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3D Bioceramic scaffolds for bone tissue engineering

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 Bioengineering, Biomaterials & Nanomedicine Research Center, CIBER-BBN, Spain.

NIS colloquium
"Advances in biomaterials: combining simulations and experiments"
 Torino, 28-29 November 2013





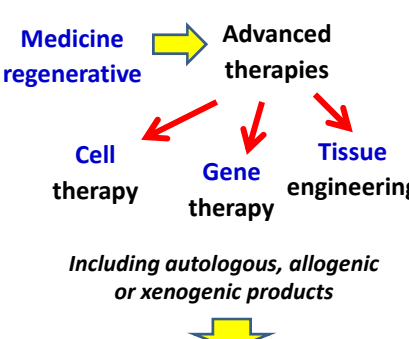
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Types of transplants of tissues authorized today

- Cornea, sclera and conjunctiva
- Ligaments, cortical and trabecular bone
- Cardiac valves: pulmonary aortic, mitral
- Vascular segments
- Skin
- Amniotic membrane
- Hematopoietic progenitors
- Pancreatic islets

The future organs and tissues for transplants

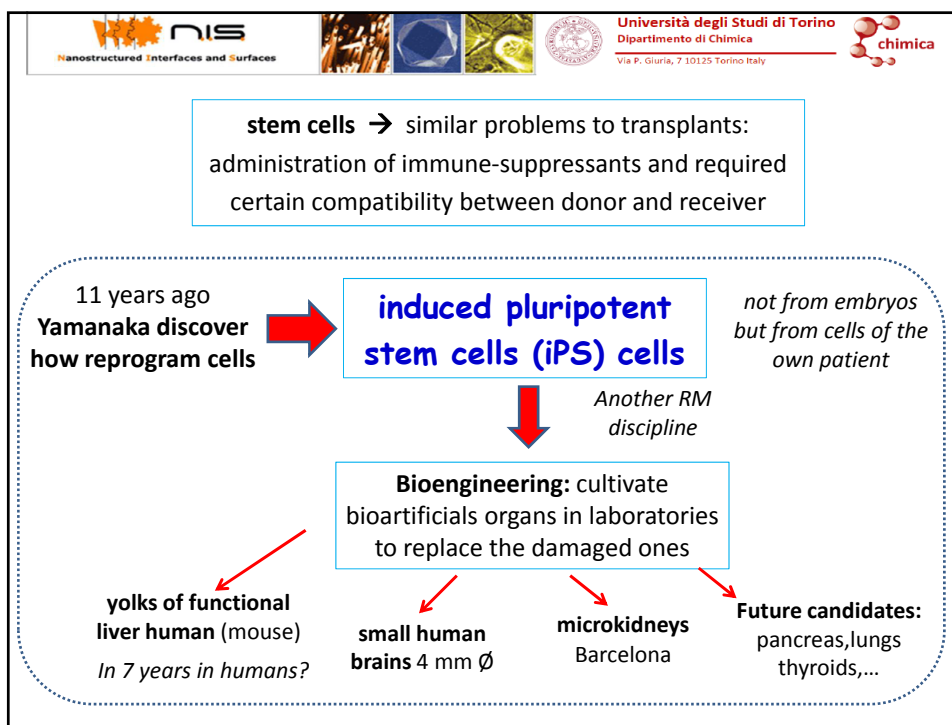
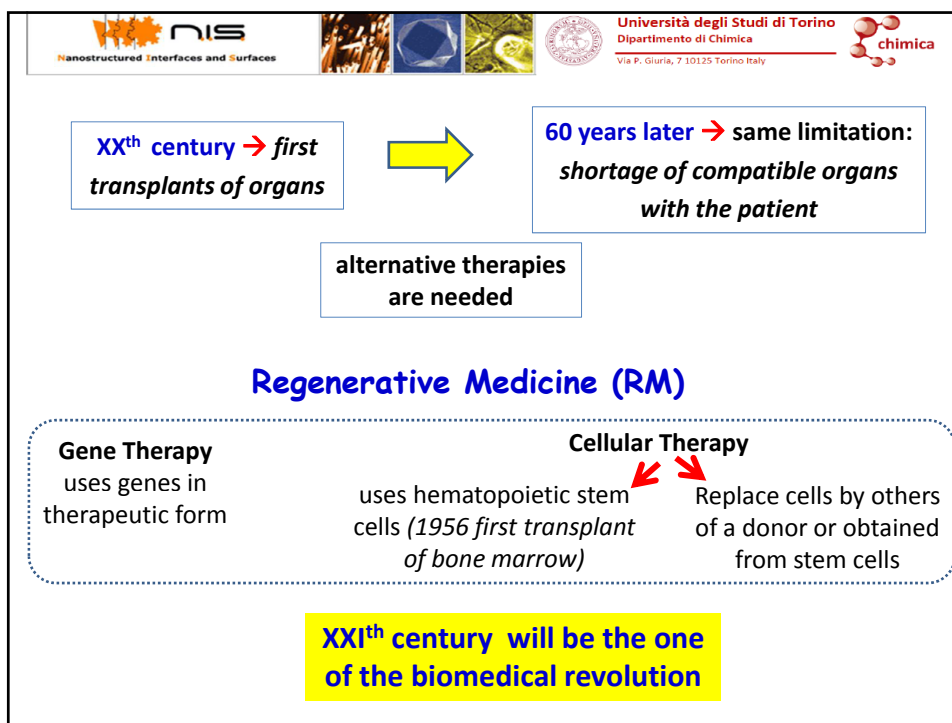


