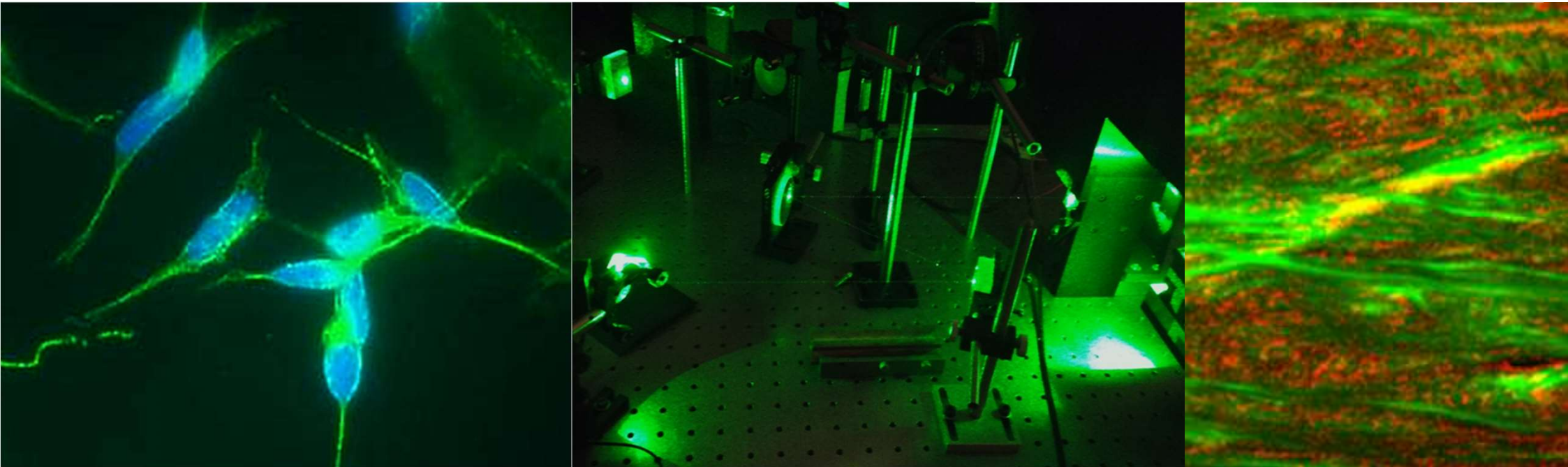


BIOPHOTONICS: BRINGING LIGHT INTO LIFE SCIENCES

FRANCESCO BONACCI, DANIELE FIORETTO, MAURIZIO MATTARELLI (UNIPG)

SILVIA CAPONI (CNR) silvia.caponi@cnr.it

An emerging multidisciplinary research area,
embracing all light-based technologies
applied to the life sciences and medicine

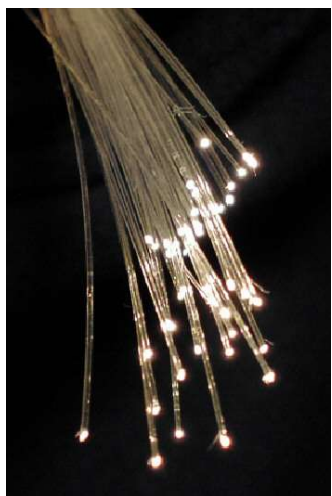


COS'È LA FOTONICA

La fotonica è una branca dell'ottica che studia l'**emissione, trasmissione, rilevamento e manipolazione** della luce.

La luce è diventato un nuovo strumento di indagine della materia, ma anche uno strumento per la trasmissione di informazioni.

La fotonica ha una vasta gamma di **applicazioni** in numerosi settori. Alcuni esempi includono telecomunicazioni, elaborazione ottica dei segnali, sensori, imaging medico, laser, e dispositivi optoelettronici per computer e comunicazioni, conversione di luce in elettricità e viceversa.

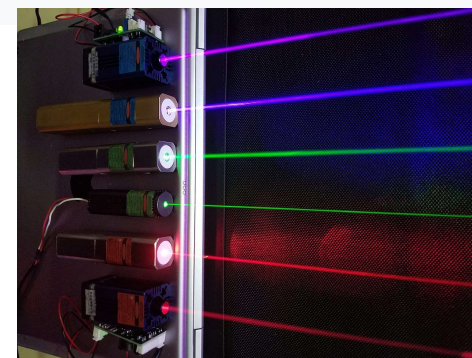


Di BigRiz - First upload: (Sep 25 2004) en:Wikipedia, CC BY-SA 3.0,
<https://commons.wikimedia.org/w/index.php?curid=46561>



Jacek Halicki CC BY-SA 4.0,
https://commons.wikimedia.org/wiki/File:2019_Rozebrane_dyski_twarde.jpg

Di 彭嘉傑 - Opera propria, CC BY 2.5,
<https://commons.wikimedia.org/w/index.php?curid=60733412>



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NOBEL PRIZES

[HTTPS://WWW.OPTICA.ORG/HISTORY/OPTICA_NOBEL_LAUREATES/](https://www.optica.org/history/optica_nobel_laureates/)

45 members have been awarded a Nobel Prize in Physics, Chemistry or Physiology/Medicine

Physics

Pierre Agostini (2023)

Optica Fellow



(jointly with Ferenc Krausz and Anne L'Huillier) "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter."

Ferenc Krausz (2023)

Optica Fellow



(jointly with Pierre Agostini and Anne L'Huillier) "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter."

Anne L'Huillier (2023)

Optica Fellow



(jointly with Pierre Agostini and Ferenc Krausz) "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter."

Alain Aspect (2022)

Optica Honorary Member



(jointly with John F. Clauser and Anton Zeilinger) "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science"

John F. Clauser (2022)

Optica Emeritus



(jointly with Alain Aspect and Anton Zeilinger) "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science"

Anton Zeilinger (2022)

Optica Fellow



(jointly with Alain Aspect and John F. Clauser) "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science"

Chemistry

Moungi Bawendi (2023)



(jointly with Louis Brus and Alexei Ekimov) "for the discovery and synthesis of quantum dots."

Louis Brus (2023)



(jointly with Moungi Bawendi and Alexei Ekimov) "for the discovery and synthesis of quantum dots."

Alexei Ekimov (2023)



(Jointly with Moungi Bawendi and Louis Brus) "for the discovery and synthesis of quantum dots."

Jacques Dubochet (2017)



(jointly with Joachim Frank and Richard Henderson) "for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution."

