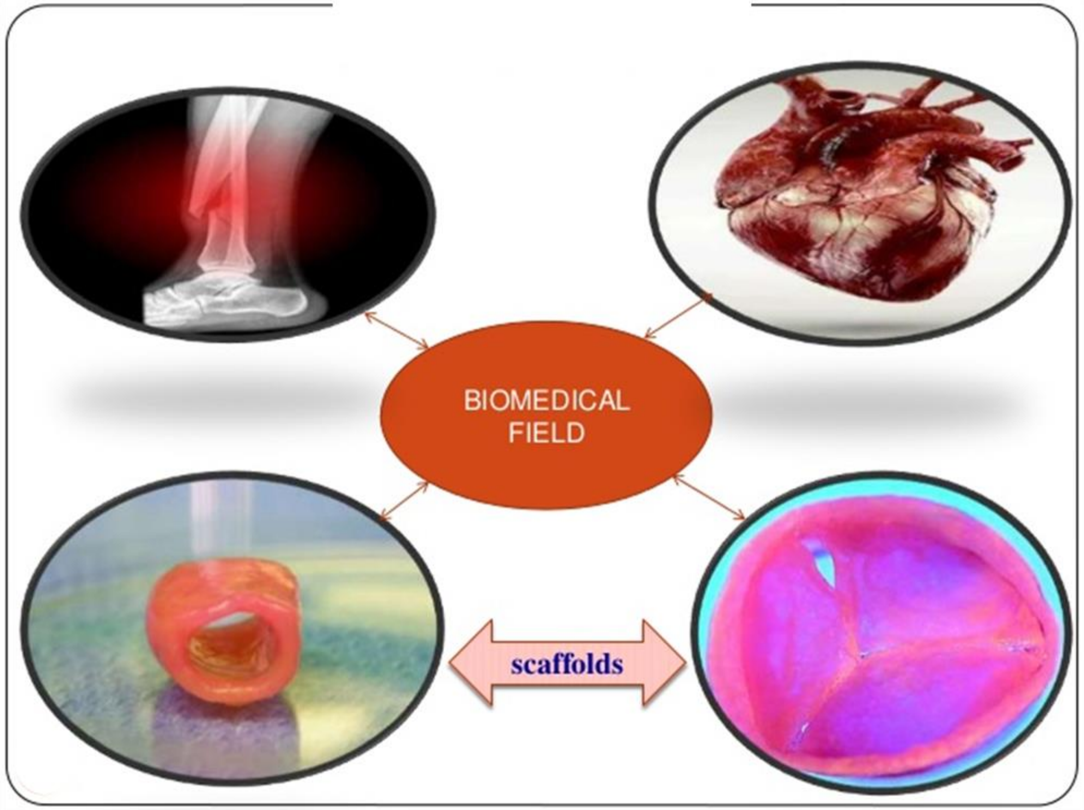
Polymeric biomaterials – production and application



«Modern European trends in biomedical higher education: Bionanomaterials.» № 620717-EPP-1-2020-1-UA-EPPJMO-MODULE

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INTRODUCTION

BIOMATERIALS

- Non-living materials mainly used for medical purposes.
- Designed to interact with biological systems.

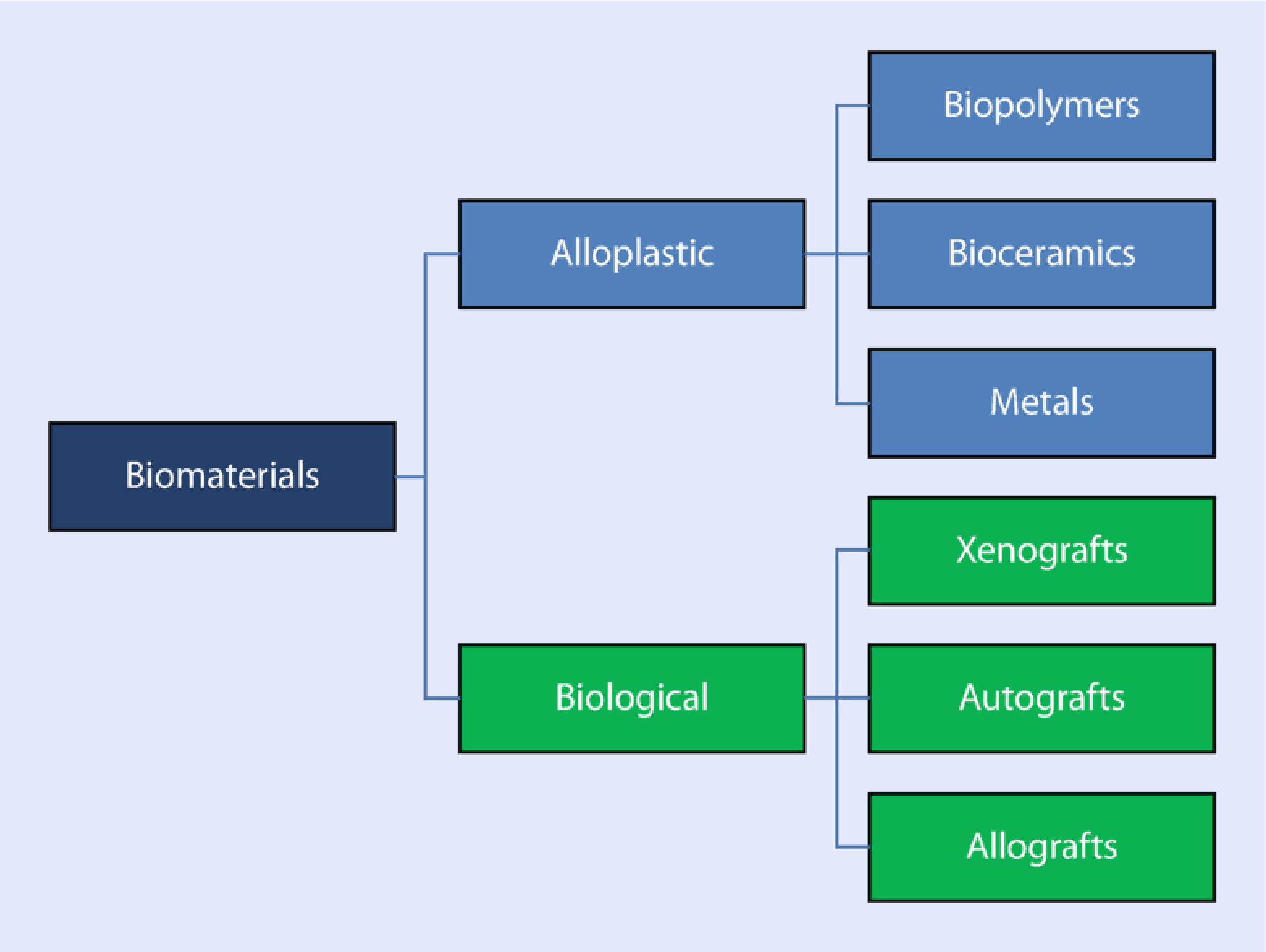
BIODEGRADABLE MATERIAL

- Its mechanical properties does not change during its life time.
- It gets degrades gradually without leaving trace.

TISSUE ENGINEERING

Maintenance, replacement or regeneration of damaged biological tissues.

Polymeric biomaterials - application in regenerative medicine and tissue engineering



Based on the chemical composition

The artificial material substituted for tissue grafts is called **alloplastic**.

Xenograft - a tissue graft or organ transplant from a donor of
* a different species from the recipient

doi.org/10.1007/978-3-319-74854-2_6

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Evolution of Biomaterials

Structural → **First generation**

Soft Tissue Replacements → **Second Generation**

Functional Tissue Engineering Constructs → **Third Generation**

(Scaffolds)

***Scaffolds** are materials that have been engineered to cause desirable cellular interactions to contribute to the formation of new functional tissues for medical purposes. Cells are often 'seeded' into thes structures capable of supporting three-dimensional tissue formation.

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Properties Of Biomedical Polymers

- Flexibility;
- Resistance to biochemical attack;
- Good biocompatibility;
- Light weight;
- Available in a wide variety of compositions with adequate physical and mechanical properties and
- Can be easily manufactured into products with the desired shape.

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Selection Parameters For Biomedical Polymers

The design and selection of biomaterials depend on different properties –

Host Response

- Biocompatibility
- Biofunctionality
- Functional Tissue Structure and Pathobiology
- Toxicology
- Appropriate Design and Manufacturability
- Mechanical Properties of Biomedical polymers

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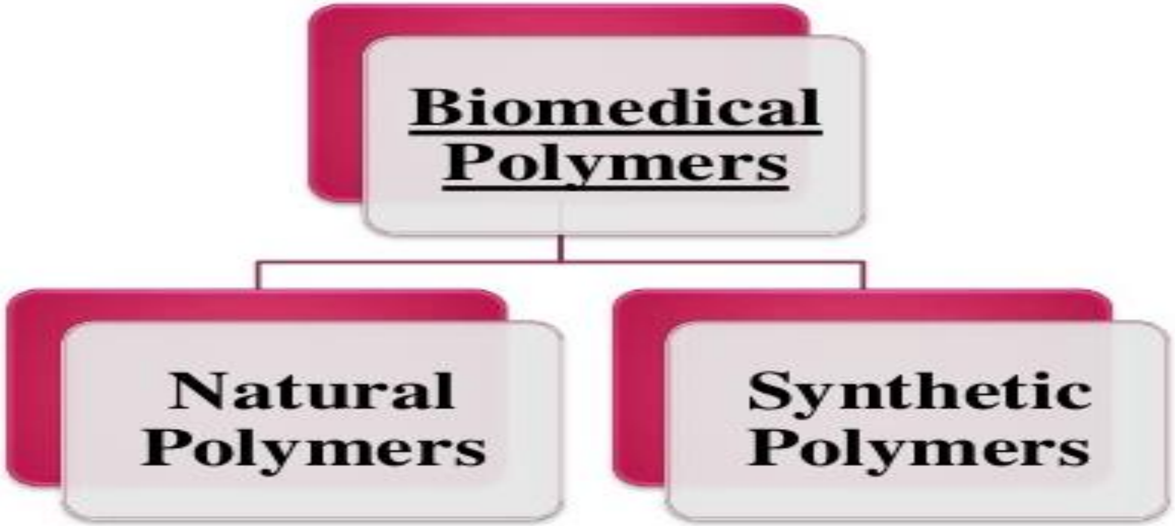
Classification



