TEL AVIV UNIVERSITY
Pursuing the Unknown

ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Bioinspired Peptide-Based Materials for Regenerative Therapies

Prof. Lihi Adler-Abramovich

Chair, Department of Oral Biology, The Goldschleger School of Dental Medicine, Gray Faculty of Medicine,
The Center for Nanoscience and Nanotechnology,
Tel-Aviv University, Tel Aviv, ISRAEL

CRS 2025 Annual Meeting
Philadelphia, PA, USA
July 14-18, 2025

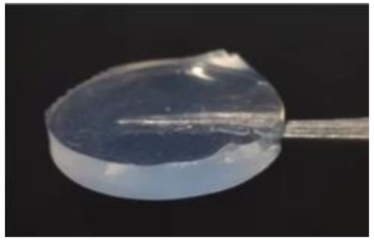
ADLER-ABRAMOVICH LAB

BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Bioinspired Materials and Nanotechnology

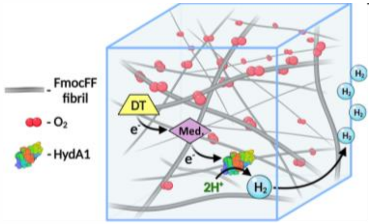
Materials Sciences

- Self assembly of peptides
- Low molecular wight hydrogelators
- 3D bioprinting



Biology

- Enzyme encapsulation
- 3D cell model in microgravity

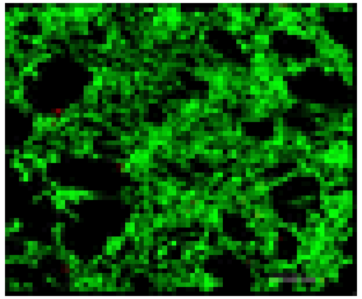


Medicine

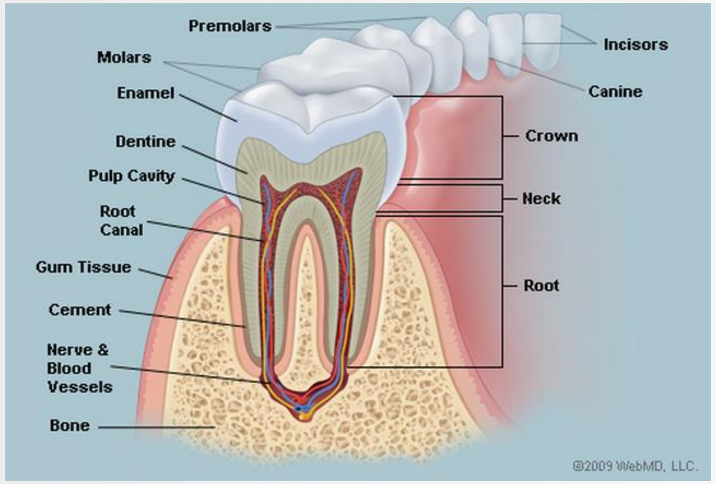
- Tissue regeneration
- Antimicrobial peptides

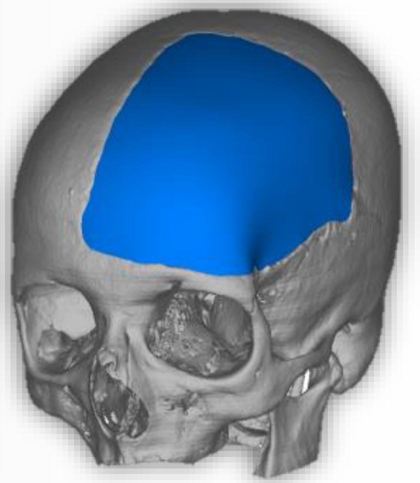
Chemistry

- Renewable energy (H_2 production)
- Agriculture- OP bioremediation



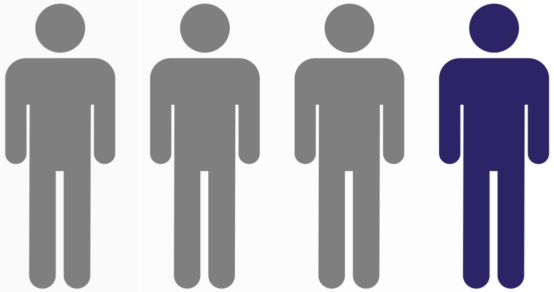
The challenge: Bone Defects or a Bone Fracture





Periodontitis

Peri - implantitis

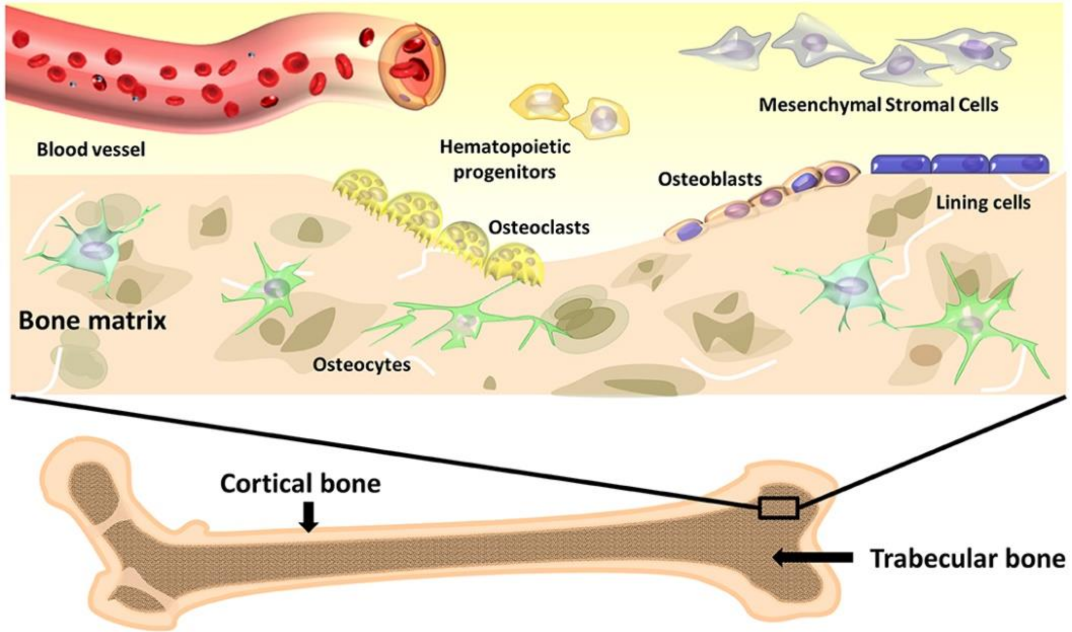


25% >74 years old

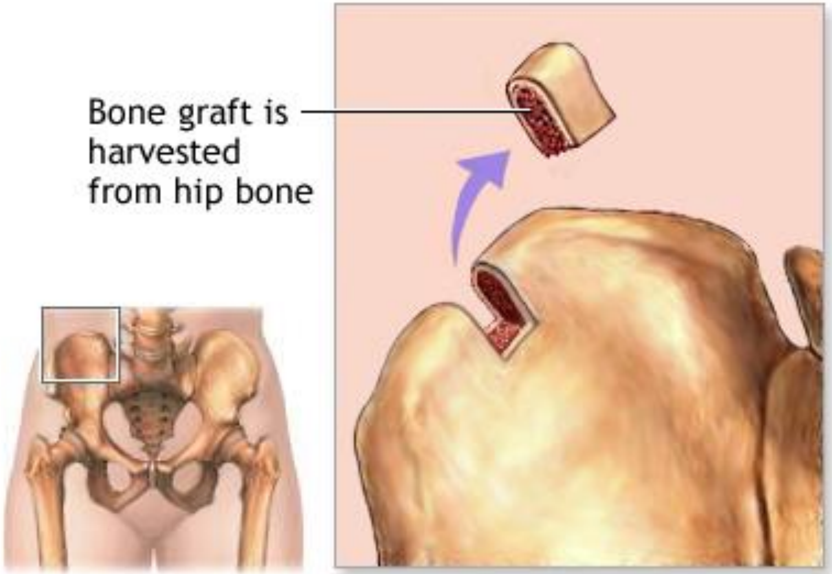
Full edentulous

Bone Tissue Regeneration

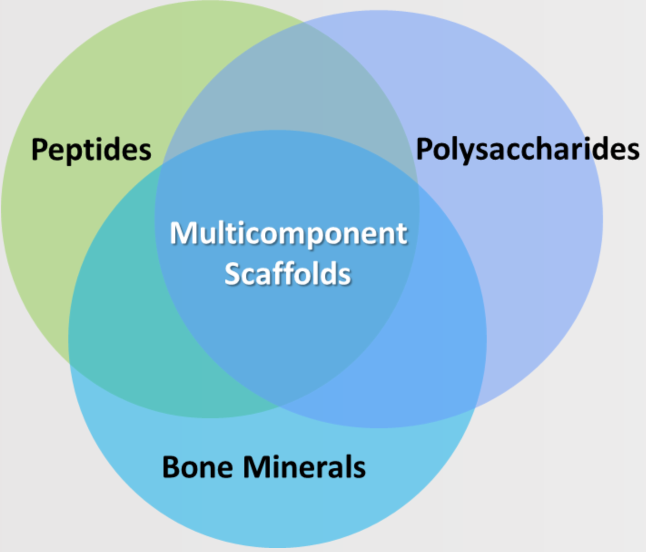
Bone can regenerate spontaneously



Current treatment: Auto-graft, allograft, xenograft, bone substitutes



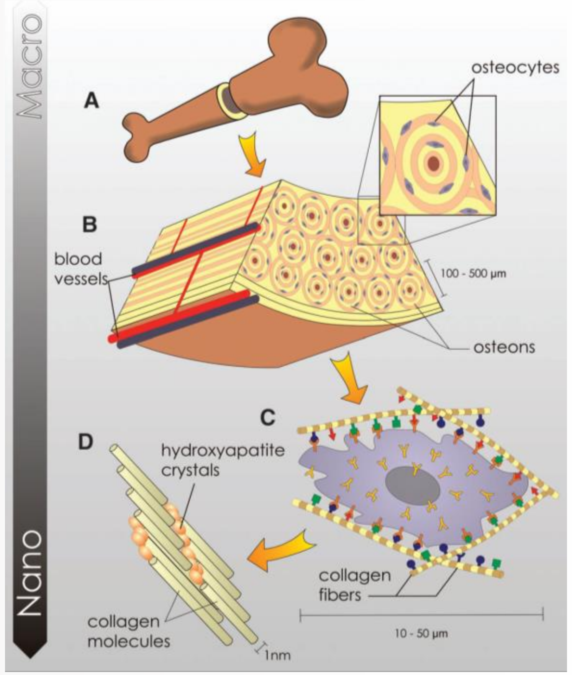
“Smart” Multicomponent Scaffolds



+ Growth factors

Osteogenesis ➡ **BMPs –**
Bone Morphogenetic Proteins

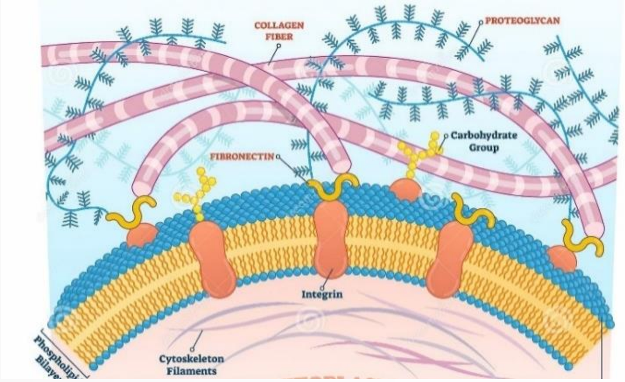
Angiogenesis ➡ **VEGF –**
Vascular Endothelial Growth Factor



Stevens and George, Science 2005

Scaffold requirements

Biocompatibility
3D support
Adaptable to the defect shape
Stiffness for mechano-sensing
Space maintenance over time
Controlled degradation rate
Growth factors and drugs delivery



Extracellular Matrix (ECM)

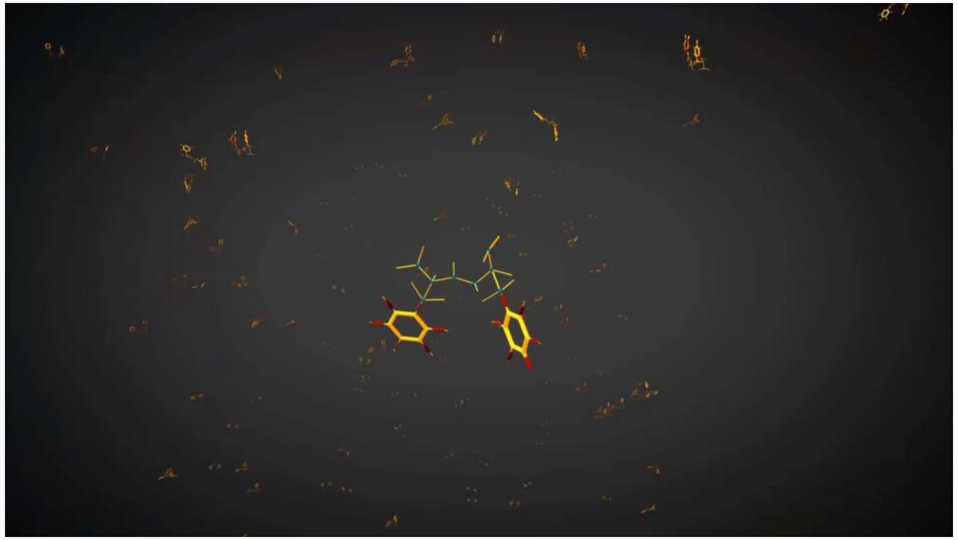
ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

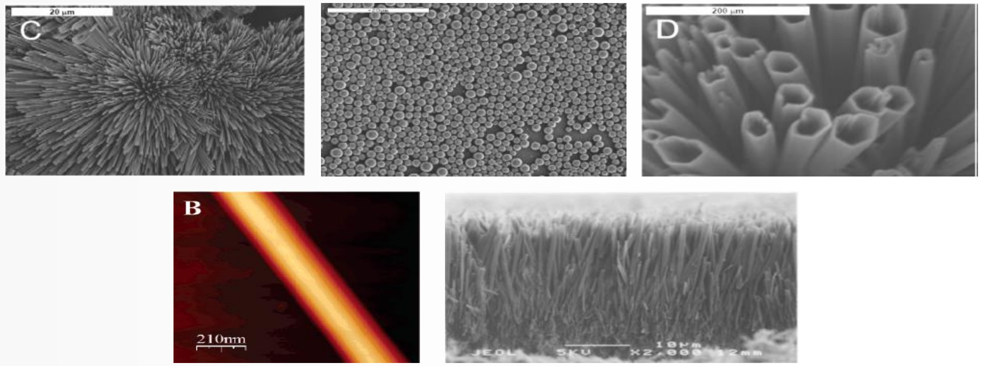
TEL AVIV UNIVERSITY
Pursuing the Unknown

Aromatic Dipeptide Nanostructure Library

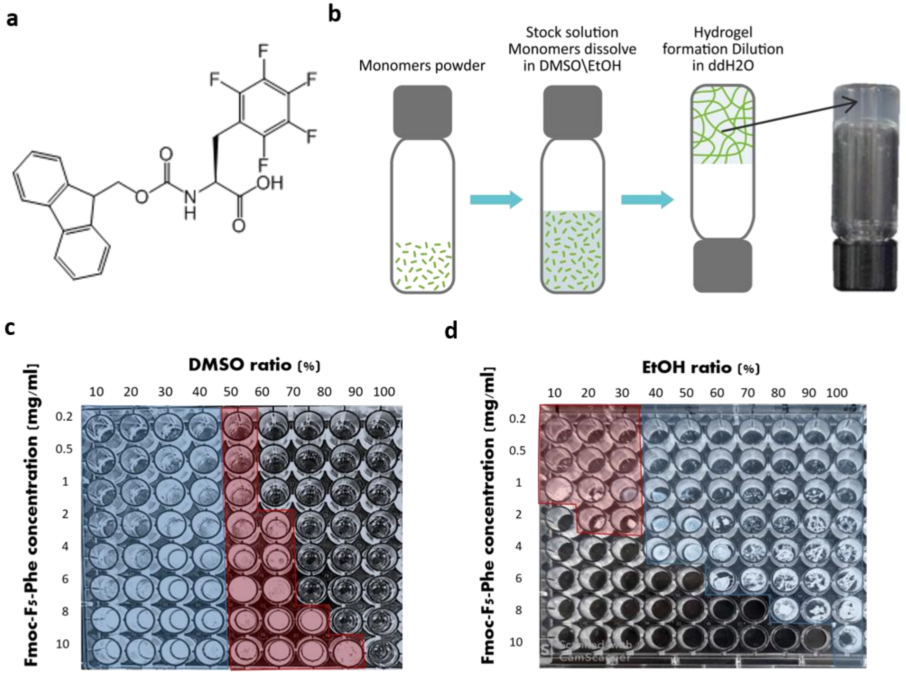
Compound name	Assemblies structured	Additional information
H-Phe-Phe-OH (FF)	Tubes, spheres, quantum-dots	Young modulus = 19–30 GPa, β-sheet
H-Phe-Phe-NH_2	Nanotubes	
Ac-Phe-Phe-NH_2	Nanotubes	
H-Phg-Phg-OH	Nanospheres	
H-Cys-Phe-Phe-OH	Nanospheres	
Boc-Phe-Phe-OH (Boc-FF)	Tubes, spheres	Young modulus = 140–275 GPa
Cbz-Phe-Phe-OH	Amyloid-like structures	
Cyclo-Phe-Phe	Tubular structures	α-Helix or β-turn
Fmoc-Phe-Phe-OH	Fibrous-hydrogel	$G' = 2 \times 10^4$ Pa, β-sheet
Fmoc-Phe-Gly-OH	Fibrous-hydrogel	
Fmoc-2-Nal-OH	Fibrous-hydrogel	β-Sheet
Fmoc-Gly-Phe-OH	Microtubes	
Fmoc-Phe-Arg-Gly-Asp-OH	Fibrous-hydrogel	β-Sheet
Fmoc-Arg-Gly-Asp-Phe-OH	Fibrous-hydrogel	β-Sheet
Fmoc-Arg-Gly-Asp-OH	Nanotubes	
Fmoc-Phe-Ser(*t*Bu)	Spheres	
Fmoc-Phe-Pro-OH	Spheres	
di-D-1-napthylalanine	Tubular structures	
di-D-2-napthylalanine	Tubular structures	Point stiffness ~1.25 GPa
H-(*p*-fluoro-Phe)-(*p*-fluoro-Phe)-OH	Tubular structures	
H-(pentafluoro-Phe)-(petafluoro-Phe)-OH	Tubular structures	
H-(*p*-iodo-Phe)-(*p*-iodo-Phe)-OH	Fibrillar structures	
H-(*p*-nitro-Phe)-(*p*-nitro-Phe)-OH	Fibrillar structures and spheres	9
H-(4-phenyl-Phe)-(4-phenyl-Phe)-OH	Squared plates	
H-Phe-Phe-Phe-OH	Nanoplates	β-Sheet