Joachim Frank (2017)



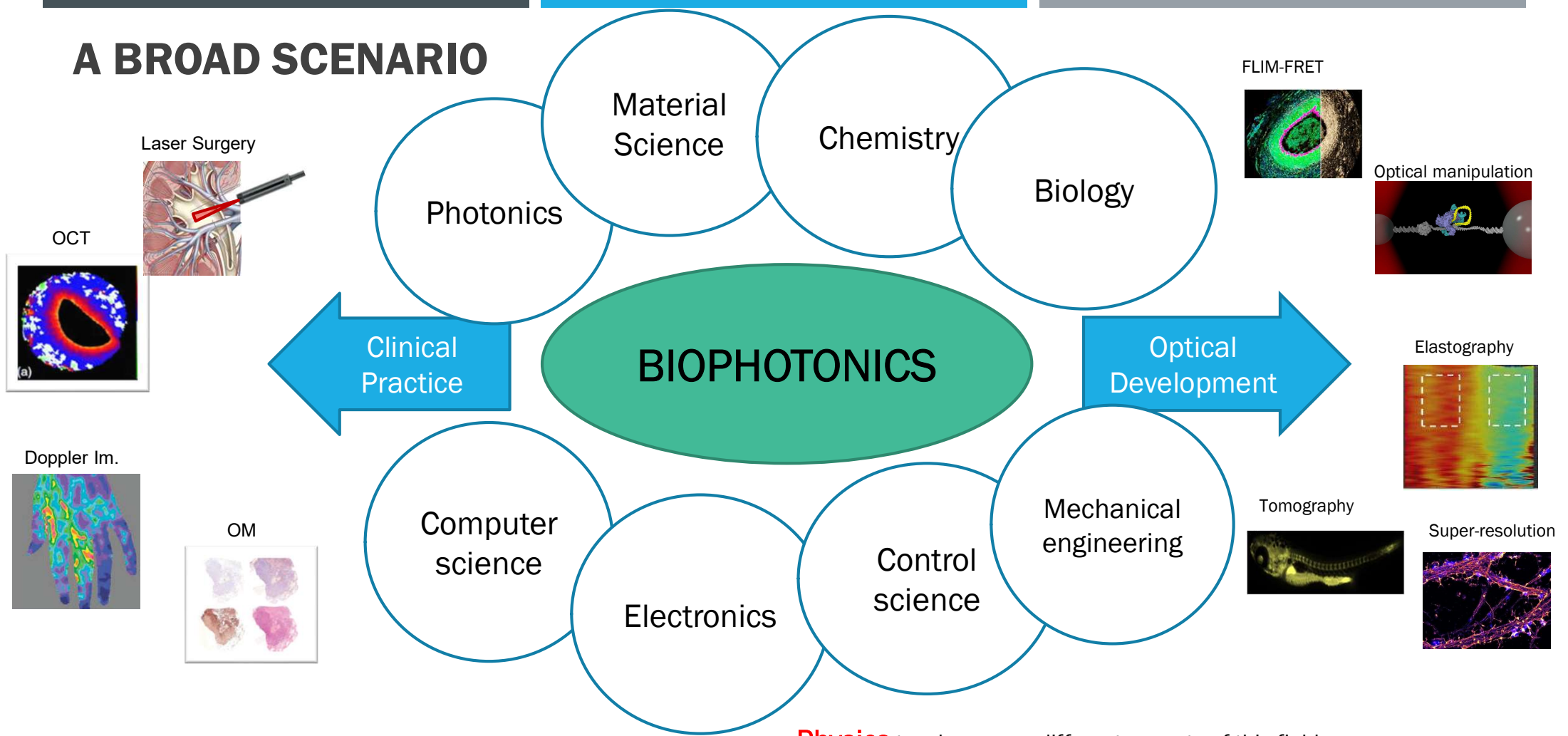
(jointly with Jacques Dubochet and Richard Henderson) "for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution."

Richard Henderson (2017)



(jointly with Jacques Dubochet and Joachim Frank) "for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution."

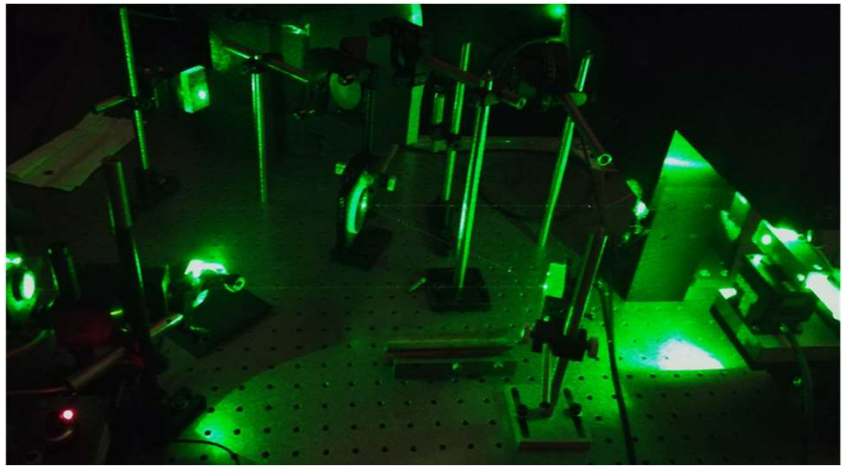
A BROAD SCENARIO



Physics touches many different aspects of this field:
from the optics of the instrument design, to the interaction mechanism of light and matter, to biophysics, to the design of biomimetic materials

BIOPHOTONICS IN PERUGIA

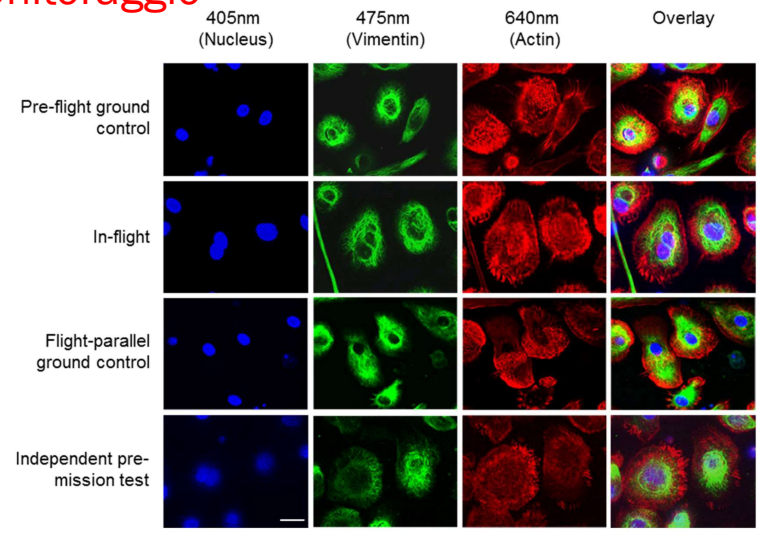
- Disegno e realizzazione di **strumenti per la spettroscopia ottica e per l'imaging spettroscopico.**
- Studio, anche a scopo diagnostico, delle **proprietà meccaniche e molecolari in cellule e tessuti**
- Proprietà elastiche di sistemi nanostrutturati-**biomateriali e nanomateriali**
- Spettroscopia e Imaging per **monitoraggio ambientale**



