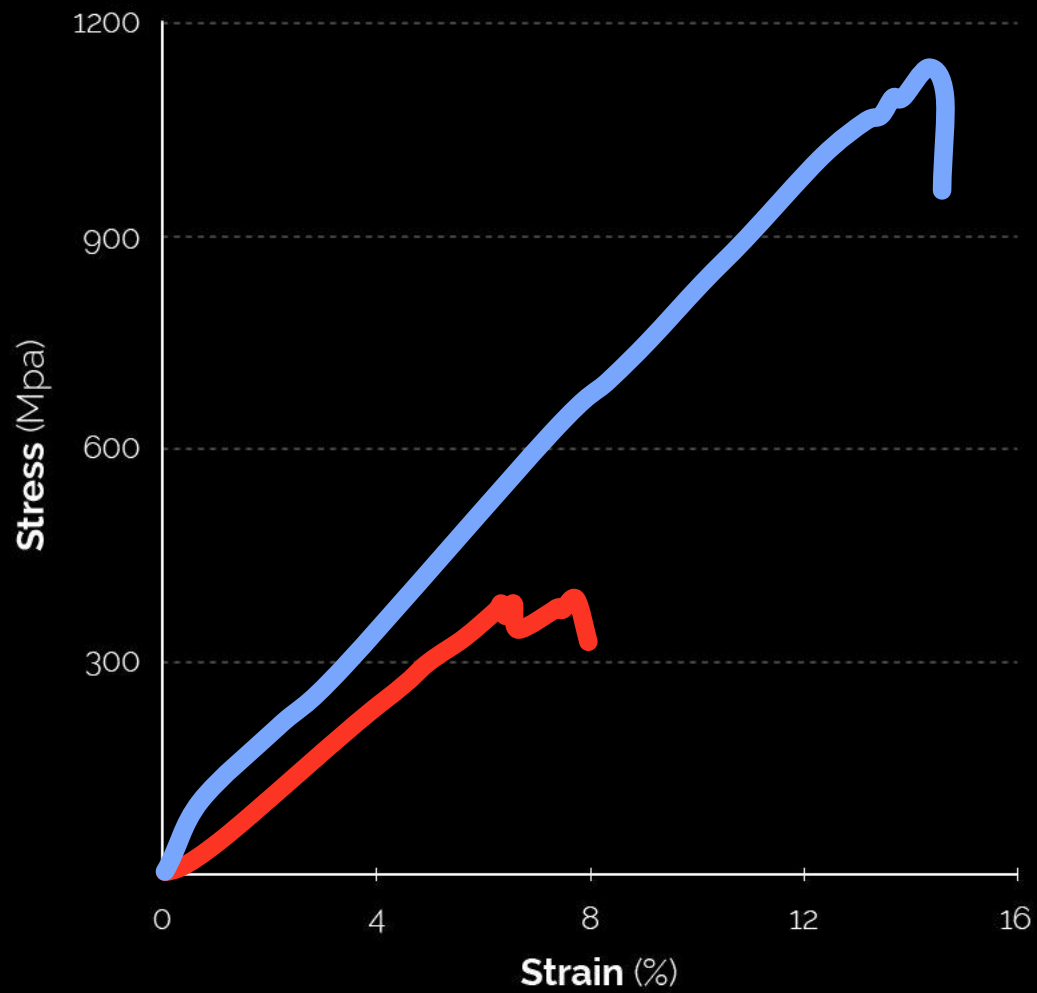
Melodea  
Bio Based Solutions



Converting  
environmental problem  
**to a goldmine**

