La ricerca transdisciplinare come modello di integrazione tra Ingegneria e Medicina

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Direttore del Dipartimento Cardio-Toraco-Vascolare – Ospedale Policlinico San Martino
Direttore del centro di ricerca BELONG – Università degli Studi di Genova
Direttore del Laboratorio di Biologia Vascolare Clinica e Sperimentale – Università degli Studi di Genova e Ospedale Policlinico San Martino

OSPEDALE POLICLINICO SAN MARTINO

Sistema Sanitario Regione Liguria

UNIVERSITÀ DEGLI STUDI
DI GENOVA

DISC

DICCA

UNIVERSITÀ DEGLI STUDI DI GENOVA

1512 > 2012

cinquecento anni di insegnamento medico a Genova

1669 Istituzione del primo insegnamento di Anatomia Umana su cadavere tenuto da un medico retribuito

1847 Primo intervento chirurgico in anestesia eterea, eseguito da Bartolomeo Gherardi

1912 Il Senatore Edoardo Maragliano dispone la costruzione del nuovo centro ospedaliero e universitario sulle alture di San Martino d'Albaro

1938 Fondazione dell'Ospedale Pediatrico "Istituto G. Gaslini"

1978 Fondazione dell'Istituto Nazionale per la Ricerca sul Cancro

2000 Centre of Excellence for Biomedical Research

2001 Nanoworld Institute

2011 Nuovo Centro di Simulazione Avanzato

2011 Fusione Ist – San Martino

UNIVERSITÀ DEGLI STUDI DI GENOVA

1870 › 2020

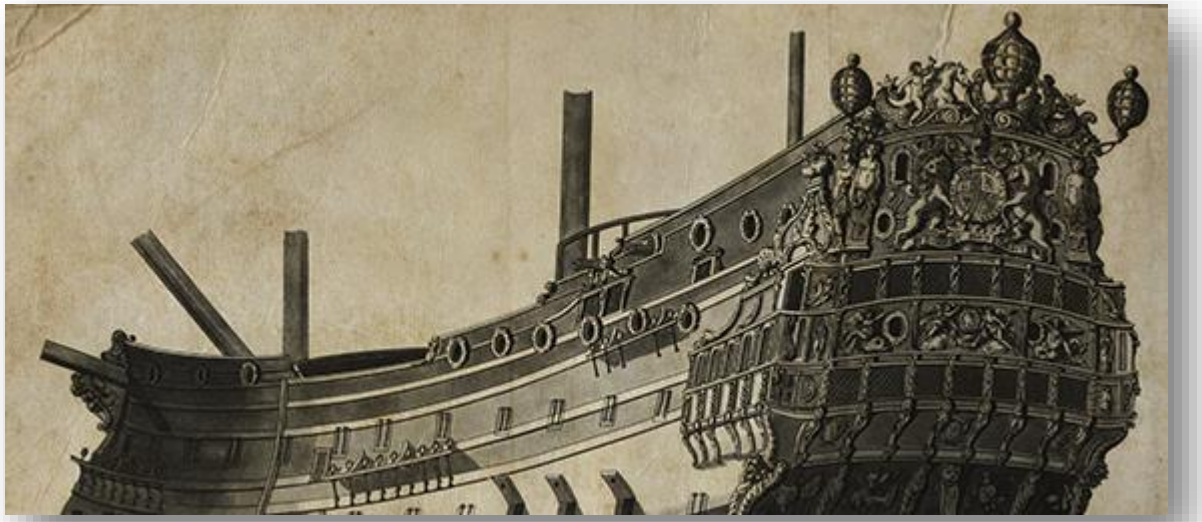
Centocinquanta anni **Regia Scuola Superiore Navale a Genova**

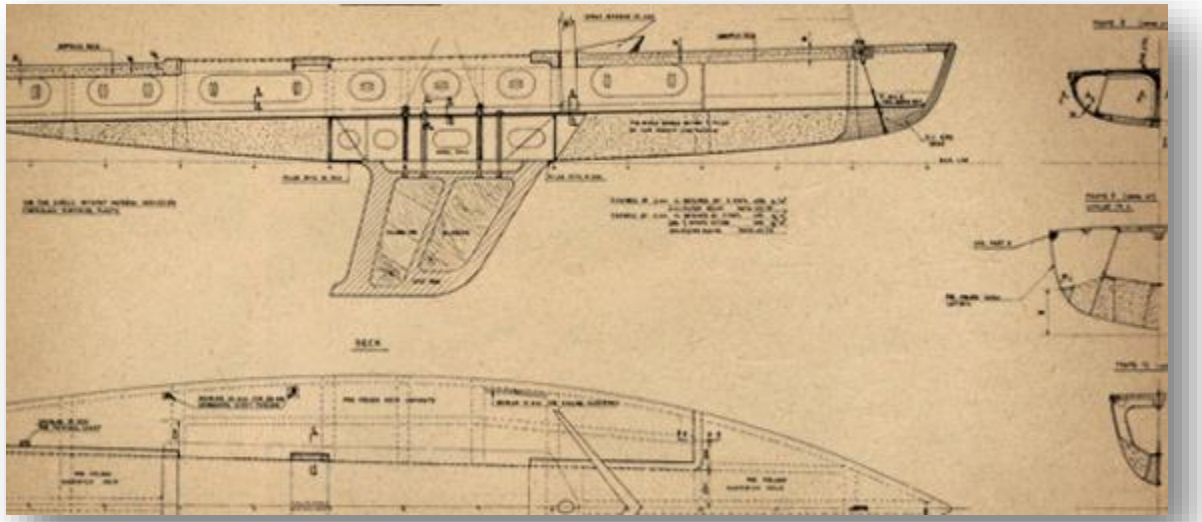
1870 Nascita della Regia Scuola Superiore Navale a Genova

1909 Inclusione nell'elenco degli istituti superiori

1921 Ottenimento della prestigiosa sede di Villa Cambiaso

1923 con la Riforma Gentile, Regia Scuola di Ingegneria Navale





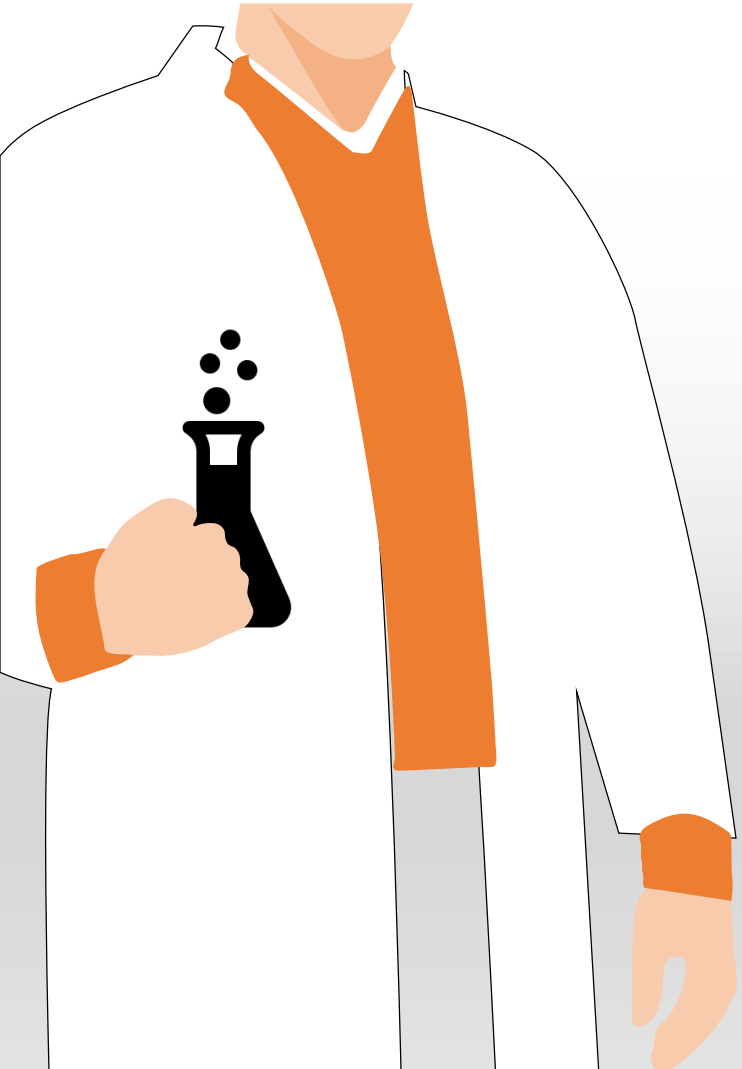
HISTORICAL MILESTONES

MEDICINE AND ENGINEERING

First anatomic studies	XV century Leonardo da Vinci
Blood fluidodynamic studies	1838 Jean Léonard Marie Poiseuille
First electrocardiograph machine	1903 Willem Einthoven
Artificial pacemaker invented	1930s Albert S. Hyman
First kidney dialysis machine	1945 Willem J. Kolff
Artificial heart valve developed	1951 Charles Hufnagel,
First laser surgery on a human cornea	1987 Steven Troke
1st EVAR	1990 Juan Carlos Parodi

HISTORICAL MILESTONES

ENGINEERING AND MEDICINE



XV century
Leonardo da Vinci

First flying machines

1930s
Edward Merrill

Studies on the viscosity of human blood

1960
Wilson Greatbatch

First totally internal pacemaker

1980s
Robert Langer

Controlled drug delivery technology developed

1943
Tofy Mussivand

First cardiac pump

1967
Godfrey Hounsfield

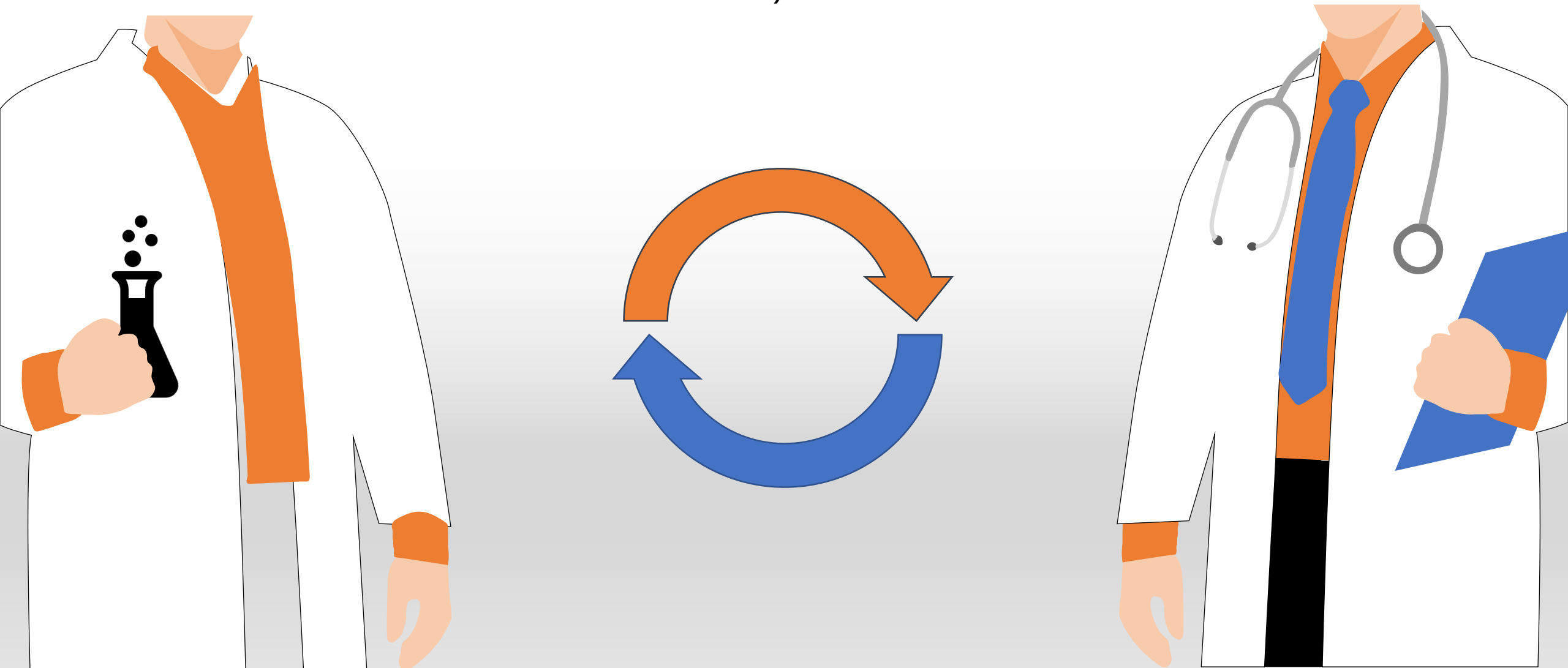
First TAC equipment

2014
Chuck Hull

3D printing

“Coming together is a beginning, staying together is progress, and working together is success"

Henry Ford



ANALOGY BETWEEN CHEMICAL ENGINEERING AND MEDICINE

Cell biology, Physiology
Modeling, Systems analysis

Surface chemistry
Materials science

Blood flow
Transport

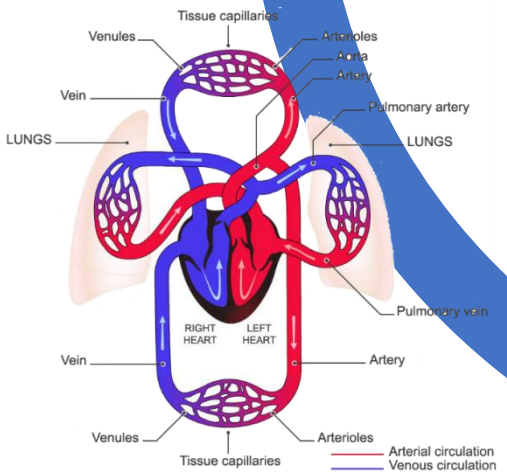
Drug design
Thermodynamics, kinetics

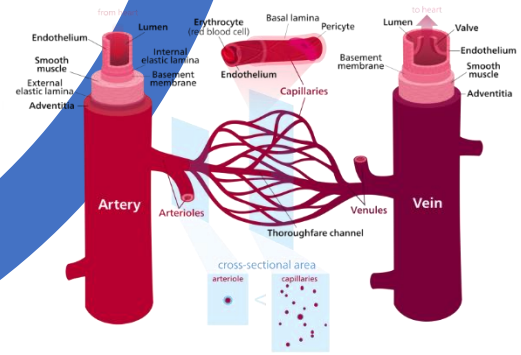
Vascular Bioengineering

Diagnostics
Drug discovery
Cell adhesion
Membrane biophysics

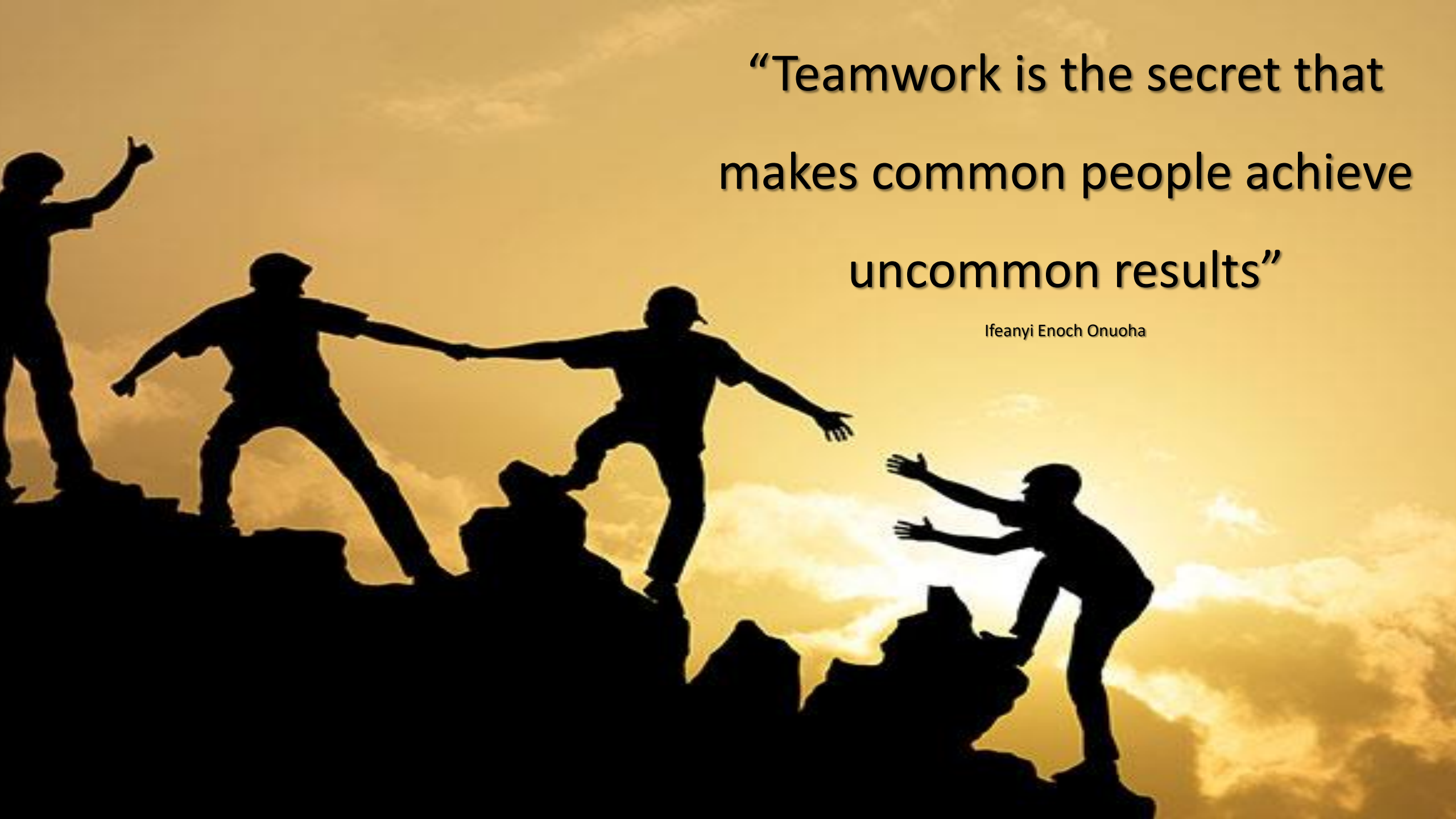
Clinical applications

Mechanistic studies





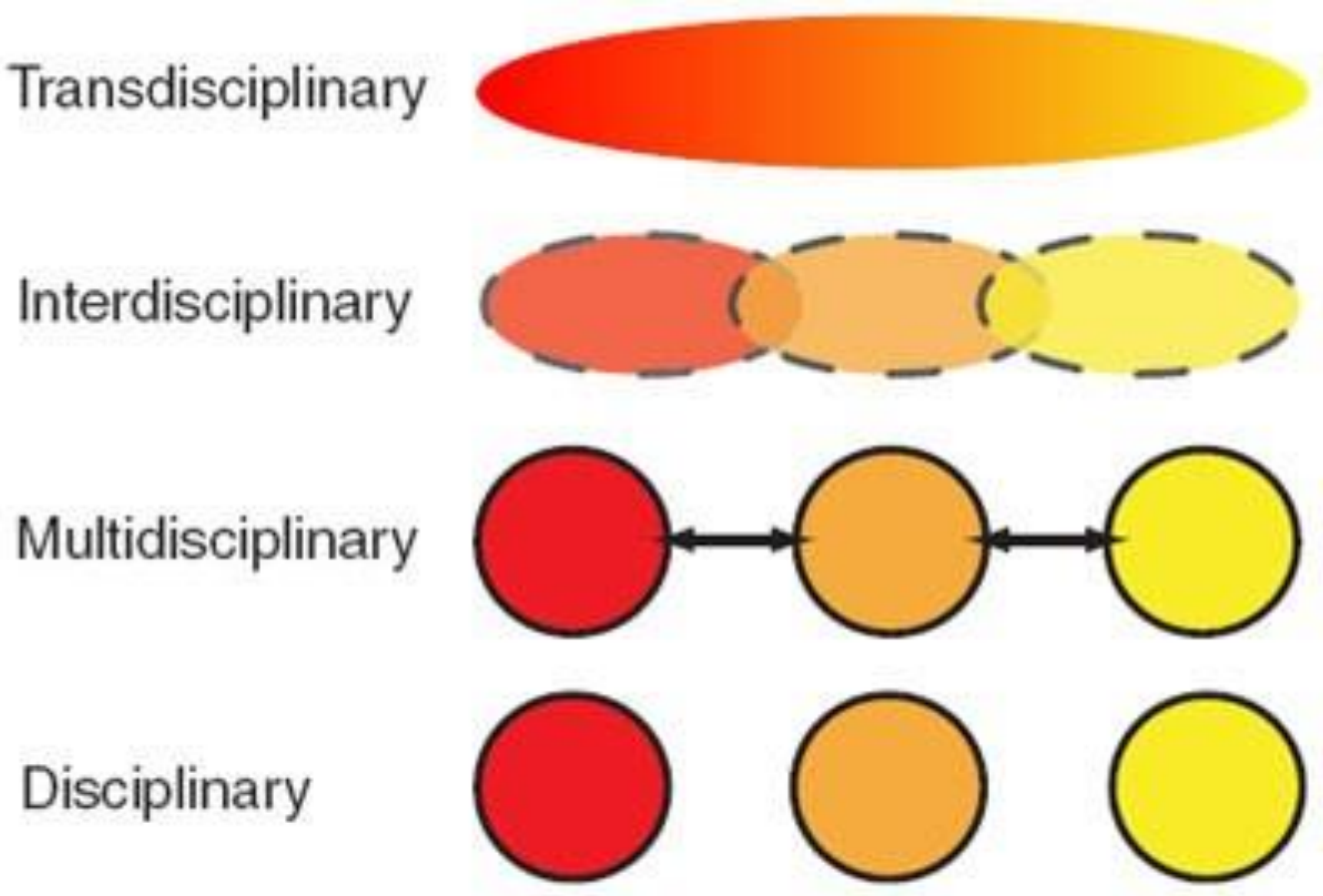

As a Team...
TOGETHER WE CAN MOVE MOUNTAINS!
...We can achieve anything!