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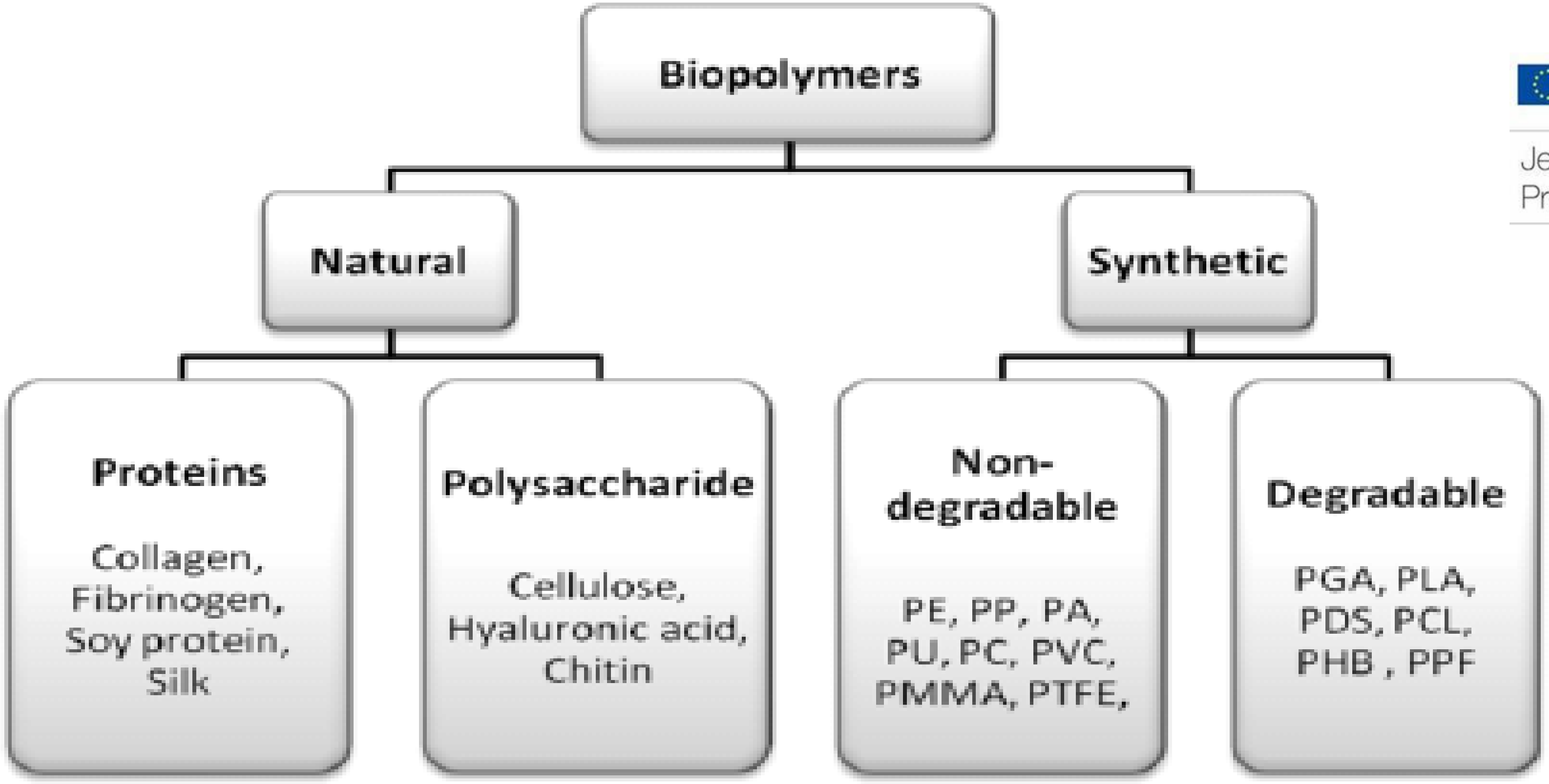

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Natural polymers

Natural polymers, or polymers, derived from living creatures, are of great interest in the biomaterials field.

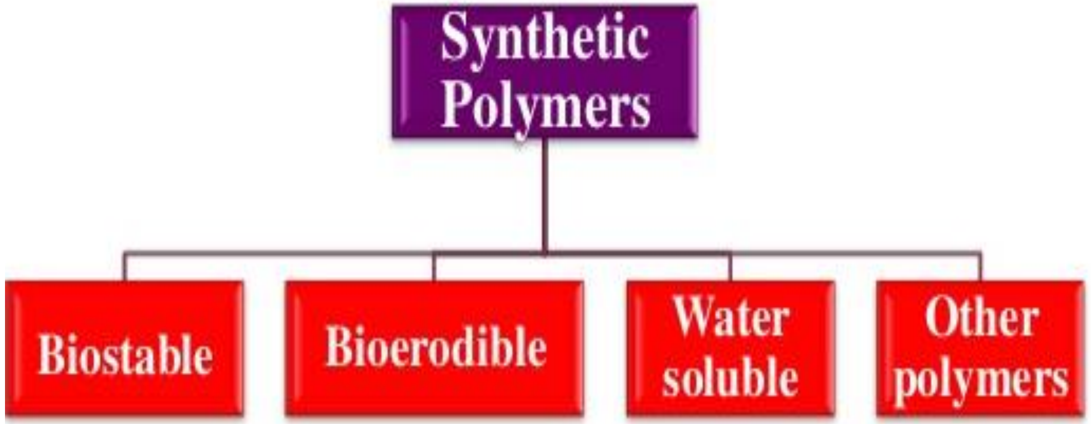
Properties of natural polymers:

- Biodegradable;
- Non-toxic/ non-inflammatory;
- Mechanically similar to the tissue to be replaced;
- Highly porous;
- Encouraging of cell attachments and growth;
- Easy and cheap to manufacture
- Capable of attachment with other molecules (to potentially increase scaffold interaction with normal tissue).

Example of natural polymers

- Collagen
- Cellulose
- Alginates
- Dextrans and
- Chitosan

Classification of synthetic polymers

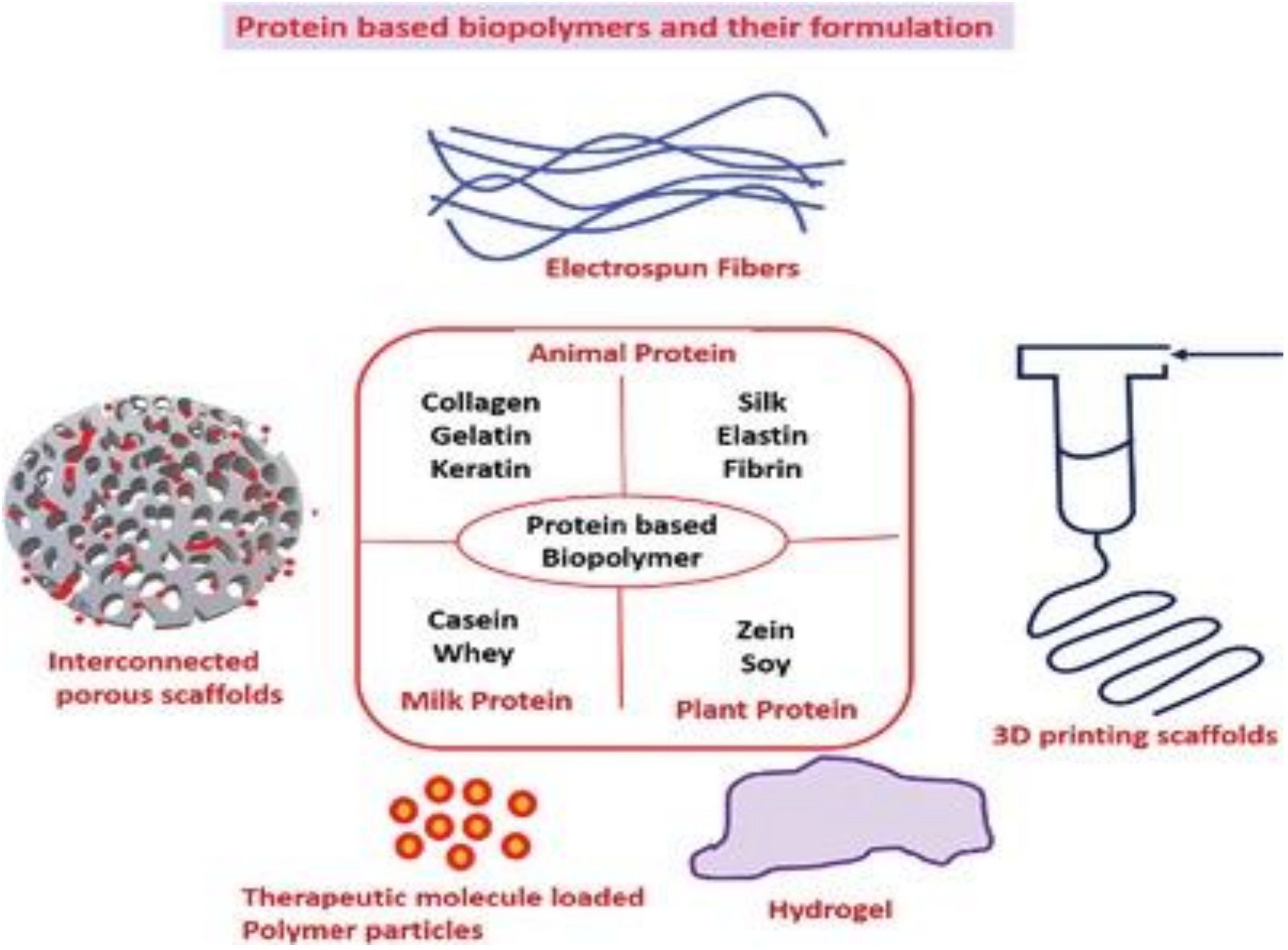


Applications:

Medical disposable supplies, Prosthetic materials, Dental materials, implants, dressings, polymeric drug delivery, tissue engineering products

Synthetic Polymers

- Advantages of Synthetic Polymers
  - Ease of manufacturability
  - process ability
  - reasonable cost
- The Required Properties
  - Biocompatibility
  - Sterilizability
  - Physical Property
  - Manufacturability



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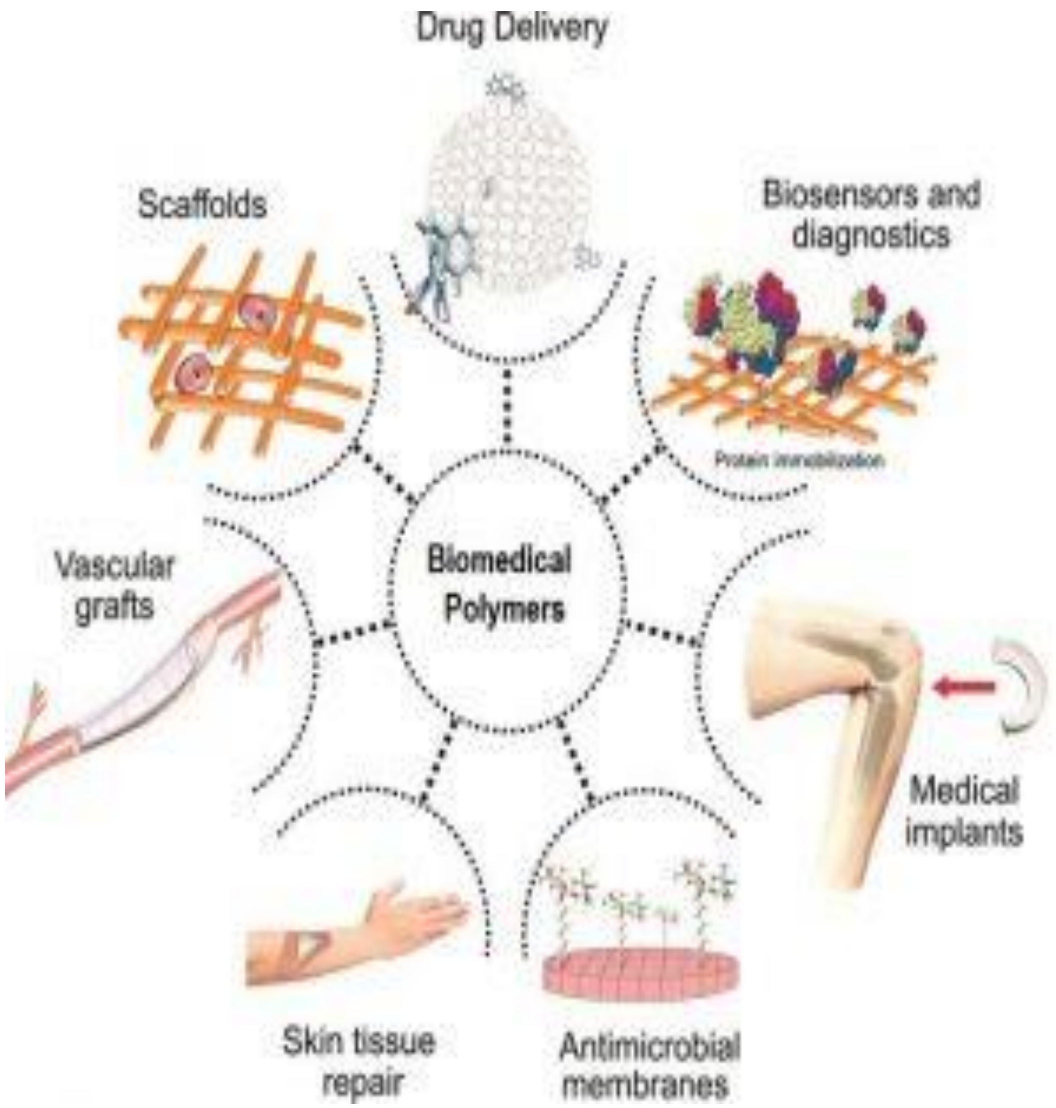

Application

- Cardiovascular Applications
- Bones, Joints, And Teeth
- Contact Lenses And Intraocular Lenses
- Artificial Kidney And Hemodialysis Materials
- Oxygen-Transport Membranes
- Surgical Sutures
- Tissue Ingrowth Polymers
- Controlled Release Of Drugs

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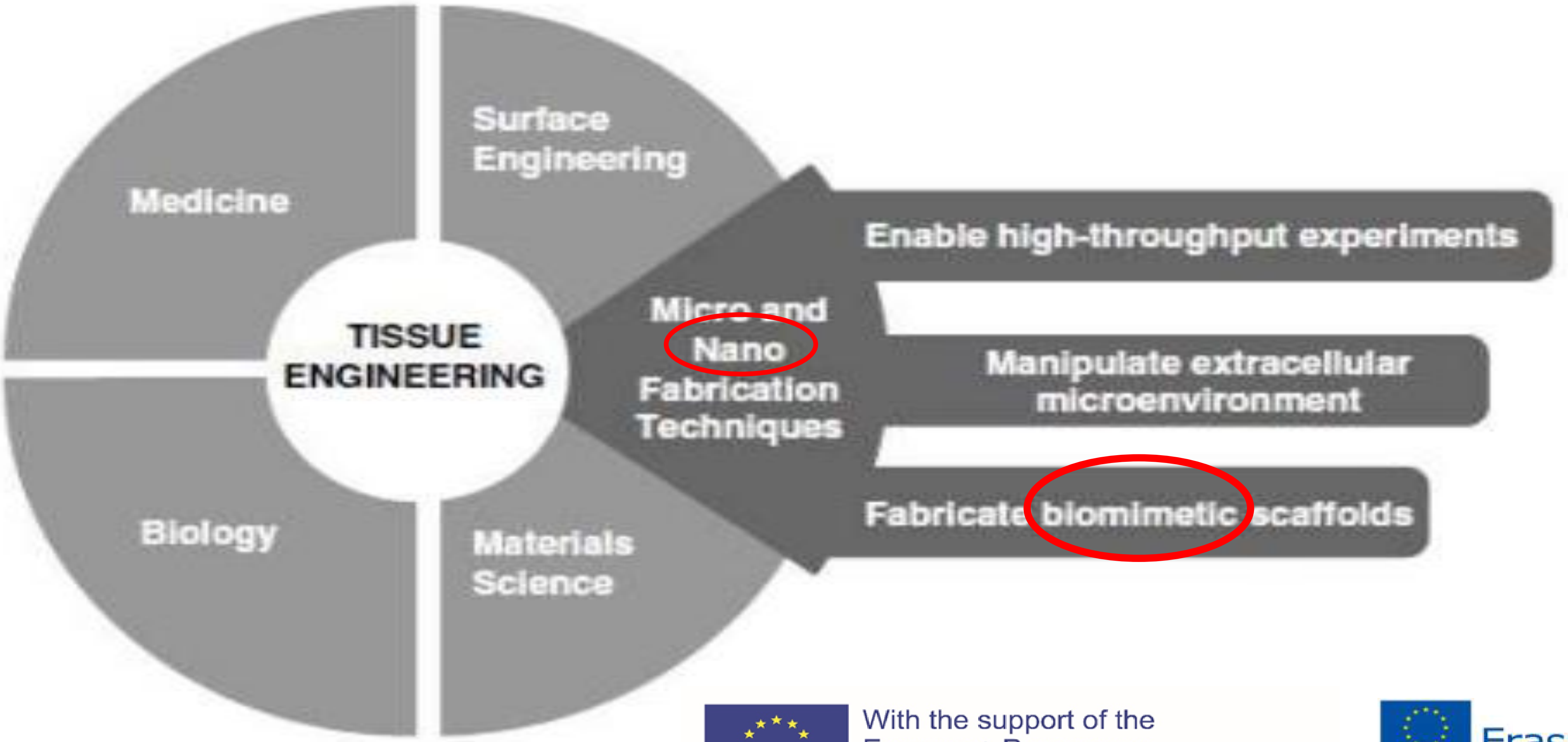
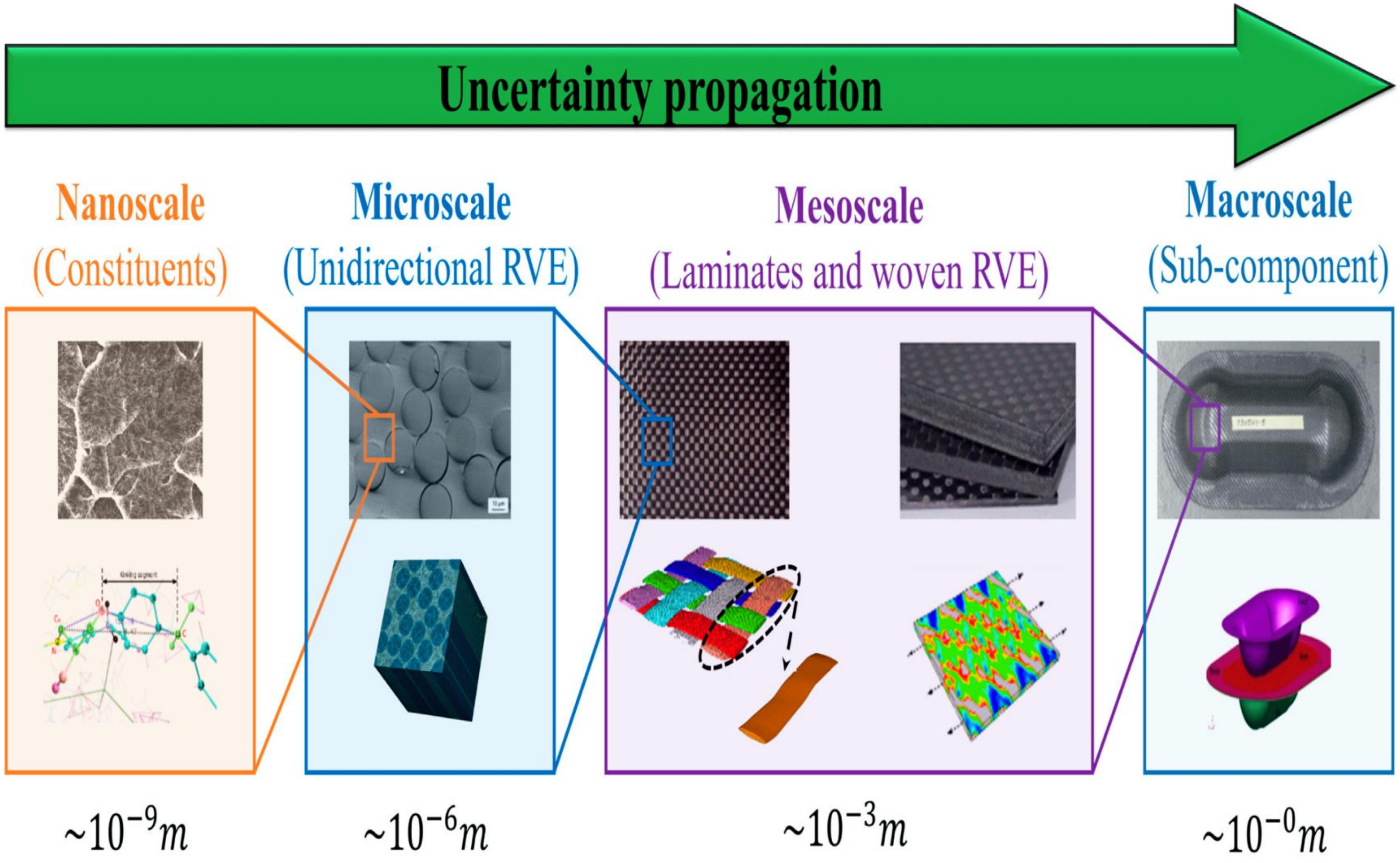