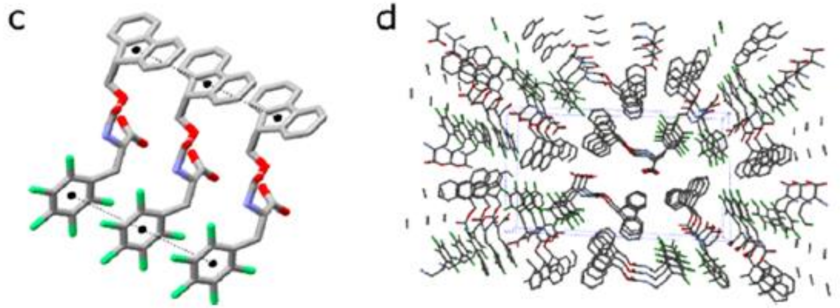
Adler-Abramovich and Gazit (2014) Chem. Soc. Rev.

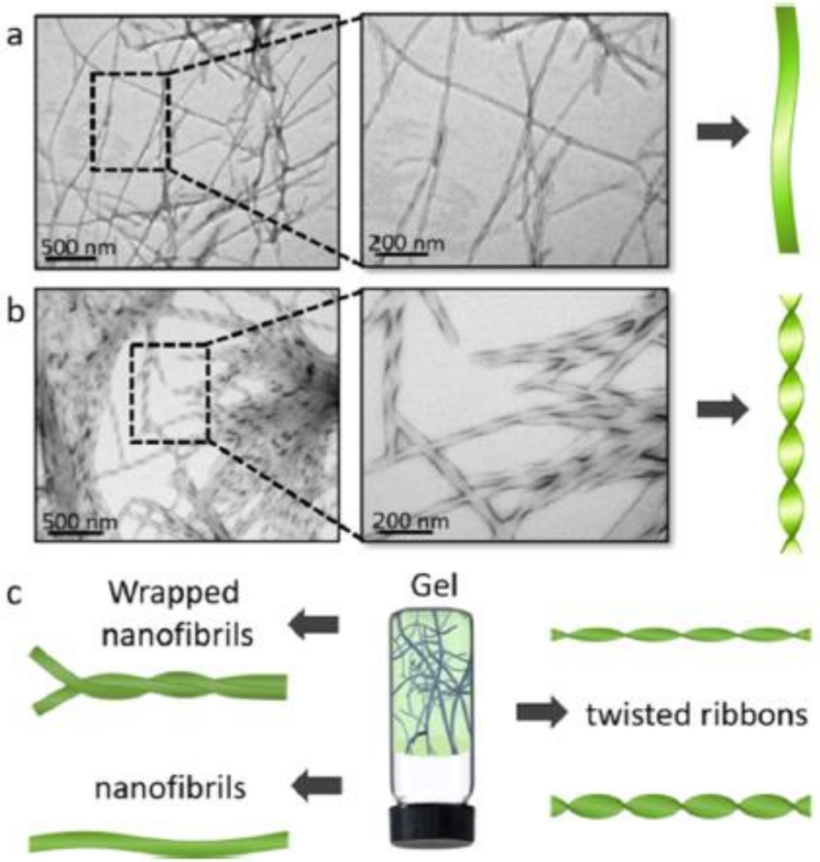




Phase Transition- The Solvent Effect

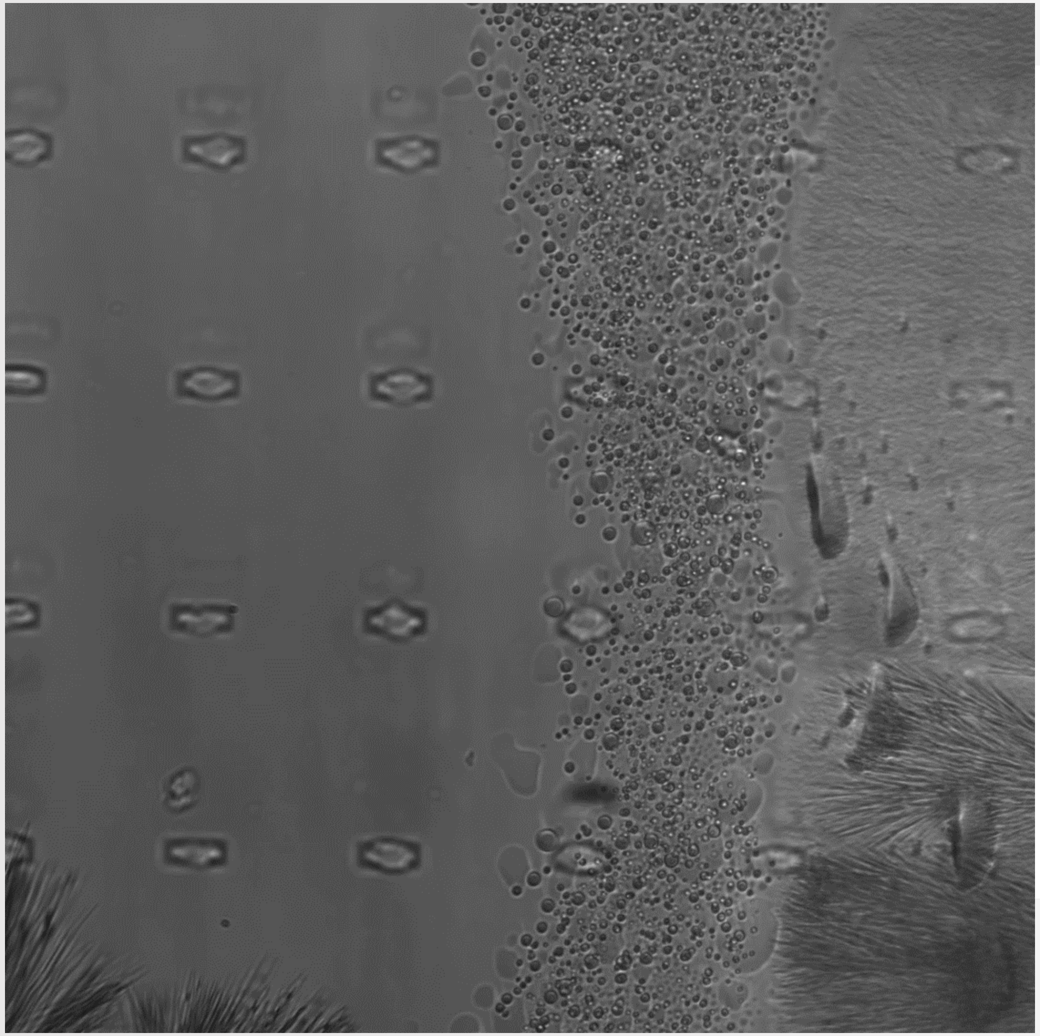


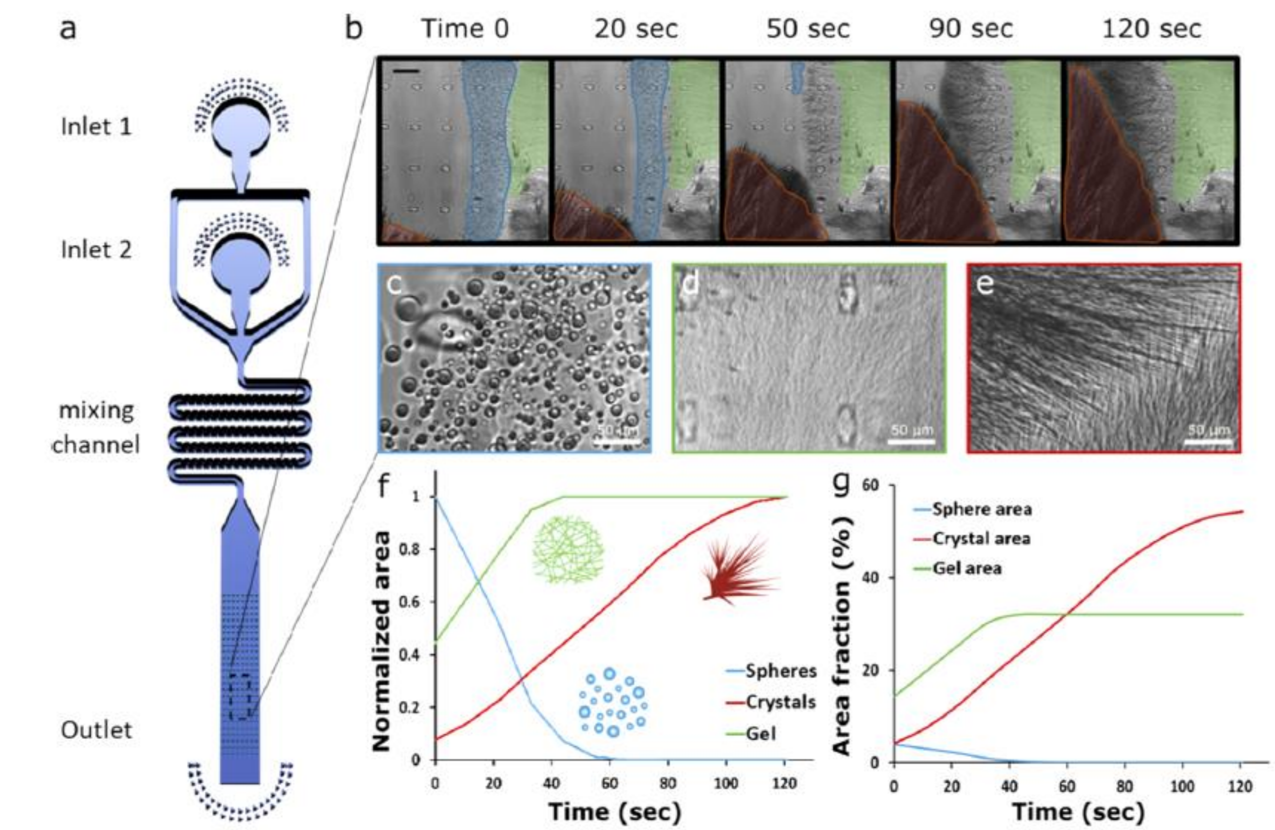




Cohen-Gerassi…Adler-Abramovich (2020) Chem. Mater

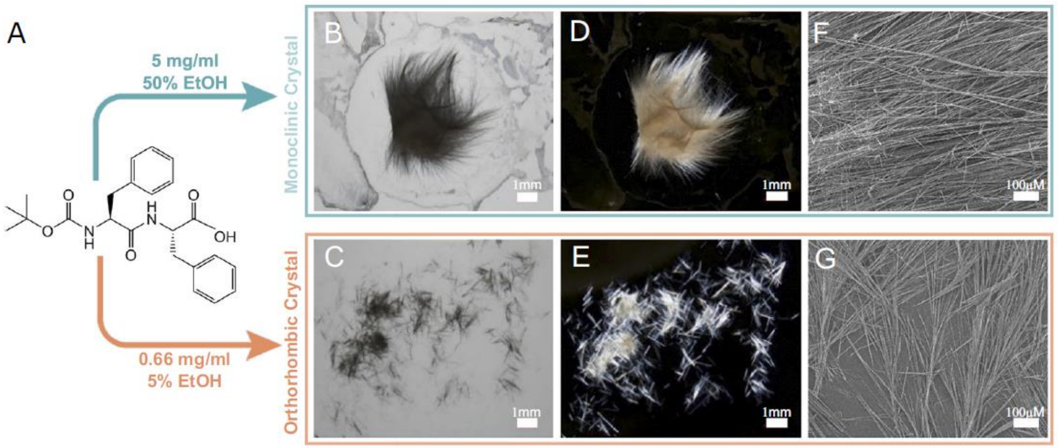
Phase Transition in Real-Time using Microfluidics

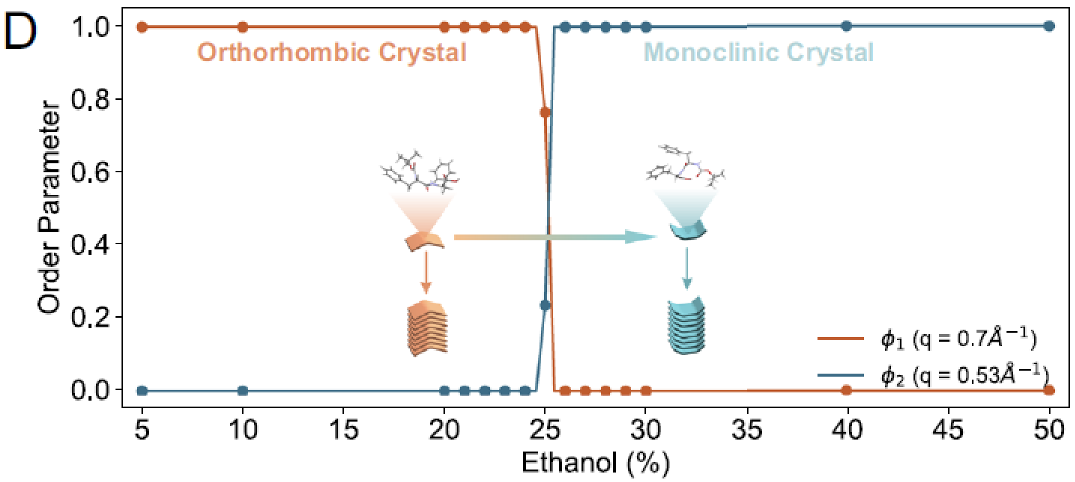


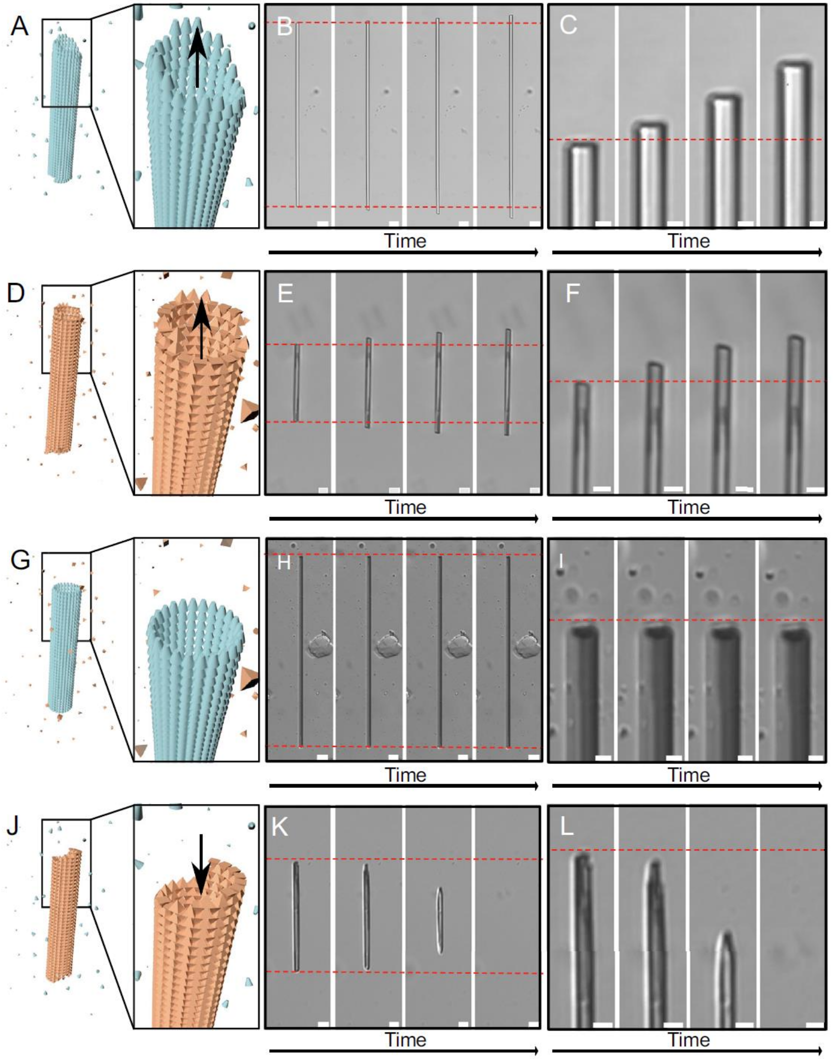


Cohen-Gerassi…Adler-Abramovich (2020) Chem. Mater

Even a 1% Change in Ethanol Concentration Can Determine the Crystalline structure







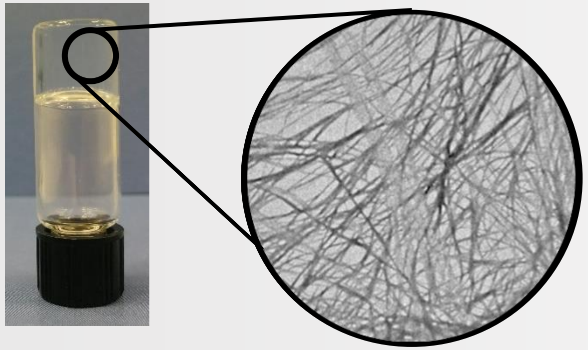
ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Dan# ,Arnon#…Adler-Abramovich (2025) Nat. Comm.