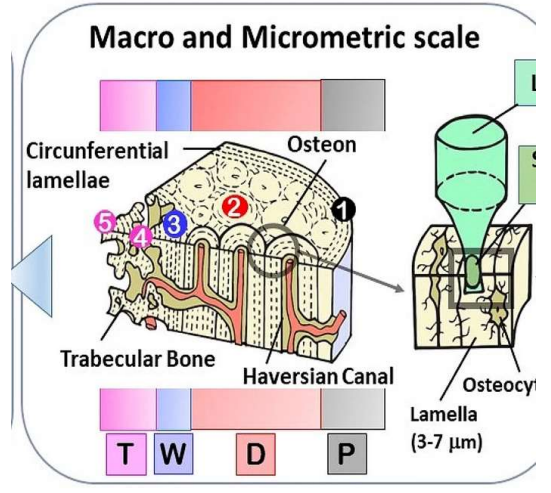
Dal AA: 2022-2023
Bio-fotonica (6 cfu) nel corso di Laurea magistrale in Fisica
Curriculum di Fisica della Materia e di Fisica medica.



Agronomy 2020, 10(2), 303;



Int. J. Mol. Sci. 2019, 20(8), 2033;
<https://doi.org/10.3390/ijms20082033>



Cardinali, M.A et al. Sci Rep 10, 17341 (2020).



A.D. 1308
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UNIVERSITÀ DEGLI STUDI
DI PERUGIA

IL GRUPPO DI RICERCA IN BIO-FOTONICA

iO ISTITUTO
OFFICINA DEI
MATERIALI



S. Caponi



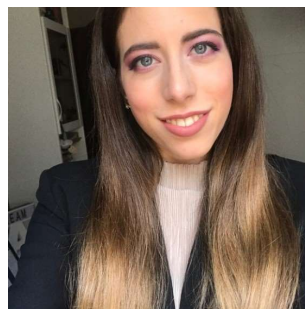
D. Fioretto



M. Mattarelli



F. Bonacci



A.A. Passeri

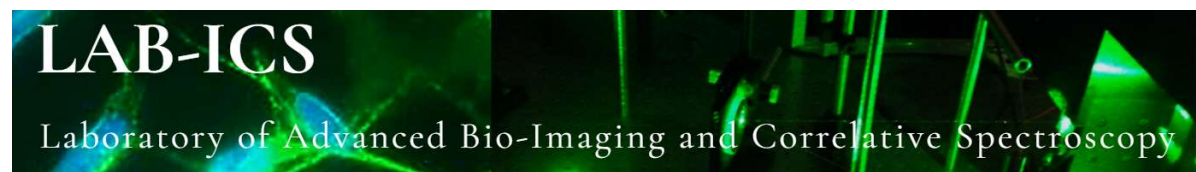


V. D. Paccioia

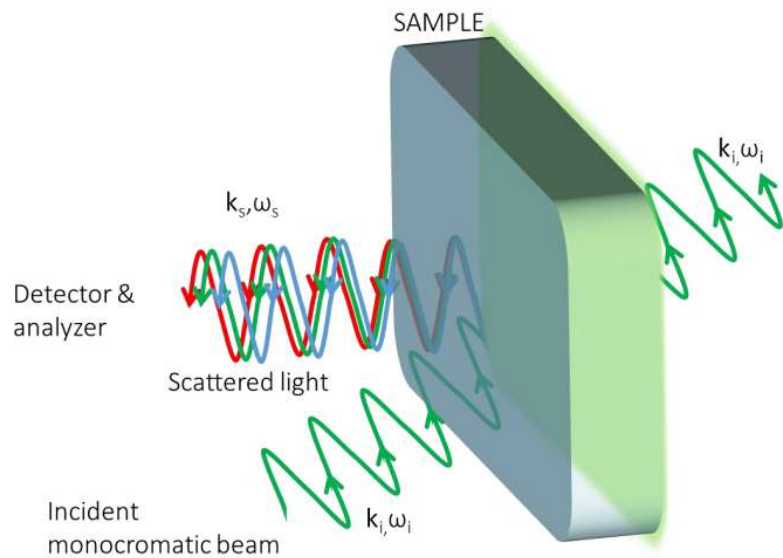
<https://www.lab-ics.com/>



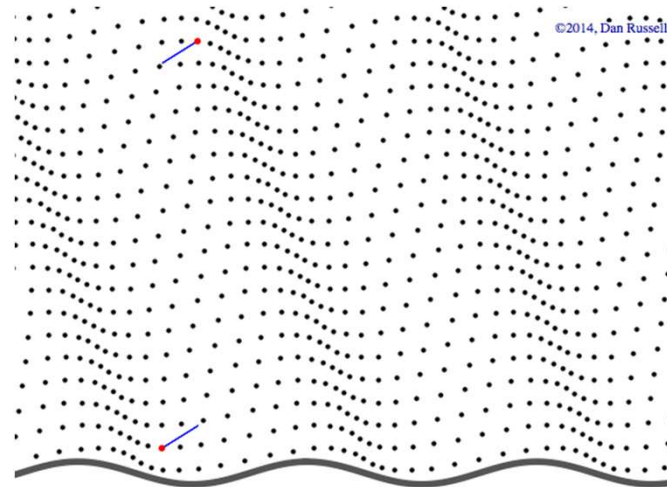
<https://sites.google.com/view/ghost-laboratory/>



MISURA DELLE PROPRIETÀ ELASTICHE E CHIMICHE ...USANDO UN LASER

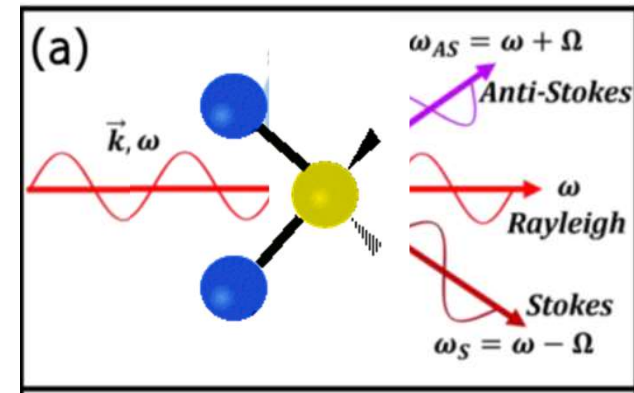


Spettroscopia Brillouin



Animation courtesy of Dr. Dan Russell,
Grad. Prog. Acoustics, Penn State

Spettroscopia Raman



S. Caponi, C. Canale, O. Cavalleri, M. Vassalli

«Characterization tools for mechanical probing of biomimetic materials» SPRINGER book (2019)