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graph TD
    MR[Medicine regenerative] --> AT[Advanced therapies]
    AT --> CT[Cell therapy]
    AT --> GT[Gene therapy]
    AT --> TE[Tissue engineering]
    CT --> NOD[New opportunities for treatment of some diseases]
    GT --> NOD
    TE --> NOD
          
```

Including autologous, allogenic or xenogenic products

New opportunities for treatment of some diseases









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IPS cells → not appropriated for all the tissues like cardiac tissue or bone

Tissue Engineering

To repair or replace bones, cartilage, skin, blood vessels or bladder

1993 Langer and Vacanti co cultured **chondrocytes + collagen** in scaffolds with 3D pores in a bioreactor

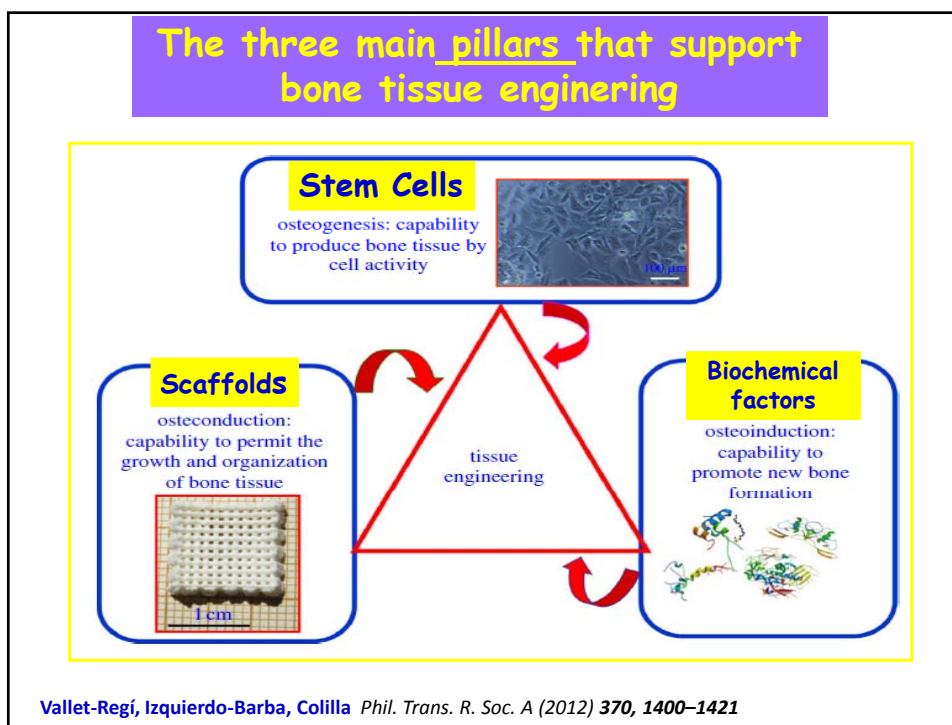
↓

3D cell culture or histo-cellular culture



Tissue-Engineered Ear Grafted on a Lab Mouse

- epidermal stem cells → grow into **keratinocytes** **skin tissue engineering**