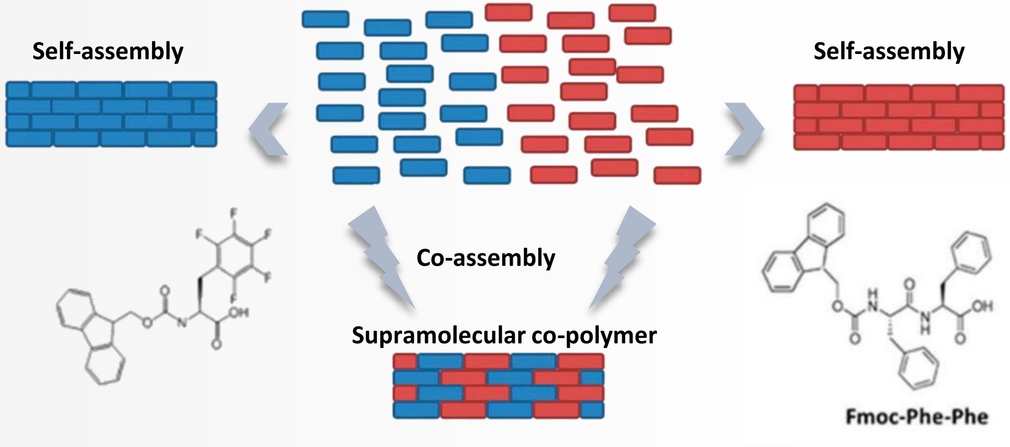
TEL AVIV UNIVERSITY
Pursuing the Unknown

Extending the Peptide Based Materials Diversity

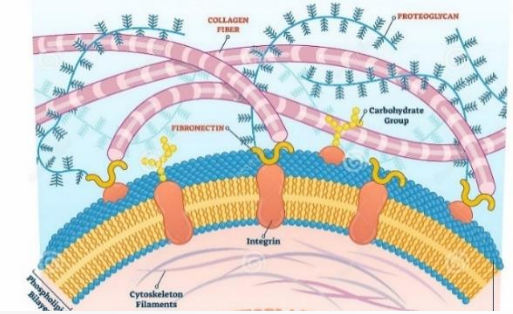
Self-assembling peptides



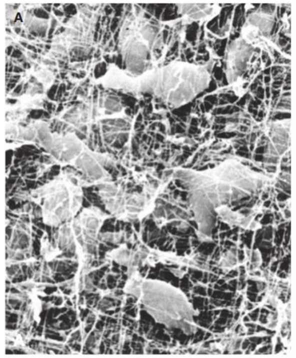
Hydrogel diversity by co-assembly



Mimicking complexed biological systems



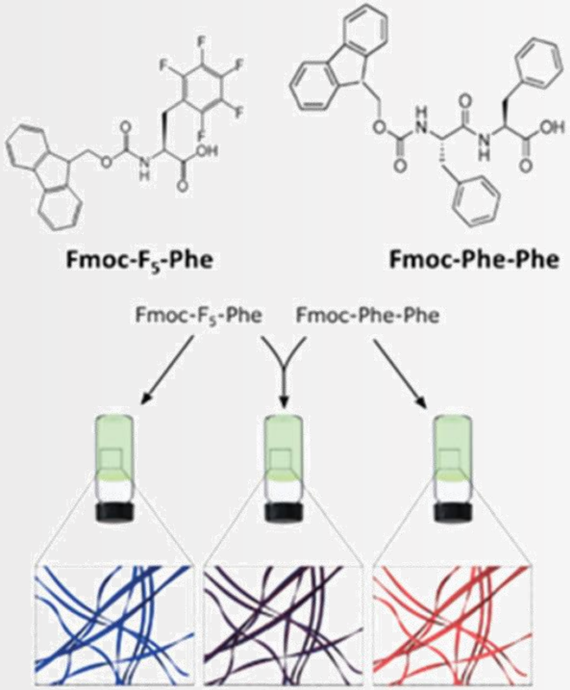
Extracellular Matrix (ECM)



Pollard, *Cell Biology*, 3rd ed.

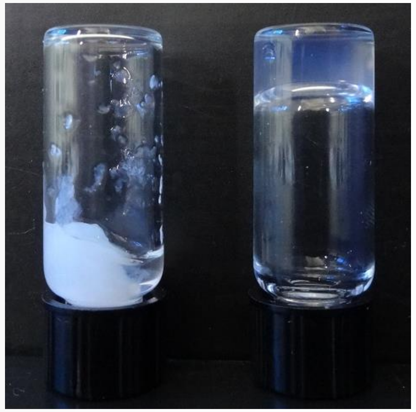
Adler-Abramovich *et al.* (2014) Chem. Soc. Rev.
Halperin…Adler-Abramovich (2017) Chem. Commun.
Ghosh… Adler-Abramovich (2017) Biomacromolecules

Stabilizing Hydrogels by Co-assembly



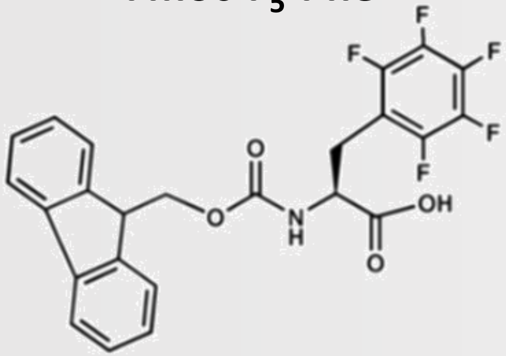
FmocFF 3:1 1:1 1:3 Fmoc-F$_5$-Phe

After 20 days



Fmoc-F$_5$-Phe 1:1

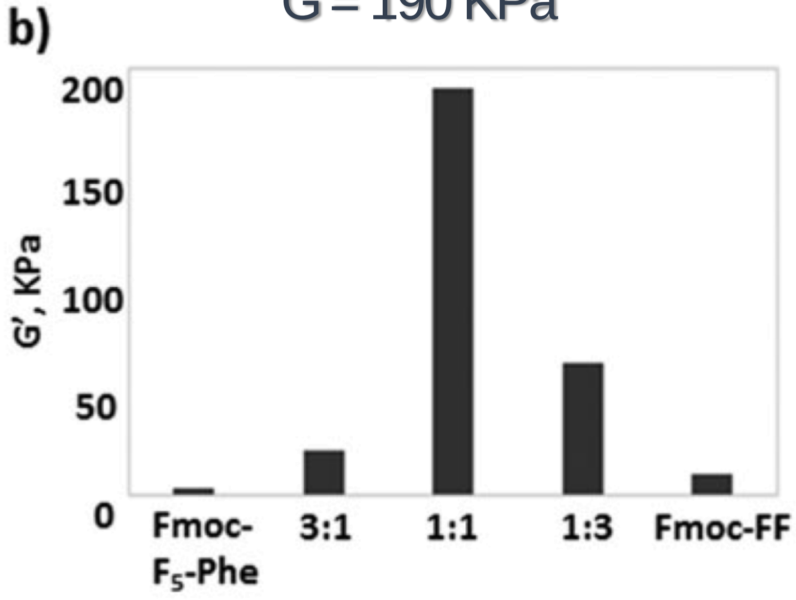
Fmoc-F$_5$-Phe

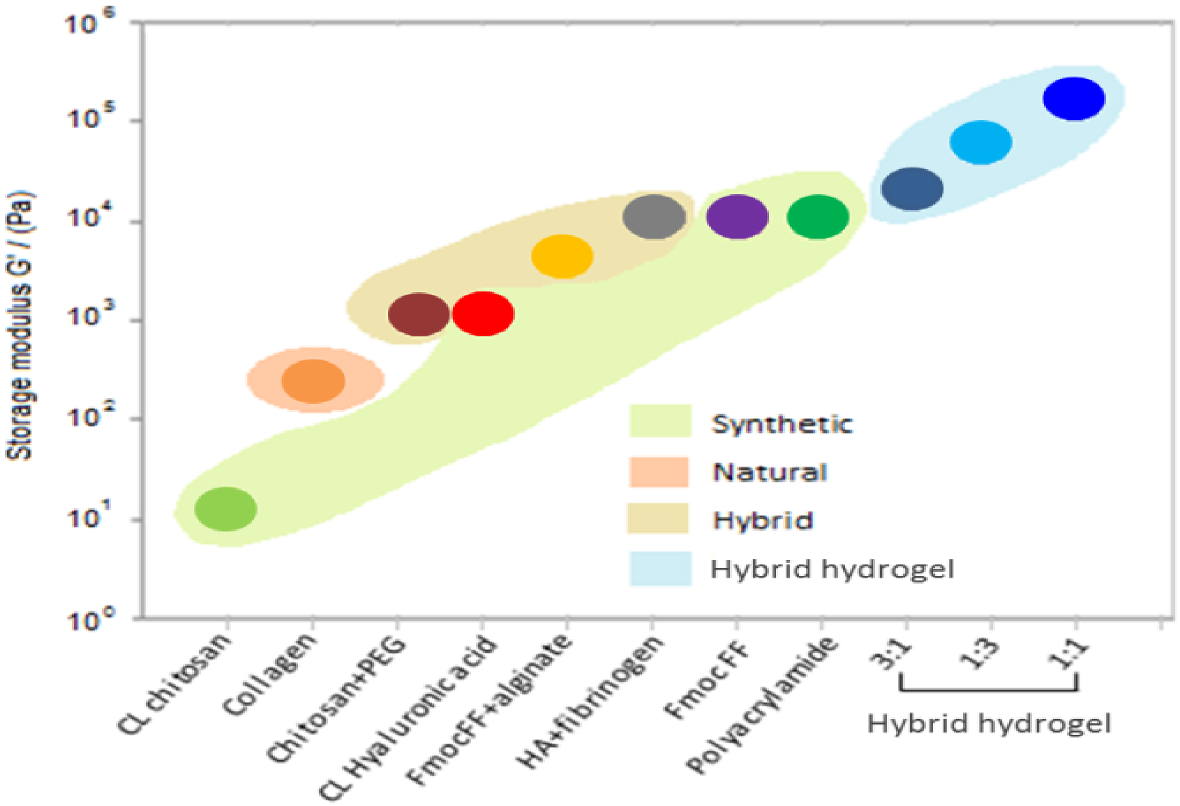


Halperin-Sternfeld*, Ghosh*…Adler-Abramovich (2017) Chem. Commun.

Exceptionally Rigid Hydrogels

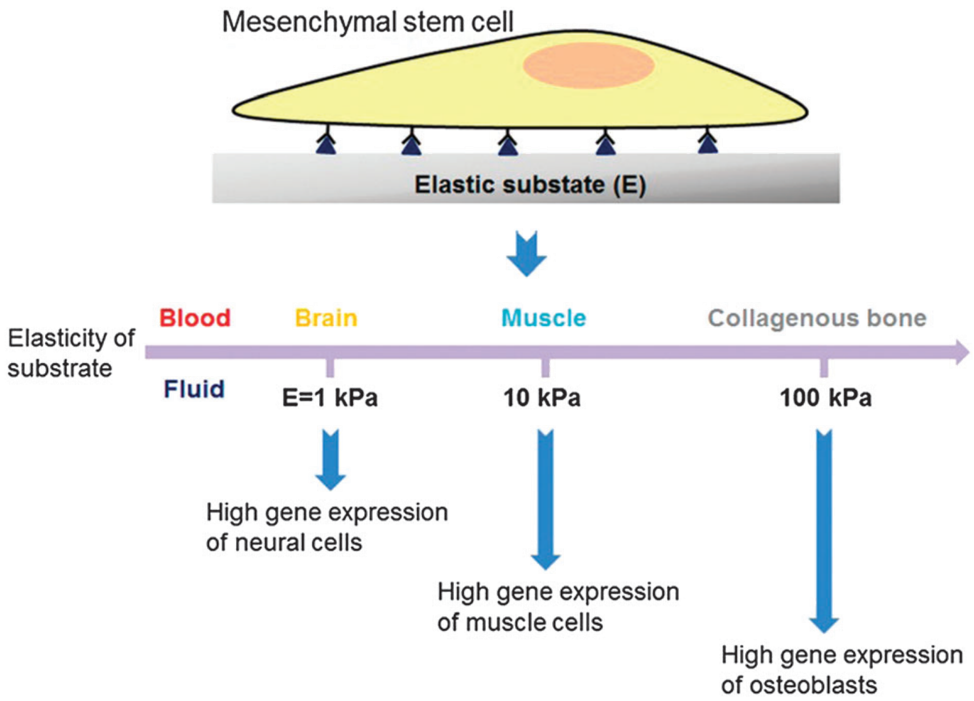
Synergistic Improvement
G'= 190 KPa

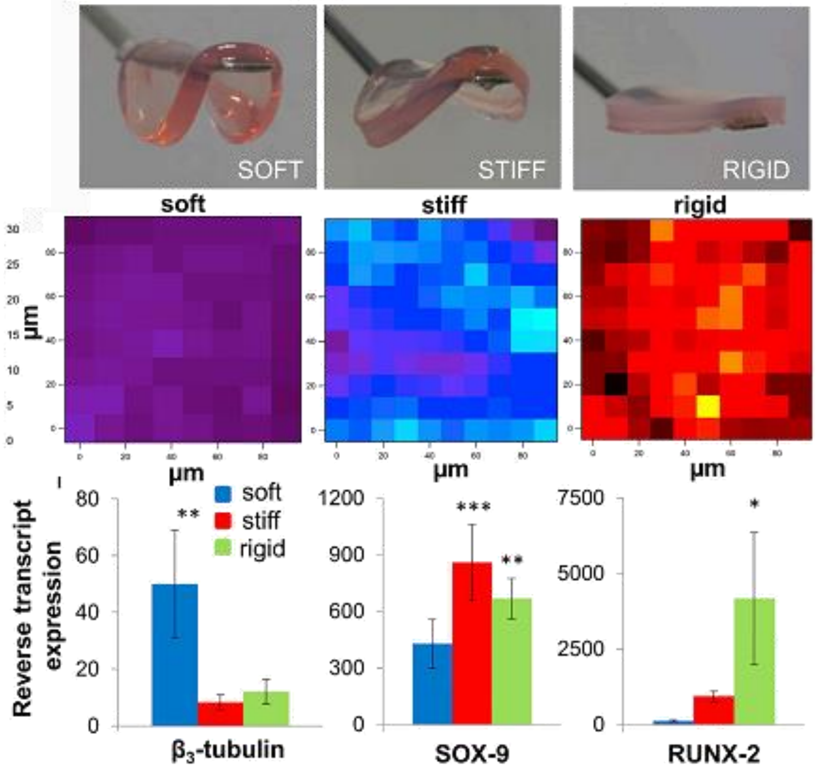




Halperin-Sternfeld*, Ghosh*…Adler-Abramovich (2017) Chem. Commun.