“Teamwork is the secret that makes common people achieve uncommon results”
Ifeanyi Enoch Onuoha

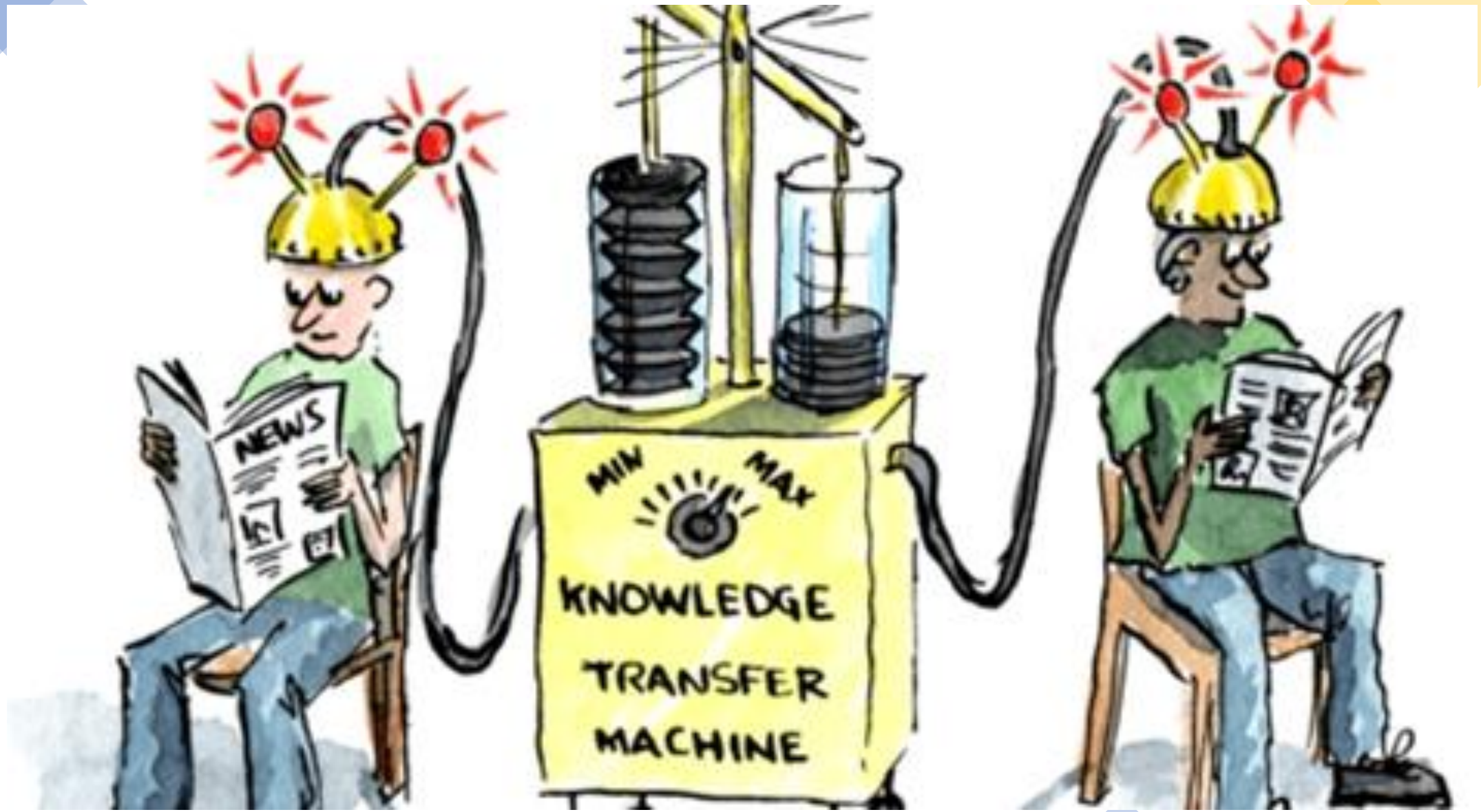

What makes a team a good-team?

Transdisciplinary approach

Two or more professions, technologies, or departments, working together towards a common goal

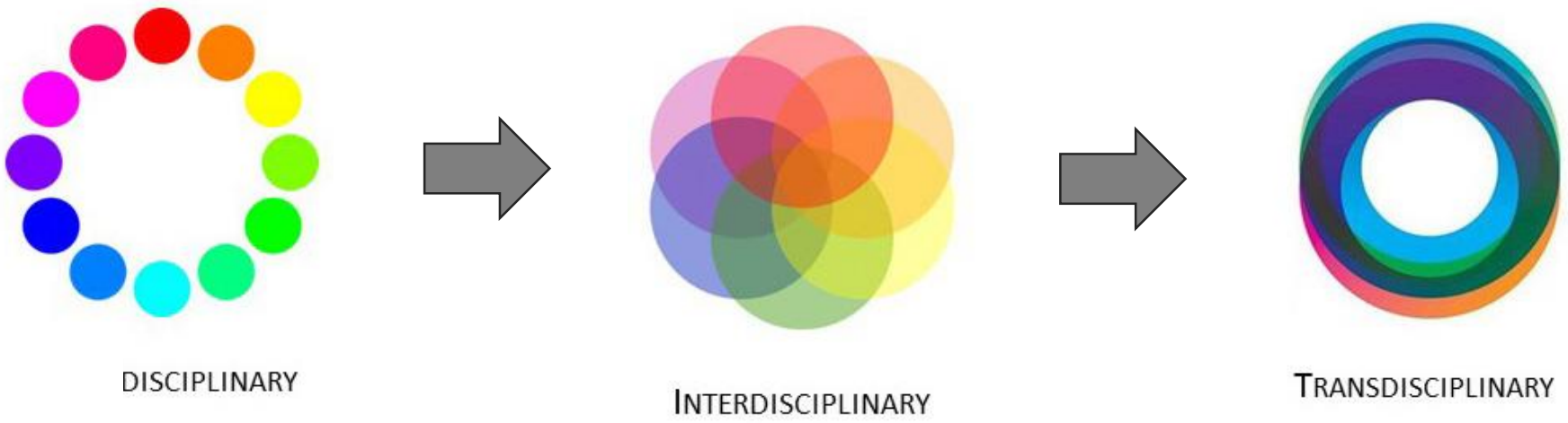

Transdisciplinary
Interdisciplinary
Multidisciplinary
Disciplinary

TRANSDISCIPLINARITY


NEWS
MIN
MAX
KNOWLEDGE
TRANSFER
MACHINE

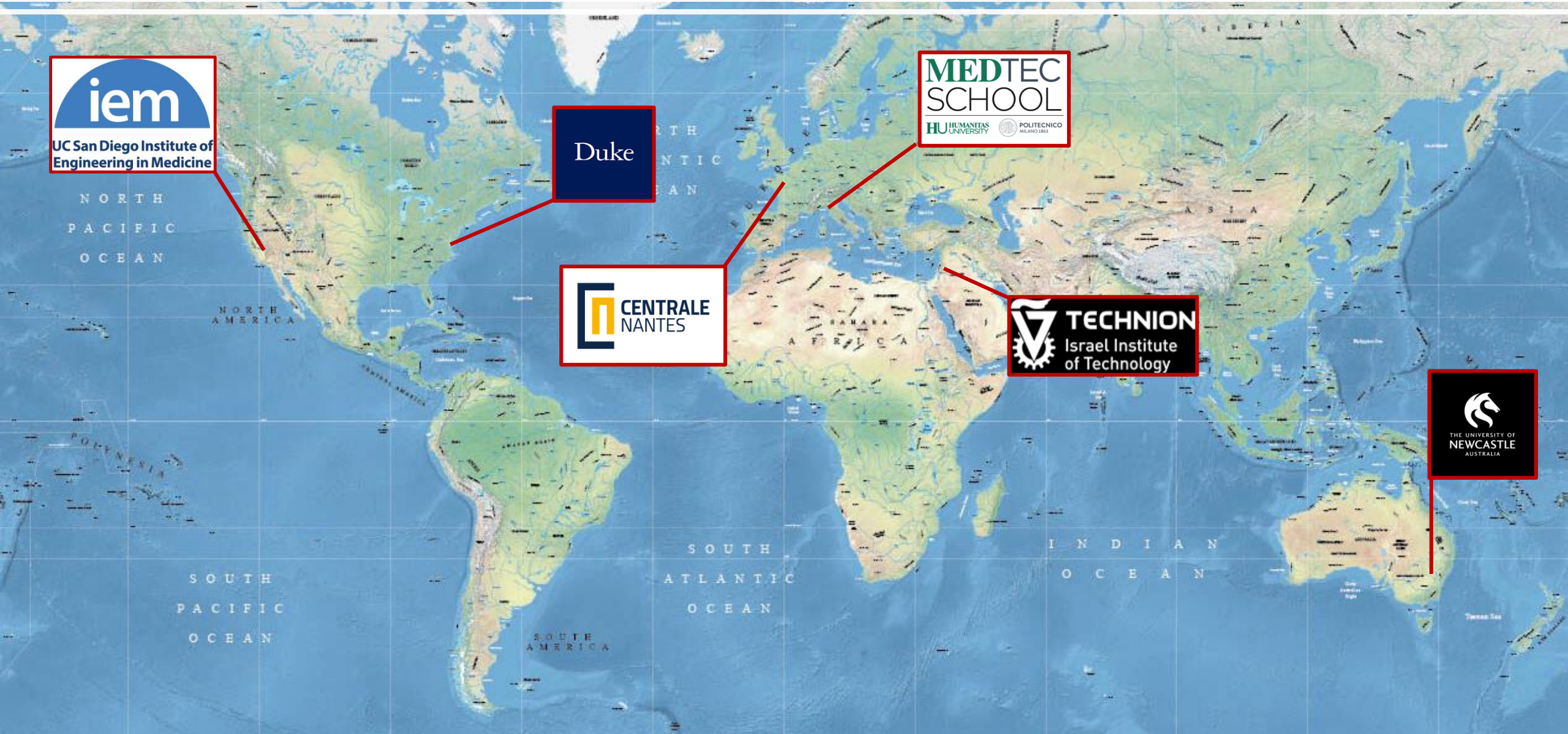
Cardiac and vascular research necessitate solutions from different backgrounds because singular disciplines are incapable of providing
a definitive solution for clinical problems

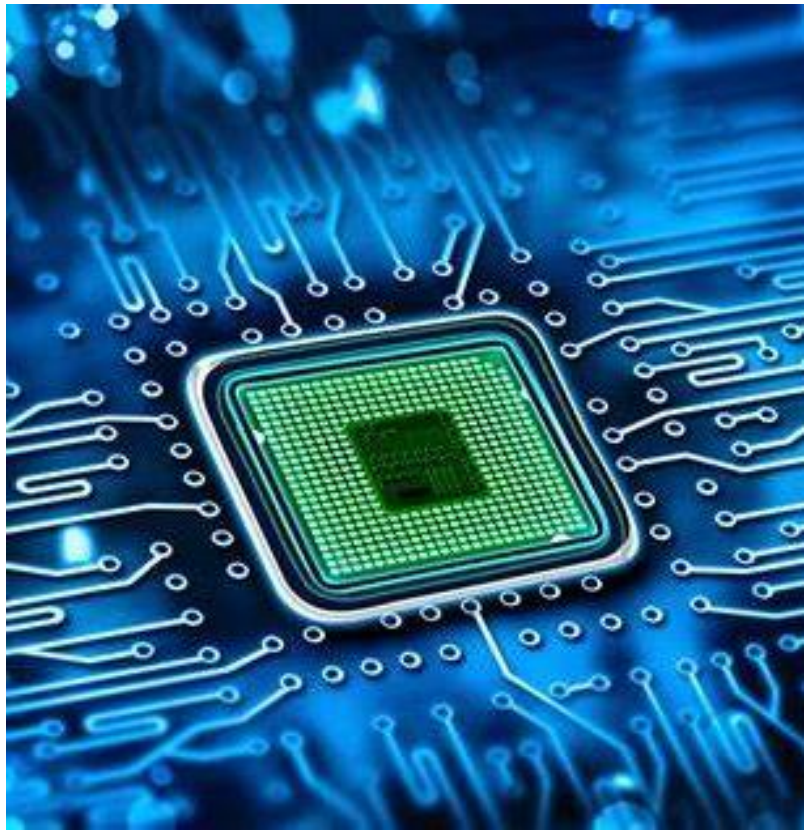
Cardiovascular research is inherently transdisciplinary



Transdisciplinarity: an established idea

ENGINEERING AND MEDICINE WORLDWIDE





Engineer with vascular pathology competence

Vascular specialist with engineering competence

Cardiac and Vascular Research Center

INTRODUCTION – Cardiac and vascular research center

OSPEDALE POLICLINICO SAN MARTINO

Cardiac and Vascular Research Center

Laboratory of Cardiovascular Biology

CELLULAR BIOLOGY AND PROTEOMICS

MOLECULAR BIOLOGY AND MICROSCOPY

OSPEDALE POLICLINICO SAN MARTINO

Cardiac and Vascular Research Center

Research Laboratory of Experimental and Clinical Vascular Biology

PROTEIN EXPRESSION ANALYSIS. HYSTOLOGY AND VASCULAR TISSUE ENGINEERING

BIOLOGICAL VALIDATION OF BIOMATERIALS, NANOPARTICLES, AND NATURAL EXTRACTS

OSPEDALE POLICLINICO SAN MARTINO

Cardiac and Vascular Research Center

Laboratory of Clinical Internal Medicine 1st

CELLULAR BIOLOGY AND PHYSIOLOGY OF PHAGOCYTES

OSPEDALE POLICLINICO SAN MARTINO
Sistema Sanitario Regione Liguria

DISC

INTRODUCTION – Cardiac and vascular research center

Cardiac and Vascular Research Center: research areas

- Cardiac hypertrophy
- Pathophysiology of phagocytes
- Endothelial dysfunction
- Tissue engineering and drug delivery
- Cardiotoxicity
- Heart failure
- Atherosclerosis
- Ischemia/reperfusion damage

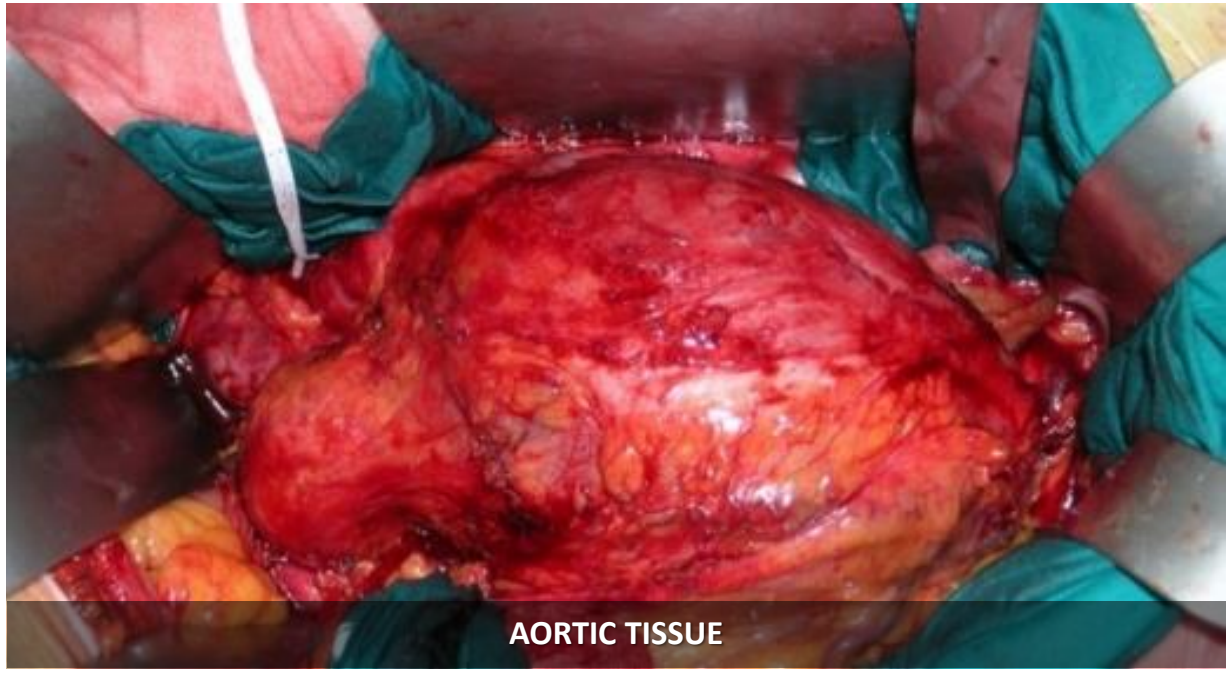
Research Laboratory of Experimental and Clinical Vascular Biology

Laboratory of Cardiovascular Biology

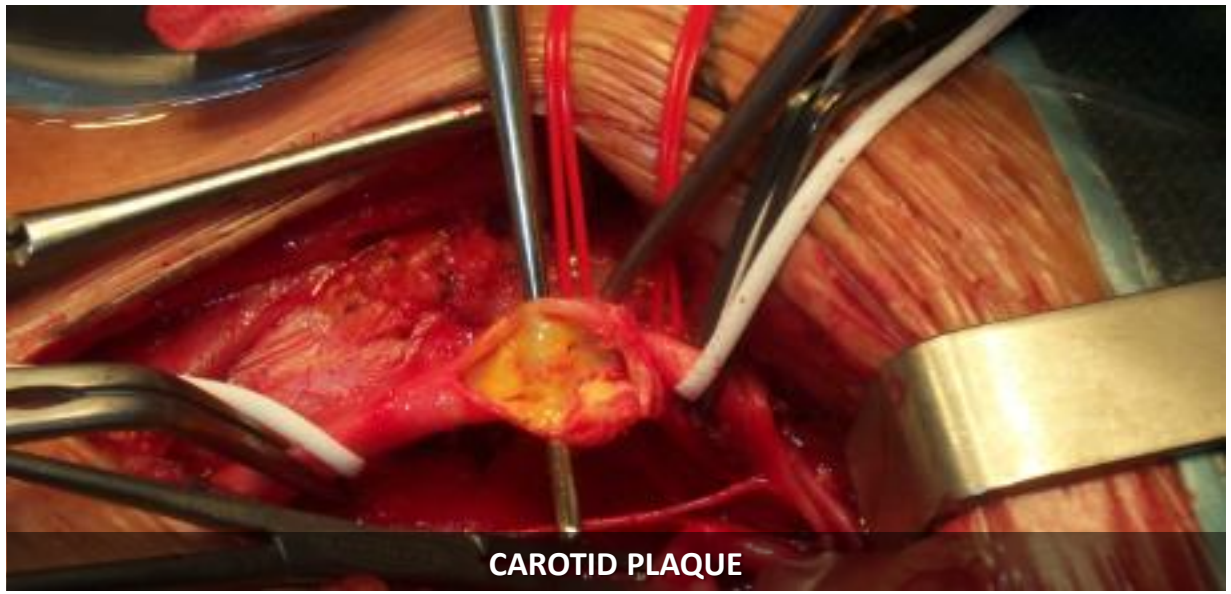
Laboratory of Clinical Internal Medicine 1

OSPEDALE POLICLINICO SAN MARTINO
Sistema Sanitario Regione Liguria

DISC



AORTIC TISSUE



CAROTID PLAQUE

VASCULAR BIO BANK

INVESTING IN EVERYBODY'S HEALTH

SAMPLE PREPARATION

OSPEDALE POLICLINICO SAN MARTINO

Sistema Sanitario Regione Liguria

DISC

DICCA

- Extraction of high-added value compounds with non-conventional techniques
- Micro- and nanoencapsulation of bioactive compouds
- Fabrication and characterization of polymeric biomaterials
- Mathematical modeling of biological phenomena
- Safety engineering