**Electron  
Microscope  
image of  
the CNC**



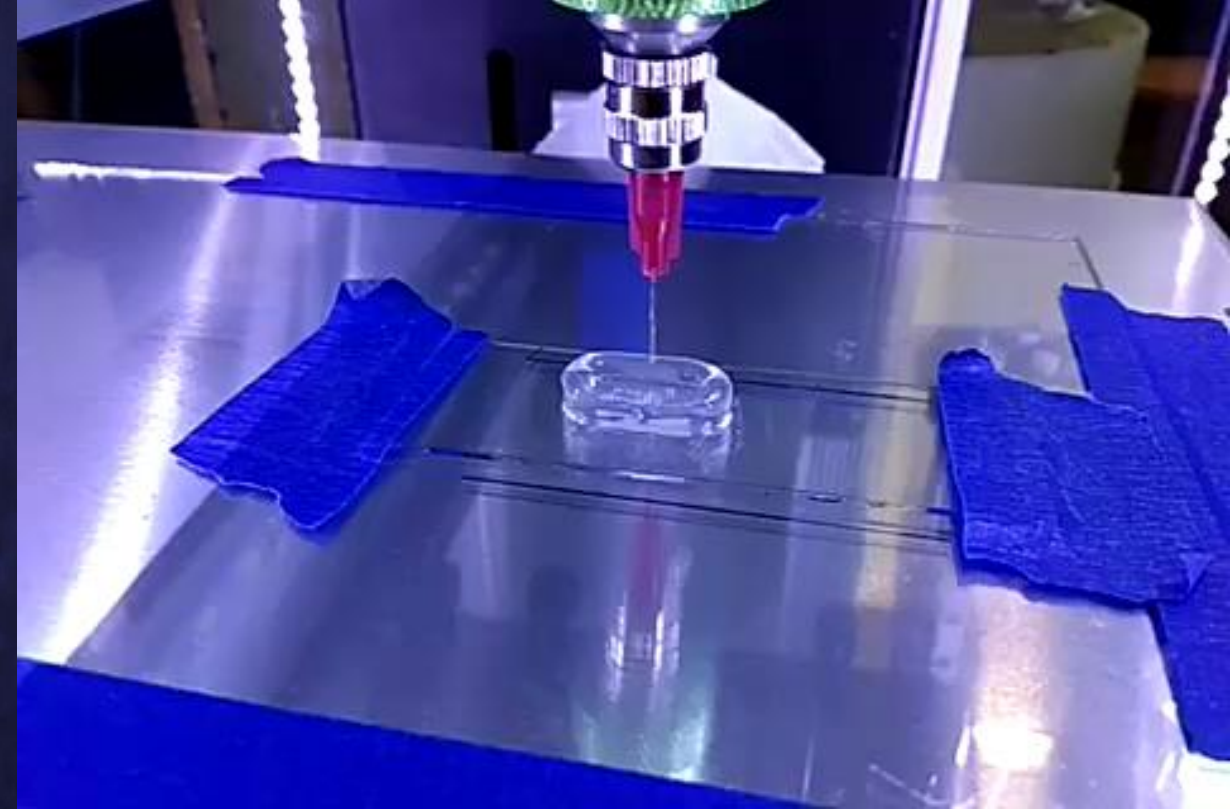
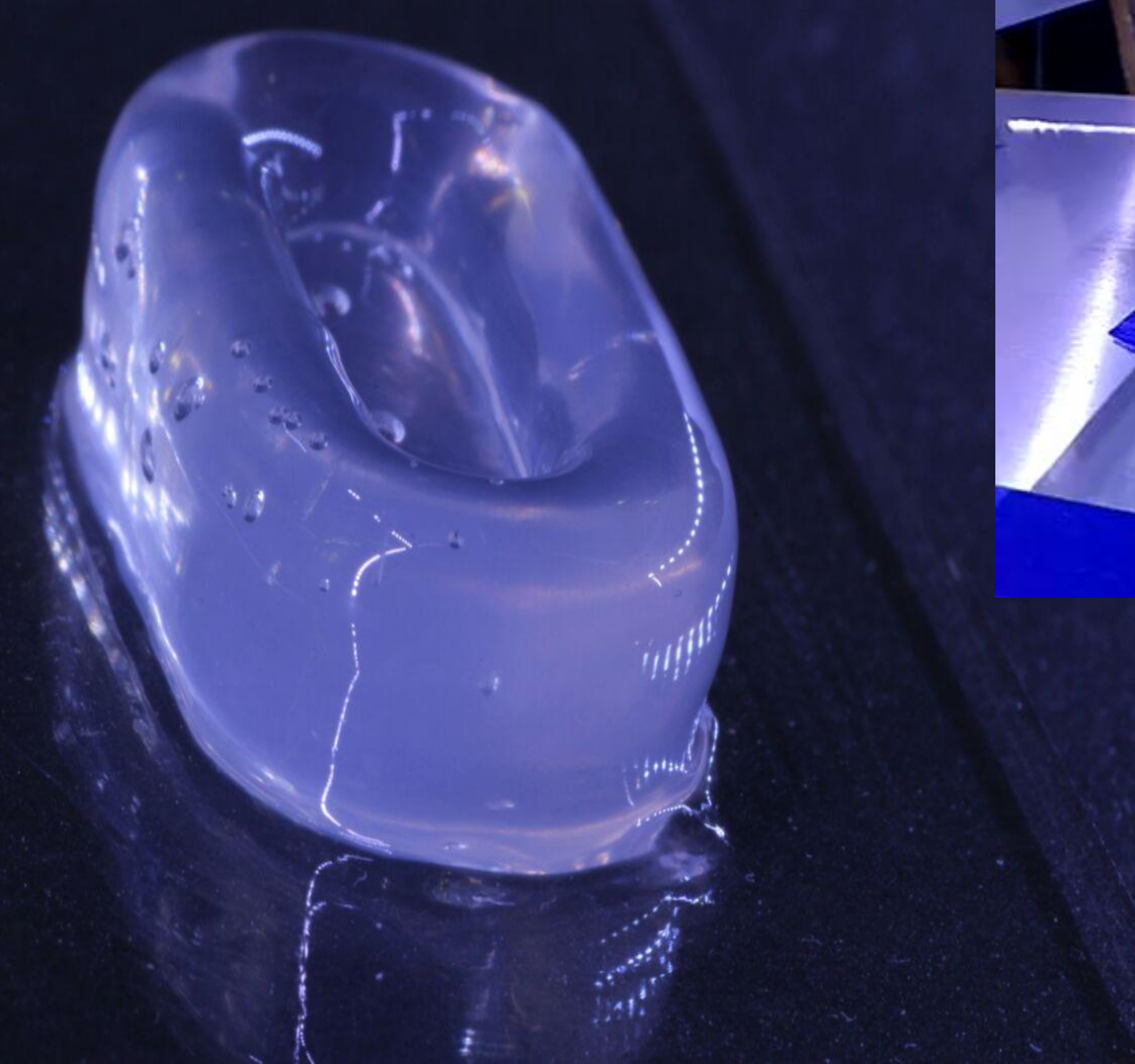