Stem Cell Differentiation and Mechano-Sensing

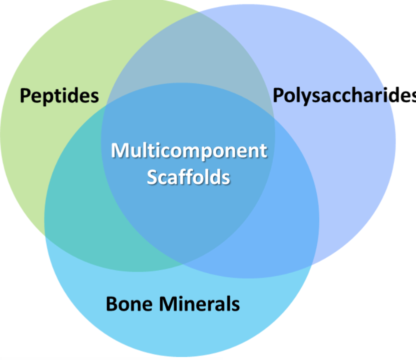


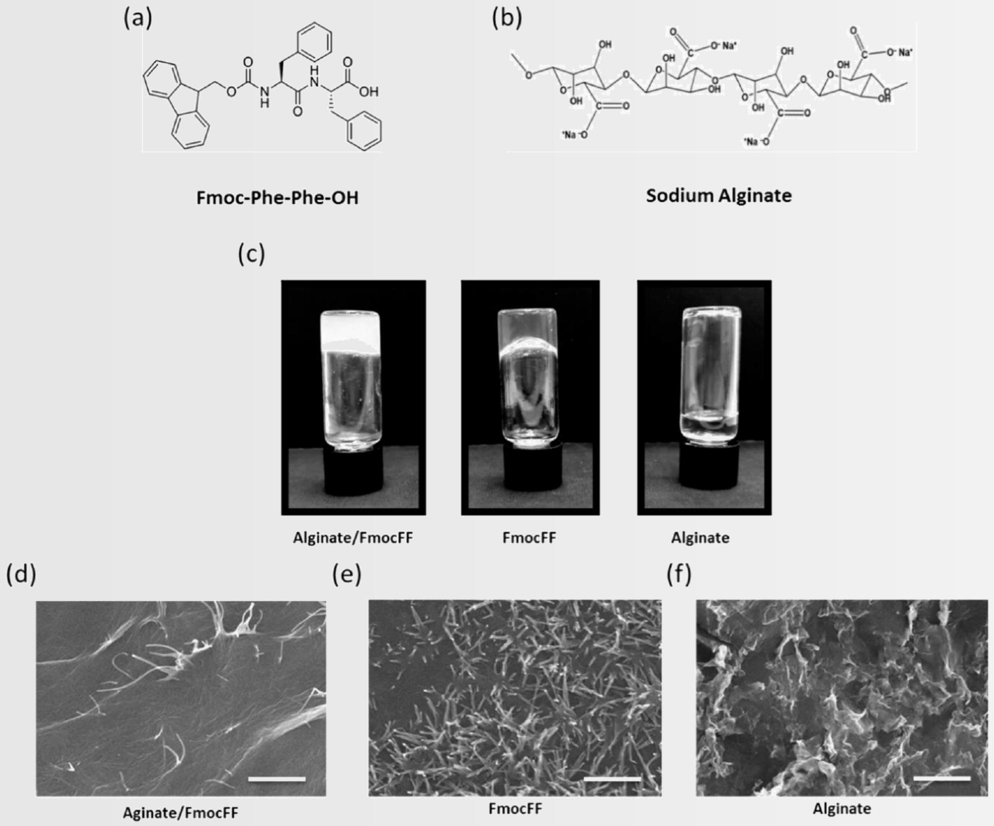


Engler *et al.* Discher. (2006) Cell
Higuchi *et al.* (2012) Chem. Rev.

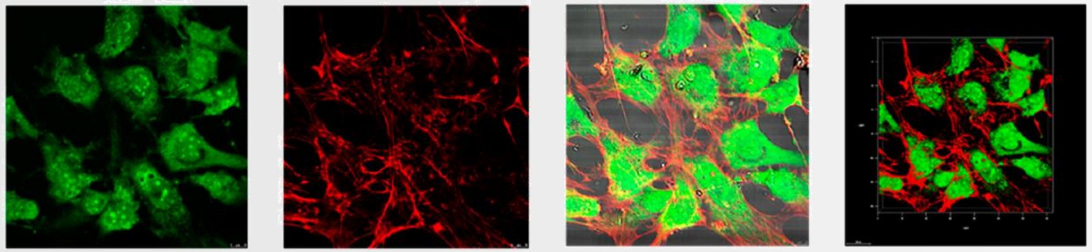
Alakpa…Ulijn (2016) Chem

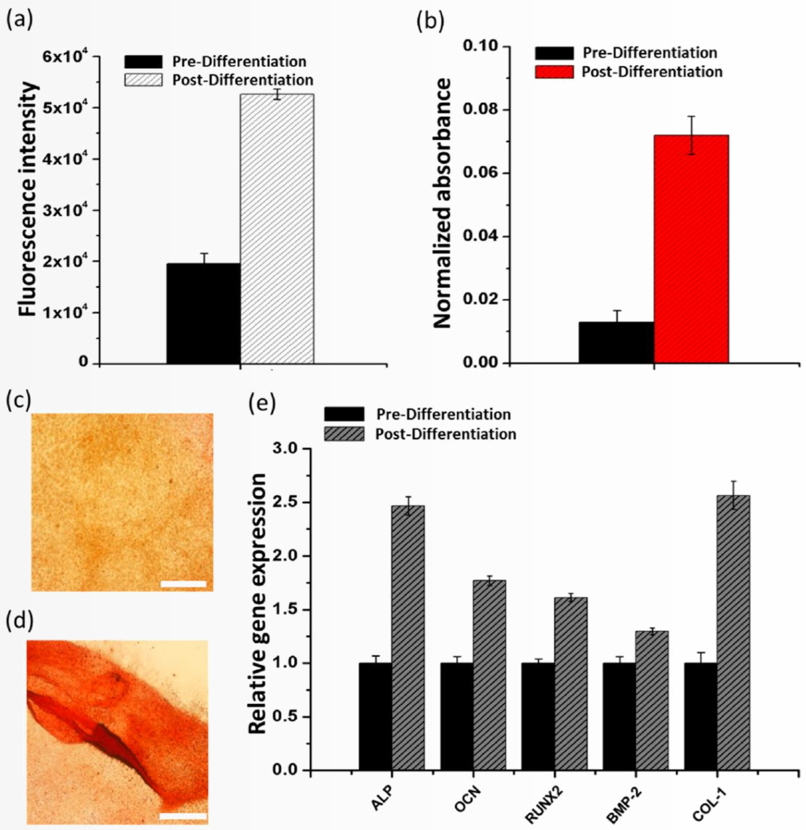
Alginate-Peptide Composite Hydrogel





MC3T3-E1 cells on Alginate/FmocFF Composite gel





ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Ghosh*, Halperin-Sternfeld*…Adler-Abramovich (2019) Nanomaterials

TEL AVIV UNIVERSITY
Pursuing the Unknown

Hyaluronic Acid in Medical Use

Orthopedics

EUFLEXXA® is injected into the knees of osteoarthritis patients to improve movement and reduce pain

Cosmetics treatments

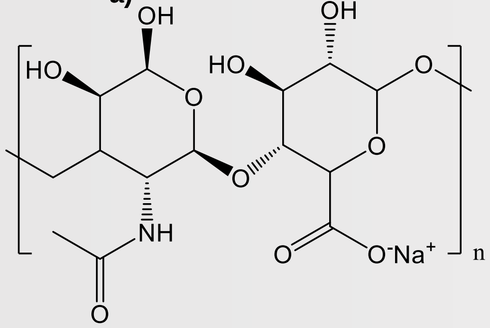
- ButaneDiol Diglycidyl Ether (BDDE) crosslinking
- Residual BDDE $<$ 2 ppm (FDA limit)
- Storage modulus, G’ up to 1,000 Pa

The problem: limited durability

Control of Hydrogel Rigidity and Durability

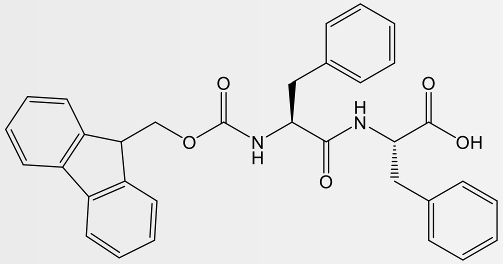
FmocFF/hyaluronic acid composite hydrogel

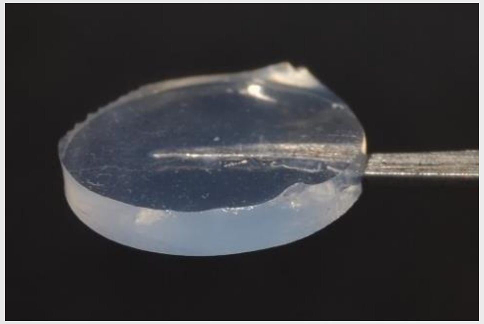
a)

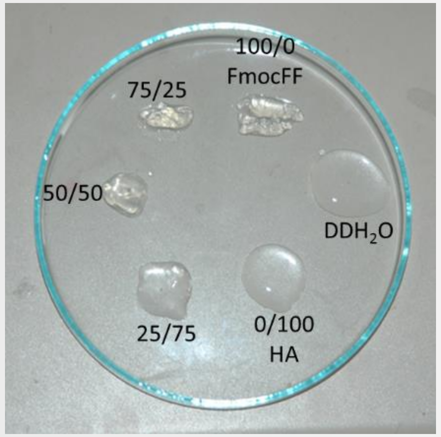


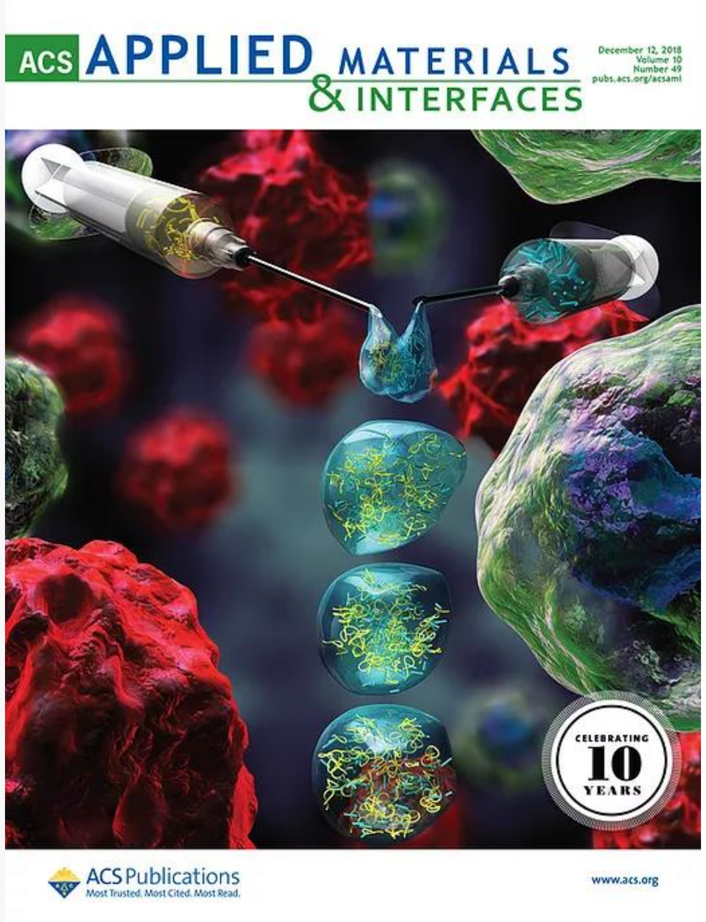
N-acetyl-glucosamine Glucuronic acid

b)





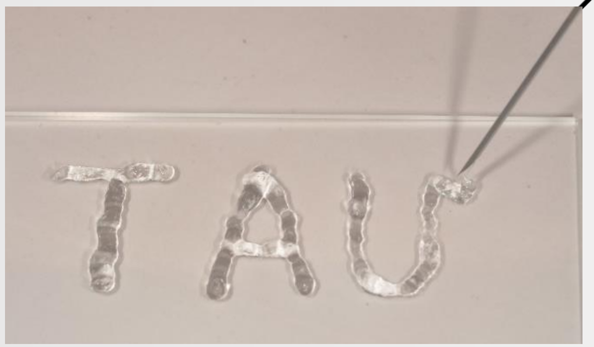




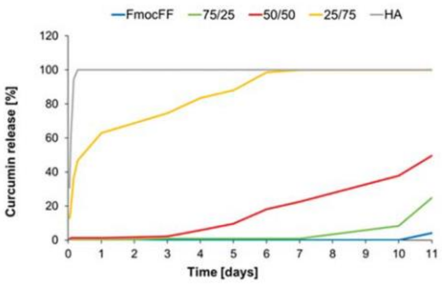
Aviv*, Halperin-Sternfeld*…Adler-Abramovich (2018) ACS Appl. Mater. Interfaces

Injectable Dermal Filler for Soft Tissue Repair

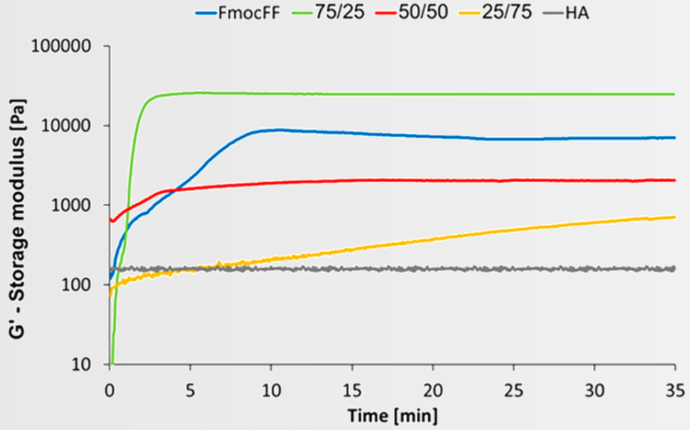
Injectable hydrogels



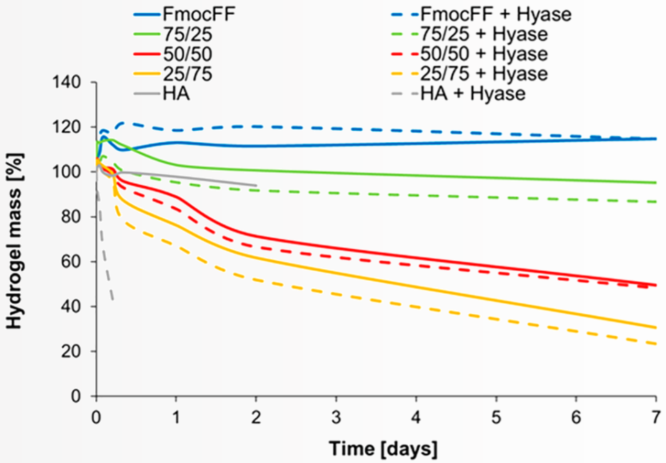
Slow release of Curcumin



Mechanical properties



Hydrogel stability against hyaluronidase



ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

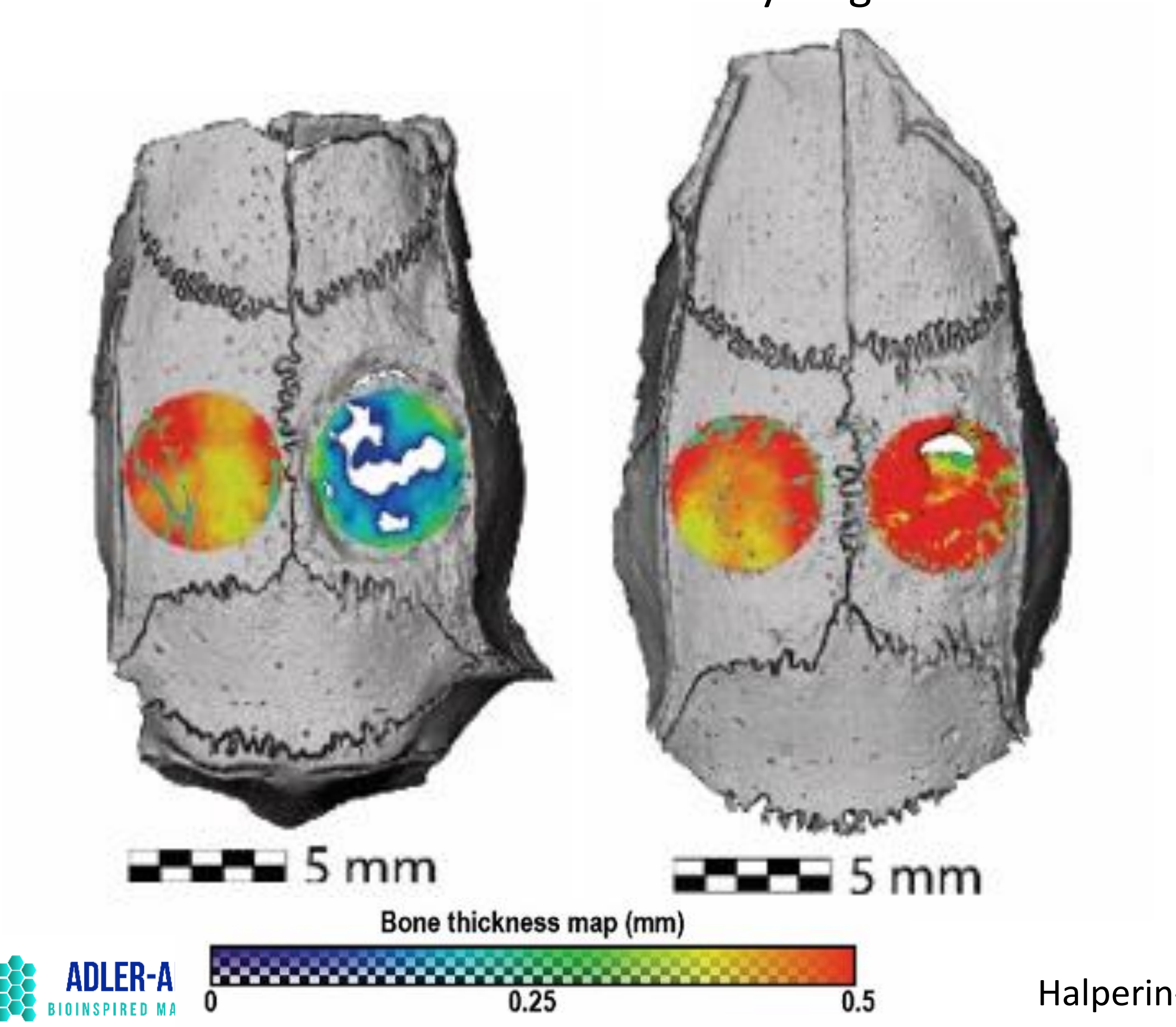
Aviv*, Halperin-Sternfeld*…Adler-Abramovich (2018) ACS Appl. Mater. Interfaces