Transdisciplinarity at University of Genoa

DISC

Nanotechnology and Tissue Engineering applied to Vascular Medicine

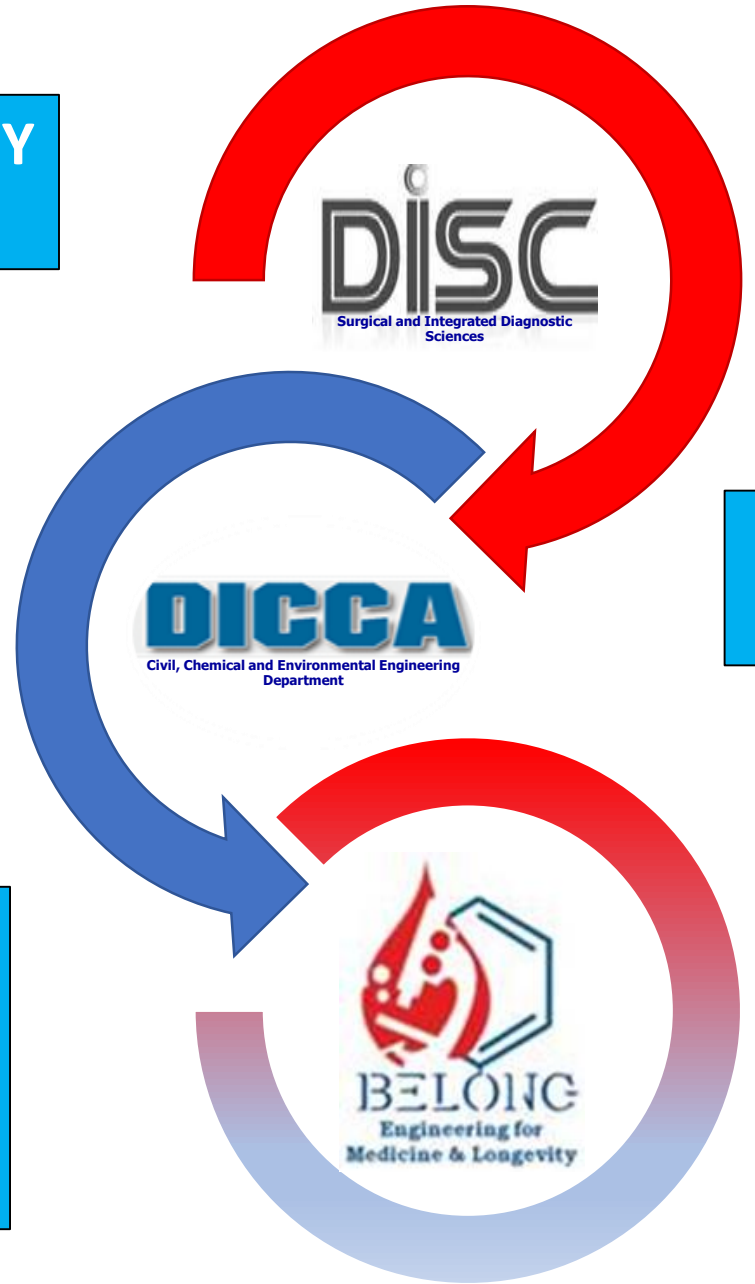
DICCA

- Pathology
- Microbiology
- Vascular surgery
- Cardiac surgery

- Enviromental safety
- Material engineering
- Fluid and biofluid mechanics
- Food engineering

From VASCULAR surgery to CHEMICAL engineering

VASCULAR BIOLOGY AND MEDICINE



CHEMICAL ENGINEERING

RESEARCH CENTER OF BIOLOGICALLY INSPIRED ENGINEERING IN VASCULAR MEDICINE AND LONGEVITY

A MODEL OF TRANSDISCIPLINARITY

INTRODUCTION – Our research centers

University of Pavia

DICCA
Civil, Chemical and Environmental Engineering Department

DISC
Department of Surgical and Integrated Diagnostic Sciences

OSPEDALE POLICLINICO SAN MARTINO

LABORATORY OF CLINICAL AND EXPERIMENTAL VASCULAR BIOLOGY

BELONG
Engineering for Vascular Medicine & Longevity

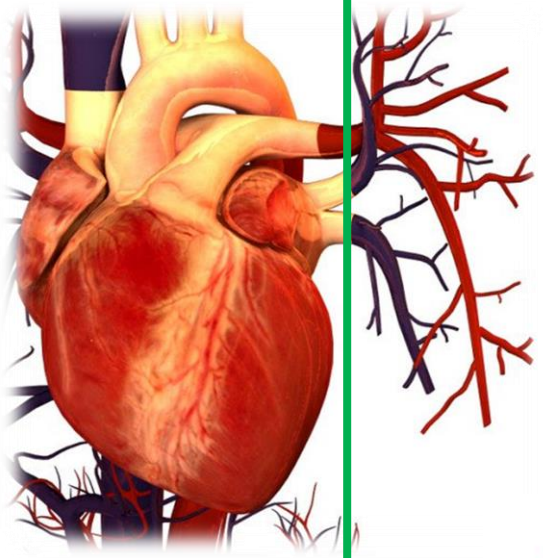
U.O. Chirurgia Vascolare ed Endovascolare

Cardiac and Vascular Research Center

BELONG

INTRODUCTION – Research topics

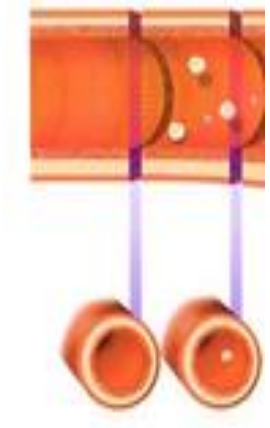
- **VASCULAR BIOLOGY: polyphenols and inflammation;**
- **VASCULAR DRUG DELIVERY: nanoparticles as an innovative drug delivery system for atherosclerosis;**
- **VASCULAR TISSUE ENGINEERING: biological validation of small-diameter biodegradable vascular prosthesis;**
- **BIOREACTORS AND FLUIDODYNAMICS STUDIES: mechanobiology of bioprostheses;**
- **VASCULAR REMODELING AFTER ENDOVASCULAR TREATMENT: quantitative analysis of medical images.**
- **SAFETY ENGINEERING**



BELONG
Engineering for Vascular Medicine & Longevity

MODULATING INFLAMMATORY PROCESS

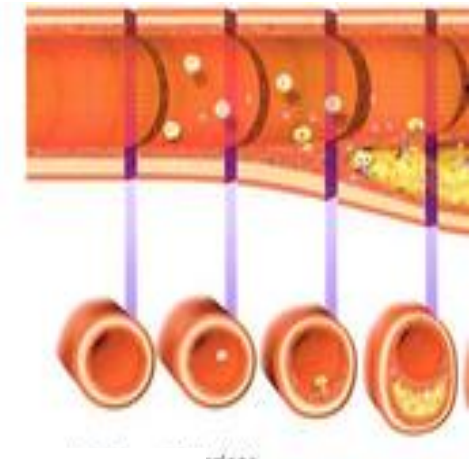
PREVENTION



Normal artery

Endothelial activation

THERAPY

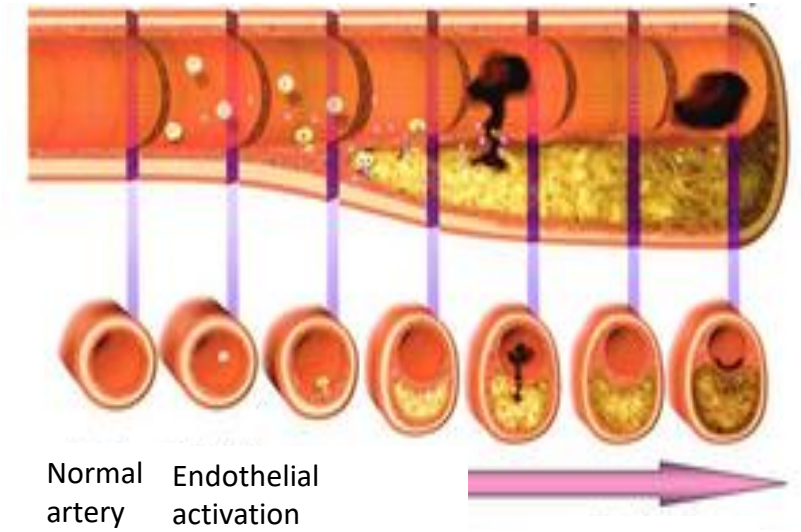


Normal artery

Endothelial activation

REMODELLING

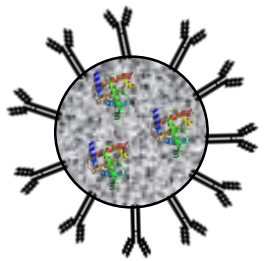
SUBSTITUTION



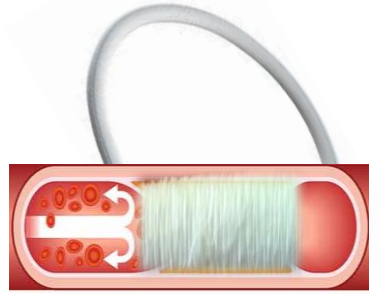
Normal artery

Endothelial activation

BIOACTIVE COMPOUNDS

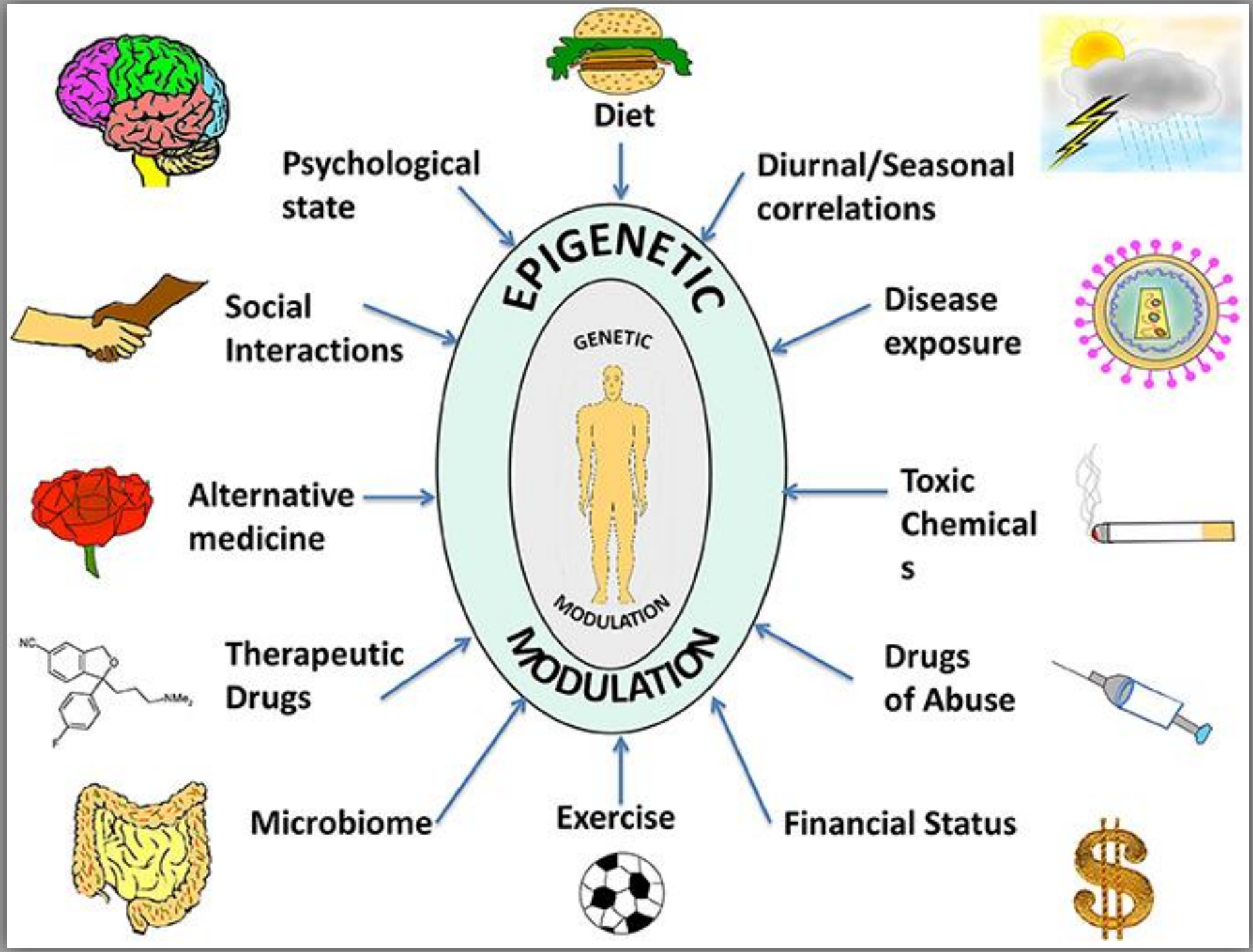


NANOSYSTEMS FOR DRUG DELIVERY



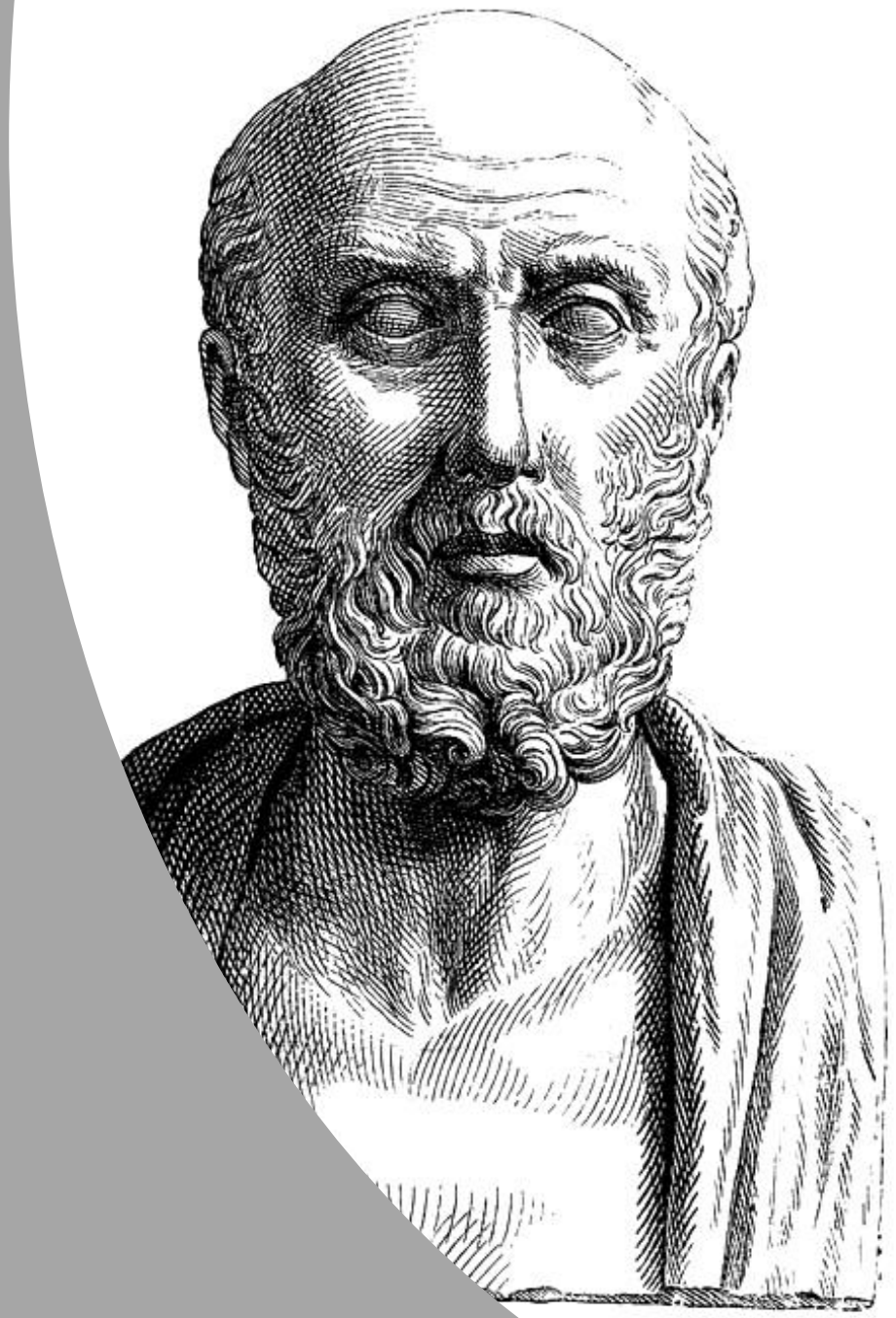
VASCULAR TISSUE ENGINEERING

Food engineering in vascular diseases


Diet
Psychological state
Diurnal/Seasonal correlations
EPIGENETIC
GENETIC
MODULATION
MODULATION
Social Interactions
Disease exposure
Alternative medicine
Toxic Chemicals
Therapeutic Drugs
Drugs of Abuse
Microbiome
Exercise
Financial Status

« Let food be thy medicine, And let medicine be thy food »

Hippocrates of Kos

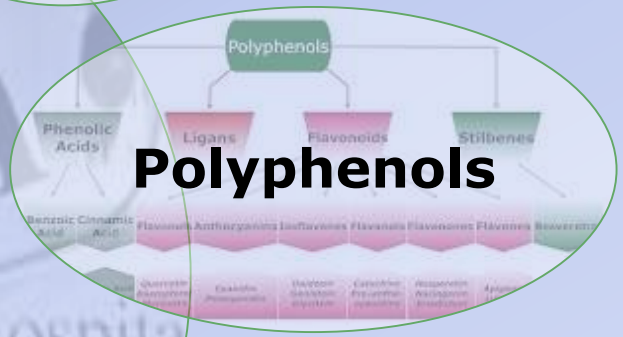


«An apple a day keeps the doctor away, as long as you aim well! »

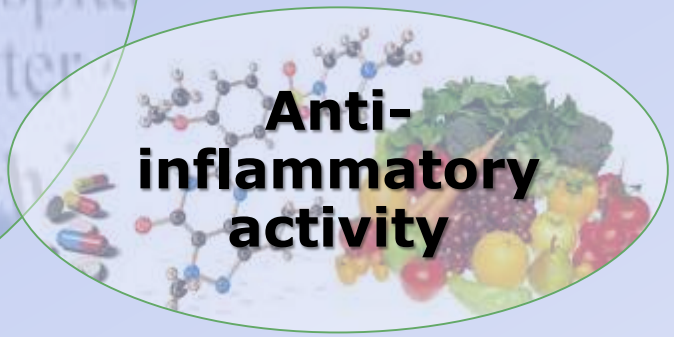
W. Churchill

Prevention

Lifestyle



Polyphenols



Anti-inflammatory activity

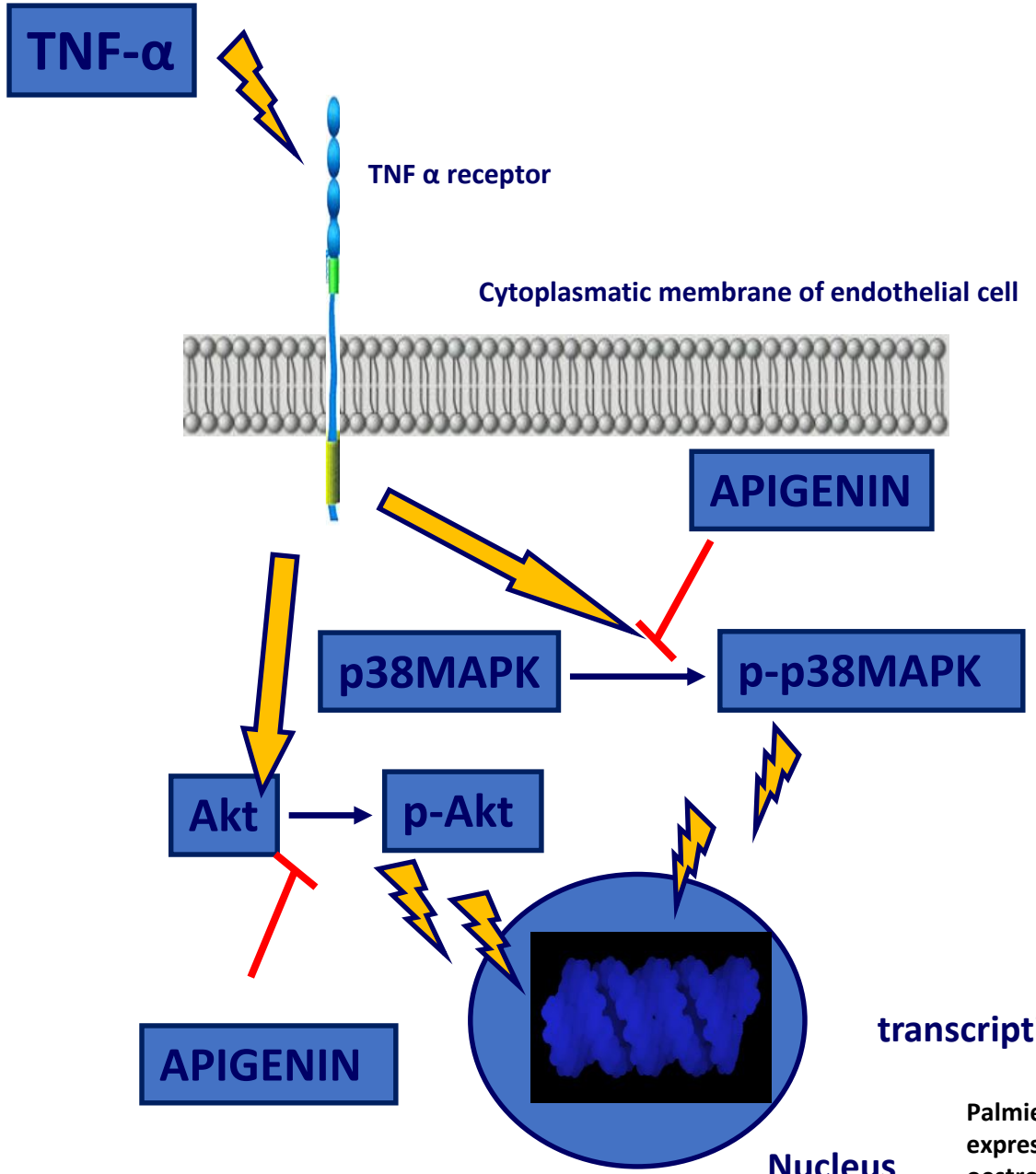
Mura M. et al. «Simultaneous ultrasound-assisted water extraction and β-cyclodextrin encapsulation of polyphenols from *Mangifera indica* stem bark in counteracting TNFα-induced endothelial dysfunction». Nat Prod Res. 2015; 29(17): 1657-63. doi: 10.1080/14786419.2014.996753.