**CNC dramatically**  
improves strength of cotton fibers

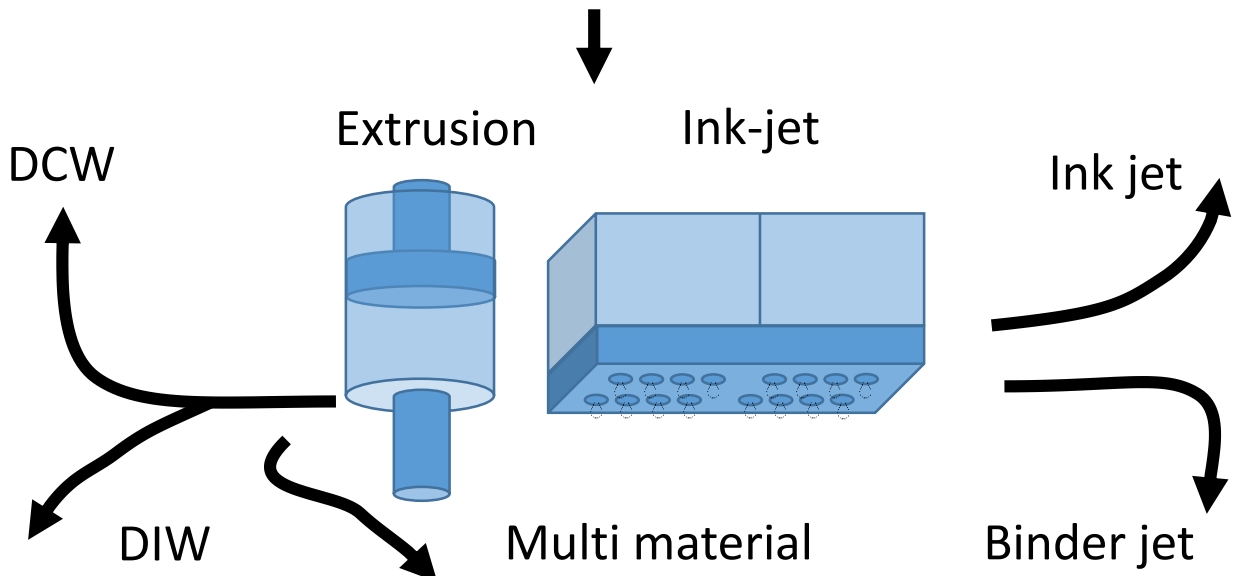


Photo: MizC / iStockphoto