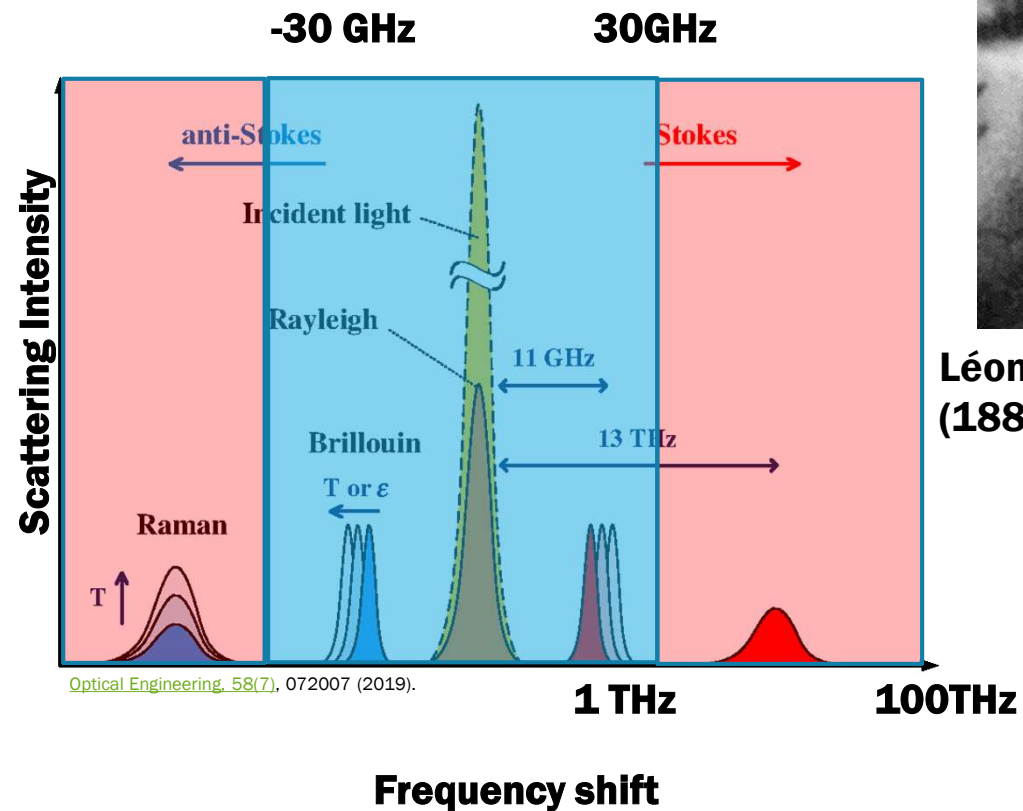
BRILLOUIN AND RAMAN SPECTROSCOPY



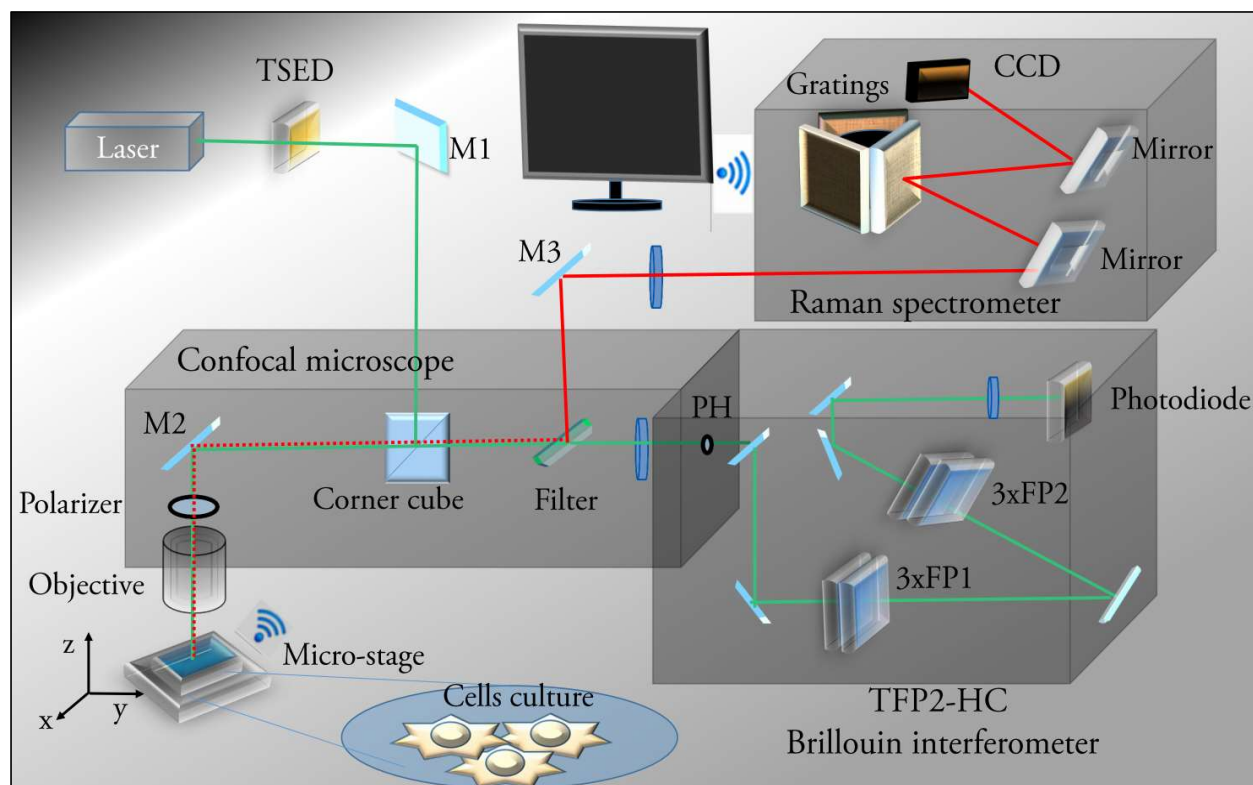
Sir C. V. Raman
(1888 – 1970)



Léon Nicolas Brillouin
(1889–1969)



NEW SETUP FOR SIMULTANEOUS μ -BRILLOUIN AND μ -RAMAN SPECTROSCOPY



**vibrational modes
of molecules**
*Chemical
properties -
composition,
structure*

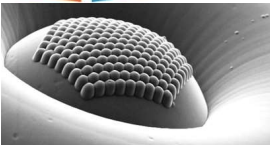
**thermally activated
acoustic waves**
*Mechanical
properties
In the continuum
description*

F. Scarponi et al. PRX 7, 031015 (2017);
S. Mattana et al. Nature Light: Science & Applications 7, 17139 (2018);
R. Mercatelli et al. Nature: Comms Biology 2 117 (2019).