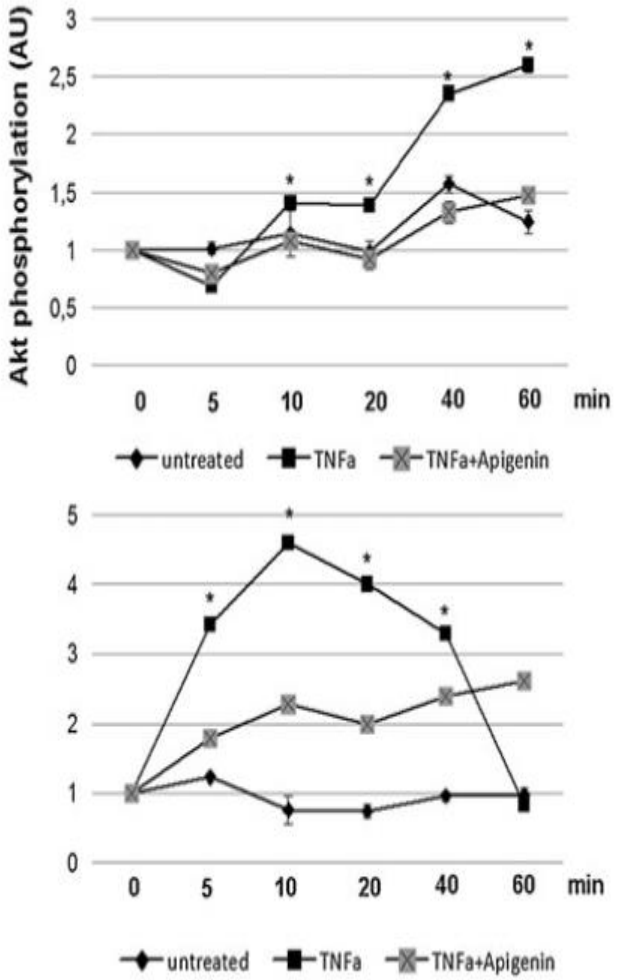
Palmieri D. et al. «Effects of polyphenol extract from olive pomace on anoxia-induced endothelial dysfunction». Microvasc Res. 2012; 83(3): 281-9. doi: 10.1016/j.mvr.2012.02.010.

Aliakbarian B. et al. «Antioxidant activity and biological evaluation of olive pomace extract». Nat Prod Res. 2012;26(24): 2280-90. doi: 10.1080/14786419.2012.660692.

Palmieri D. et al. «Apigenin inhibits the TNFα-induced expression of eNOS and MMP-9 via modulating Akt signalling through oestrogen receptor engagement». Mol Cell Biochem 2012 ; 371(1-2): 129-36. doi: 10.1007/s11010-012-1429-1.

Polyphenols and *in vitro* inflammation





transcription → **Translation of proteins able to induce inflammation**

Palmieri D, Perego P, Palombo D. Apigenin inhibits the TNFα-induced expression of eNOS and MMP-9 via modulating Akt signalling through oestrogen receptor engagement. Mol Cell Biochem (2012) 371:129–136

Polyphenols and *in vivo* inflammation

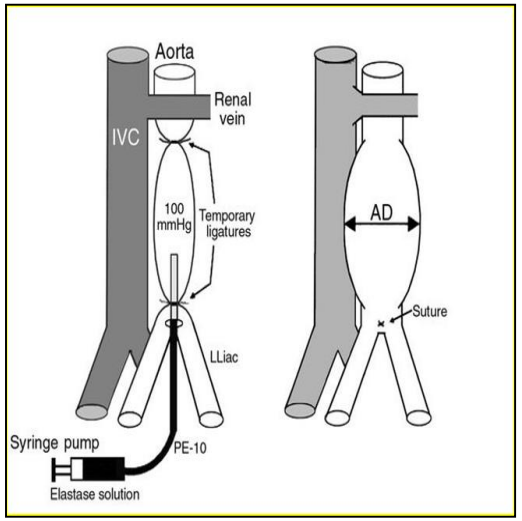
30 male rats Sprague Dawley

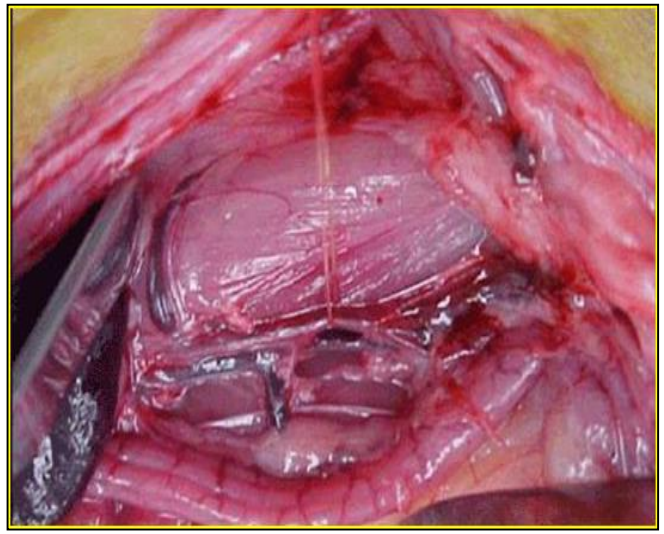
↓

15 rats treated with RESVERATROL (10 mg kg/die in etanolo)
15 rats treted with placebo (just ethanol)

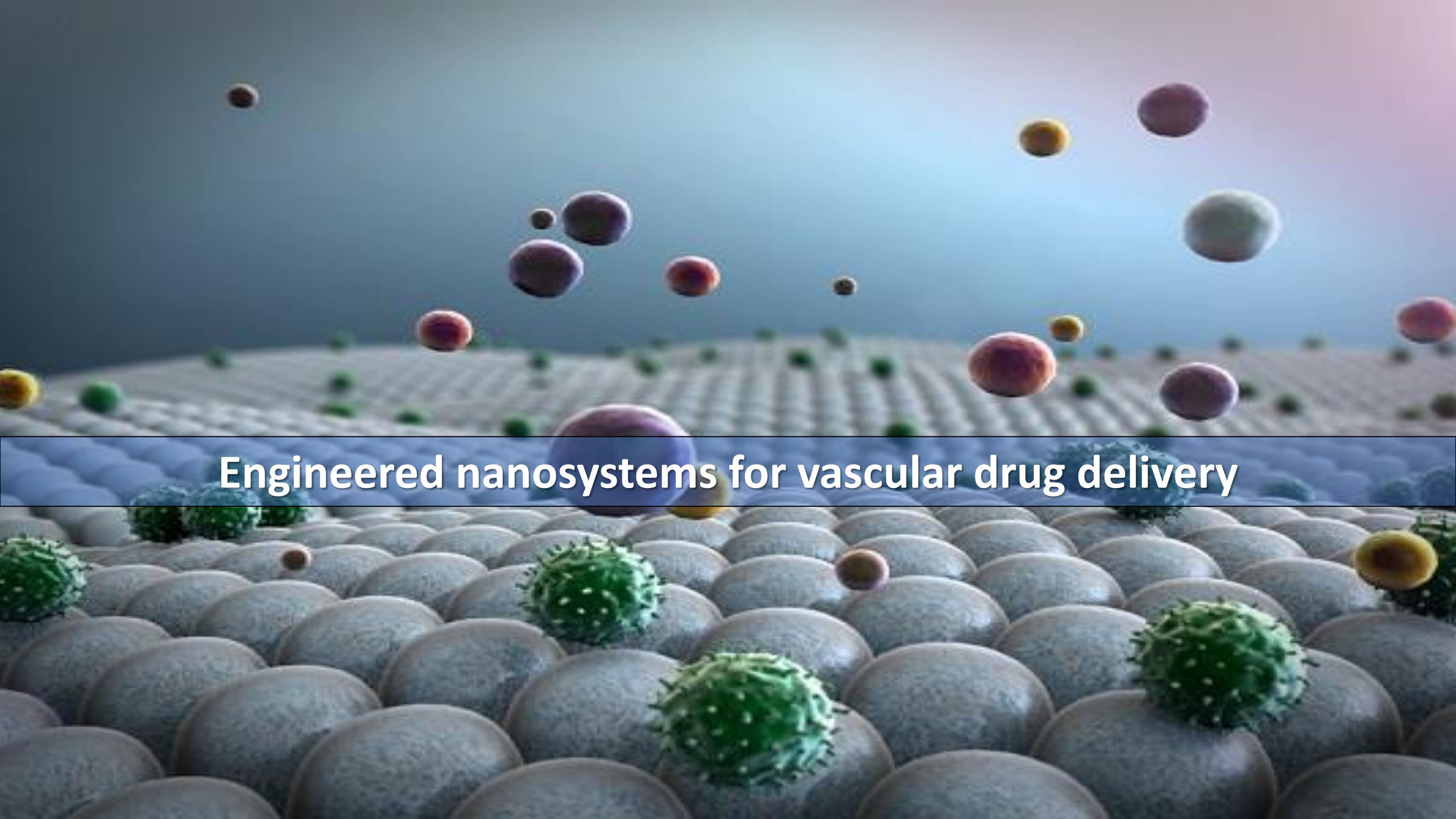
↓

Infusion of pancreatic elastase



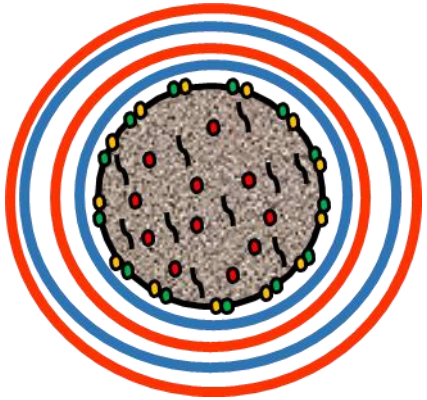


Palmieri D et al. Resveratrol counteracts systemic and local inflammation involved in early abdominal aortic aneurysm development. J Surg Res. 2011 Dec; 171(2): e237-46. doi: 10.1016/j.jss.2011.07.041.

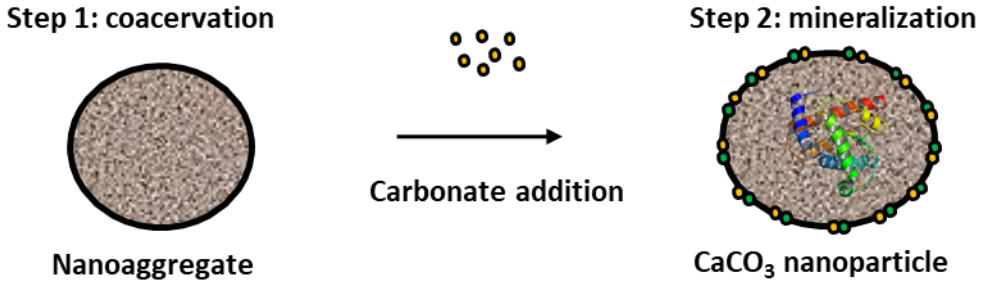

Engineered nanosystems for vascular drug delivery

VASCULAR DRUG DELIVERY - Micro- and nanoencapsulation techniques

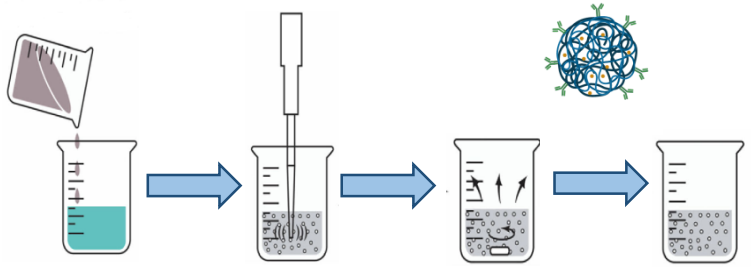
SONICATION



LAYER-BY-LAYER



COMPLEX COACERVATION



EMULSION SOLVENT EVAPORATION

ENGINEERED $CaCO_3$ NANOPARTICLES WITH TARGETING ACTIVITY: A SIMPLE APPROACH FOR A VASCULAR INTENDED DRUG DELIVERY SYSTEM

Pier Francesco Ferrari,[1]* Bahar Aliakbarian,[1,2] Elena Zattera,[3] Laura Pastorino,[3] Domenico Palombo[2,4] and Patrizia Perego[1,2]


Contents lists available at ScienceDirect
LWT - Food Science and Technology
journal homepage: www.elsevier.com/locate/lwt
Microencapsulation of phenolic compounds from olive pomace using spray drying: A study of operative parameters
Marco Paini, Bahar Aliakbarian, Alessandro A. Casazza, Alberto Lagazzo, Rodolfo Botter, Patrizia Perego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ISBN 978-88-95608-34-1; ISSN 2283-9216
Effect of encapsulating agent on physical-chemical characteristics of olive pomace polyphenols-rich extracts
Bahar Aliakbarian[a,b*], Marco Paini[a,b], Alessandro Alberto Casazza[a,b], and Patrizia Perego[a,b]

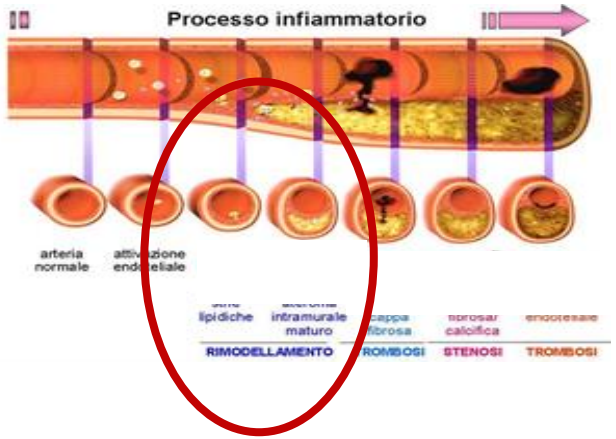
In collaboration with:

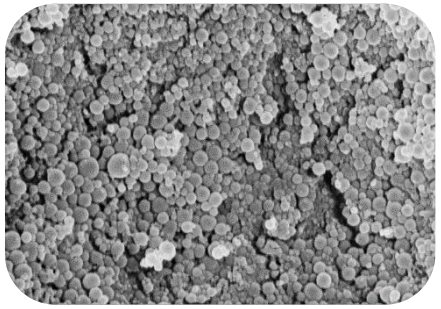
DICCA
Civil, Chemical and Environmental Engineering Department

Polytechnic School

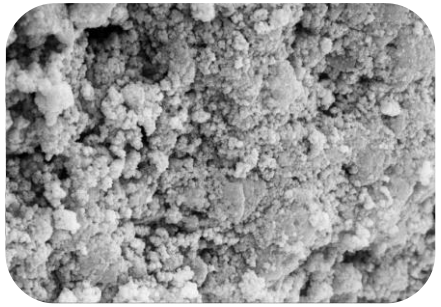
Dibris

VASCULAR DRUG DELIVERY - Micro- and nanoparticles



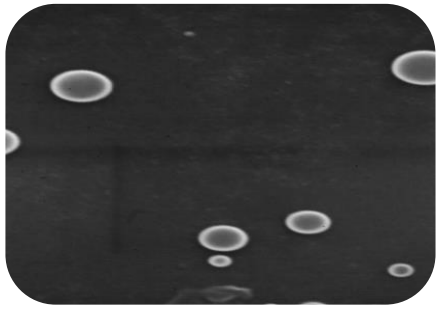


POLYMERIC NANOPARTICLES

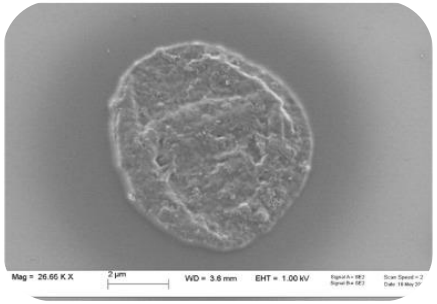


NANOLIPOSOMES

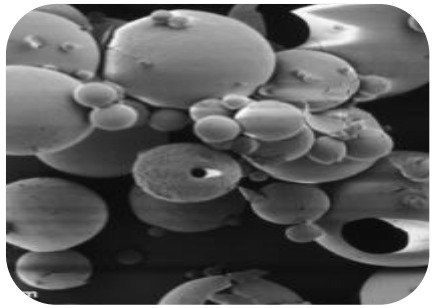
In collaboration with:



$CaCO_3$ NANOPARTICLES



LAYER-BY-LAYER-BASED PARTICLES

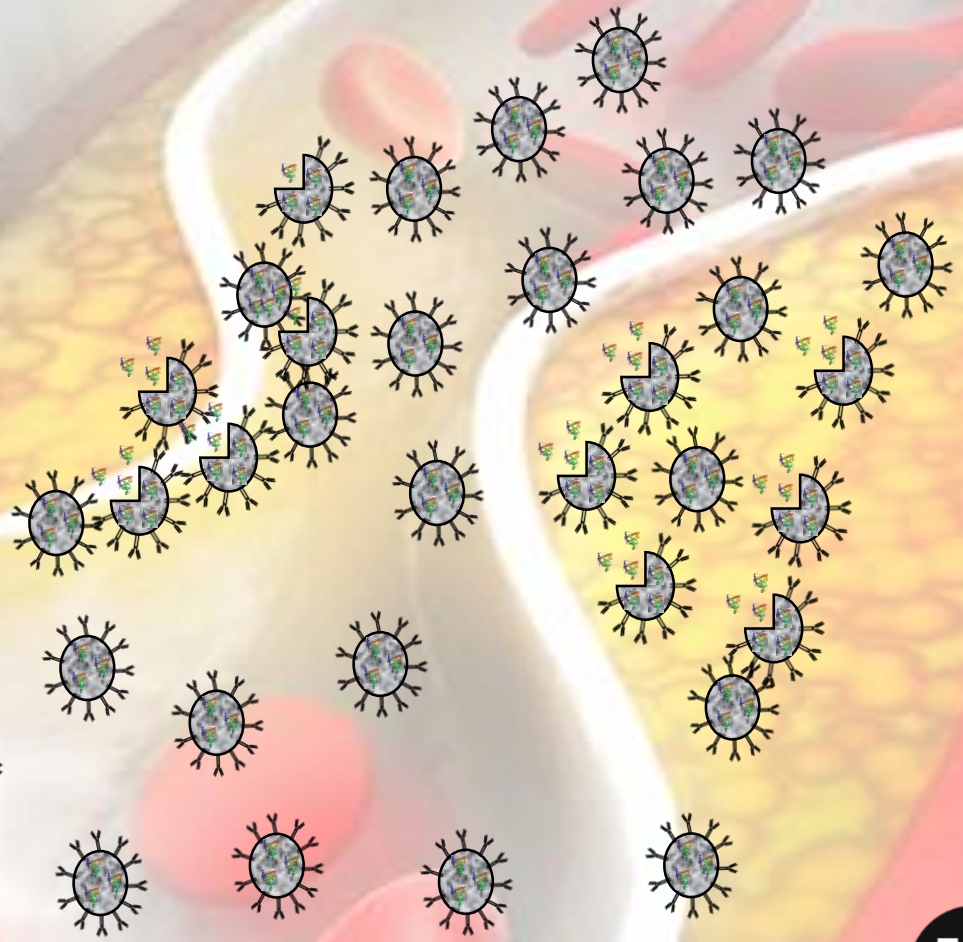


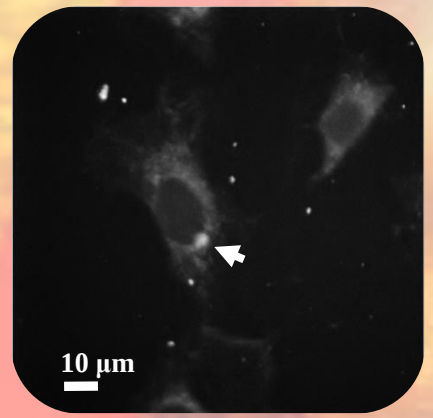
SPRAY DRYER-BASED PARTICLES

Ferrari PF, Aliakbarian B, Zattera E, Pastorino L, Palombo D, Perego P, 2017. Engineered $CaCO_3$ nanoparticles with targeting activity: a simple approach for a vascular intended drug delivery system. The Canadian Journal of Chemical Engineering 95: 1683-1689.