Photo: Brendan Hunter / iStockphoto

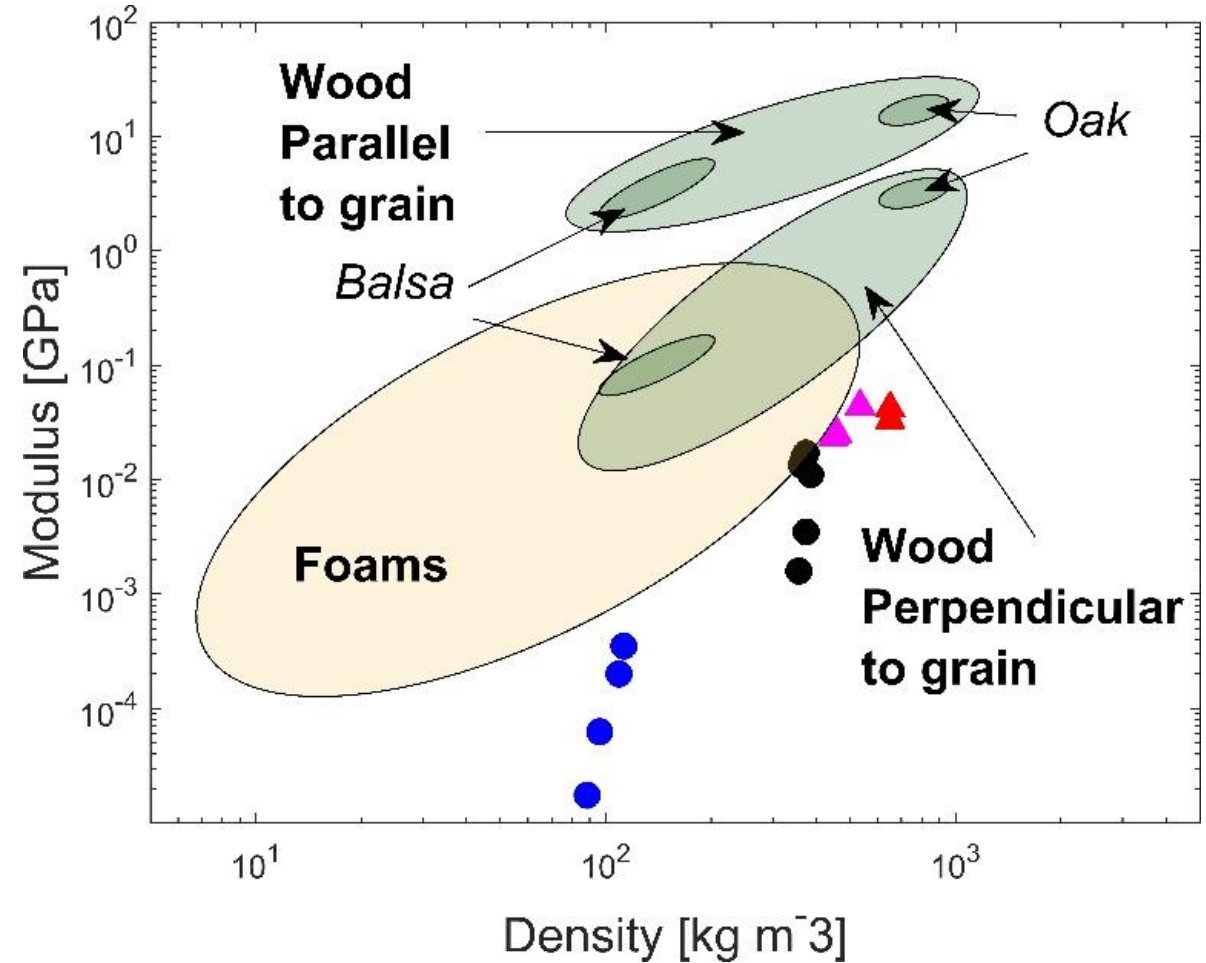
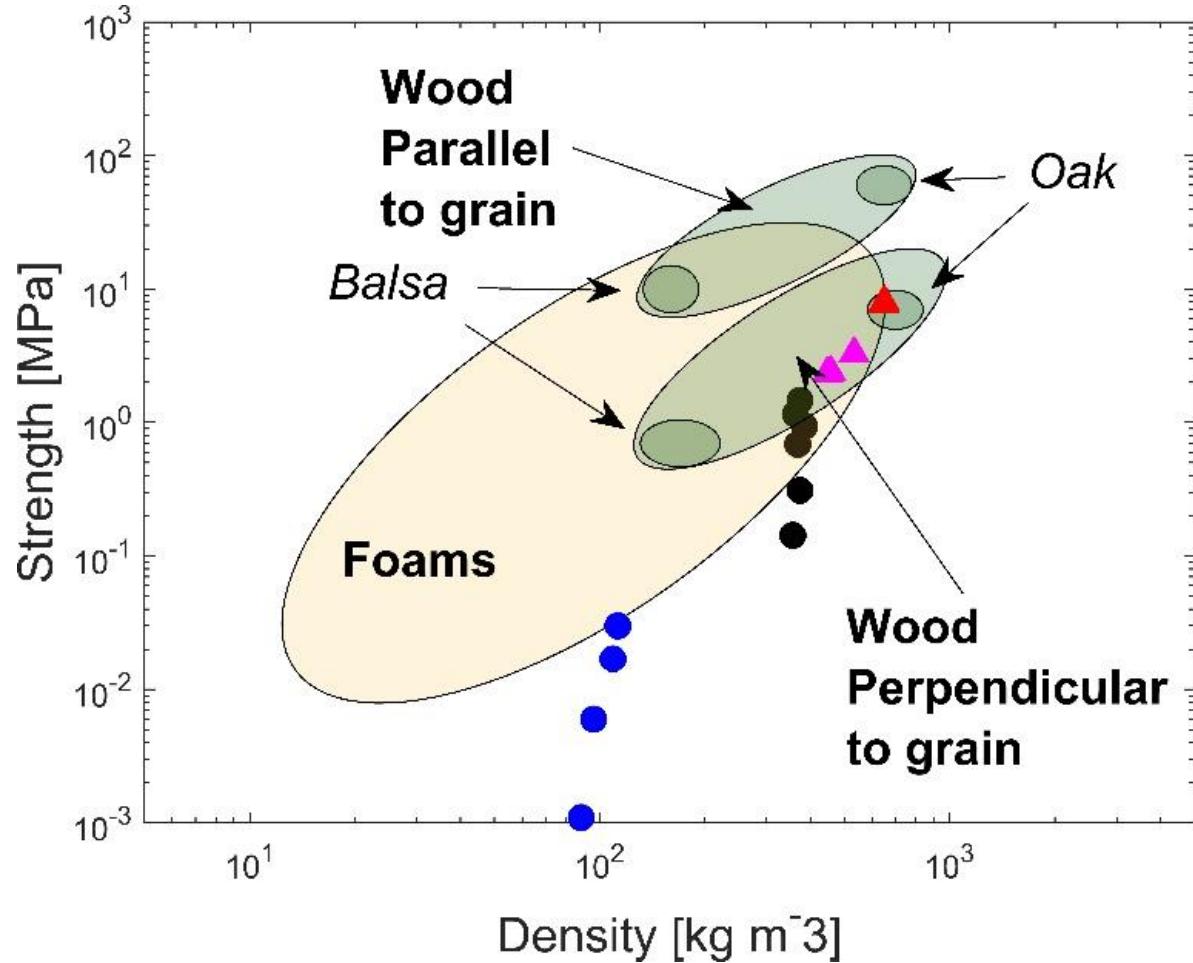