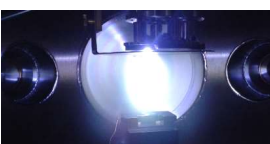
Brillouin microscopy

Irina Kabakova¹✉, Jitao Zhang², Yuchen Xiang³, Silvia Caponi⁴, Alberto Bilenca⁵, Jochen Guck^{6,7}
& Giuliano Scarcelli^{8,9}

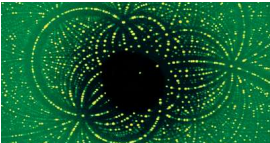




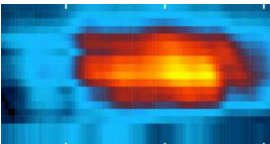
Lithography & Patterning



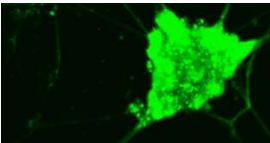
Growth & Synthesis



Structural & Morphological Characterization



Electronic, Chemical & Magnetic Characterization

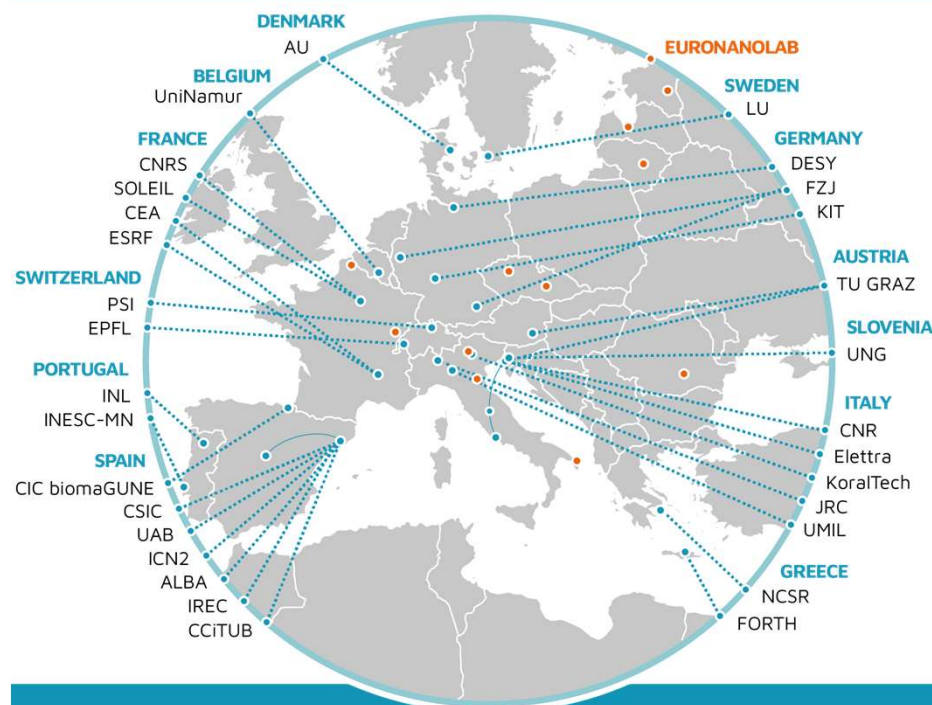


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2026

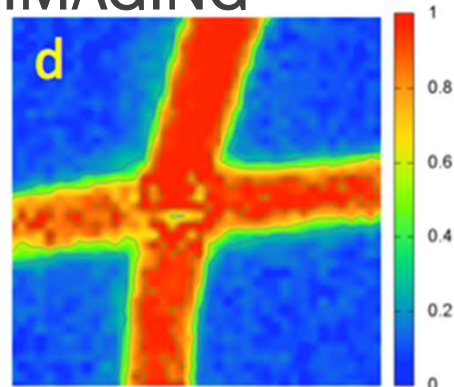


NFFA-Europe has received funding from the EU's H2020 framework program for research and innovation. Grant agreement n. 101007417, NFFA-Europe Pilot Project.

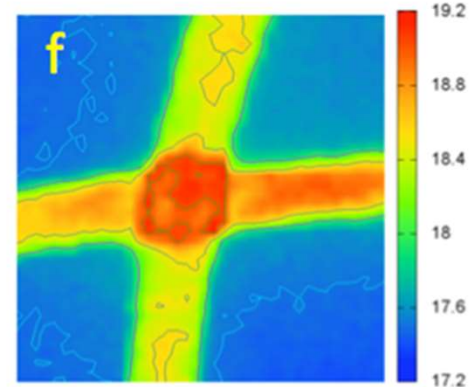
BRILLOUIN AND RAMAN IMAGING

Two wool fibers embedded
into epoxy film

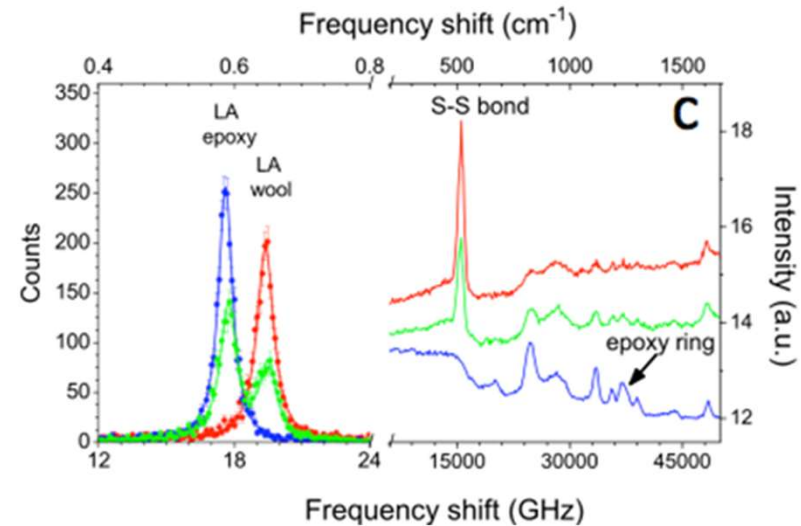
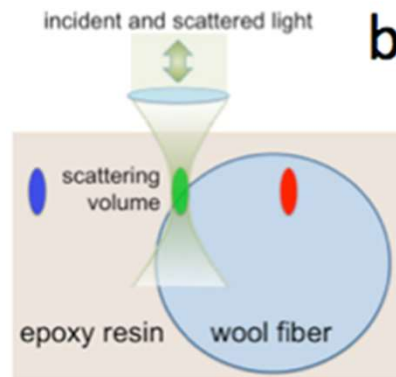
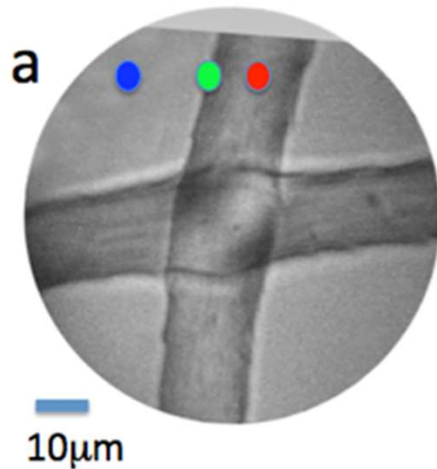
2 μ m step, 40 $\times$ 40 points
10 s
P=5mW