Ferrari PF, Aliakbarian B, Bagnato P, Palombo D, Perego P, 2017. An innovative drug delivery system for atherosclerosis. **ESCVS 2017 YOUNG VASCULAR AWARD**

Drug delivery system for atherosclerosis





In collaboration with:

University of Lorraine

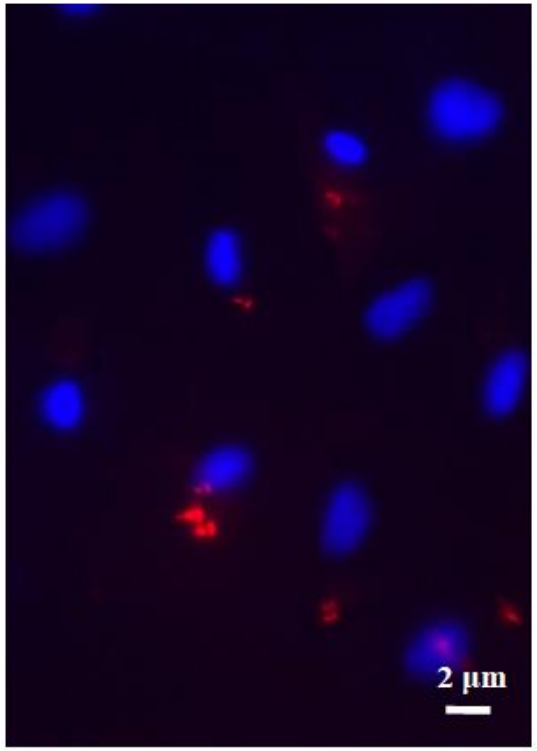
(Nancy, France)

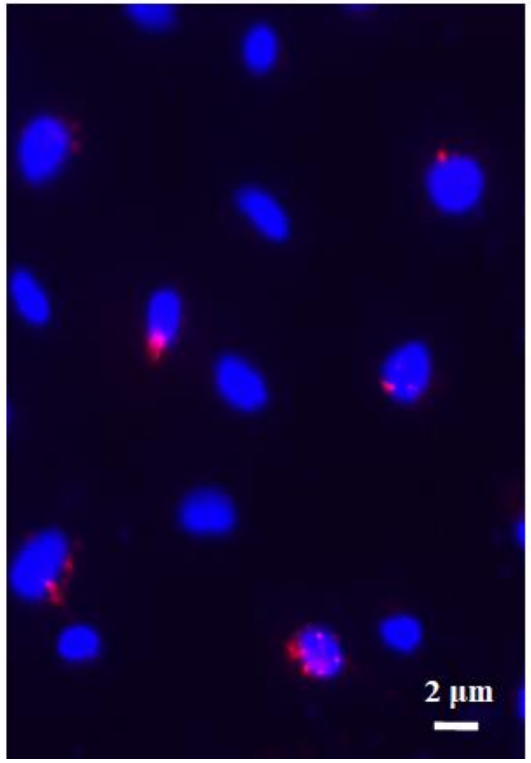
University of Porto

(Porto, Portugal)

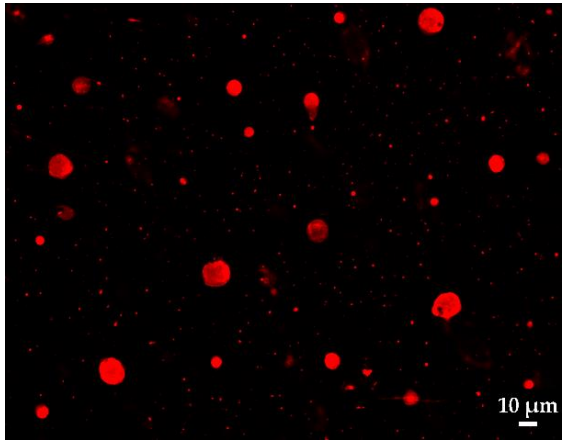
Schematic representation of nanoparticles encapsulating therapeutic proteins

In vitro

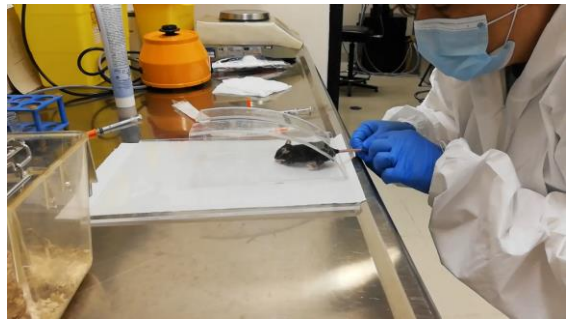




In vivo



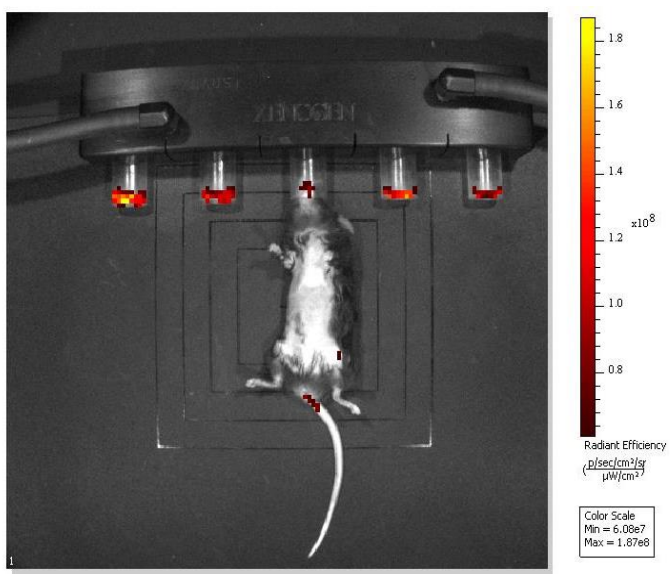
Functionalized polymeric nanoparticles marked with rhodamine



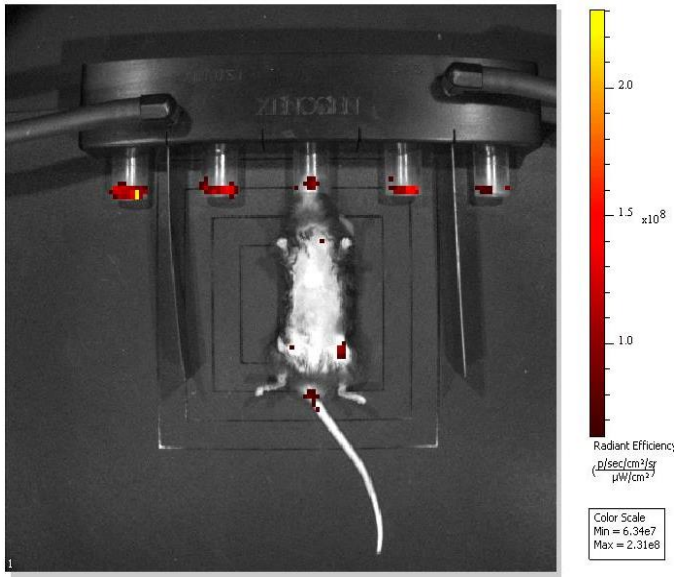
VASCULAR DRUG DELIVERY - *In vitro* cellular uptake & *in vivo* test

VASCULAR DRUG DELIVERY - *In vivo* test

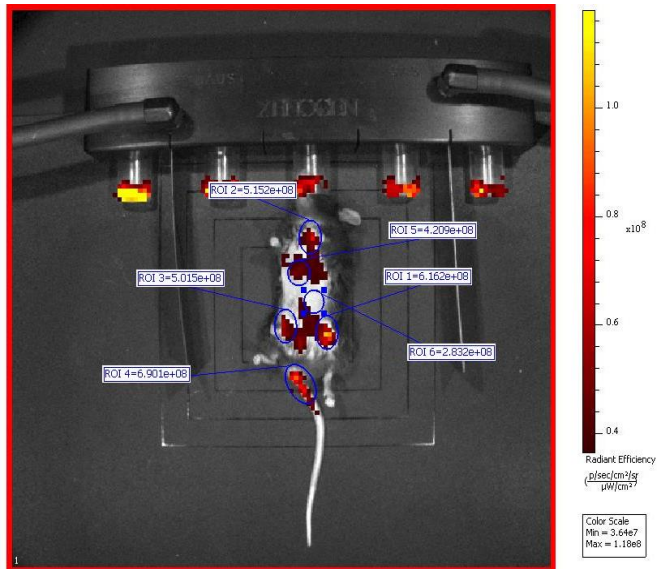
DISTRIBUTION OF NANOPARTICLES MARKED WITH RHODAMINE



10 minutes



30 minutes

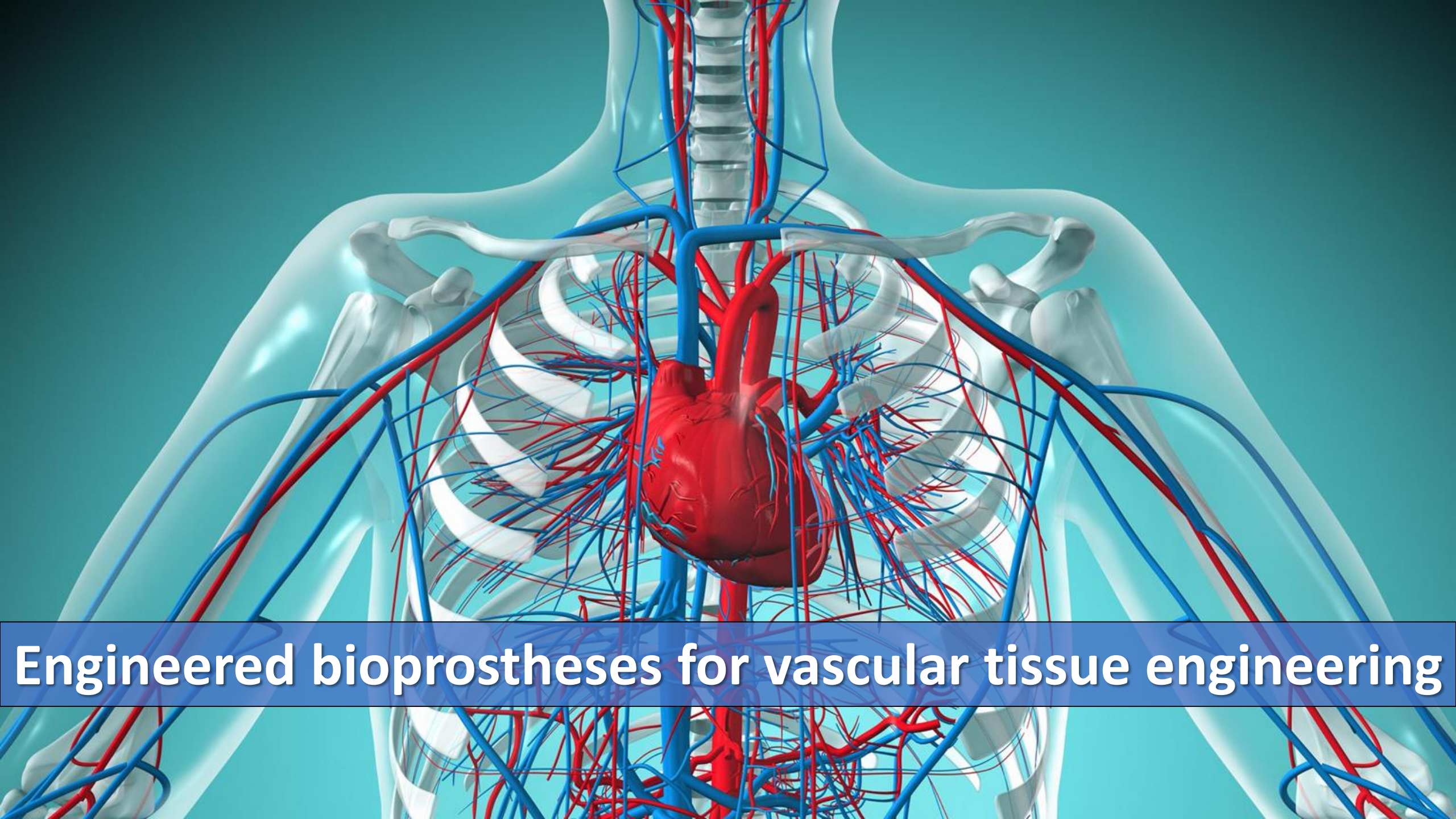


60 minutes

TIME

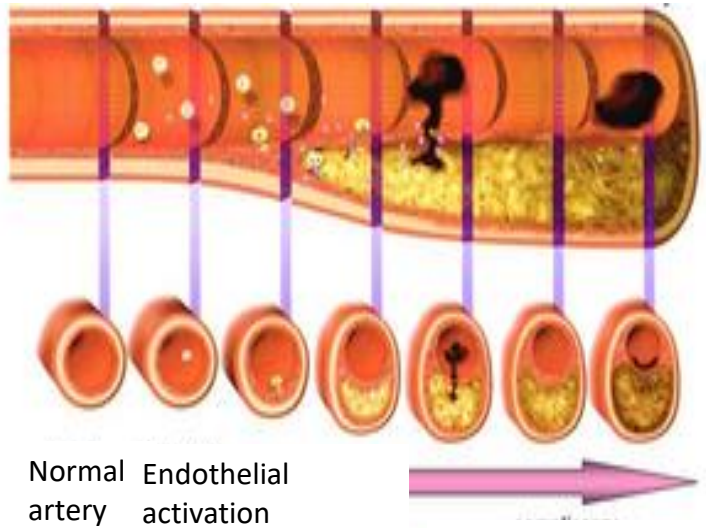
PATENT:

Perego P, Palombo D, Ferrari PF, Campardelli R, Pratesi G, 2019. Engineered nanoliposomes for a targeted therapy of atherosclerosis and their preparation procedures. Application number: 102019000008745, registered on 12th June 2019.



Engineered bioprostheses for vascular tissue engineering

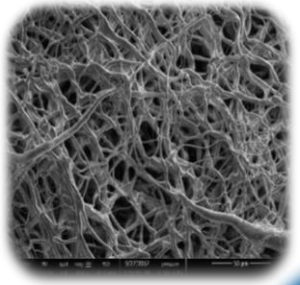
VASCULAR TISSUE ENGINEERING

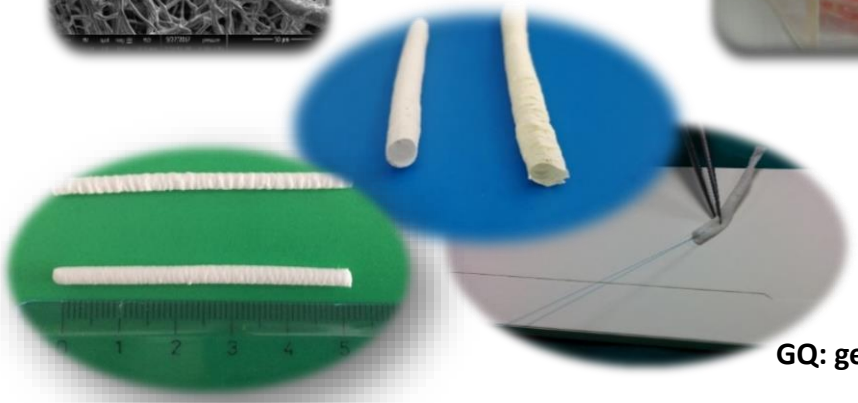


Normal artery

Endothelial activation

OCCLUSION





Q: quercetin
GQ: gelatin and quercetin

Small diameter vascular prostheses (2 and 5 mm in diameter)

In collaboration with

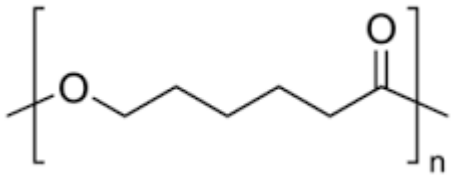
DICCA

Ferrari PF, Aliakbarian B, Lagazzo A, Tamayol A, Palombo D, Perego P, 2017. Tailored electrospun small-diameter graft for vascular prosthesis,
International Journal of Polymeric Materials 66, 635-643.
Ferrari PF, Aliakbarian B, Palombo D, Perego P, 2017. Small diameter vascular grafts coated with gelatin. Chemical Engineering Transactions 57.
Aliakbarian B, Ferrari PF, Bagnato P, Palombo D, Perego P. Engineered small diameter vascular grafts with anti-inflammatory properties. The Journal of Cardiovascular Surgery, abstract book, Vol. 58 – Suppl. 2 to n° 3, 14.

Biodegradable and biocompatible polymers for vascular bioprostheses

Poly (ε-caprolactone) (PCL)

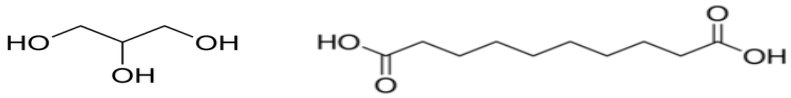
- Biodegradable polyester
- FDA approved
- Suitable for electrospinning
- Good mechanical properties
- Hydrophobic properties



PCL

Poly (glycerol sebacate) (PGS)

- Synthetic elastomer
- Biodegradable
- Biocompatible
- Hydrophilic properties

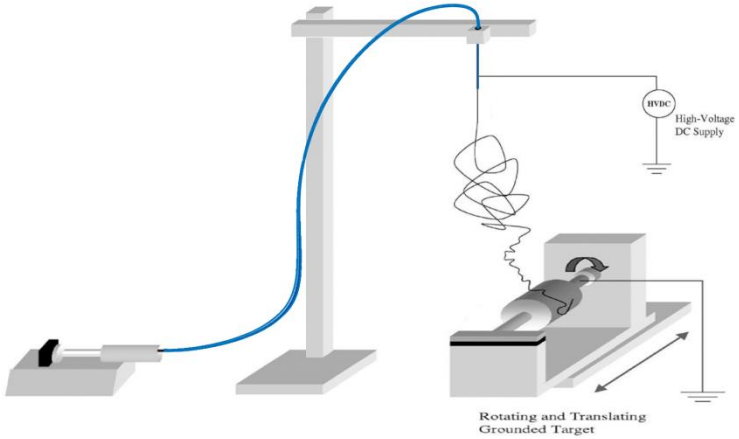


glycerol + sebacic acid

PGS

PCL:PGS (1:1, v/v)

Materials and methods – Electrospinning

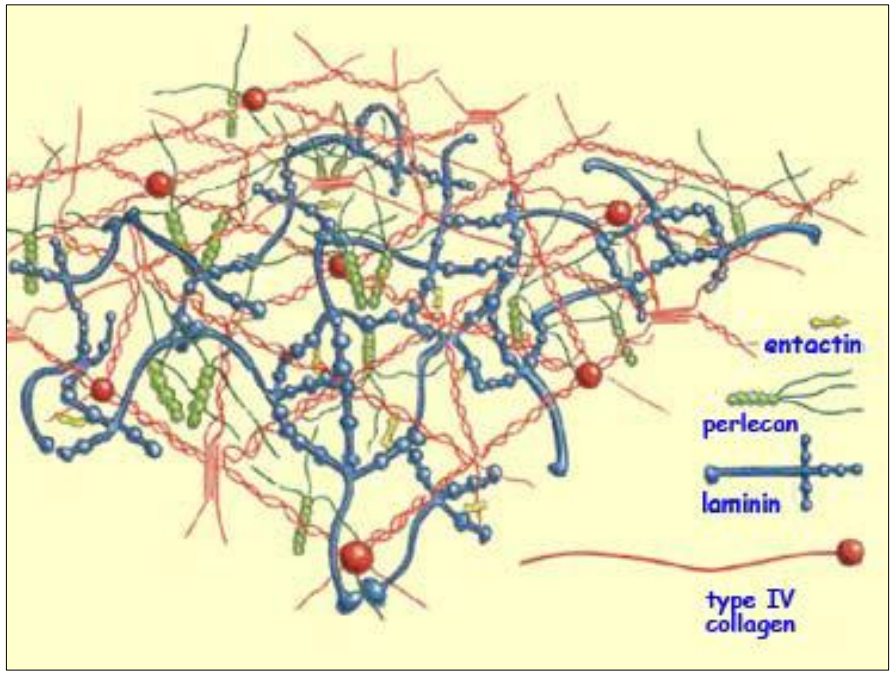


Small-diameter electrospun vascular scaffolds:

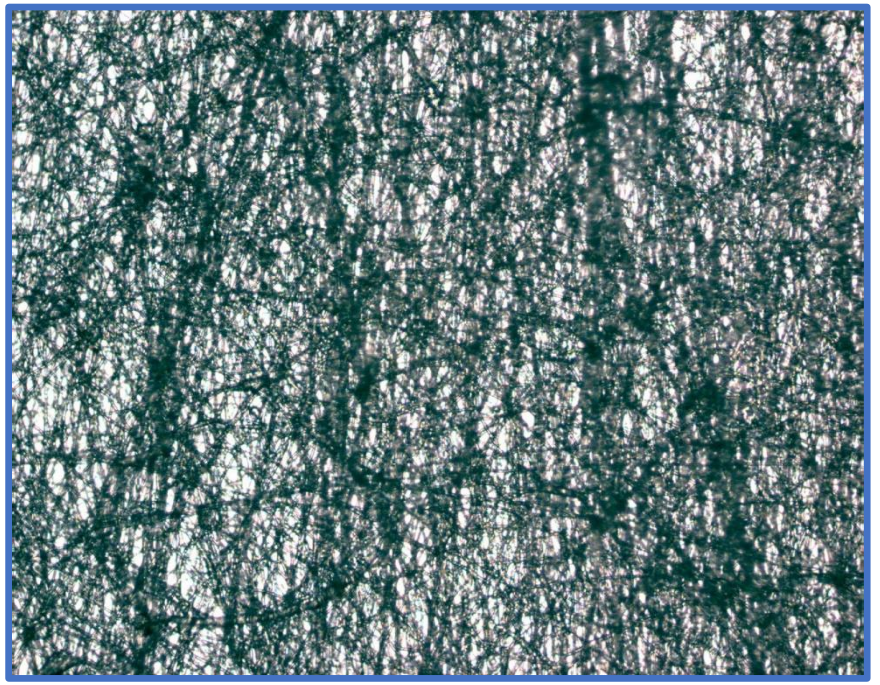
2 mm in diameter

5 mm in diameter

Why electrospinning?