TEL AVIV UNIVERSITY
Pursuing the Unknown

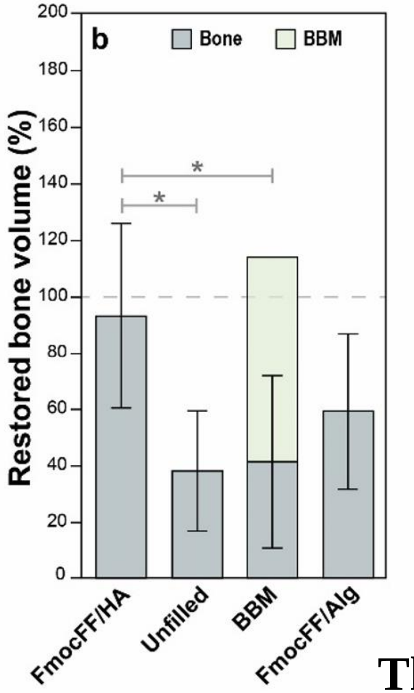
Injectable Hydrogel for Bone Regeneration

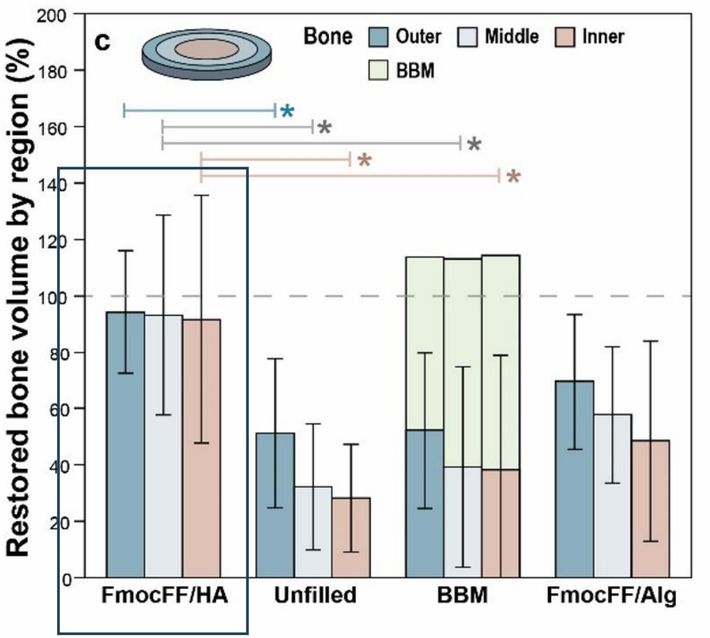
In collaboration with Prof. Rachel Sarig

Sham Hydrogel

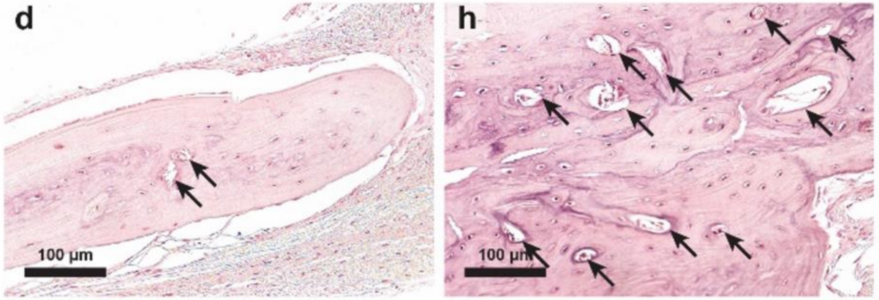


The hydrogel treatment resulted in approximately 93% bone restoration





The hydrogel promote bone regeneration in the middle of the defect

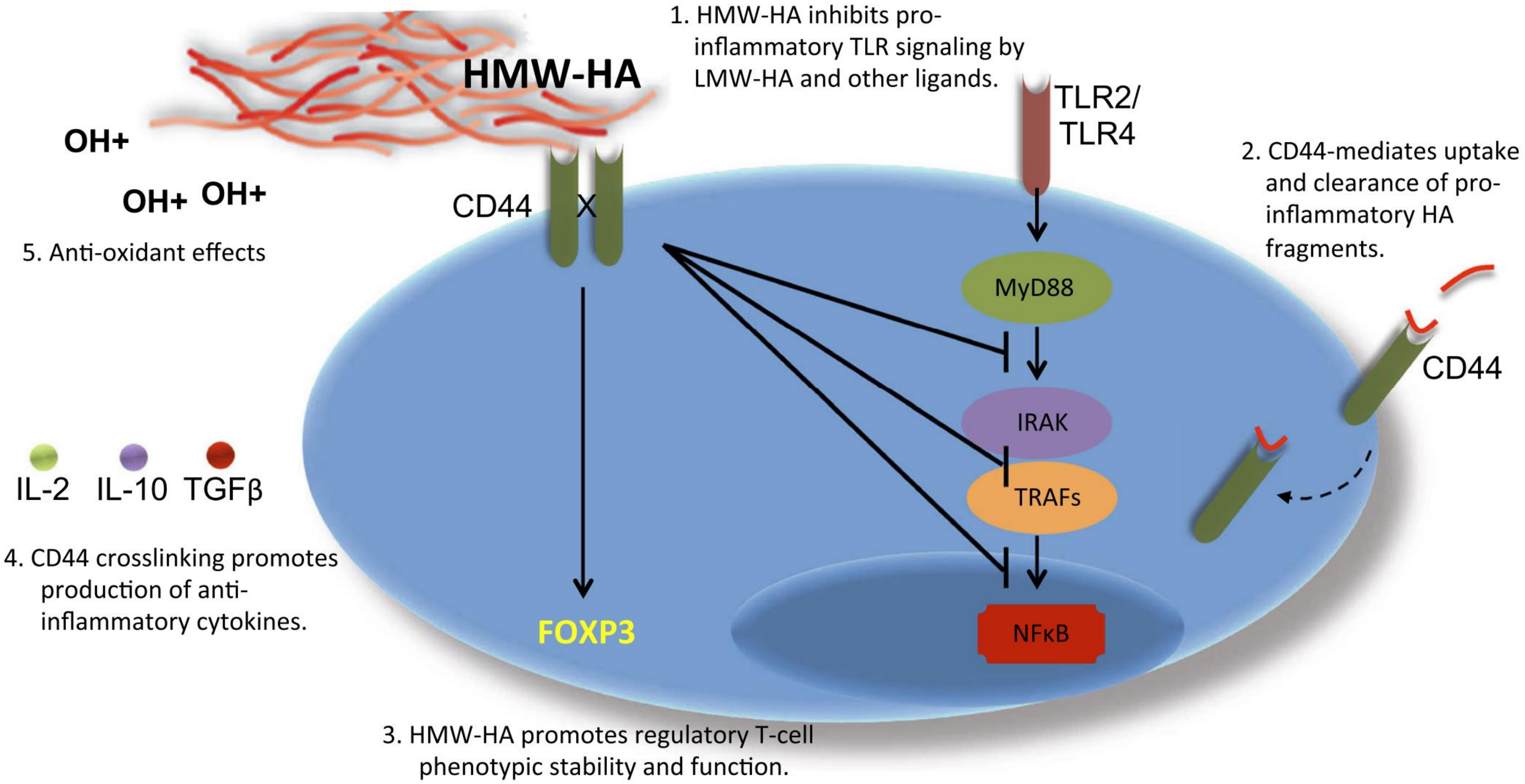


Halperin-Sternfeld... Adler-Abramovich (2023) J. Clin. Periodontol.

ADLER-A BIOINSPIRED MA

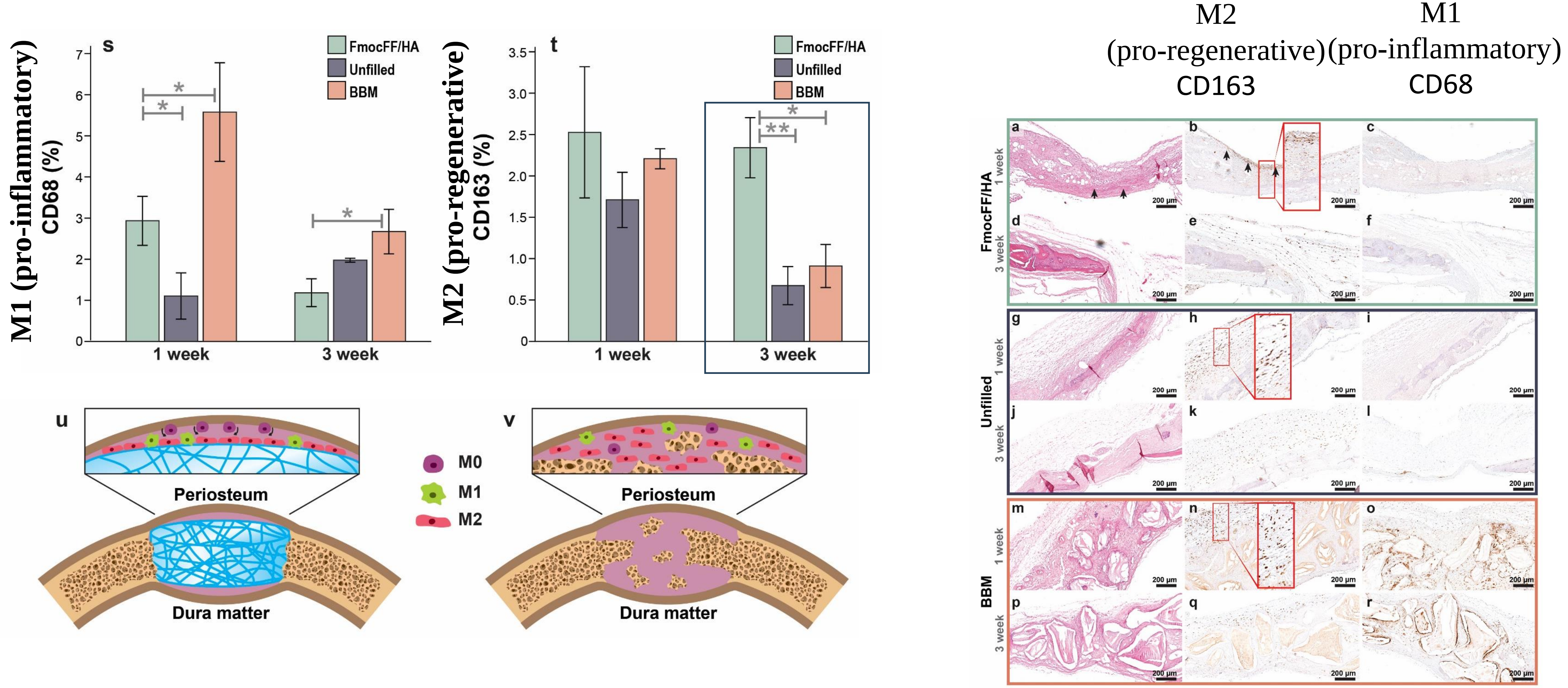
TEL AVIV UNIVERSITY Pursuing the Unknown

High Molecular Weight HA Interacts with CD44 Receptor and Promotes Production of Anti-inflammatory Cytokines



Immunol Res (2014) 58:186–192

The Biomaterials cause Macrophages Immunomodulation- M1 (pro-inflammatory) to M2 (pro-regenerative)



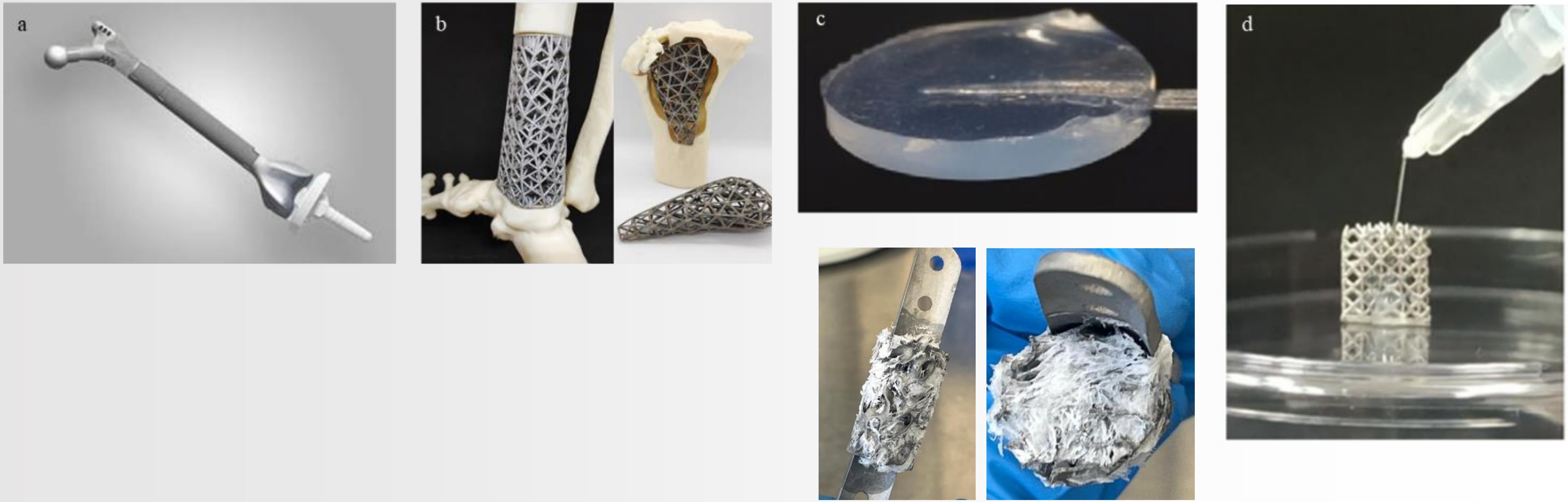
ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Halperin-Sternfeld… Adler-Abramovich (2023) J. Clin. Periodontol.