Chemical mapping



Mechanical mapping

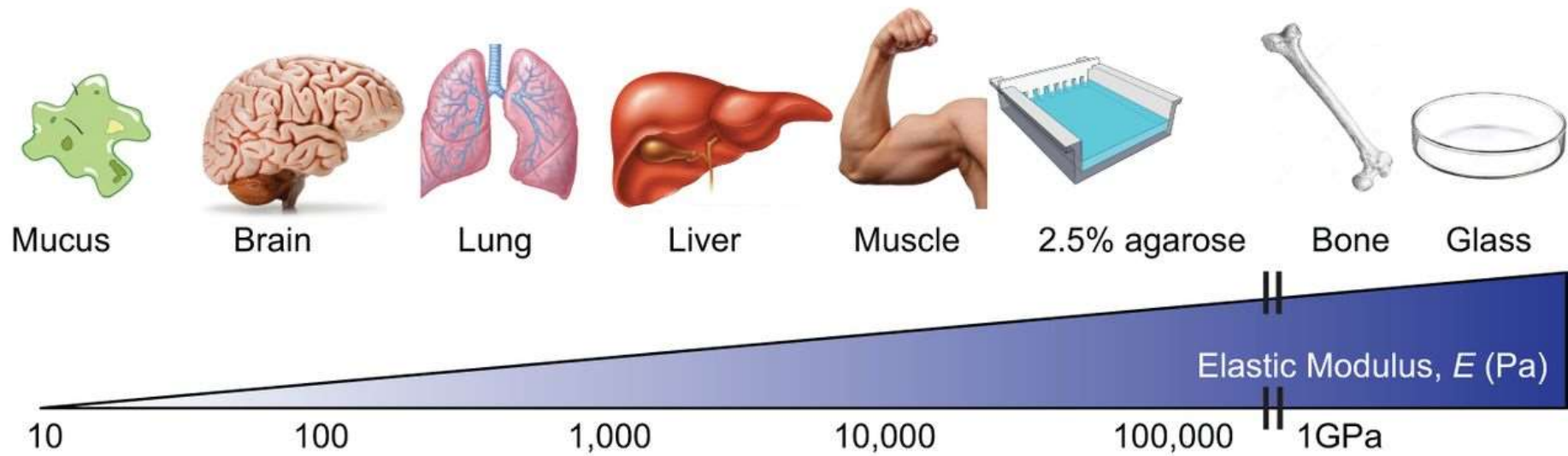


Fioretto et al. Biomedical Optics Express (2019)

USING LIGHT TO PROBE AND IMAGE THE MATERIALS PROPERTIES

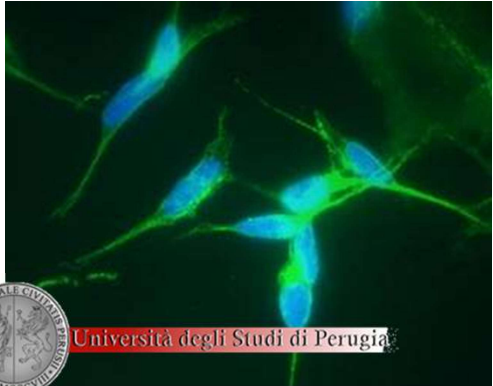
Mechanics in biology

Tissues and cells shape, size and also mechanical properties strongly depend on their function