Surface Engineering
Medicine
TISSUE ENGINEERING
Micro and Nano Fabrication Techniques
Enable high-throughput experiments
Manipulate extracellular microenvironment
Fabricate biomimetic scaffolds
Biology
Materials Science



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What are scaffolds?

Scaffolds: Serve as temporary or permanent artifical Extracellular Matrices (ECM) to accommodate cells and support 3D tissue regenerations .

What is ECM?

blend of macromolecules (proteins and carbohydrates) **around cells—as space fillers.**

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Biomemtic Scaffolds

- Biomimetics is defined as the application of methods and systems, found in nature, to technology and engineering.
- Mimicking the naturally occurring extracellular matrix (ECM) and how this is a promising approach to effectively tailor cell response and to successfully engineer replacement tissues.

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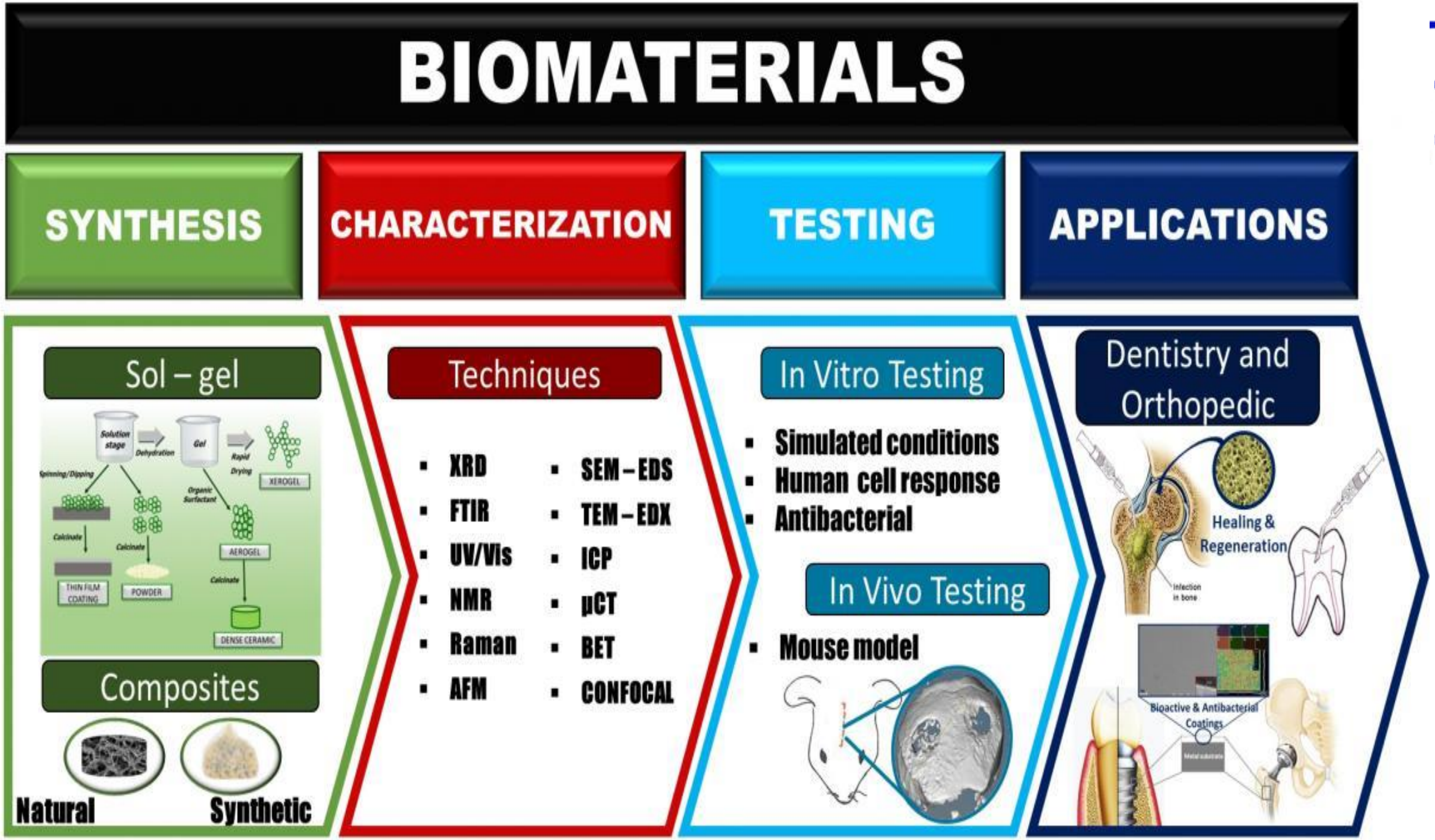

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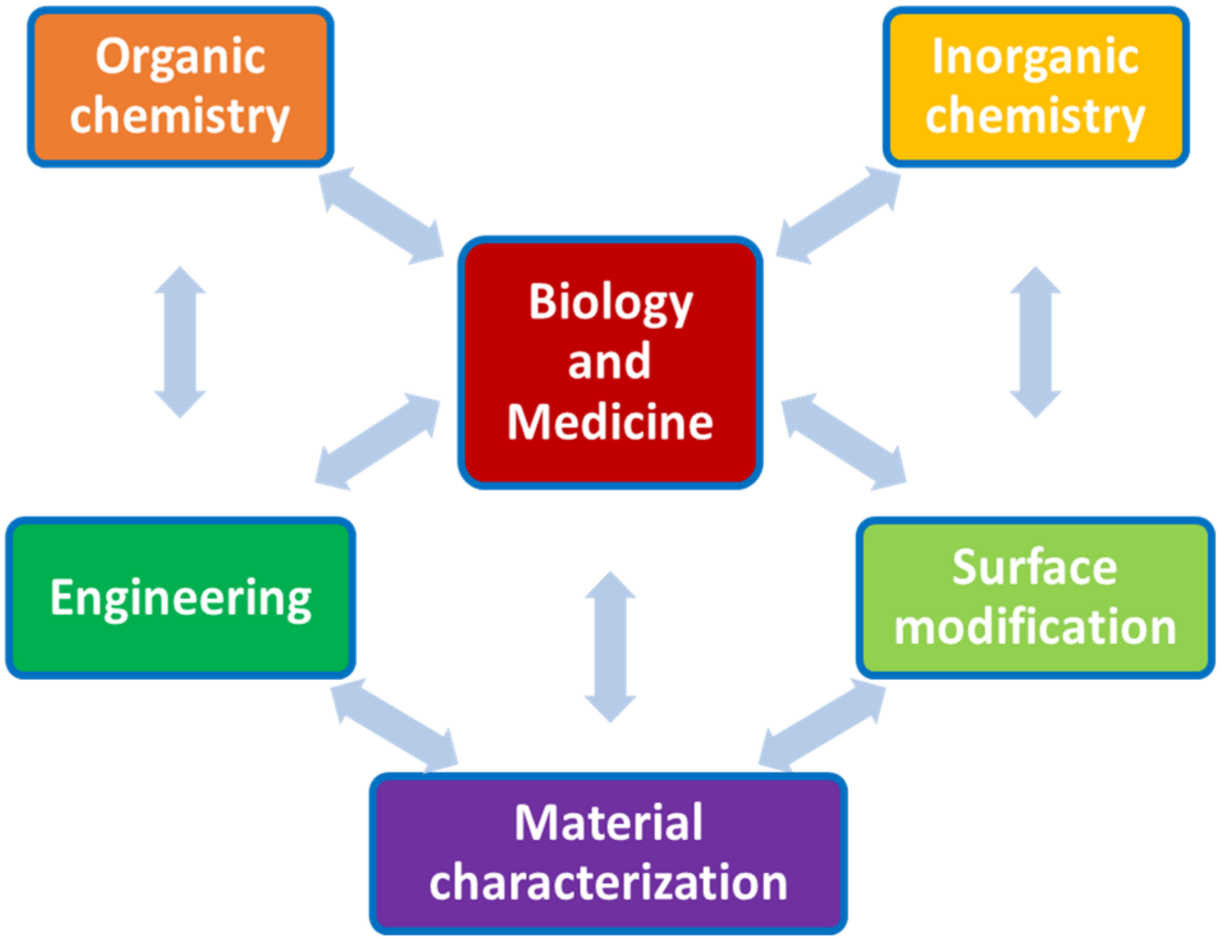
Multidisciplinary approach