TEL AVIV UNIVERSITY
Pursuing the Unknown

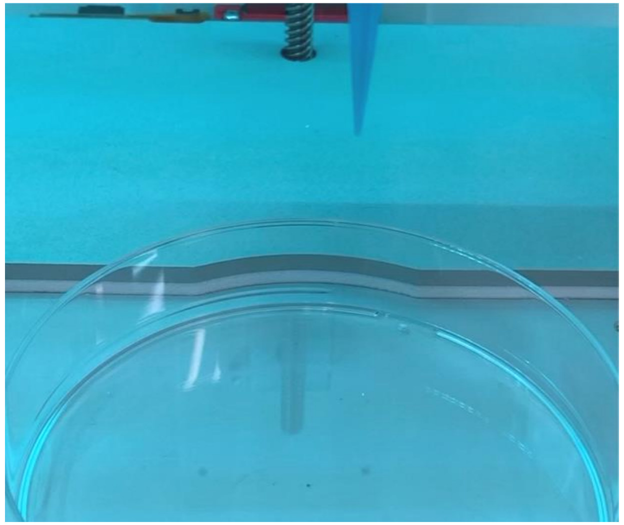
Bioactive Patient-specific Titanium "Cage" Implants

In collaboration with Dr. Solomon Dadia, the Levin Center for 3D Printing and Surgical Innovation, Tel Aviv Sourasky Medical Center

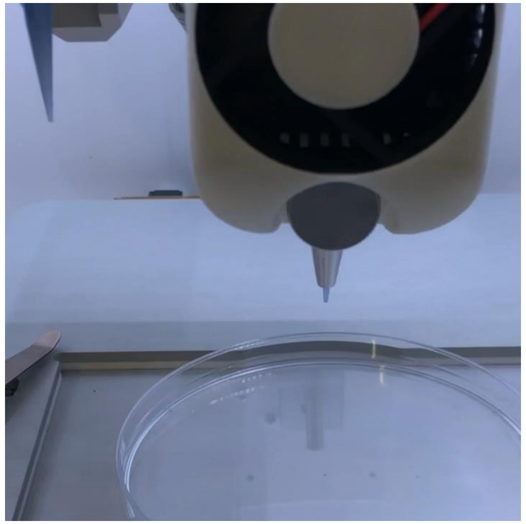


Rattner…Adler-Abramovich (2025) Submitted

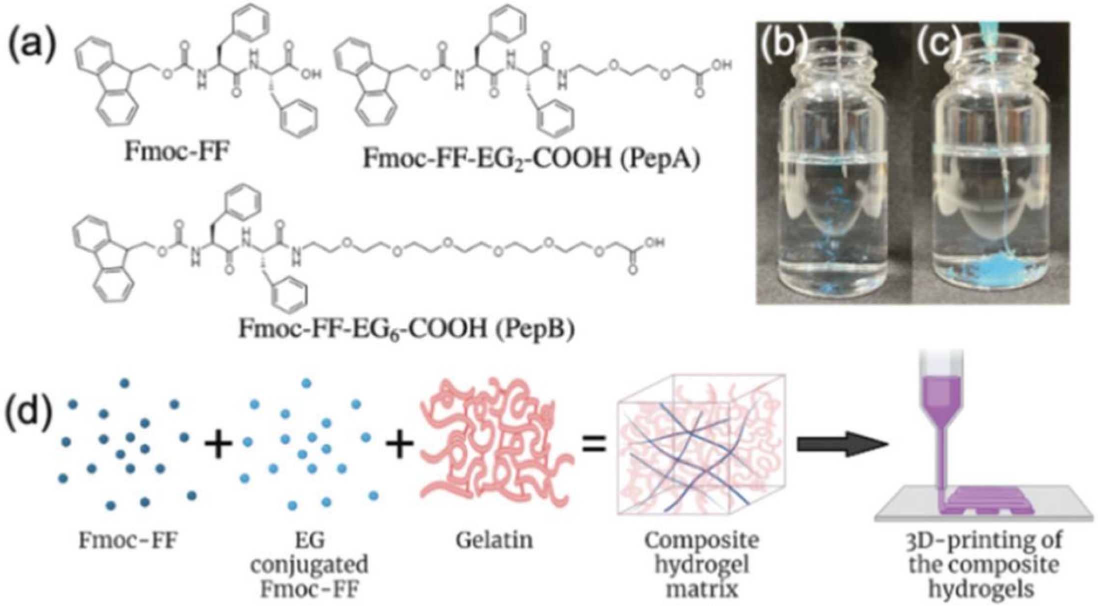
3D Printing of the Scaffolds



1:1 Fmoc-FF:Pepβ Hydrogel

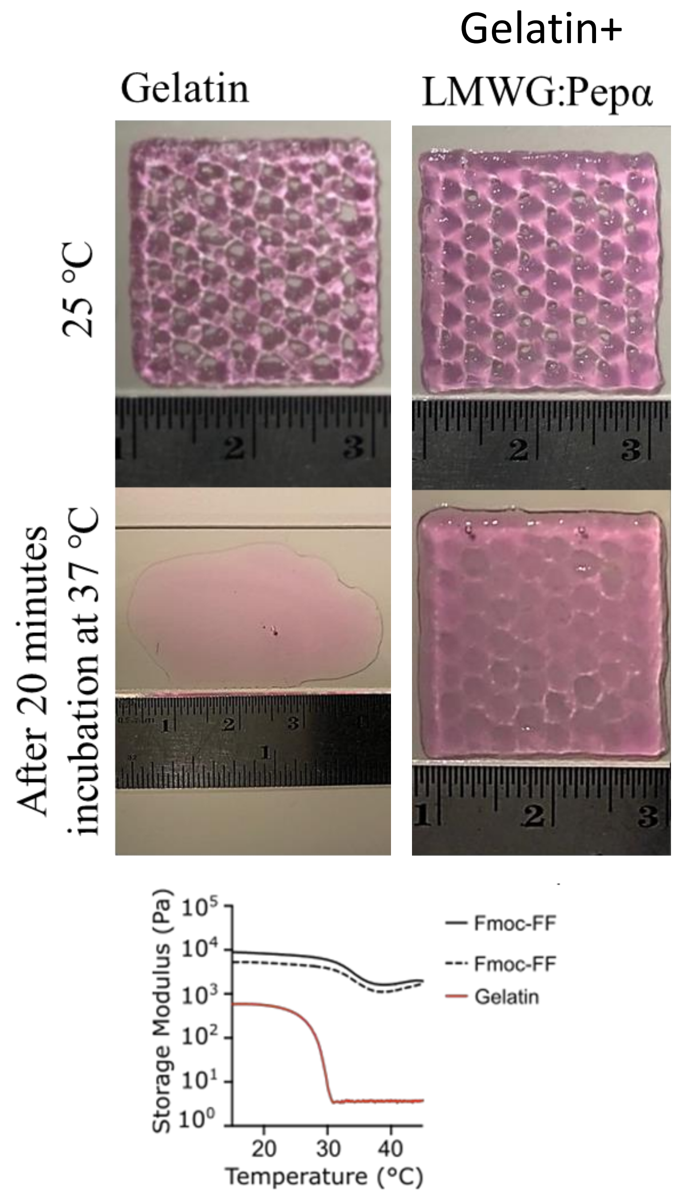


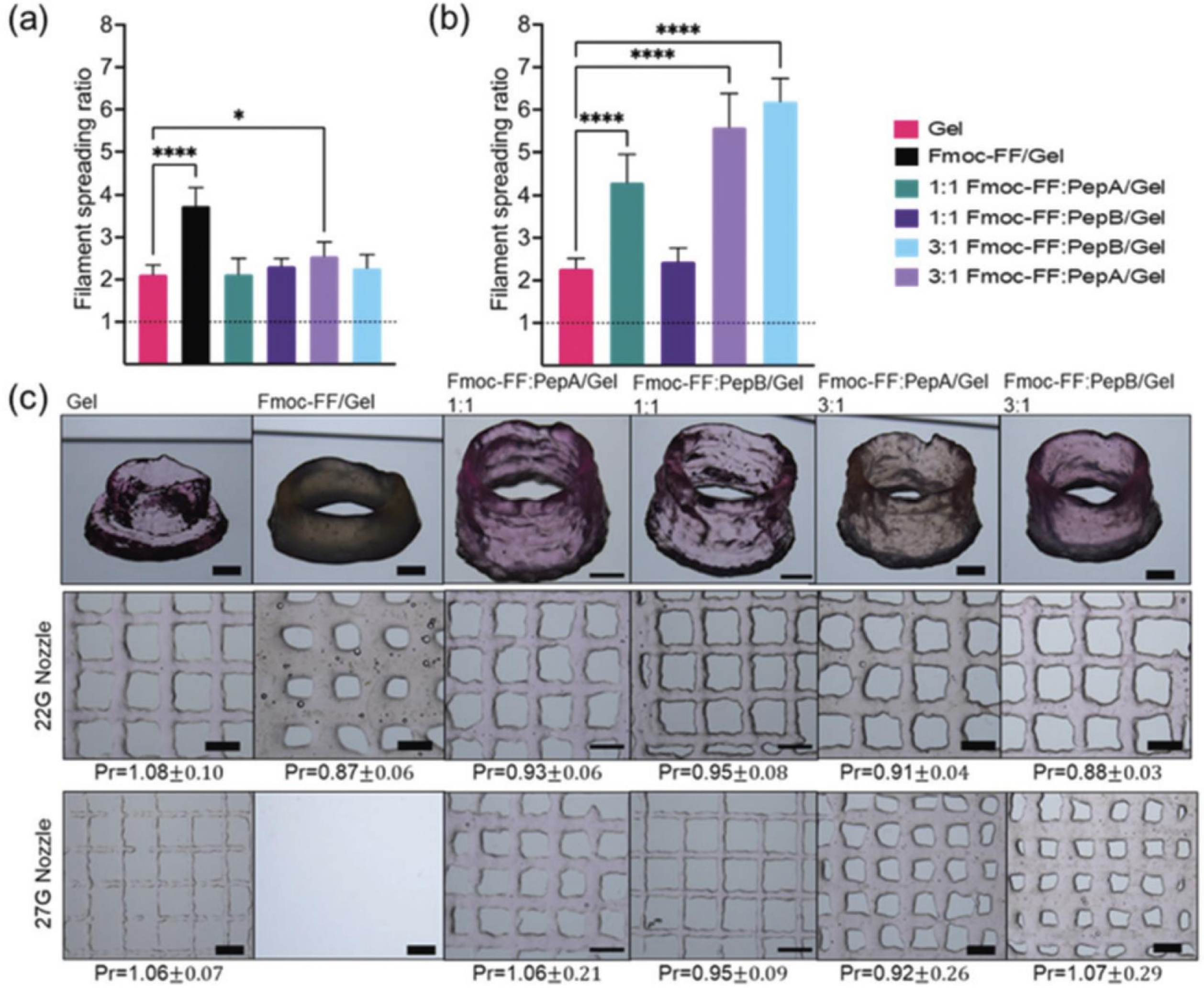
1:1 Fmoc-FF:Pepβ/Gelatin Hydrogel



Netti…Adler-Abramovich (2022) Nanoscale

Ethylene-Glycol Conjugated Peptide Hydrogels



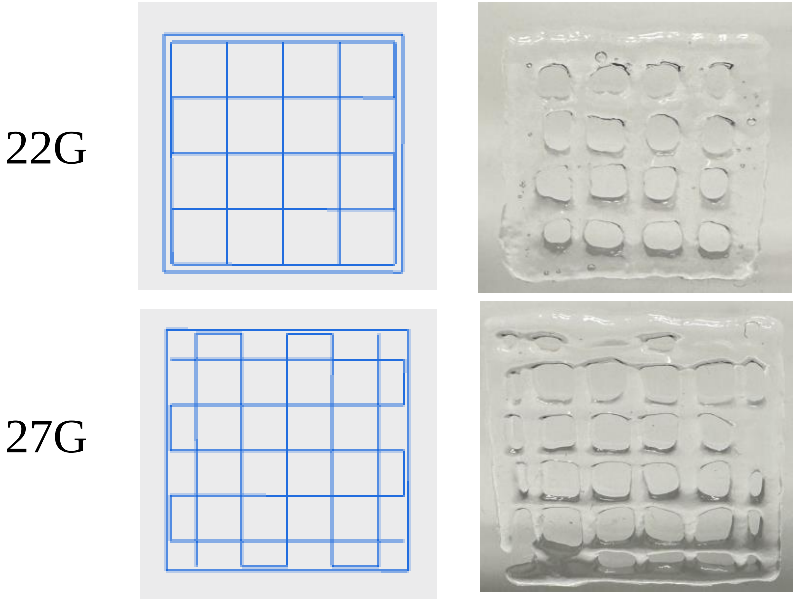


Netti…Adler-Abramovich (2022) Nanoscale

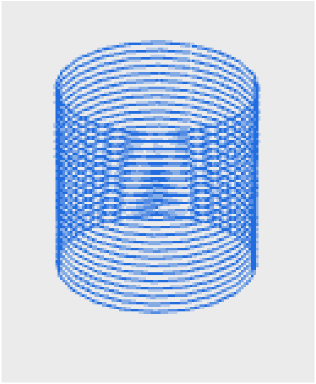
TEL AVIV UNIVERSITY
Pursuing the Unknown

Bioink 3D-printability

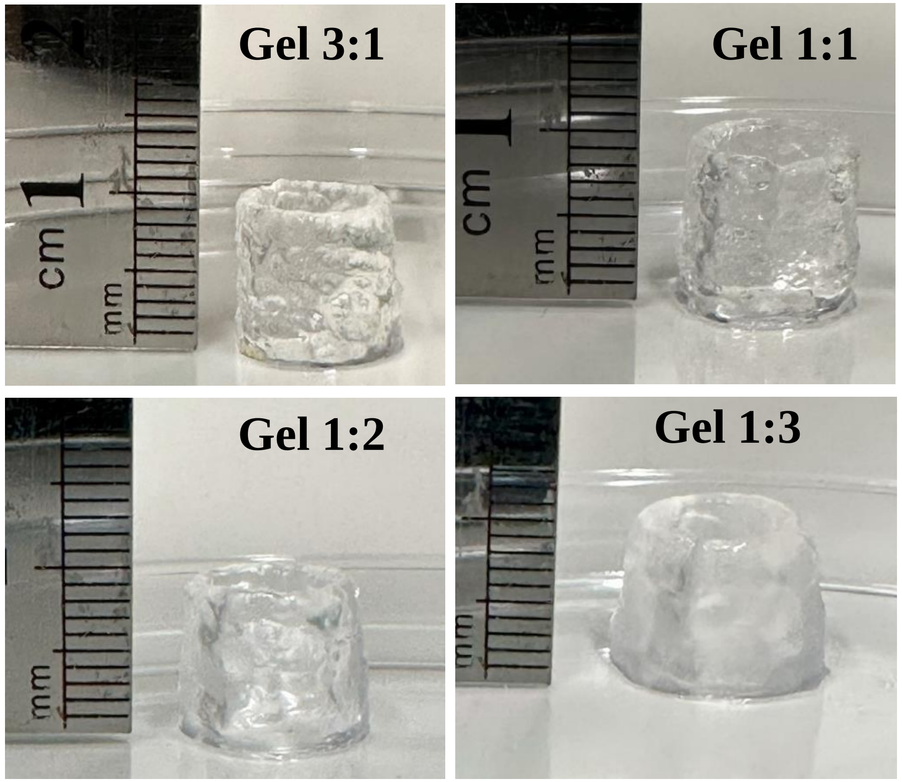
Testing different gauge capacity



24 layers

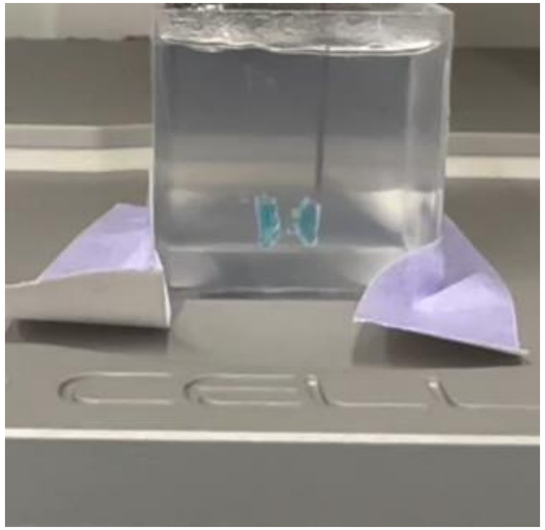


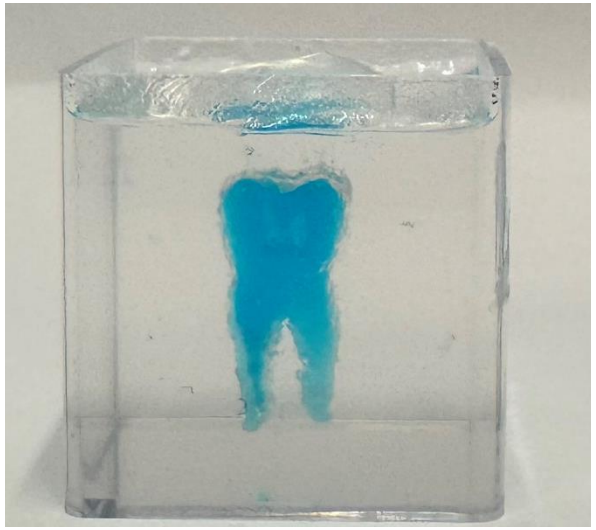
Testing self support properties

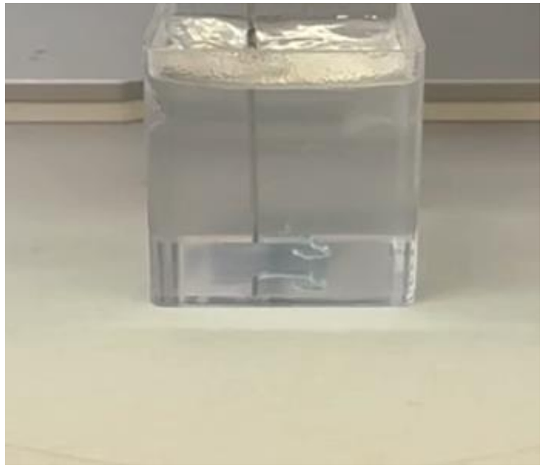


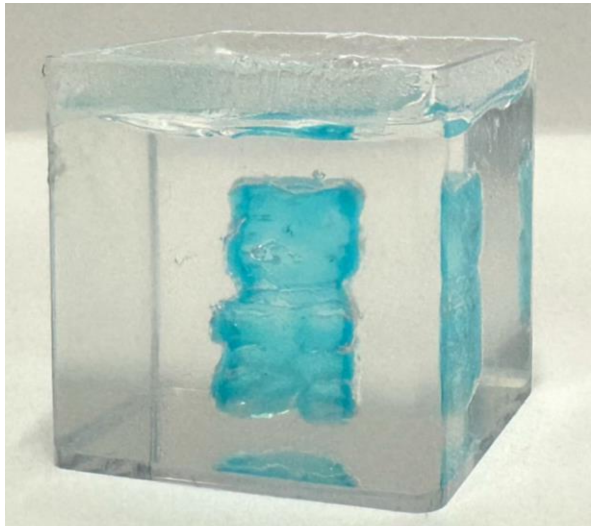
Netti…Adler-Abramovich (2025) Under review