Extracellular matrix

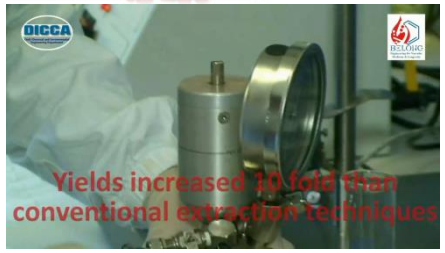


Electrospun scaffold fibers

Electrospinning is a fiber-forming technique to fabricate nanofibers from different natural or synthetic polymers

These fibers mimic the complex 3D architecture of extracellular matrix

Scaffold functionalization



To modulate post-surgery inflammation

To induce re-endothelialization

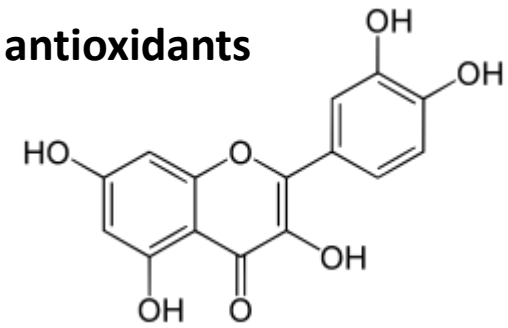
proteins

Green sustainable extraction techniques

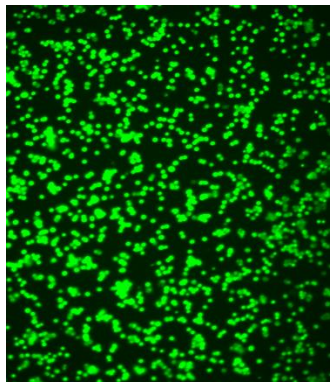
SCAFFOLD FUNCTIONALIZATION

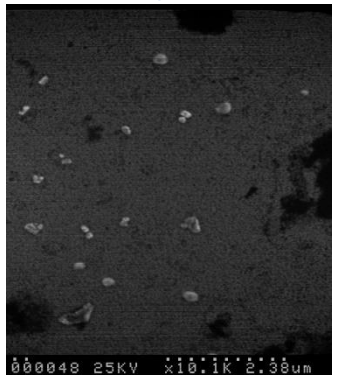
nanoencapsulation

antioxidants

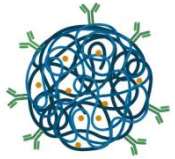


quercetin





Morphological characterization of nanoparticles

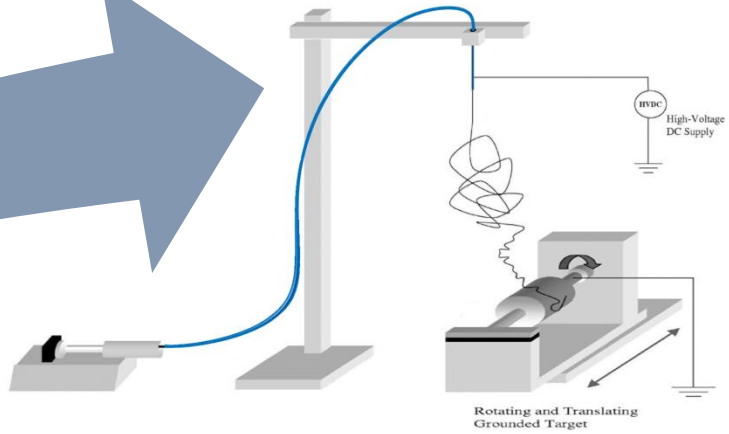


Nanoparticles

Functionalized scaffolds with antioxidants and proteins

HPTE

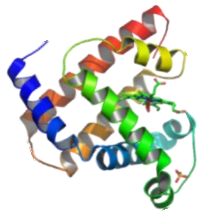
PCL:PGS solution
containing QUERCETIN



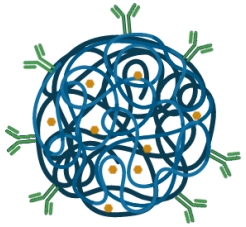
Electrospinning

Vegetables

PCL:PGS solution
containing nanoparticles
encapsulating PROTEINS



PROTEINS



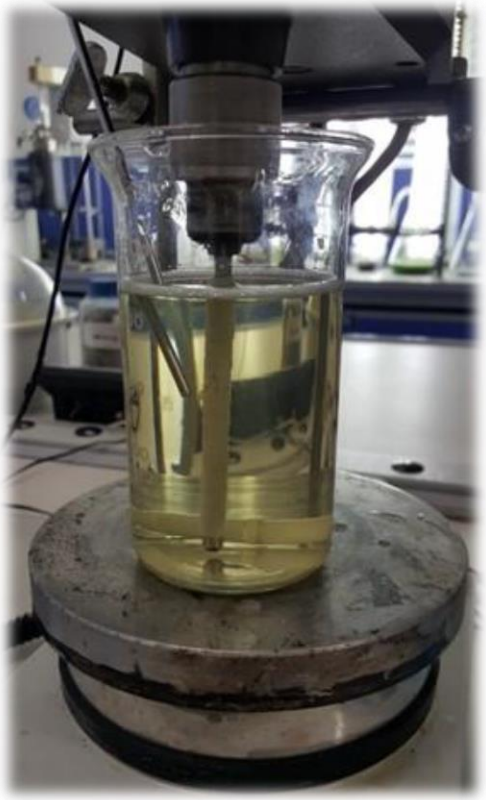
Nanoparticles
encapsulating PROTEINS

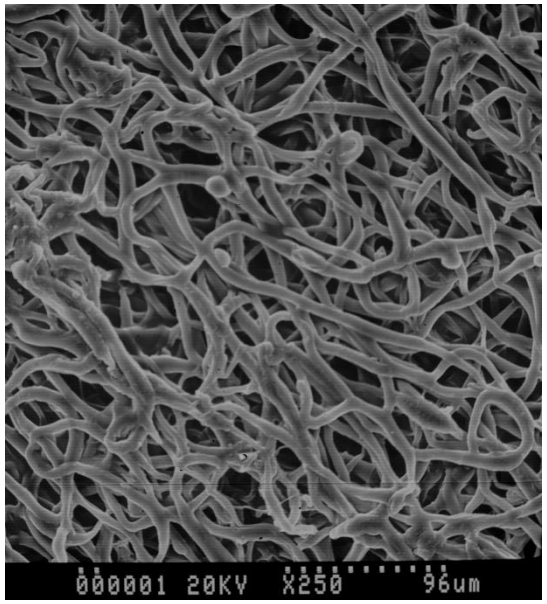
Surface coating with gelatin

Coating with gelatin (process)

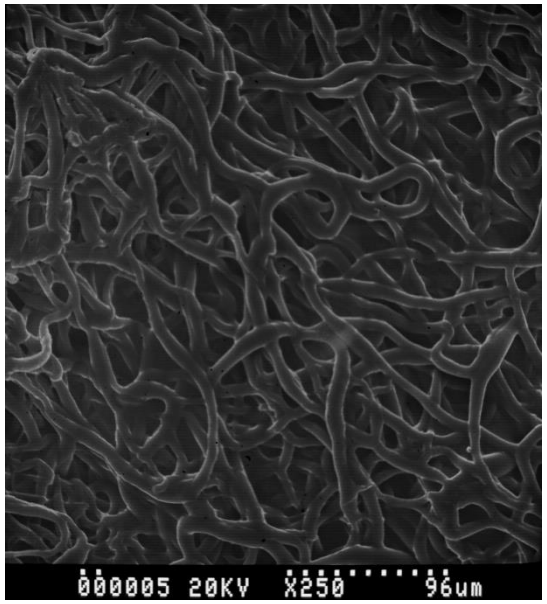
1 hour under controlled temperature (37°C) and at constant velocity of 135 rpm

Fully immersed in a gelatin solution (67 mg/mL)



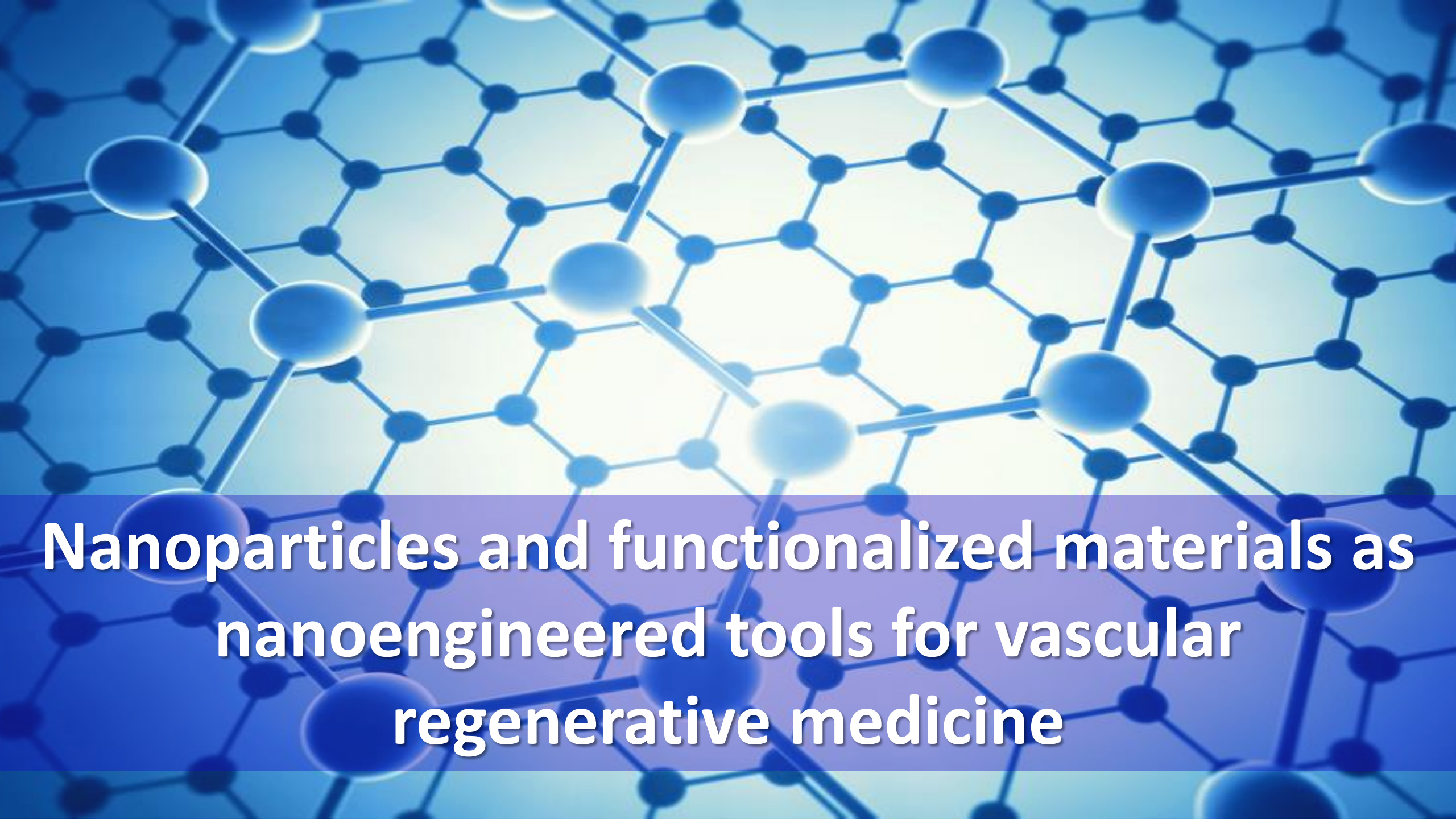


without surface coating: highly porous



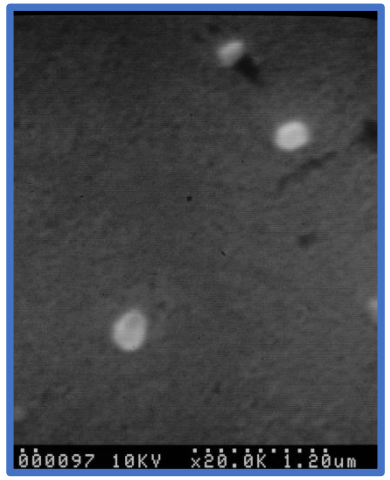
with surface coating: poorly porous

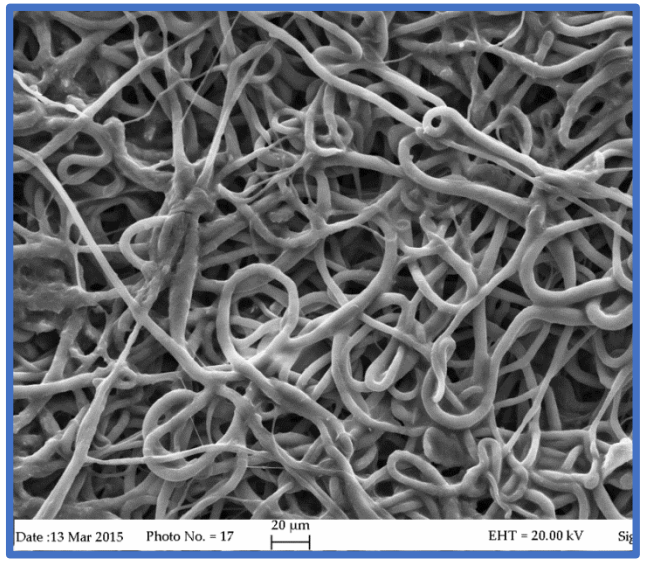
RESULTS – Scaffolds functionalized with nanoparticles (proteins)

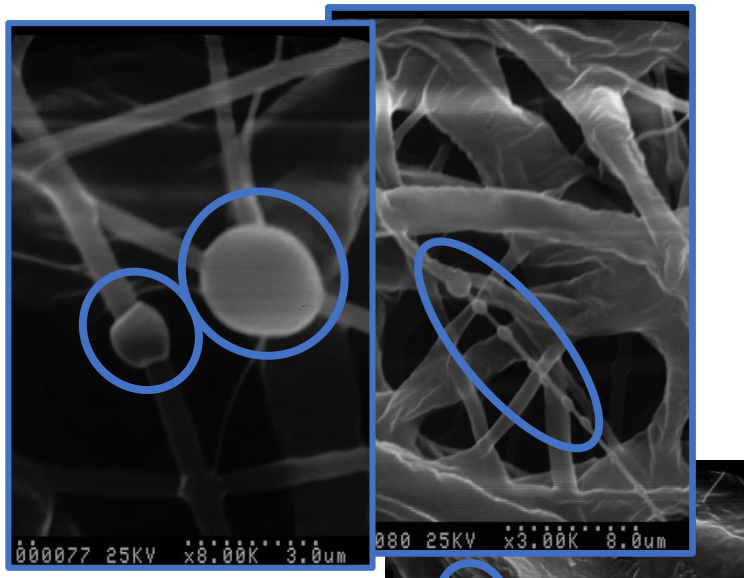

Nanoparticles and functionalized materials as nanoengineered tools for vascular regenerative medicine

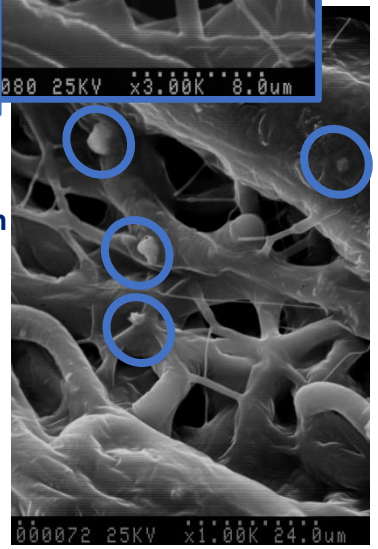
RESULTS – Scaffolds functionalized with nanoparticles (proteins)

Microscopy analysis

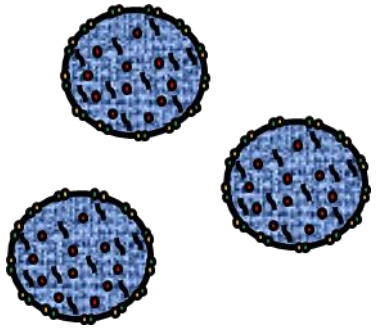




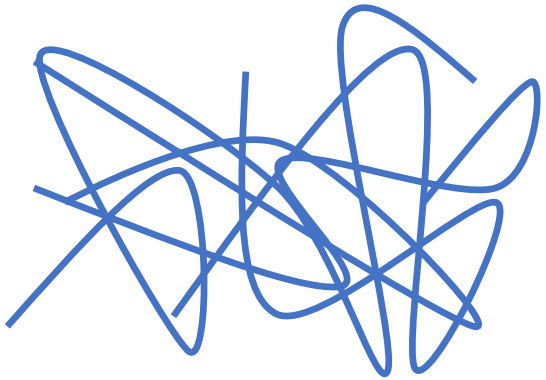




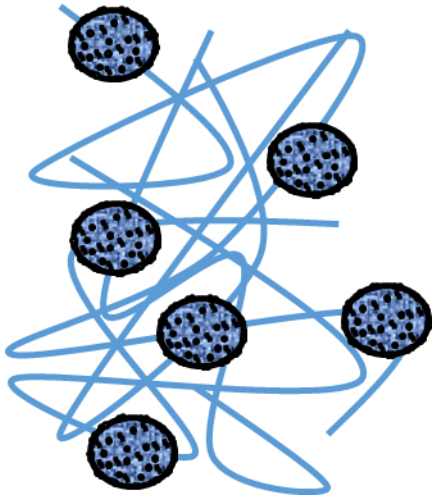
Nanoparticles (151.90±31.66 nm)



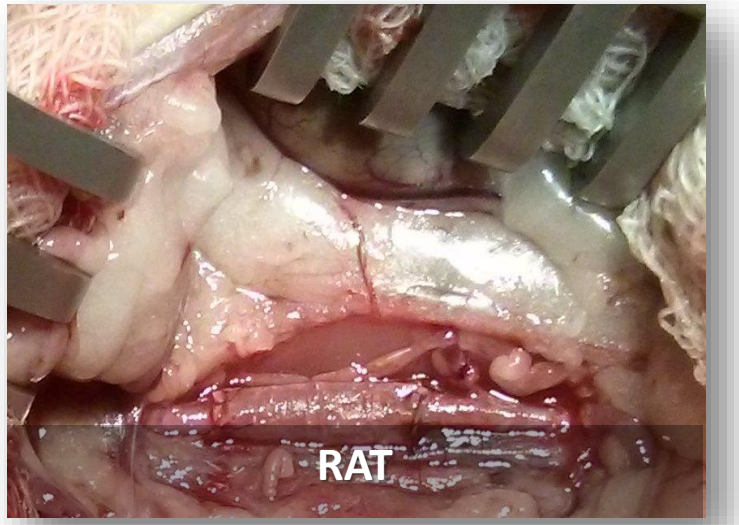
PCL:PGS scaffold (5.11±1.11 µm)