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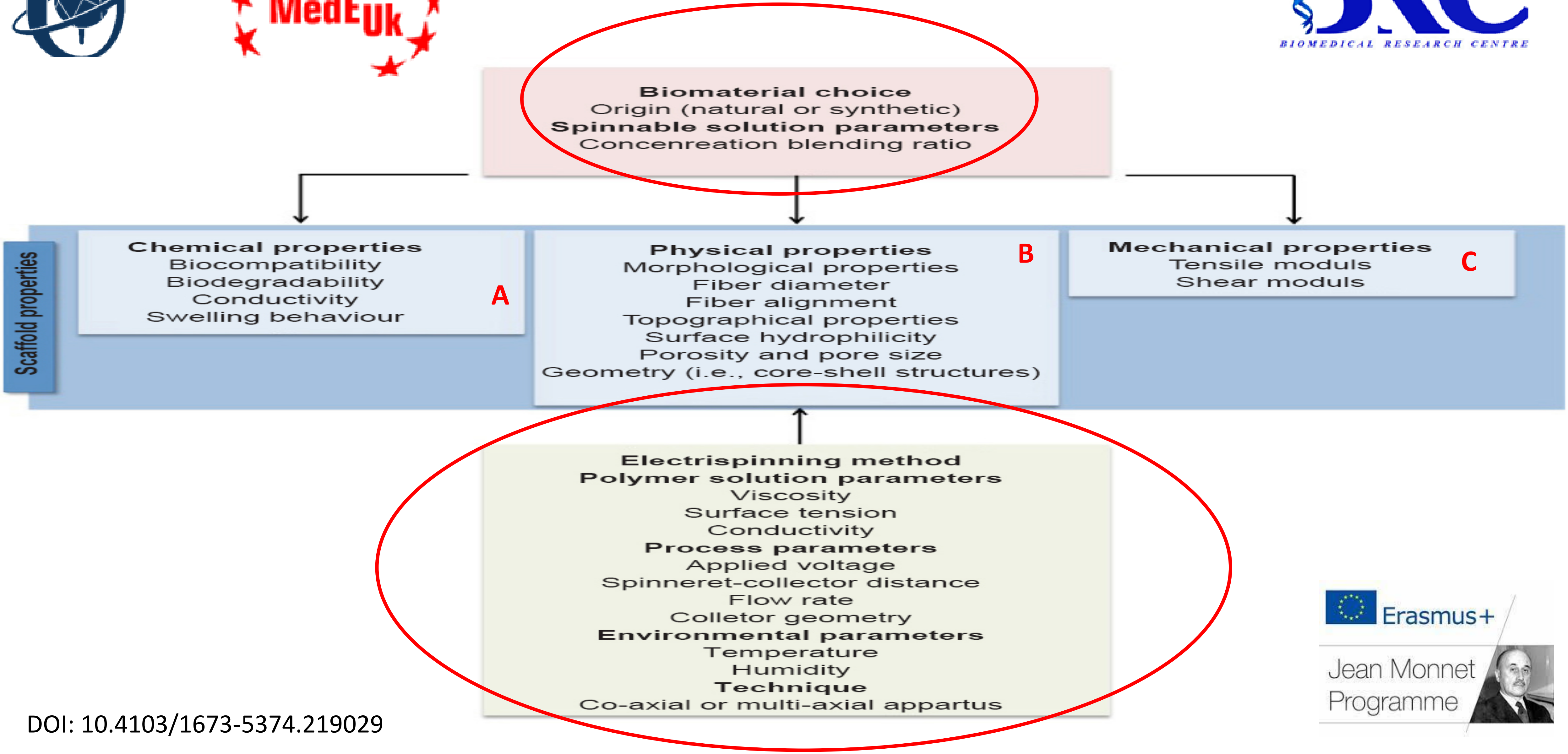
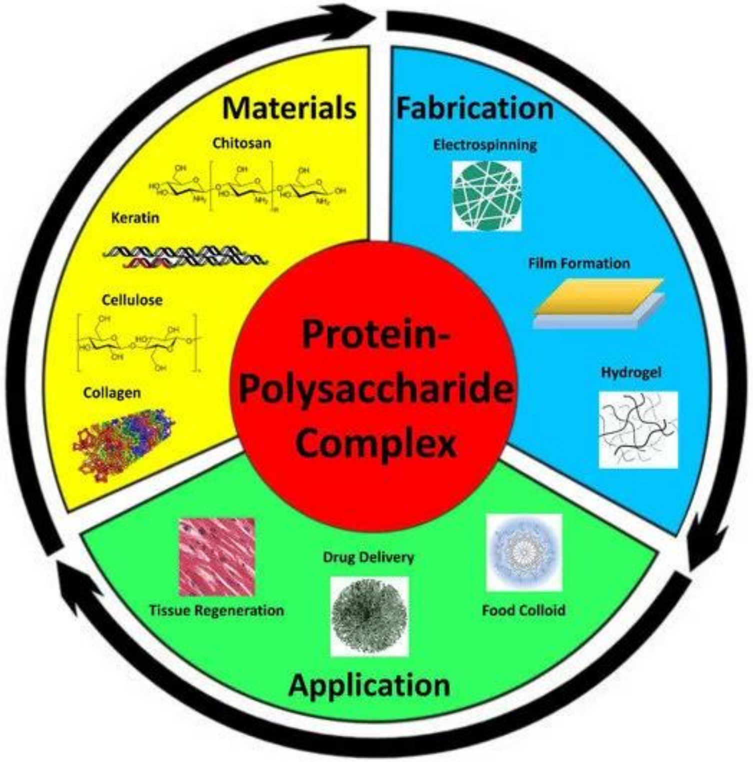
Electrospinning