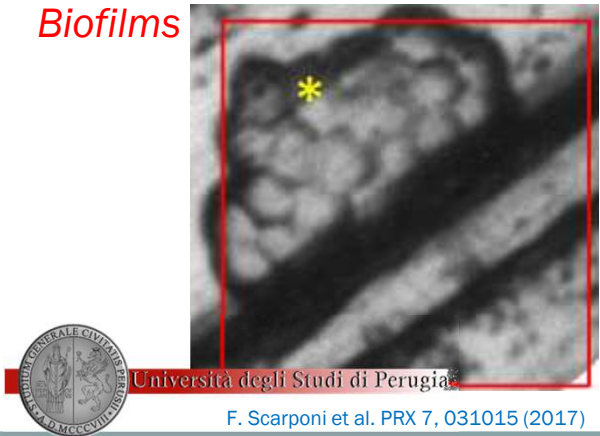


MICROSCOPIA CHIMICA E MECCANICA DI MATERIALI BIO

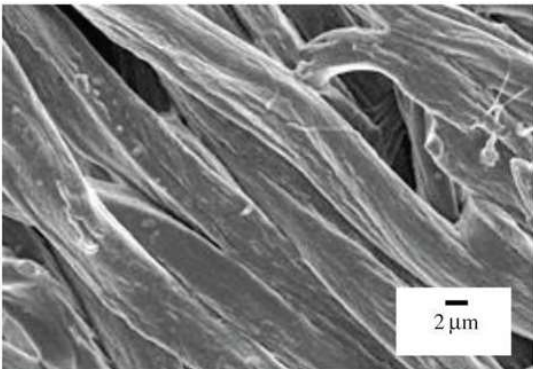
Living cells



Biofilms



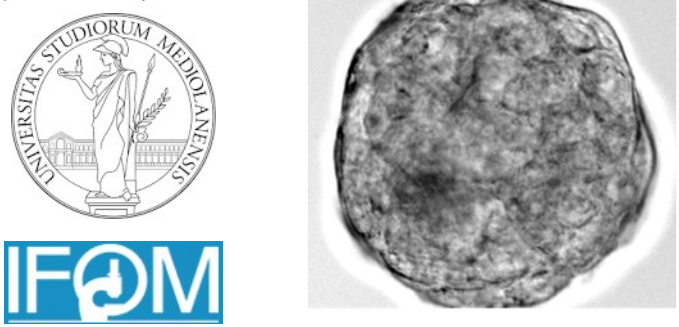
ECM: elastin



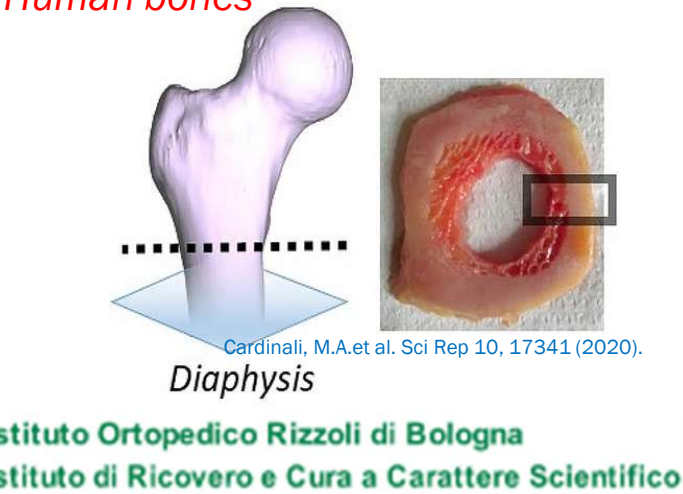
PRIN 2022- CODIR^a



PRIN PNRR- COMBINE: COUPLING
MICROFLUIDICS AND BRILLOUIN MICROSCOPY
FOR MONITORING BIOMECHANICAL
PROPERTIES OF BREAST CANCER CLUSTERS
(COMBINE)

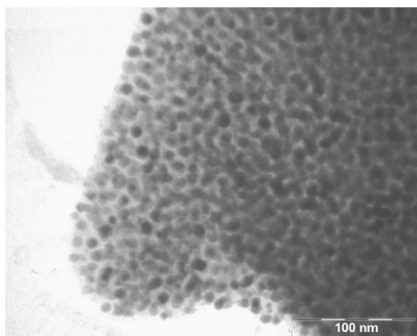


Human bones



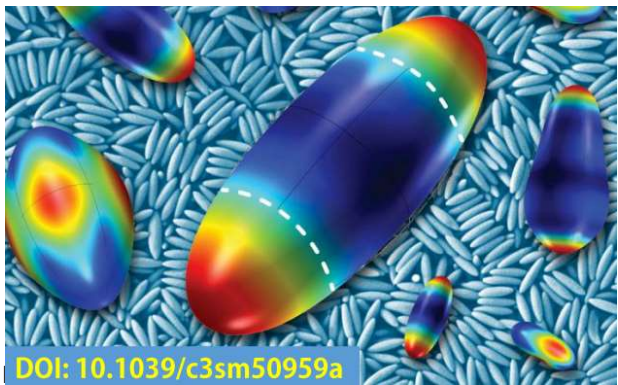
MICROSCOPIA CHIMICA E MECCANICA DI MATERIALI NANO

Vetri nanostrutturati



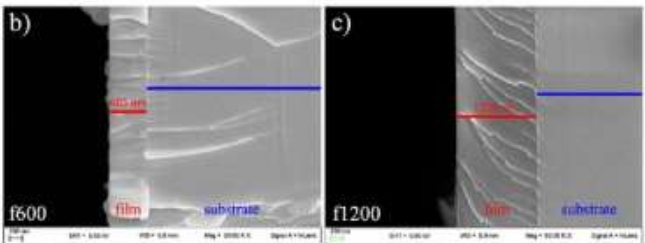
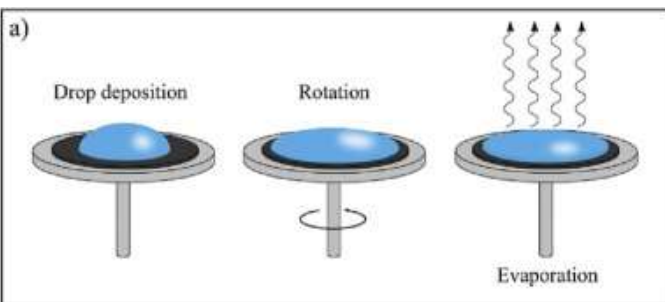
Mattarelli et al., Optical Materials 31 1362 (2009)

Nano-particles



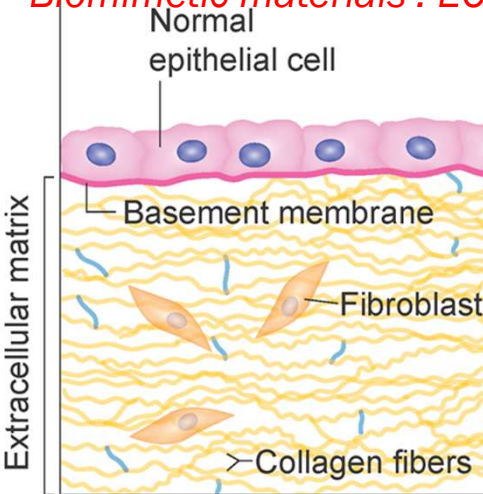
DOI: 10.1039/c3sm50959a

Thin films



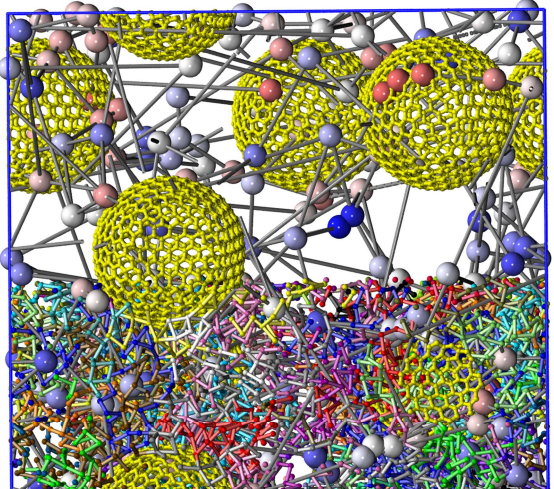
<https://doi.org/10.1016/j.bioadv.2023.213341>

Biomimetic materials : ECM



10.3390/cancers14122887

Polymer



10.3390/polym12112591

Film metallici, ceramici, polimerici
con applicazioni in campo
energetico/acustico,
Isolamento termico/acustico, filtri
ottici/acustici, coating protettivi

COLLABORAZIONI

UNIPG :

Chimica Biologia Biotecnologie
Scienze Farmaceutiche
Medicina e Chirurgia
Ingegneria dei materiali

Nazionali:

Lens
Istituto Rizzoli (BO)
UniGe
CNR-IBF (Trento, Genova)
CNR-INO (Firenze)
Università di Milano & IFOM (Milano)
CREA (Roma)
Roma «La Sapienza»

Internazionali:

Società BioBrillouin (board members)
University of Glasgow
University of Exeter

SVILUPPI FUTURI

Sviluppo di strumentazione

- **Human Technopole Milano**
- **Oculistica**
- **Sensori per droni (CREA)**

PNRR: VITALITY Ecosistema per l'innovazione
(UNIPG-CNR)



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Innovation, digitalisation and sustainability for the diffused
economy in Central Italy

What is it?