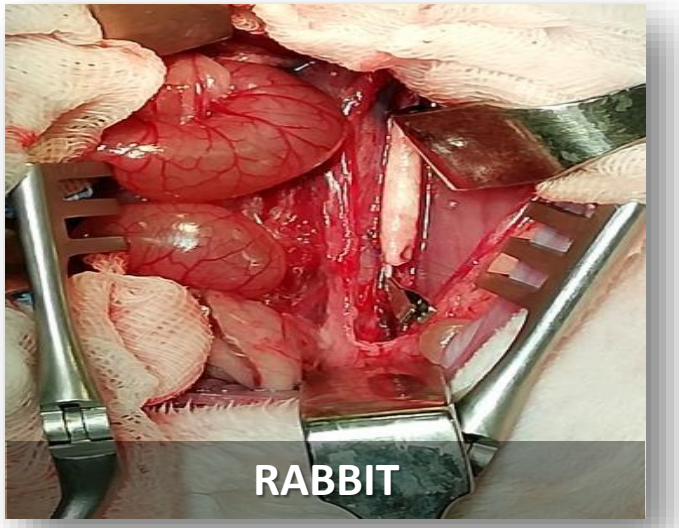


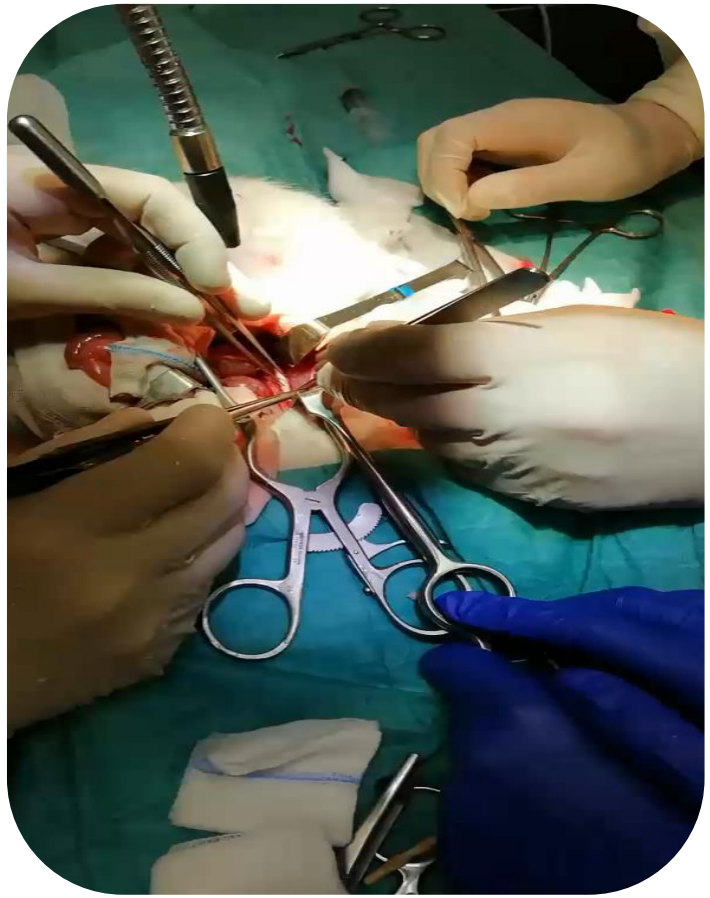
PCL:PGS scaffold functionalized with nanoparticles (2.46±1.75 µm)



In vivo implants

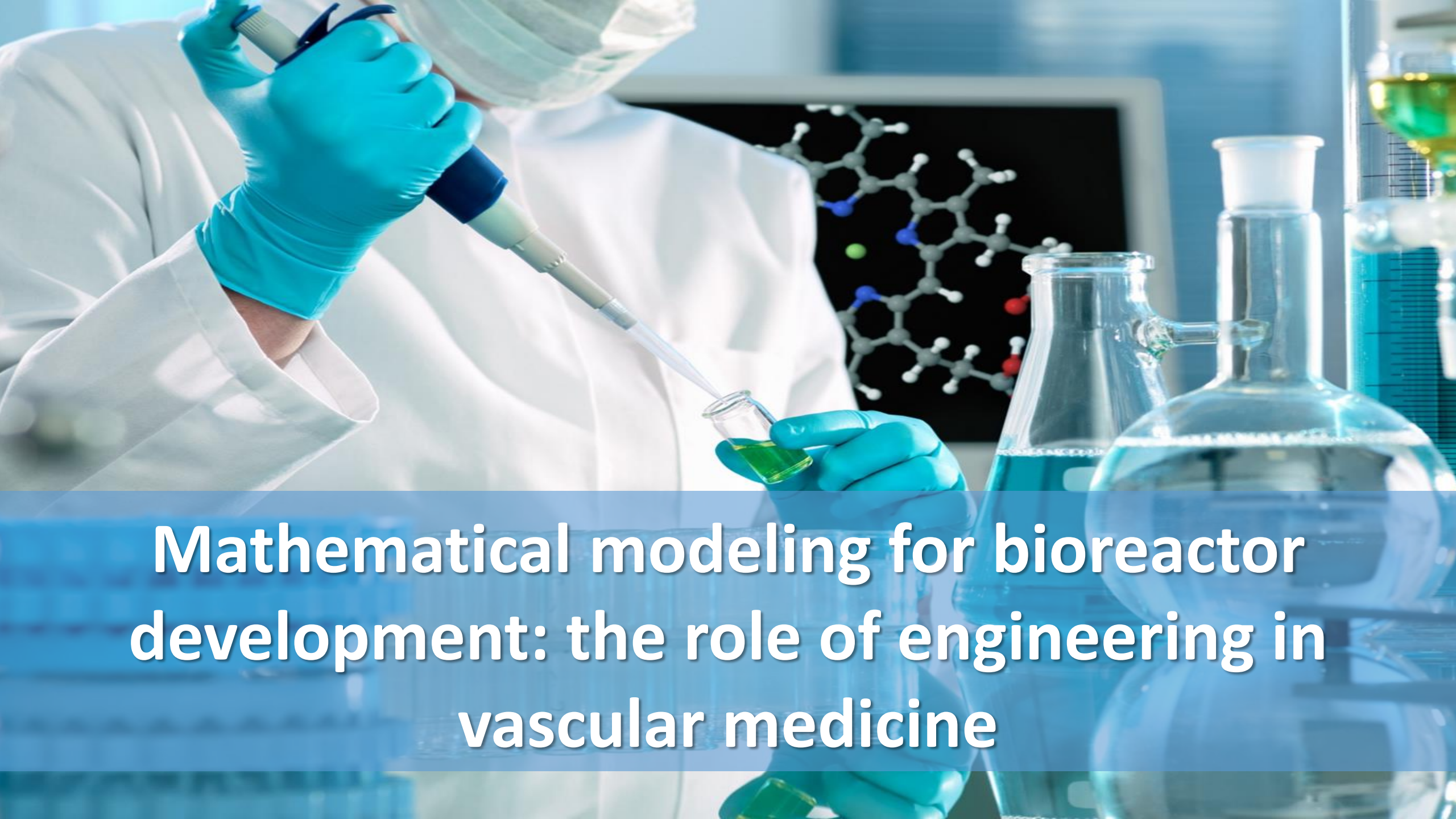






PATENT:

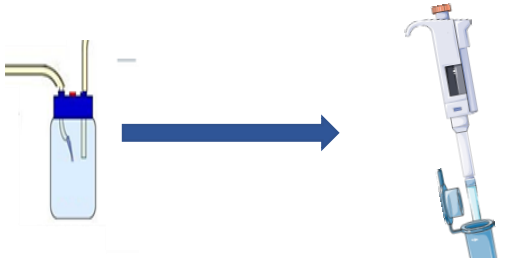
Perego P, Palombo D, Ferrari PF, Aliakbarian B, Pane B, Spinella GSG, 2019. Engineered biodegradable vascular bioprosthesis and their preparation procedures. Application number: 102019000014985, registered on 23rd August 2019.



Mathematical modeling for bioreactor development: the role of engineering in vascular medicine

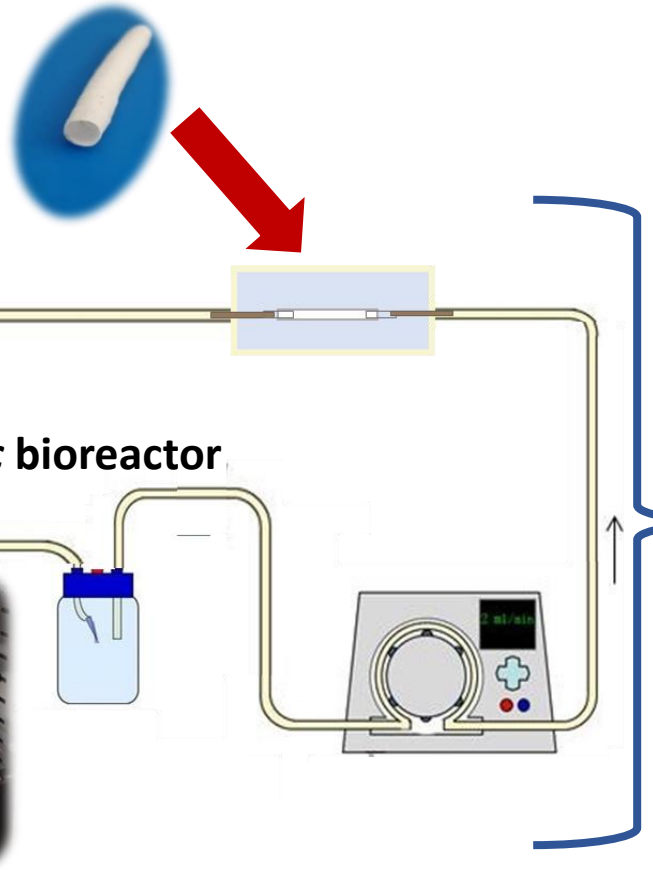
In collaboration with:

DICCA
Civil, Chemical and Environmental Engineering Department

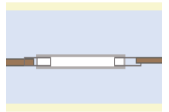


Phosphate-buffered saline

Daily measure of Q and G release from the scaffold

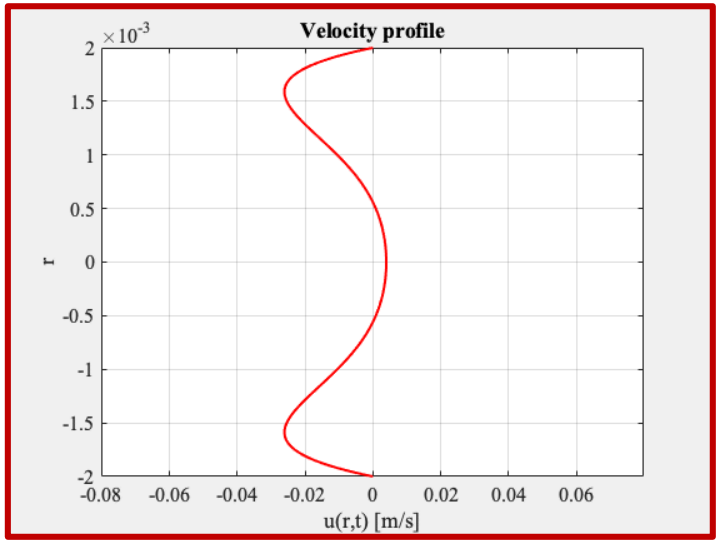


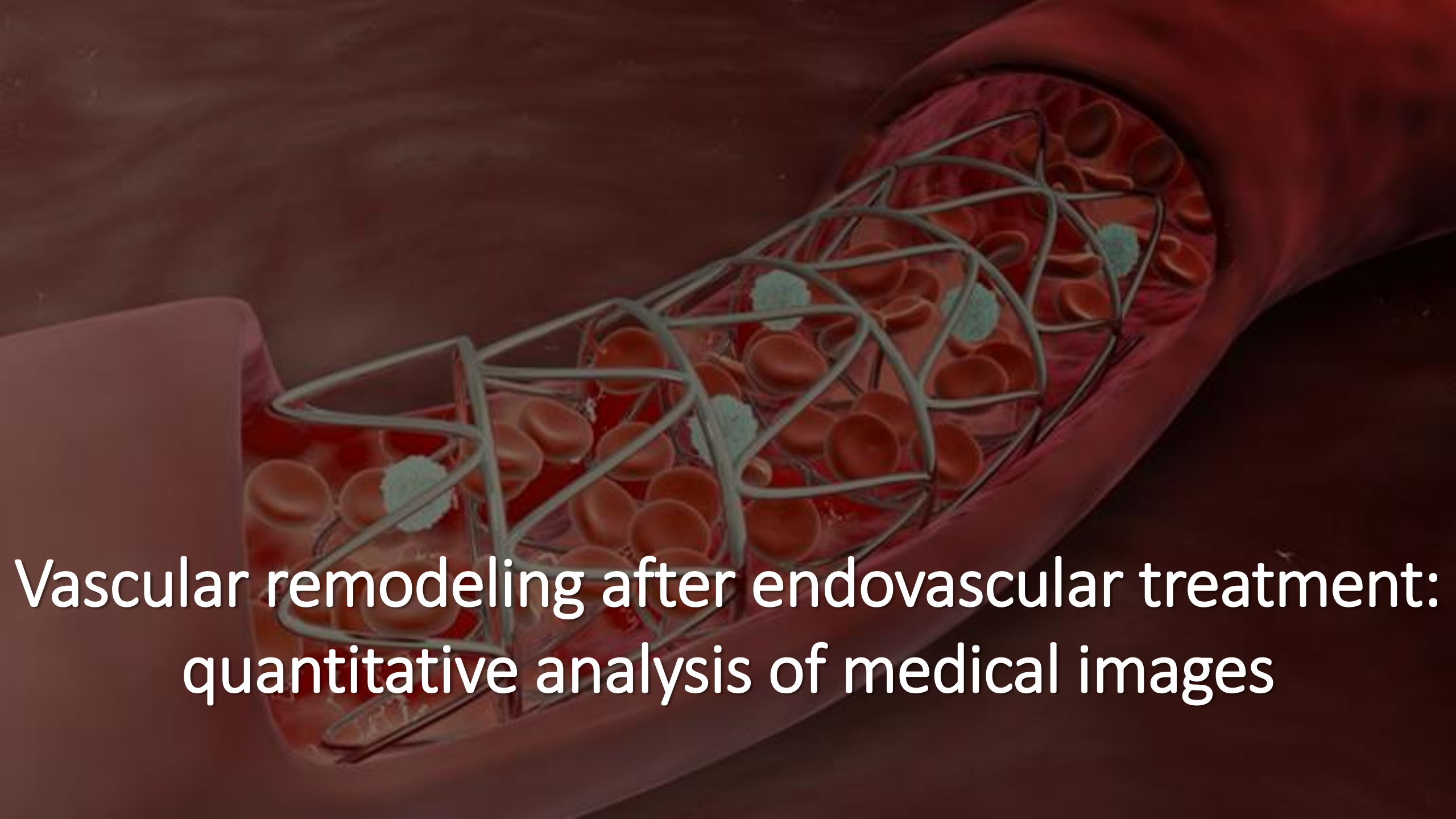
Ad hoc bioreactor



Vascular bioprosthesis

SEM and mechanical analysis

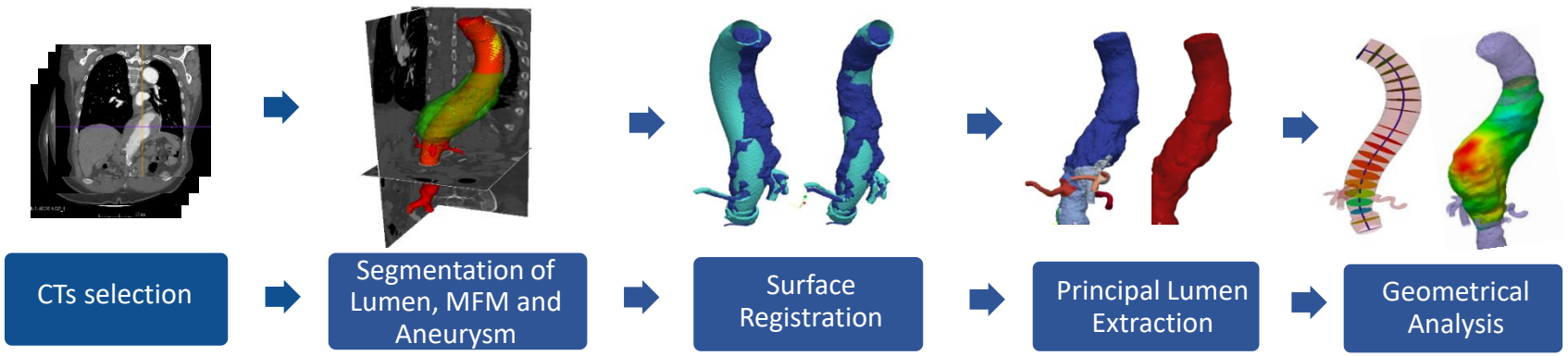




Vascular remodeling after endovascular treatment: quantitative analysis of medical images

In collaboration with:

«Medical image analysis to measure the FU geometry changes of TAAAs treated with Cardiatis Multilayed Flow Modulator stent»



From CTs, verify, through geometrical analysis:

- **perfusion** of side branches;
- **centerline changes** induced by the Cardiatis MFM;
- presence/absence of **blood flowing in the aneurysm** sac;
- **morphological changes** of the **aneurysm** sac.

G. Spinella, A. Finotello, E. Faggiano, B. Pane, M. Conti, B. Pane, V. Gazzola, F. Auricchio, and D. Palombo. Mid-term follow-up geometrical analysis of thoraco-abdominal aortic aneurysms treated with multilayer flow modulator. *Annals of Vascular Surgery.*

«Assessment of geometrical remodeling of the aortic arch and descending thoracic aorta after hybrid treatment»

Aim: Analyze the geometric changes of the **aortic arch** after hybrid treatment, with a particular focus on the **endograft landing zones**, attempting to enhance the understanding on the possible reasons for the development of device-related complications

Analysis Workflow: from CT scans to 3D geometric analysis

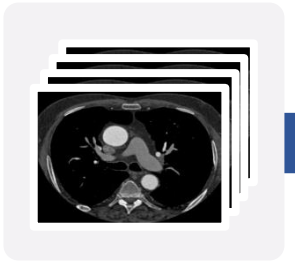
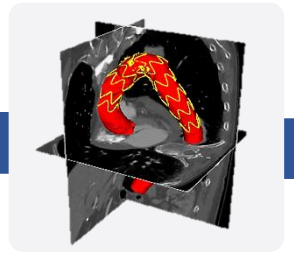
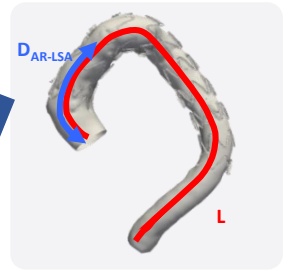


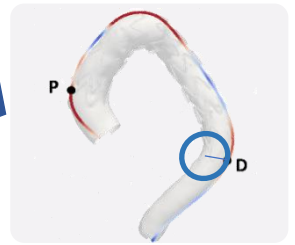
Image acquisition
- 22 patients
- Zones 0,1 and 2
- Pre-op and 1-month FU CTs



3D surface generation
- Lumen
- Endograft



Centerline distances



Outerline curvature at endograft landing zones

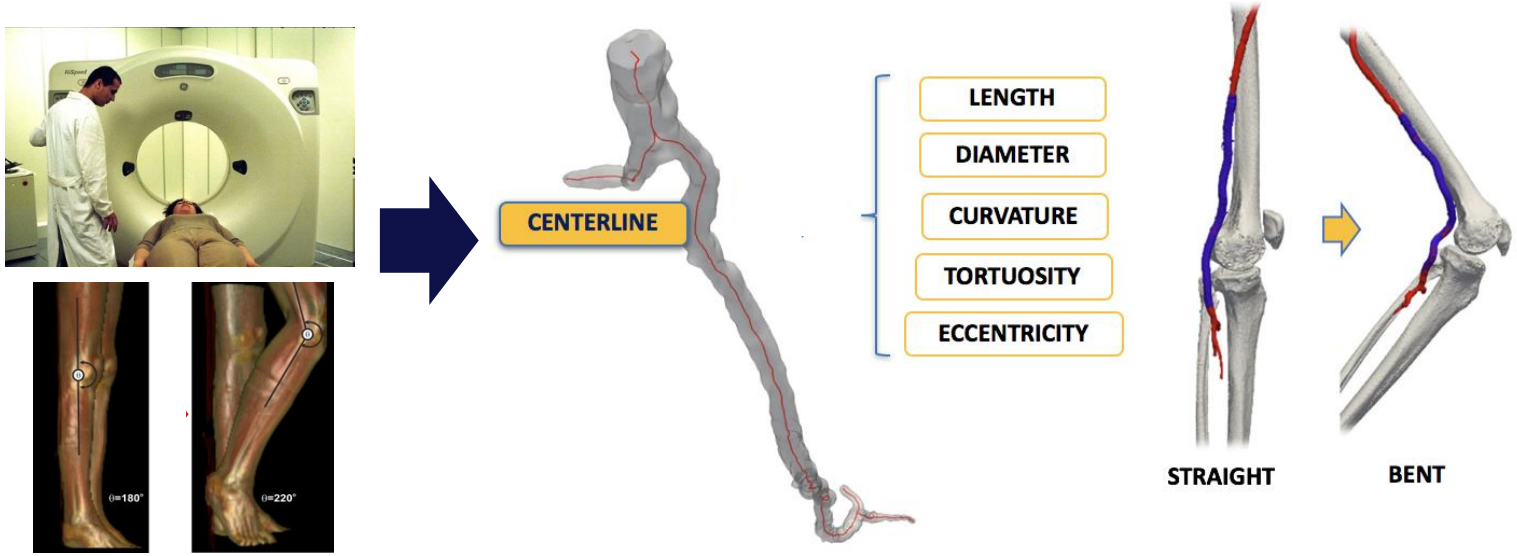
Our experience suggests that the **physiological curvature** of the aortic arch **was altered after hybrid treatment**, probably due to **spring-back force (SBF) exerted by the stent-graft at both ends of the stent-grafts.**