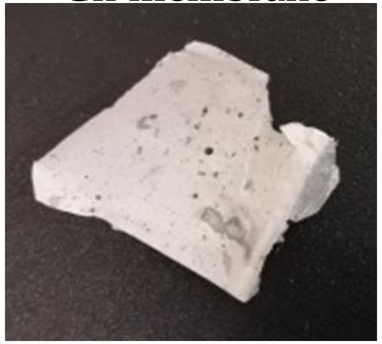


DOI: 10.4103/1673-5374.219029

Material / Method



Ch membrane



electrospinning

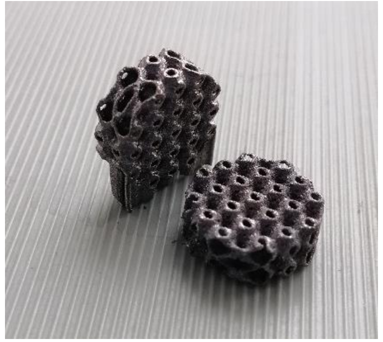
ZrNb alloy

anodization in electrolytic bath

Ch sponge

chemical crosslinking process

Ti6Al4V alloy



selective laser melting machine

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State of the art

Natural polymers

Bio-compatibility | Bio-degradability | Non-immunogenic properties

Natural abundant polysaccharides

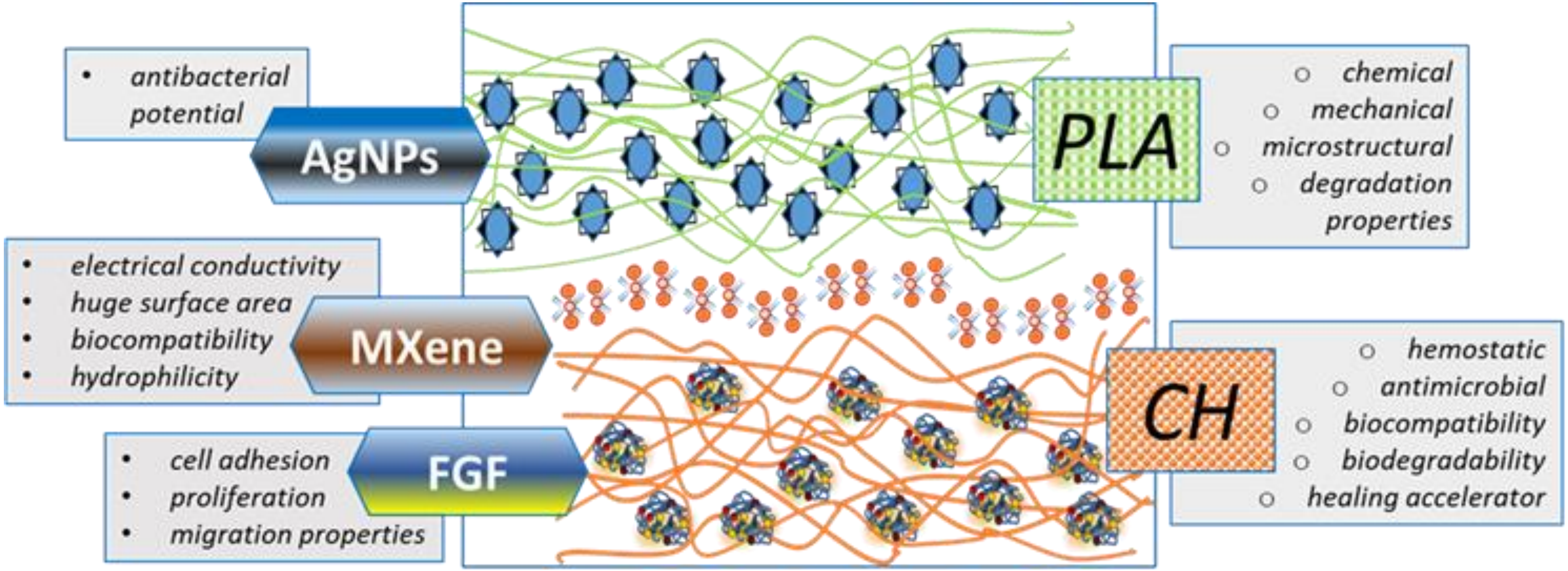
structural similar with biological macromolecules

easily recognized by the bioenvironment

easily metabolized to residues that are nontoxic and naturally eliminated

- ***TISSUE ENGINEERING SCAFFOLDS***
- ***DRUG DELIVERY VEHICLES***
- ***PERMEABLE MEMBRANES***

Project concept focused on the properties of their compounds



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Scientific objectives

Development of bi-layered electrospun nanofibrous scaffolds

- solution parameters optimization
- modification and functionalization
- electrospinning parameters optimization

Characterization of fibers and electrospun scaffolds

- surface structure
- degradability
- mechanical properties
- conductivity
- surface wettability

In vivo biological studies

- biocompatibility
- antibacterial

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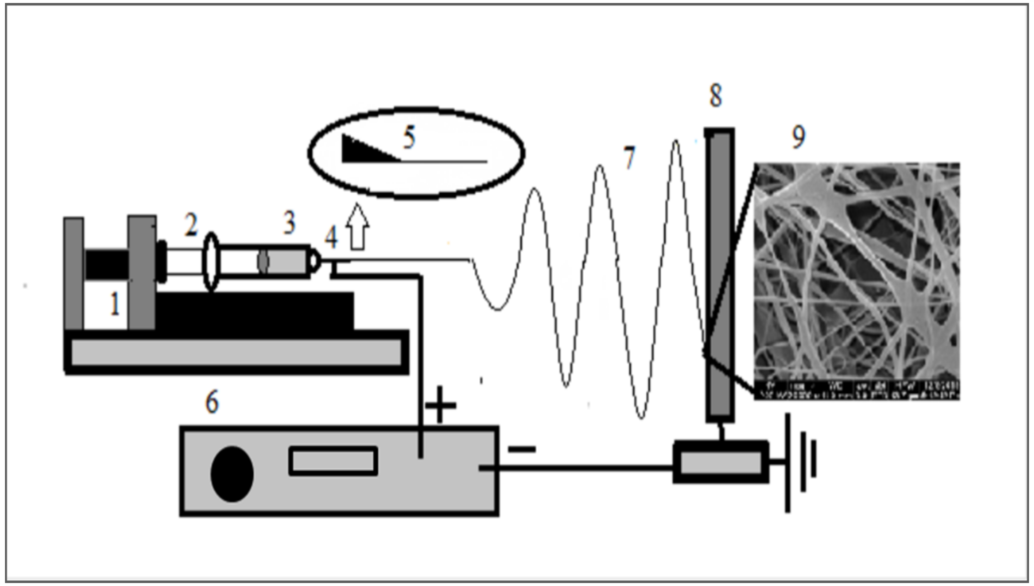
Electrospinning setup

Electrospinning system
(Linari Engineering, Italy)



Scheme of electrospinning setup for chitosan membrane production: 1 – pump; 2 – syringe; 3 – solution; 4 – needle; 5 – Taylor cone; 6 – power supply; 7 – jet; 8 – collector; 9 – nanofibers

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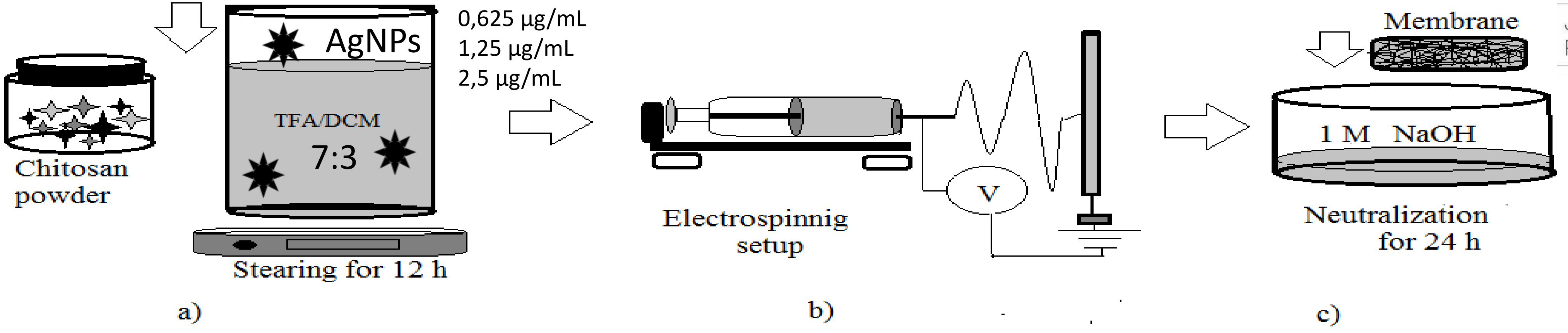
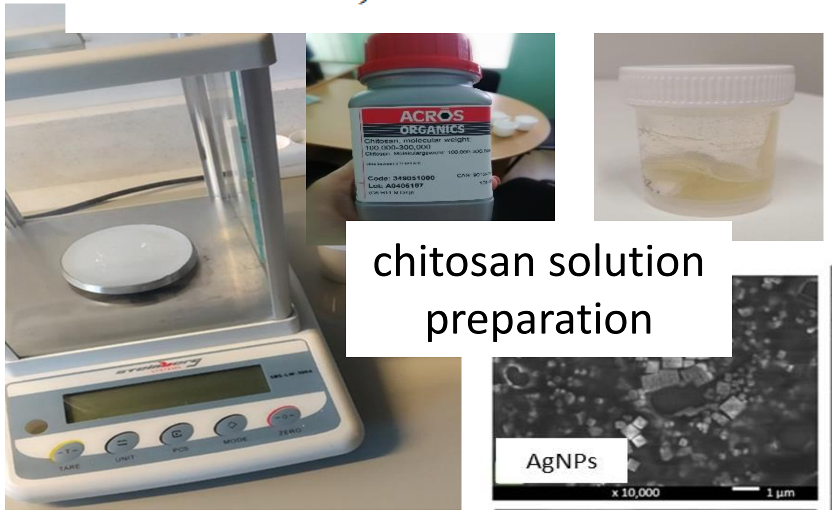
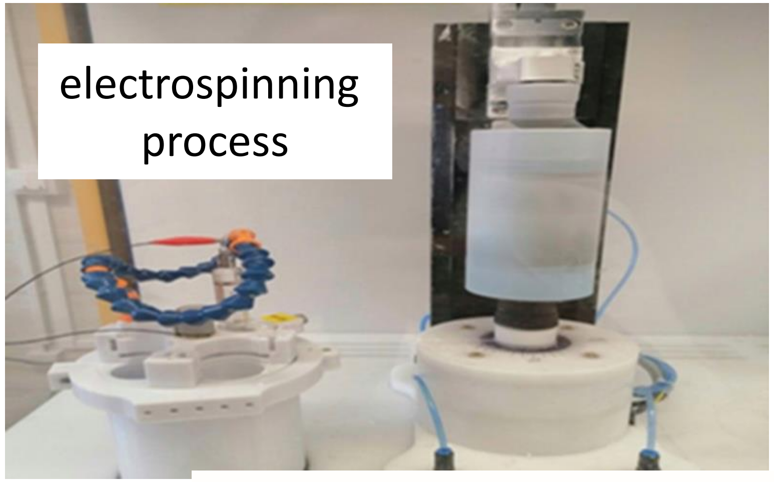
Fabrication of Ch-AgNPs nanofibers
MATERIALS/METHODS







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Fabrication of Ch-AgNPs nanofibers