3D printing of more complex constructs in suspension media









Netti…Adler-Abramovich (2025) Under review

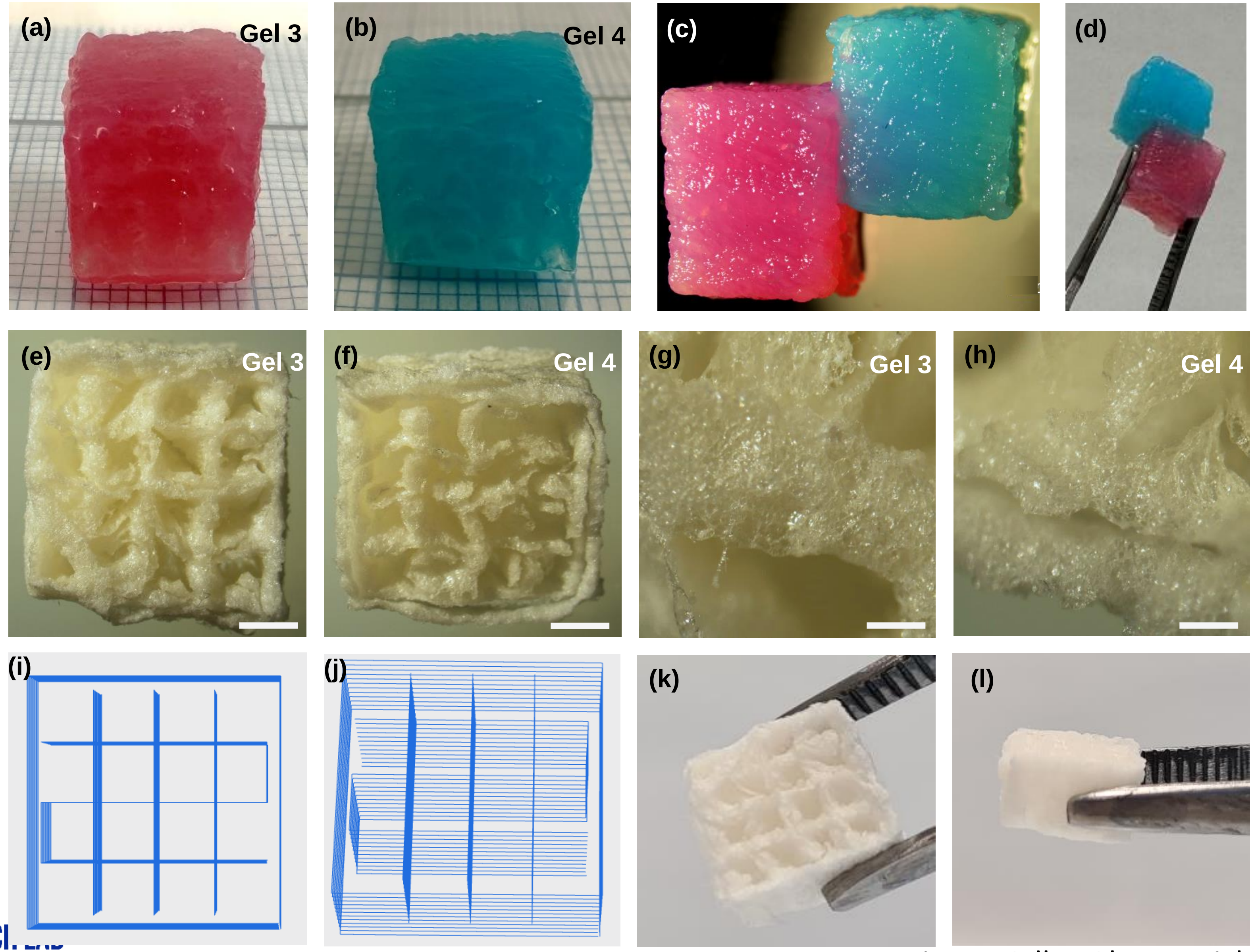
3D printing of a mandible defect

ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Netti…Adler-Abramovich (2025) Under review

TEL AVIV UNIVERSITY
Pursuing the Unknown

3D-printability and Self Assembly of Antimicrobial Peptides



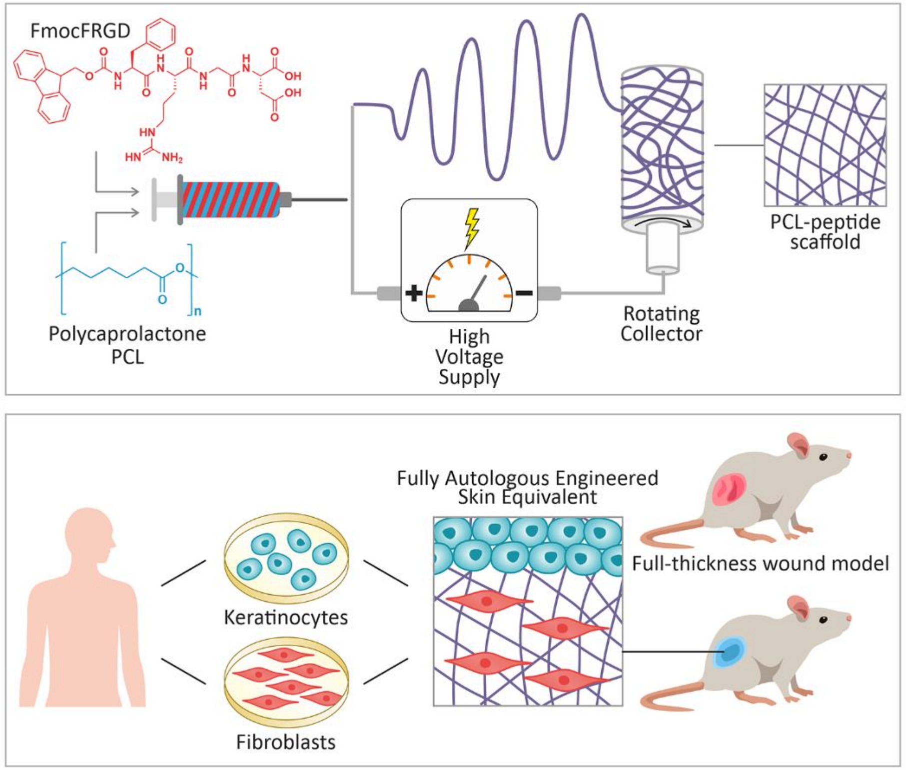
ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

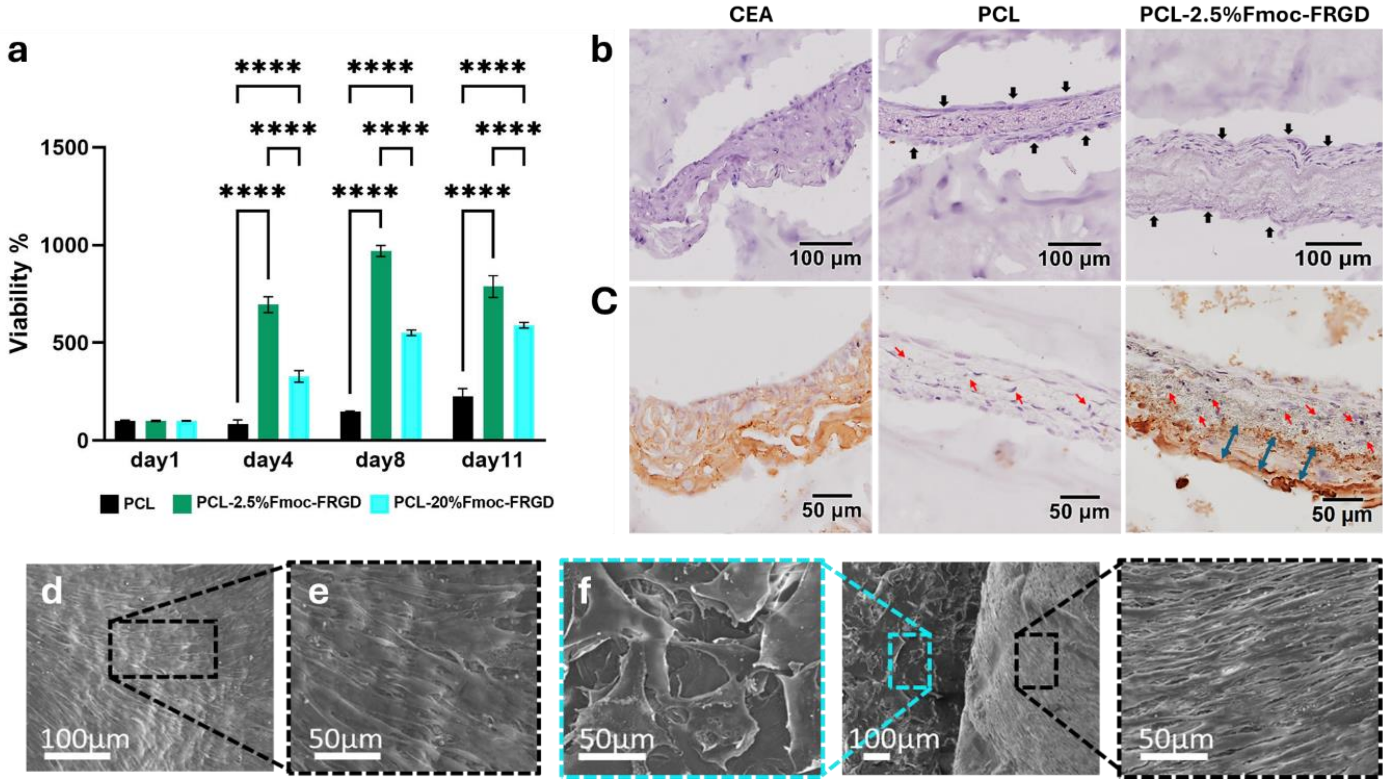
Tsuriano…Adler-Abramovich (2025) Submitted

TEL AVIV UNIVERSITY
Pursuing the Unknown

Autologous Electrospun Polymer-Peptide Skin Equivalent for Severe Burn Injuries

In collaboration with Amit Sitt and the Kaufman-Green Skin Graft Engineering Center in Sheba Hospital

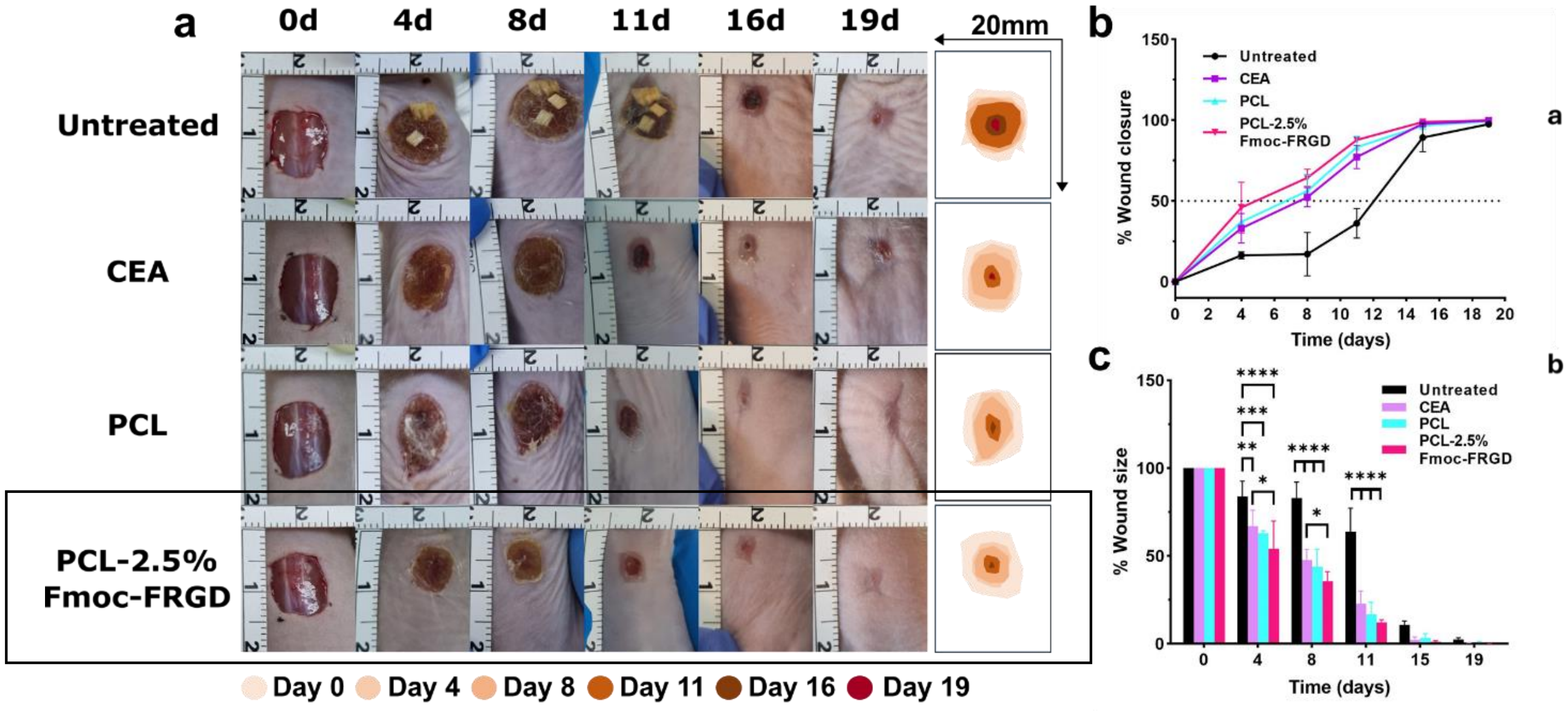


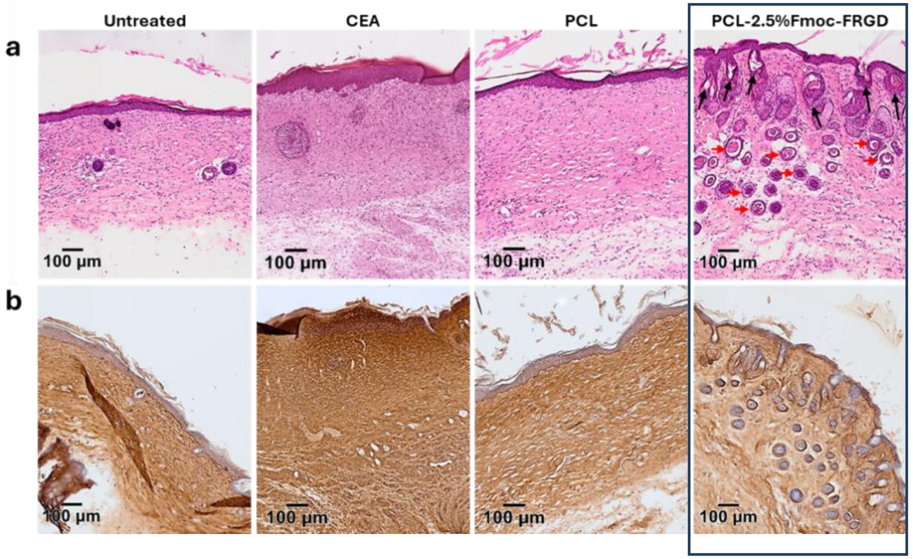


Cohen-Gerassi, et al., (2025) Adv. Funct. Mater.

Autologous Electrospun Polymer-Peptide Skin Equivalent for Severe Burn Injuries

In collaboration with Amit Sitt and the Kaufman-Green Skin Graft Engineering Center in Sheba Hospital





T_{50}=12 days was improved to T_{50}=4 days

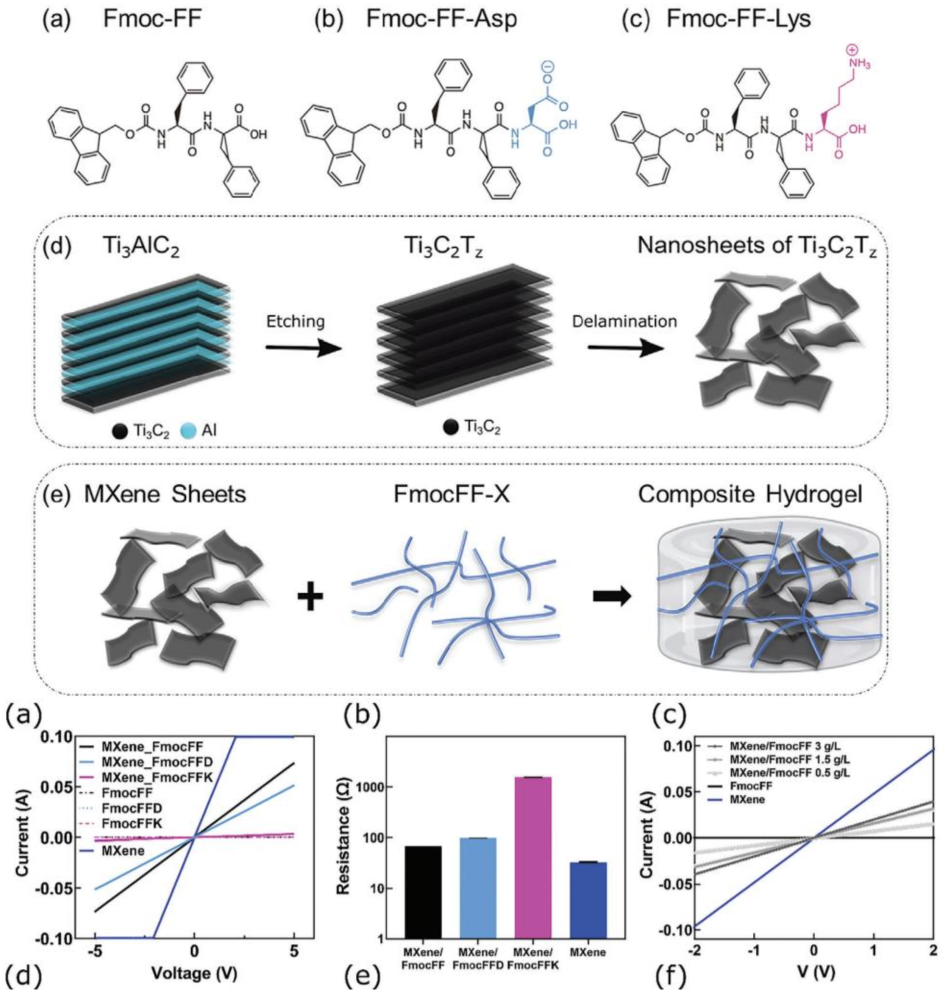
ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

Cohen-Gerassi, et al., (2025) Adv. Funct. Mater.