G. Spinella, **A. Finotello**, M. Conti, E. Faggiano, V. Gazzola, F. Auricchio, N. Chakfé, D. Palombo, B. Pane. *Assessment of geometrical remodeling of the aortic arch and descending thoracic aorta after hybrid treatment.* European Journal of Cardio Vascular Surgery. 2019

«Impact of peripheral endovascular repair on femoral popliteal artery kinematics: from clinical experience to in vivo biomechanical modeling»

Aim: evaluate morphological changes of stented FPA due to limb flexion

- definition of an acquisition protocol with extended and flexed knee
- vessel segmentation and geometric analysis



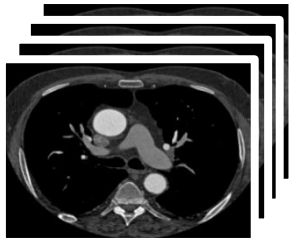
Credits to: Dr. Cittadini Giuseppe, Dr. Salsano Giancarlo (UO Radiology)

Spinella G, Finotello A, Pane B, Salsano G, Mambrini S, Kamenskiy A, Gazzola V, Cittadini G, Auricchio R, Palombo D, Conti M. In-vivo morphological changes of the femoro-popliteal artery due to knee flexion after endovascular treatment of popliteal aneurysm. **Journal of Endovascular therapy**. 2019

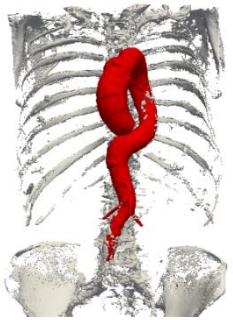
“Endovascular implants: from medical images to patient specific structural simulations”

1 Computed Tomography Angiography

2 Dicom images



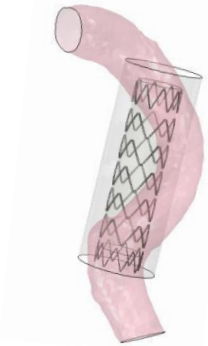
3 3D reconstruction



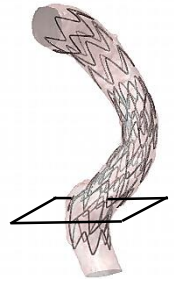
4 Endograft models

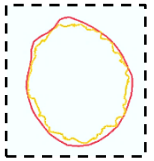
Label	FE model
ZTA P 36 161	
ZTA P 36 113	

5 Simulation results



6 Post-processing



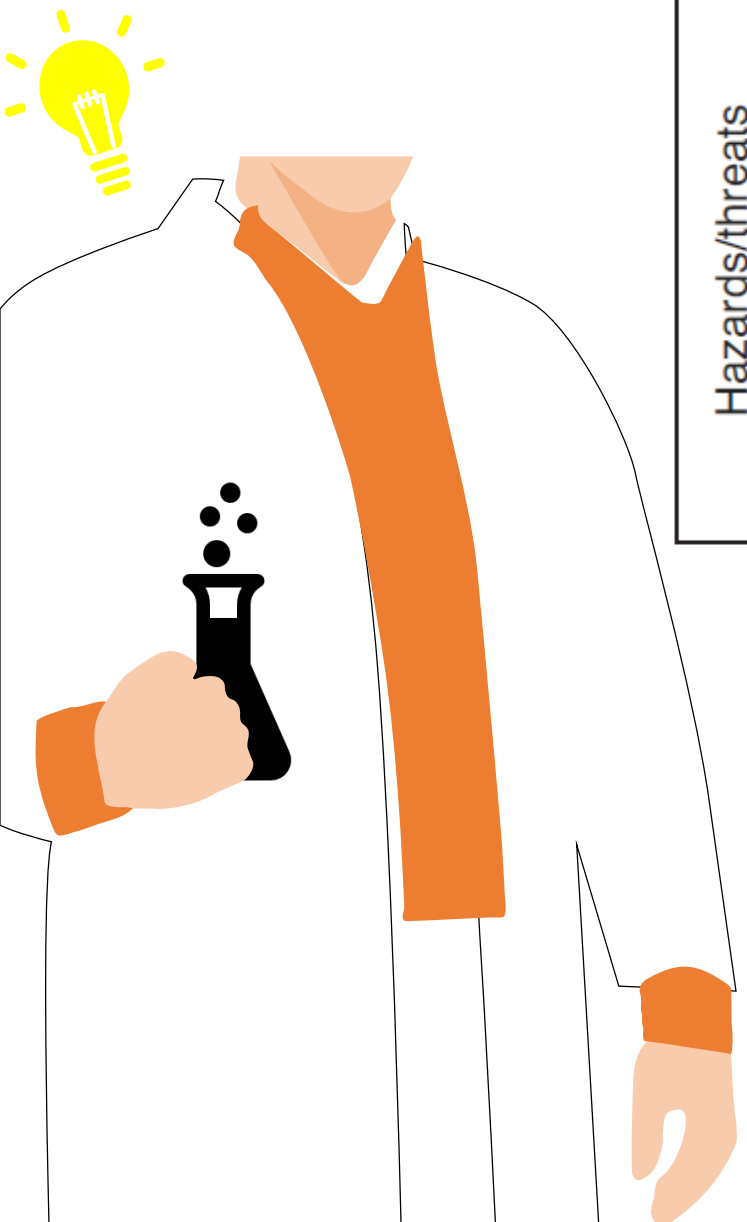


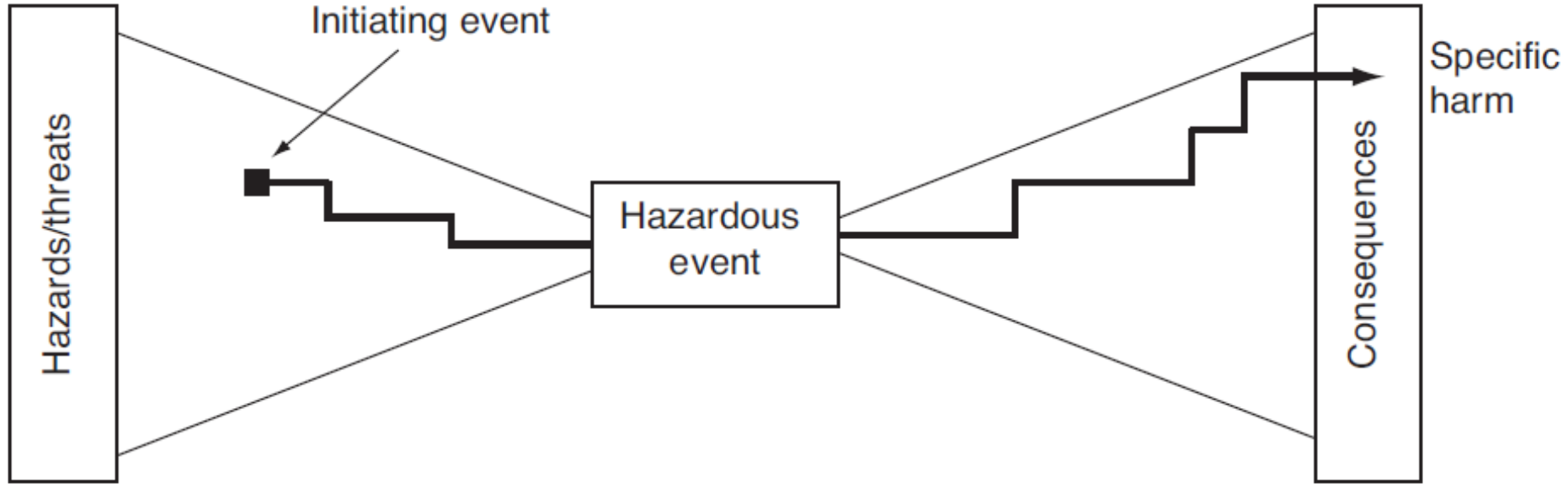
Quantify apposition to the wall: less prone to endoleak

ESCVS 2018 YOUNG SURGEON AWARD 1st PLACE

A. Finotello, G. Spinella, M. Conti, B. Pane, F. Auricchio, and D. Palombo. *Toward the use of patient-specific structural simulations of endovascular repair in the clinical practice.*

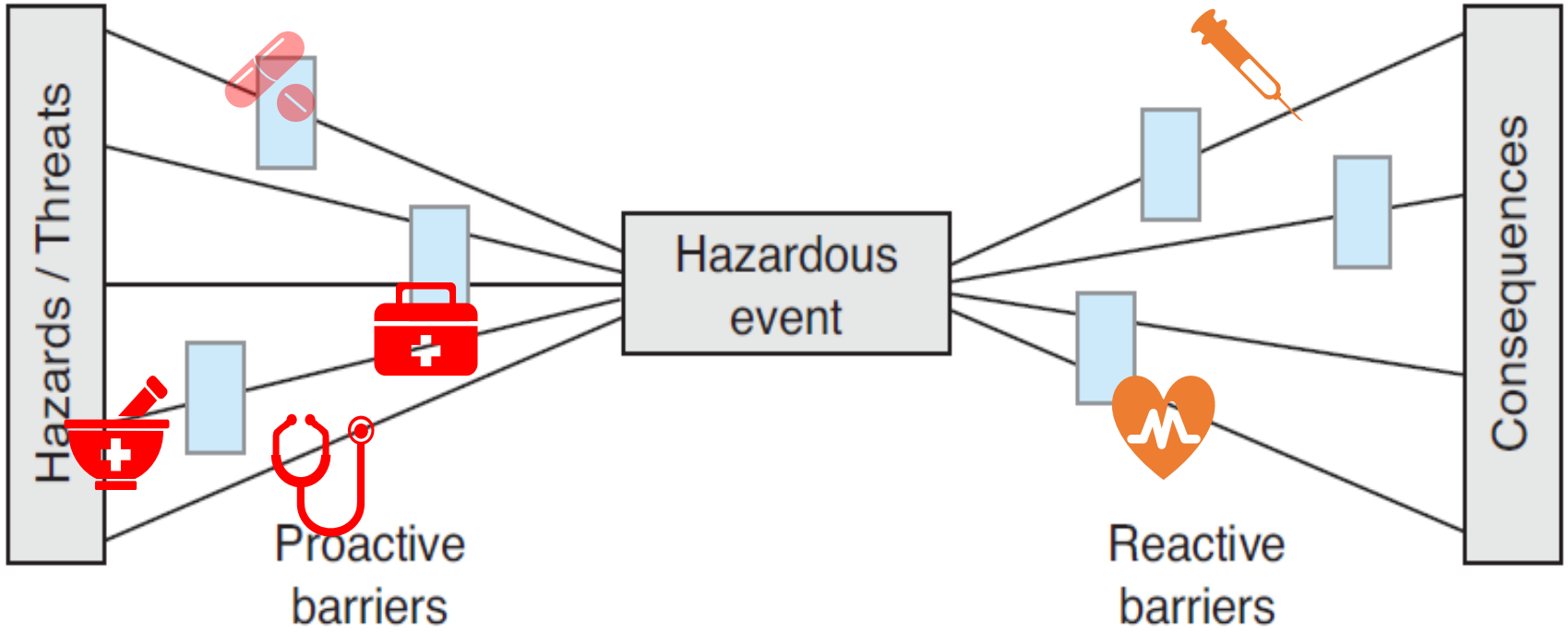
Bow-tie approach: from process safety engineering to medical fields





In collaboration with:

DICCA



In collaboration with:

DICCA

Collaboration with Engineering Schools

Department of Civil, Chemical and Environmental Engineering, University of Genoa, Italy;

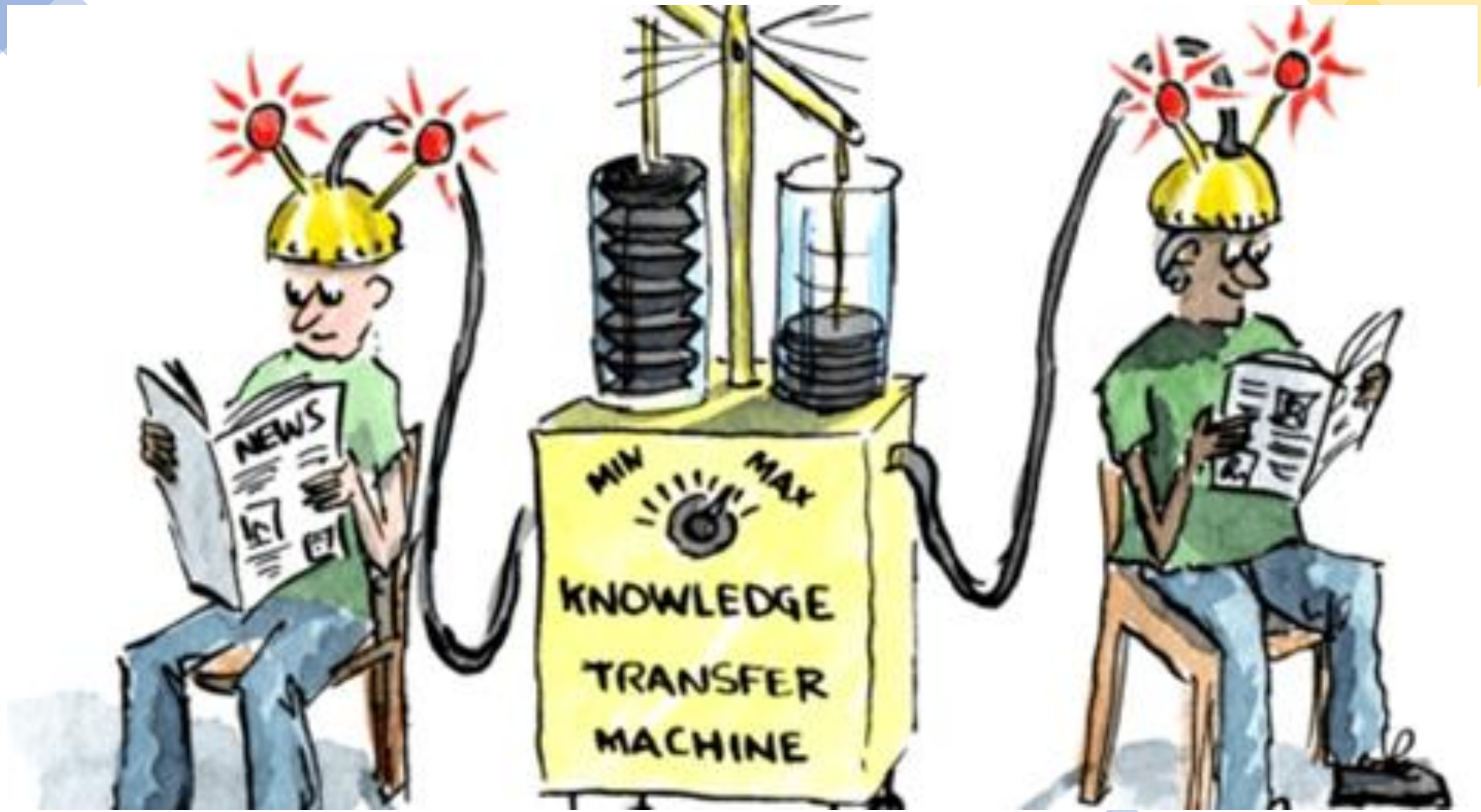
Department of Civil Engineering and Architecture, University of Pavia, Italy;

Department of Informatics, Bioengineering, Robotics and System Engineering, University of Genoa;

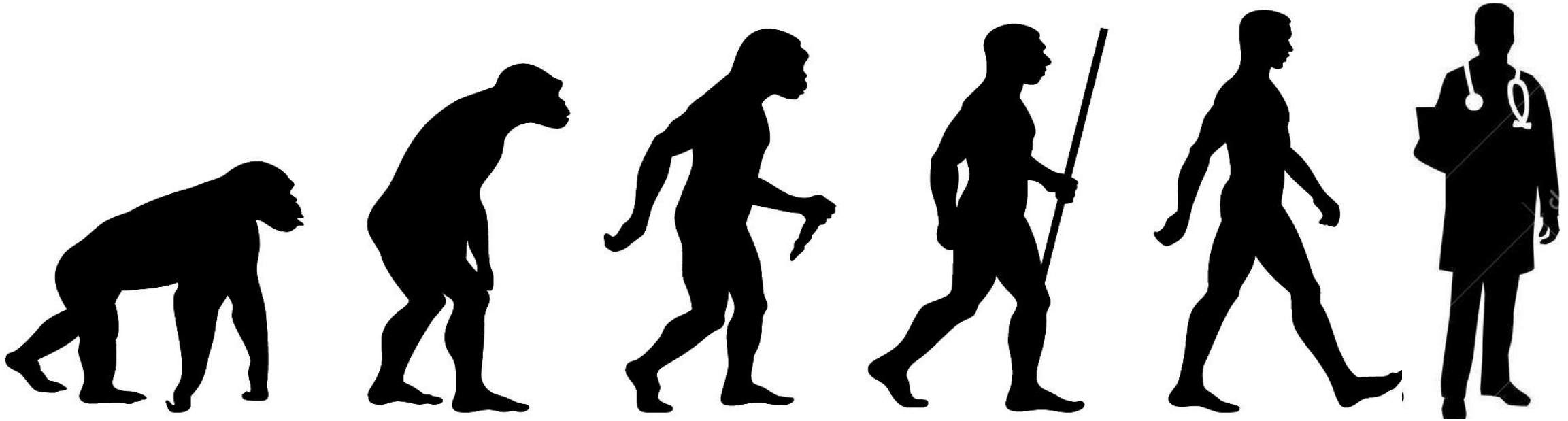
Department of Industrial Engineering, University of Salerno, Italy;

Department of Materials Science and Physical Metallurgy, Polytechnic University of Bucharest , Romania;

Massachusetts Institute of Technology, Boston, United States of America


NEWS
MIN
MAX
KNOWLEDGE
TRANSFER
MACHINE

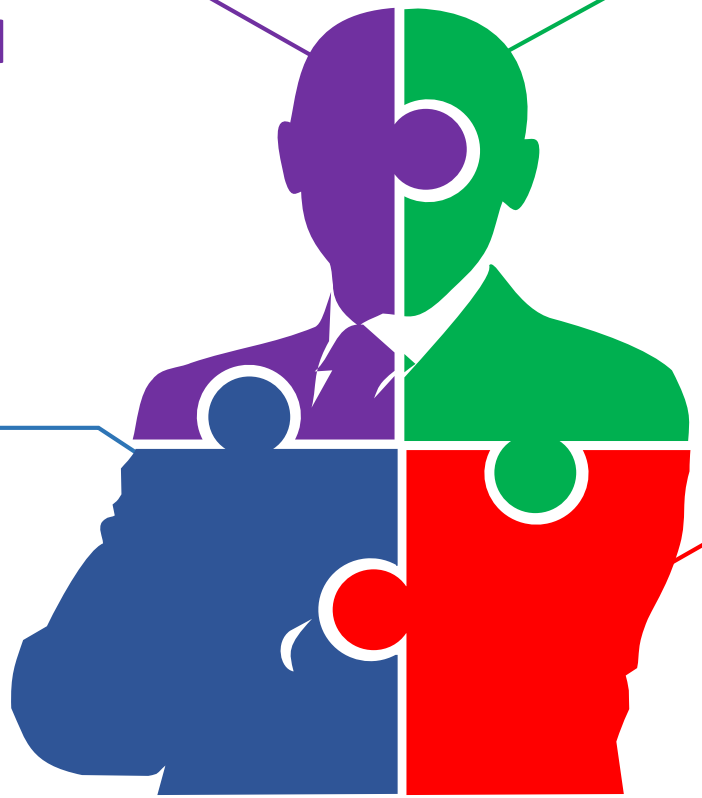
No longer just a surgeon or an engineer…



…but a «TRANSDISCIPLINAR SPECIALIST»

Endovascular and open surgery

Diagnostician



Researcher in engineering

Researcher in vascular biology

TEAMWORK...

...TURNS A PROBLEM INTO A SOLUTION


Together it’s easier!

Polytechnic School
(architecture and engineering)

San Martino Polyclinic Hospital
Pharmaceutical and Medical School

«Surgengineering»


Thank you