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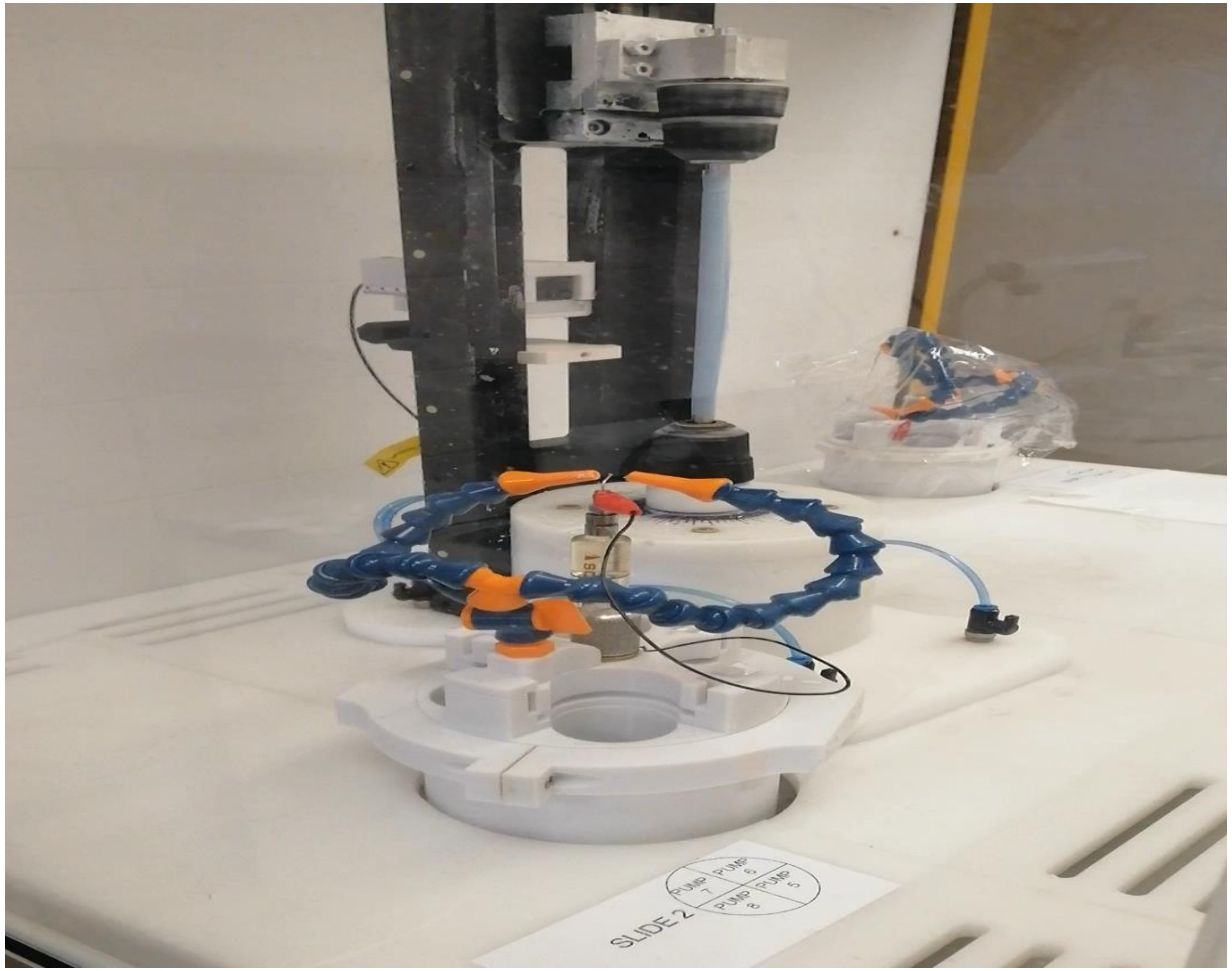

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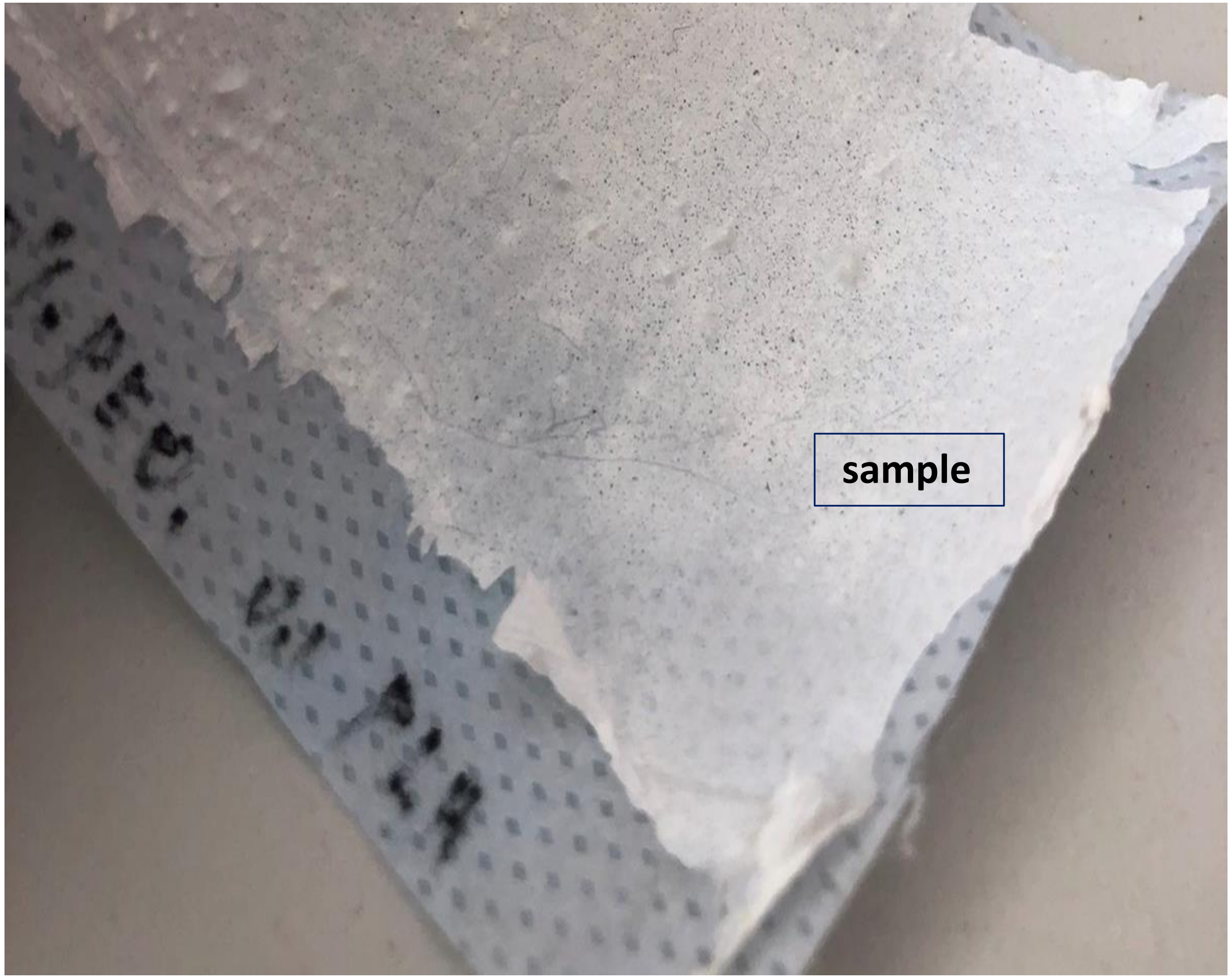
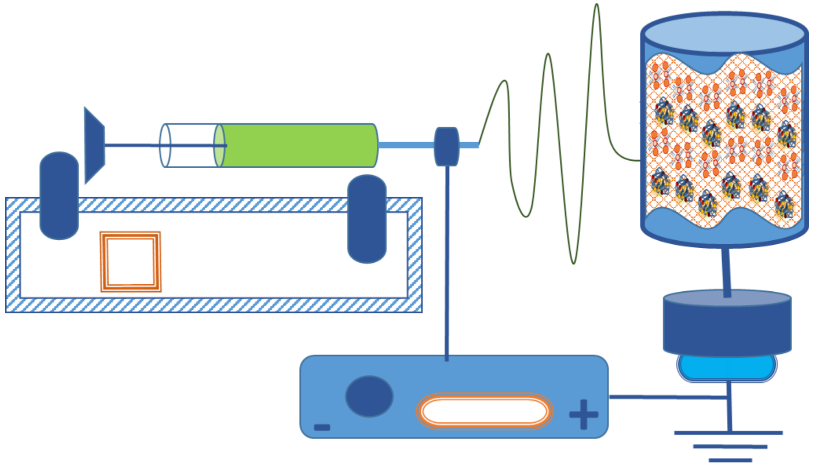
Electrospinning setup



How does it work?



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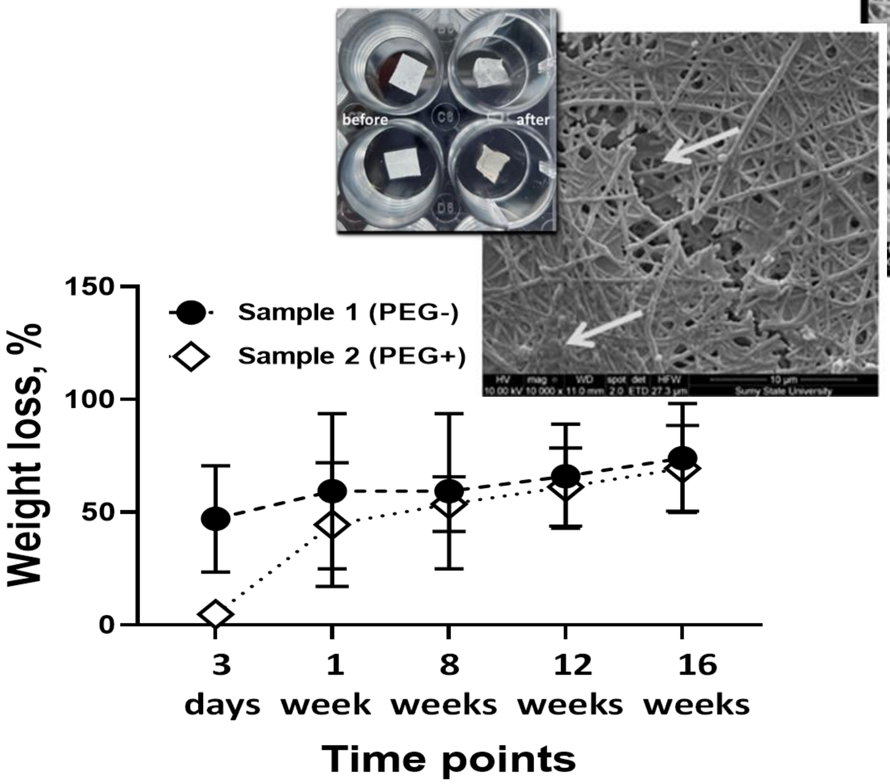
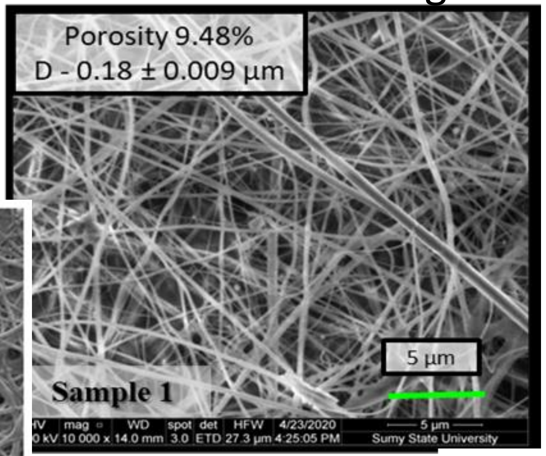
Characterization of nanofibrous electrospun scaffolds: testing of structural, chemical and surface properties