It is the NextGenerationEU funded project aimed at establishing
an **INNOVATION ECOSYSTEM** in CENTRAL ITALY

2022-2026



3 Regioni in Central Italy
Abruzzo, Marche, Umbria

<https://vitality.unipg.it/>



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Innovation, digitalisation and sustainability for the diffused
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2022-2026

Umbria

Nanostructured material
and devices

Università di
Perugia

Bio based and bio
compatible materials and
devices

Università di
Perugia

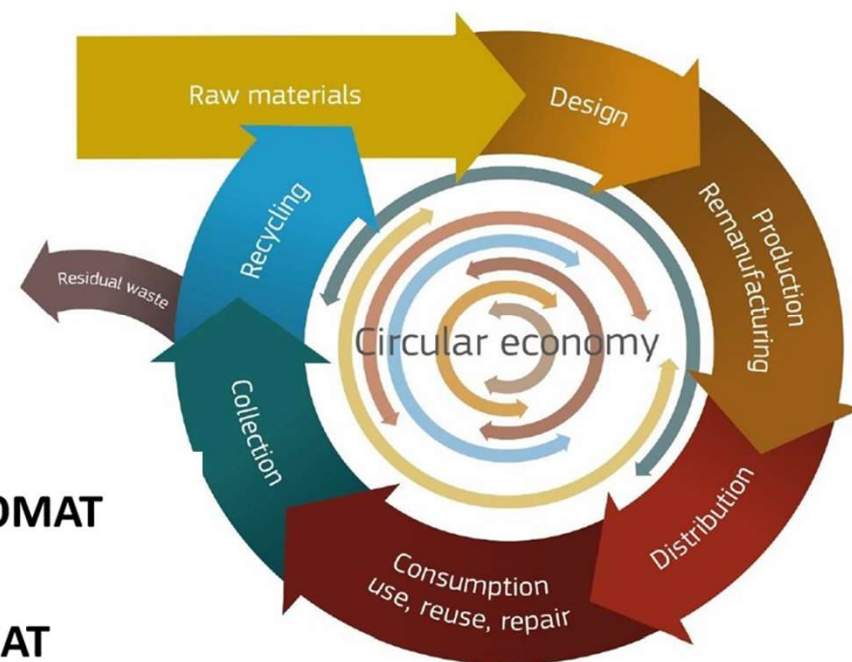
POLO NANOMAT

Nocera Umbra

POLO BIOMAT

Terni

Focus on MATERIALS



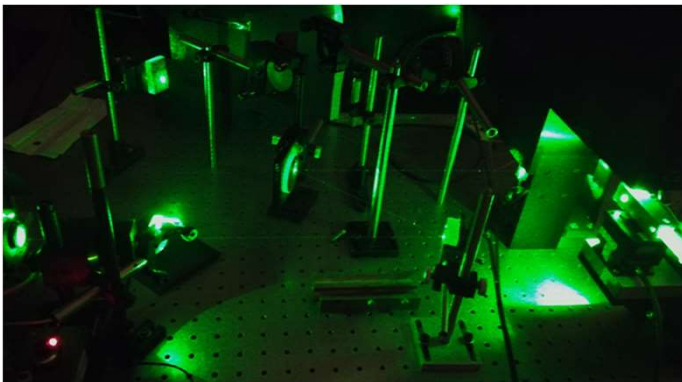
<https://vitality.unipg.it/>



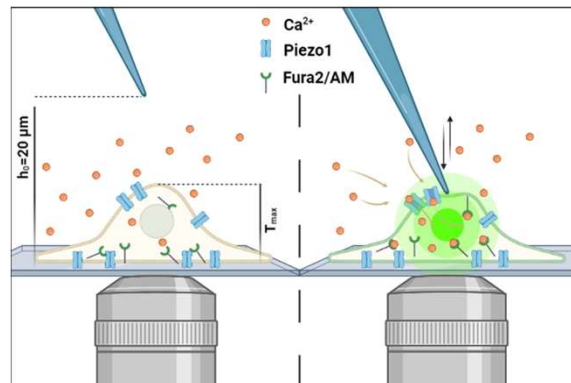
Missione 4 • Istruzione e Ricerca

POSSIBILI ARGOMENTI DI TESI

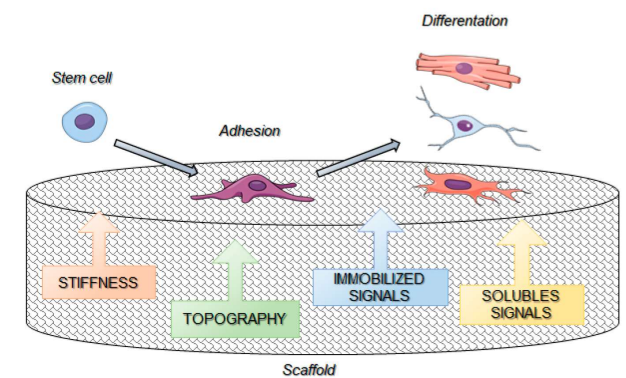
- Caratterizzazione meccanica e chimica di materiali biomimetici
- Meccanobiologia in cellule e tessuti
- Dinamiche aggregative di proteine collegate ai processi neurodegenerativi
- Ottimizzazione e sviluppo di strumentazione innovativa per analisi spettroscopica
- Studio di materiali avanzati micro e nanostrutturati



WORKSHOP DI ORIENTAMENTO ALLA LAUREA MAGISTRALE IN FISICA



[10.3390/nano12152691](https://doi.org/10.3390/nano12152691)



Cells 2019, 8, 1036; doi:10.3390/cells8091036

CONCLUSIONE

- Utilizzare la luce per investigare la materia biologica: un ampio spettro di attività.
- Tesi, Curiosità → maurizio.mattarelli@unipg.it
daniele.fioretto@unipg.it
francesco.bonacci@unipg.it
silvia.caponi@cnr.it



iOM ISTITUTO
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MATERIALI

WORKSHOP DI ORIENTAMENTO ALLA LAUREA MAGISTRALE IN FISICA



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