# Printing wood with CNC/sawdust Ink



- Density  $>0.8$  gr/ml
- Tensile modulus – 0.05 Gpa
- Strength – 8 Mpa
- Thermal conductivity – 0.05 kW/mK

## Optimal Physical Properties





CatFleas

# Jumping Skills

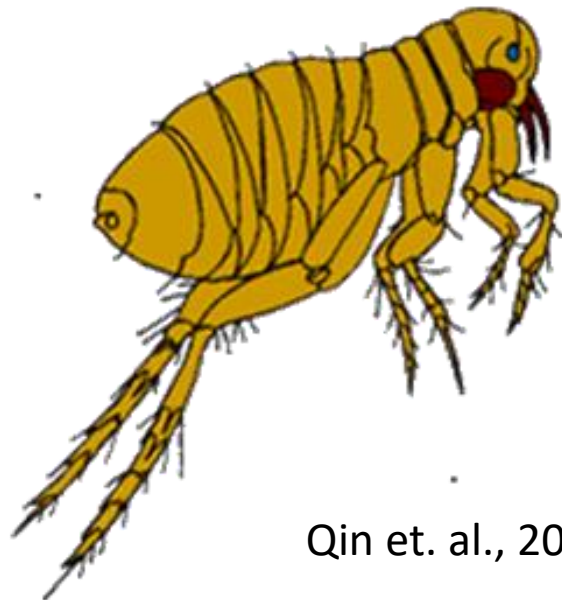




Equivalent  
to Human  
**Jumping**  
**400 m High**



# Production of Recombinant Resilin Engineered With a Cellulose Binding Domain (CBD)



Qin et. al., 2009. Biomacromolecules. 10(12):3227-34.

# Adding a drop of resilin into a stiff CNC foam





JUMP **HIGHER**



# Fabricate organs for transplantation





if you want a new idea, **open an old book**