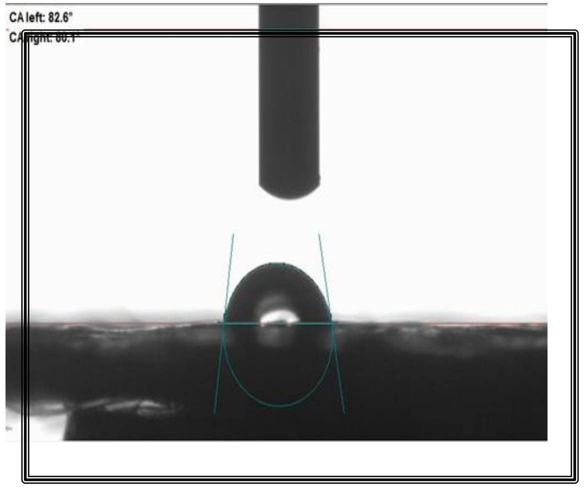
Degradation kinetics

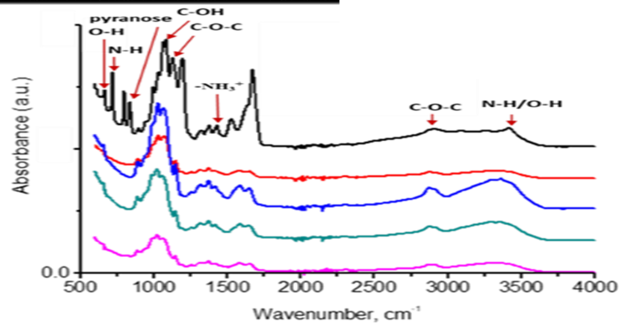


SEM image



Surface CA





FTIR spectra

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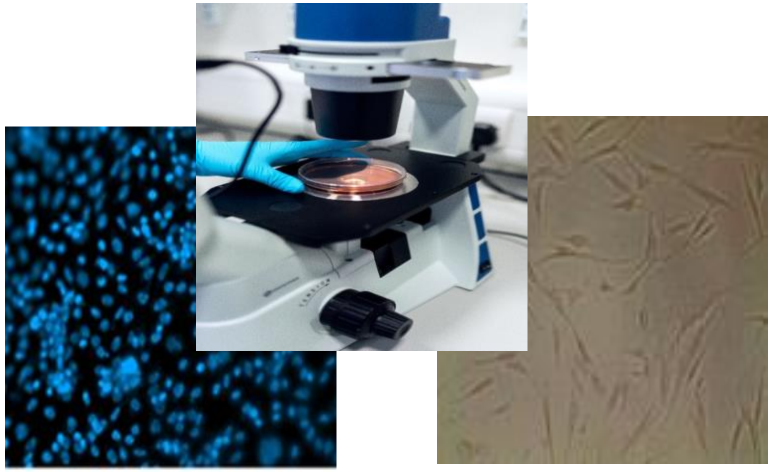
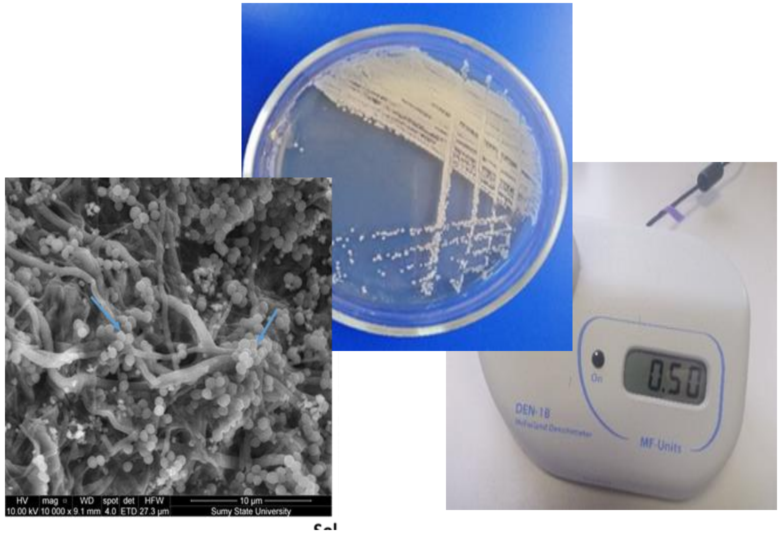
In vitro testing

To assess the cell toxicity



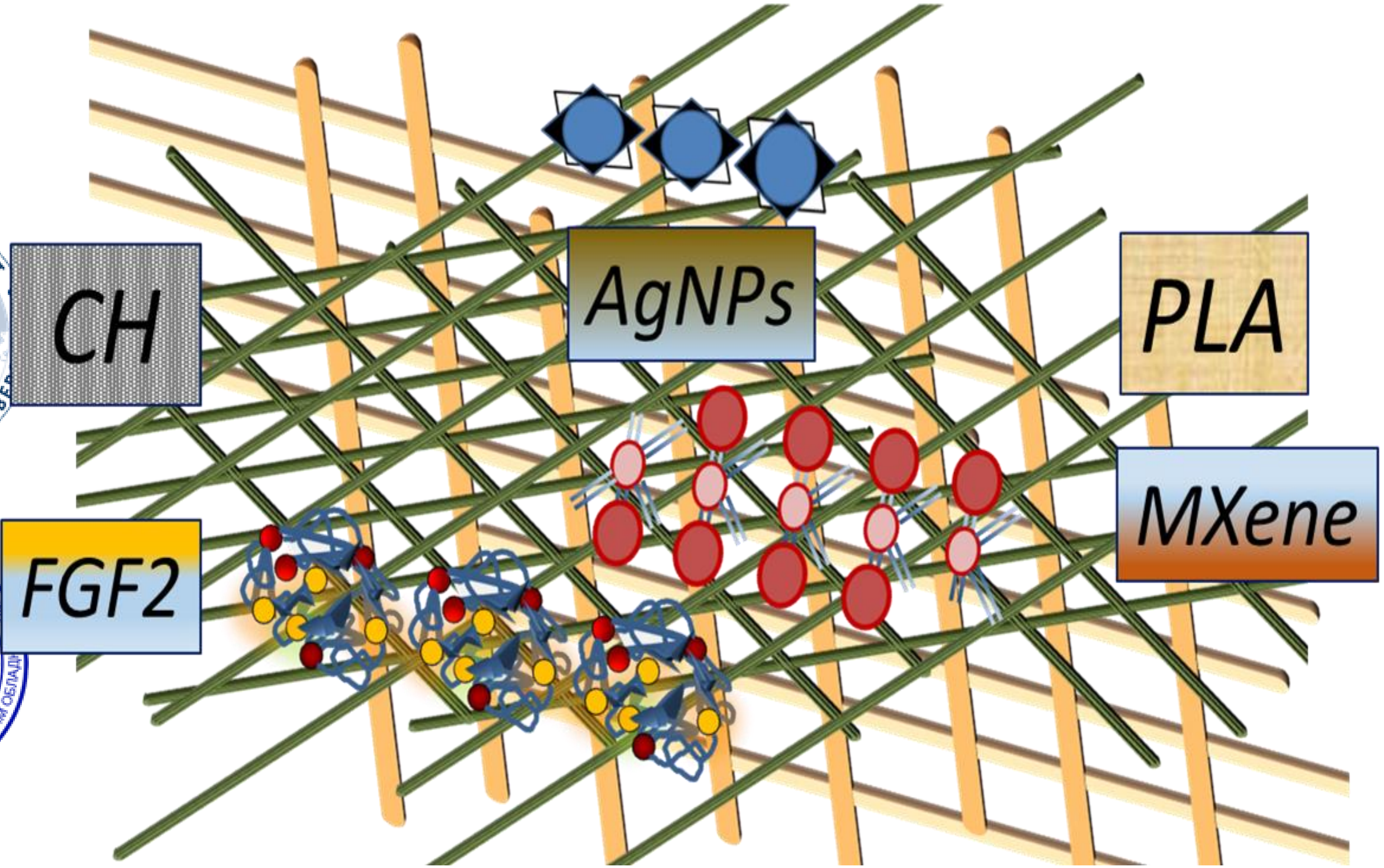
- ❖ normal human dermal fibroblasts culture
- ❖ resazurin reduction assay / CCK-based assay
- ❖ fluorescent microscopy

To assess antibacterial properties



- ❖ Staphylococcus aureus and Escherichia coli bacteria
- ❖ time-dependent bacterial growth assay
- ❖ alamar blue biofilm susceptibility testing
- ❖ SEM

Conclusions



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