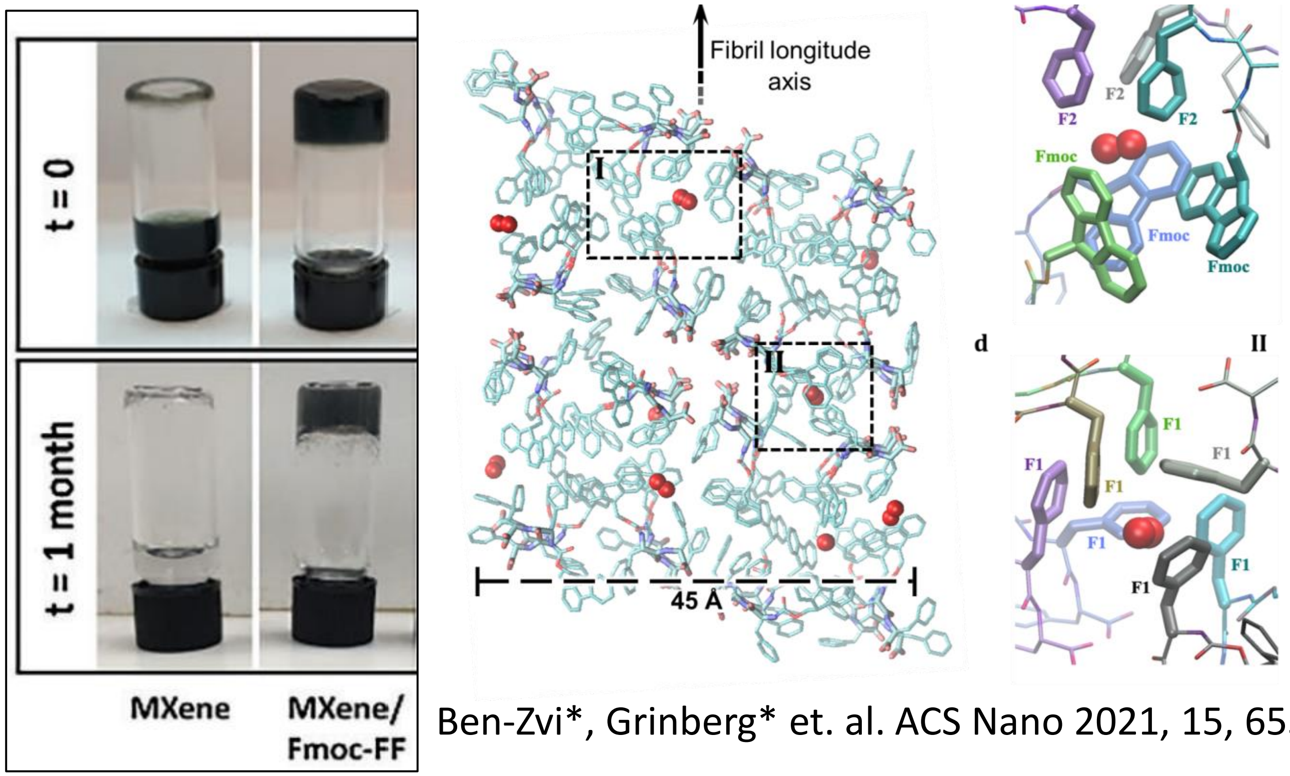
TEL AVIV UNIVERSITY
Pursuing the Unknown

Conductive Peptide-Based MXene Hydrogel as a Piezoresistive Sensor

In collaboration with Maxim Sokol (TAU)



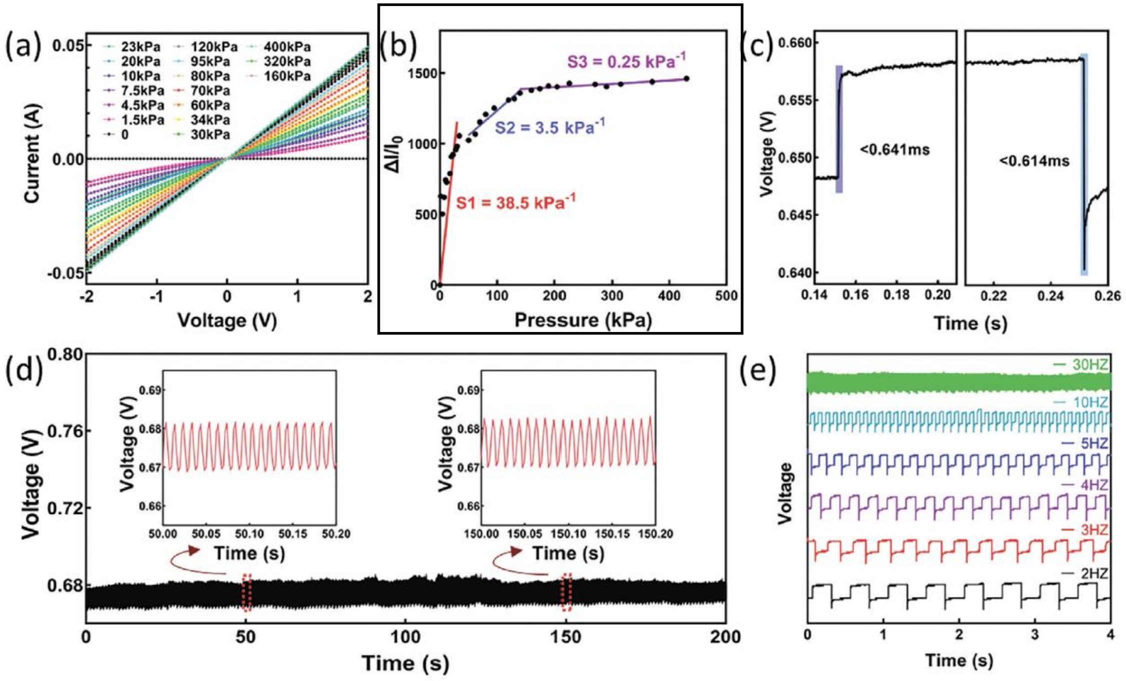
In collaboration with Phanourios Tamamis
Texas A&M

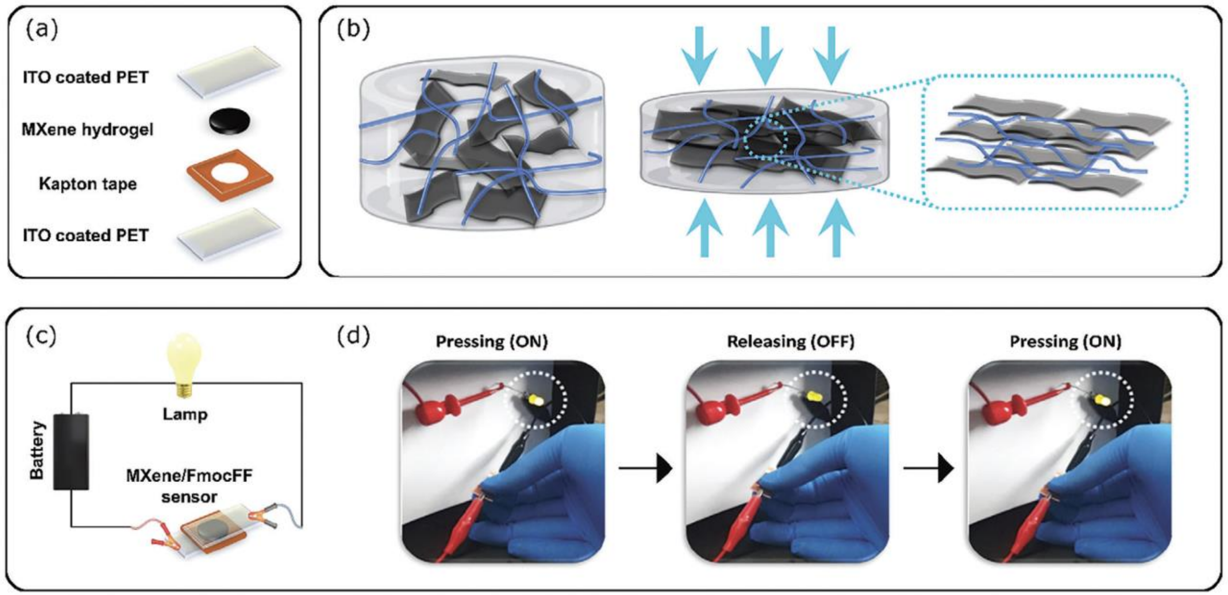


Ben-Zvi*, Grinberg* et. al. ACS Nano 2021, 15, 6530

Cohen-Gerassi…Adler-Abramovich (2024) Adv. Healthcare Mater.

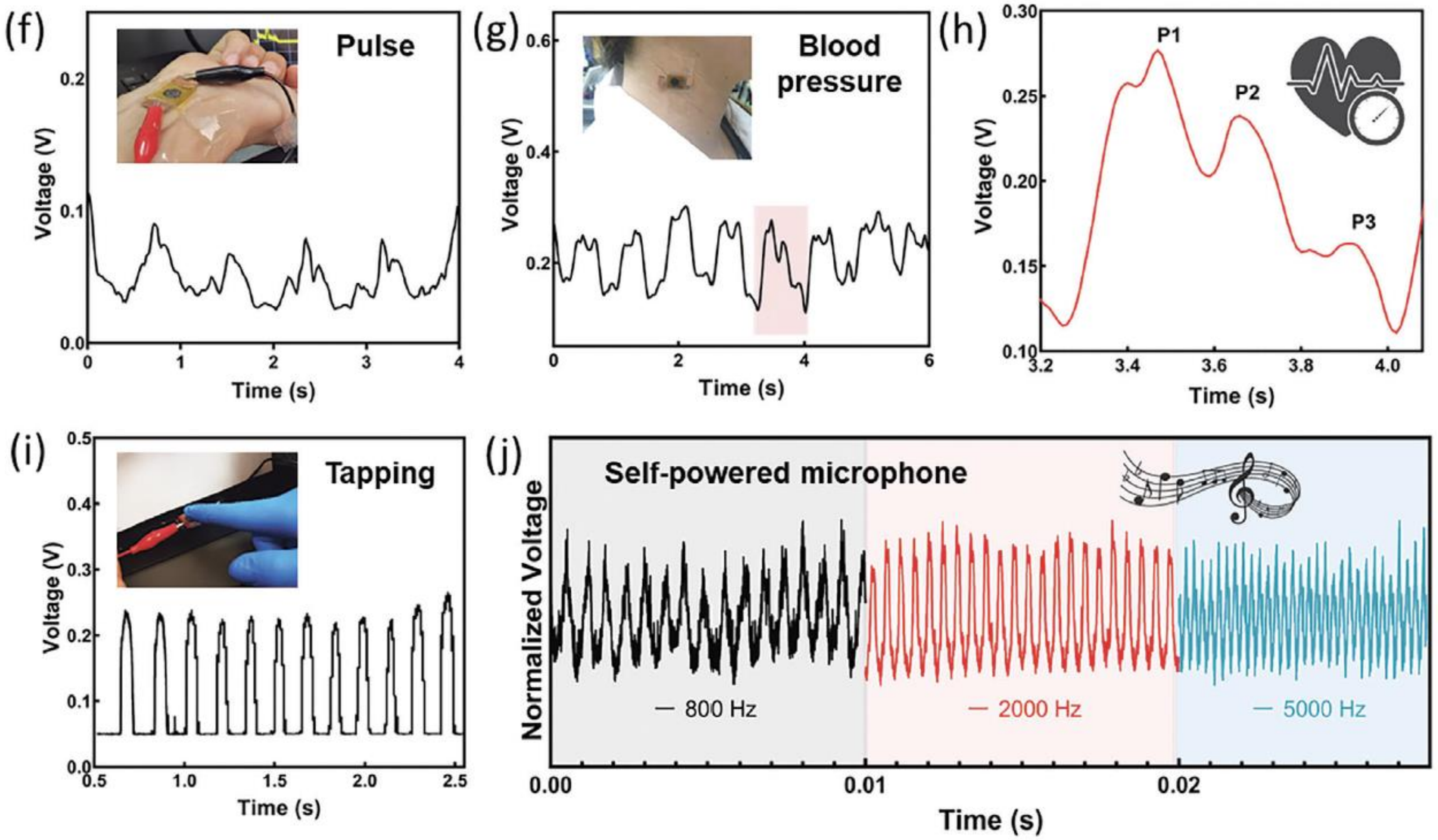
Conductive Peptide-Based MXene Hydrogel as a Piezoresistive Sensor





Cohen-Gerassi…Adler-Abramovich (2024) Adv. Healthcare Mater.

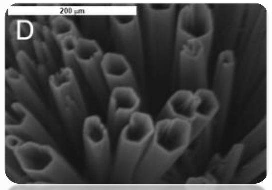
Conductive Peptide-Based MXene Hydrogel as a Piezoresistive Sensor

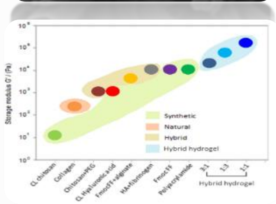


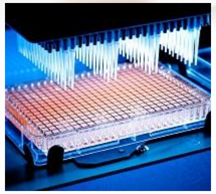
Cohen-Gerassi…Adler-Abramovich (2024) Adv. Healthcare Mater.

Summary

- ✓ We designed various peptides that can self-assemble into nanostructures as well as hydrogels with notable physical properties
- ✓ To extend the diversity of the nano-materials, we used a co-assembly approach
- ✓ We demonstrated bone regeneration and immunomodulation *in vivo*
- ✓ We combined gelatin with modified peptide to allow precise 3D printing
- ✓ We designed and fabricated electrospun polymer-peptide skin equivalent for severe burn injuries
- ✓ We incorporated MXene in the hydrogel to fabricate a piezoresistive sensitive sensor







Acknowledgments

LAA Group Members

- Dr. Moran Aviv
- Dr. Sigal Rencus-Lazar
- Dr. Tzakhi Grinberg
- Francesca Netti
- Yoav Dan
- Dana Cohen Gerassi
- Bar Shahar
- Vania Altobelli
- Noam Rattner
- Itay Kilimnik
- Offir Loboda
- Mor Tsuriano
- Dr. Ofir Doitch
- Dr. Shani Bergerson
- Jonathan Tirnover
- Tehila Carmeli

Collaborations

- Prof. Tuomas Knowles (Cambridge U.)
- Prof. Nathan Gianneschi (Northwestern U.)
- Prof. Phanourios Tamamis (Texas A&M U.)
- Dr. Solomon Dadia (Tel Aviv Medical Center)
- Dr. Dror Noy (Migal)
- Dr. Livnat Afriat-Jurnou (Migal)

Collaborations-TAU

- Prof. Itzhak Binderman
- Prof. Yosi Shacham-Diamand
- Dr. Amit Sitt
- Prof. Iftach Yacoby
- Dr. Naxim Sokol
- Dr. Michal Halperin-Sternfeld
- Prof. Ehud Gazit
- Prof. Rachel Sarig
- Dr. Eyal Rosen
- Prof. Doron Shabat

Funding

erc
European Research Council
Established by the European Commission

הקרן הלאומית למדע
ISRAEL SCIENCE FOUNDATION

BLAVATNIK CENTER
for Drug Discovery

רשות החדשנות
Israel Innovation Authority

Ministry of Agriculture
& Rural Development

ITI International Team For Implantology

משרד האנרגיה

SNOW- Smart Non-Woven Fabrics Consortium
Supported by the Israel Innovation Authority

Tel Aviv University Center for Nanoscience and Nanotechnology
Tel Aviv University

Ministry of Science, Technology and Space
Israel

TEL AVIV UNIVERSITY
Pursuing the Unknown

ADLER-ABRAMOVICH LAB
BIOINSPIRED MATERIALS & NANOTECHNOLOGY

TEL AVIV UNIVERSITY
Pursuing the Unknown

ADLER-ABRAMOVICH LAB

BIOINSPIRED MATERIALS & NANOTECHNOLOGY

LihiA@tauex.tau.ac.il
https://www.lihiadler.sites.tau.ac.il/