- Stem cells from the dermis → grown into **fibroblasts**
- 2006 Grow **bladders** in the lab from patients' own cells
- 2008 **Trachea** grown for a 30-years lady suffering tuberculosis
- A **beating rat's heart** was created





NIS
Nanostructured Interfaces and Surfaces

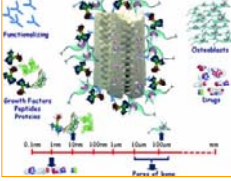


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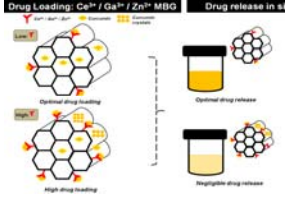
chimica

ADVANCED BIOCERAMICS FOR BONE TISSUE REGENERATION AND SCAFFOLDING

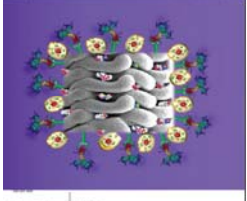


Biomater. Sci., 2013, 1, 40

Biomaterials Science

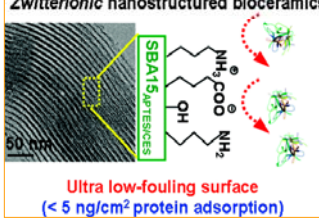


Micropor Mesopor Mater 180 (2013) 92

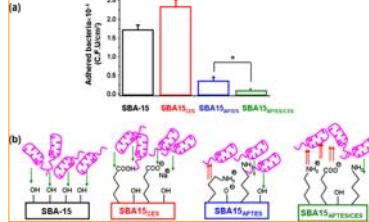


Biomater. Sci., 2013, 1, 40

ADAPTIVE-RESPONSE BIOCERAMICS FOR ANTIMICROBIAL PURPOSES



Chem Mater, 2010, 22, 6459



Acta Biomaterialia, 2011, 7, 2977

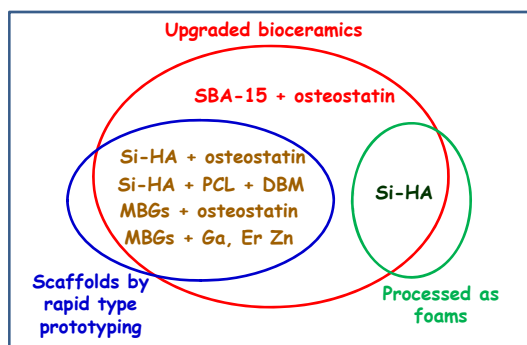
Advanced bioceramics for bone tissue regeneration

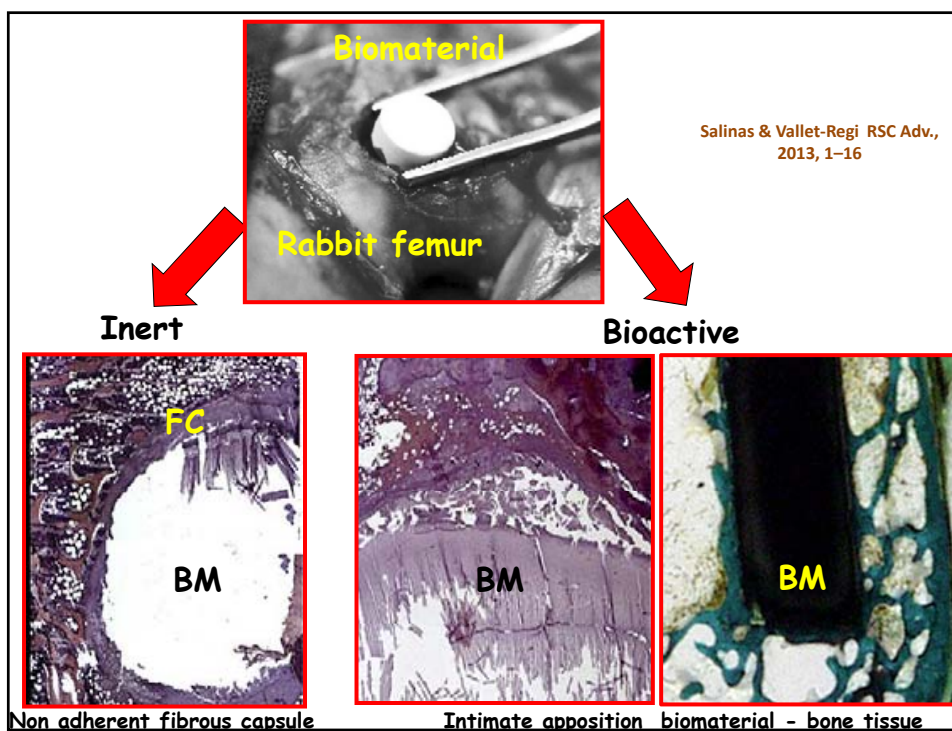
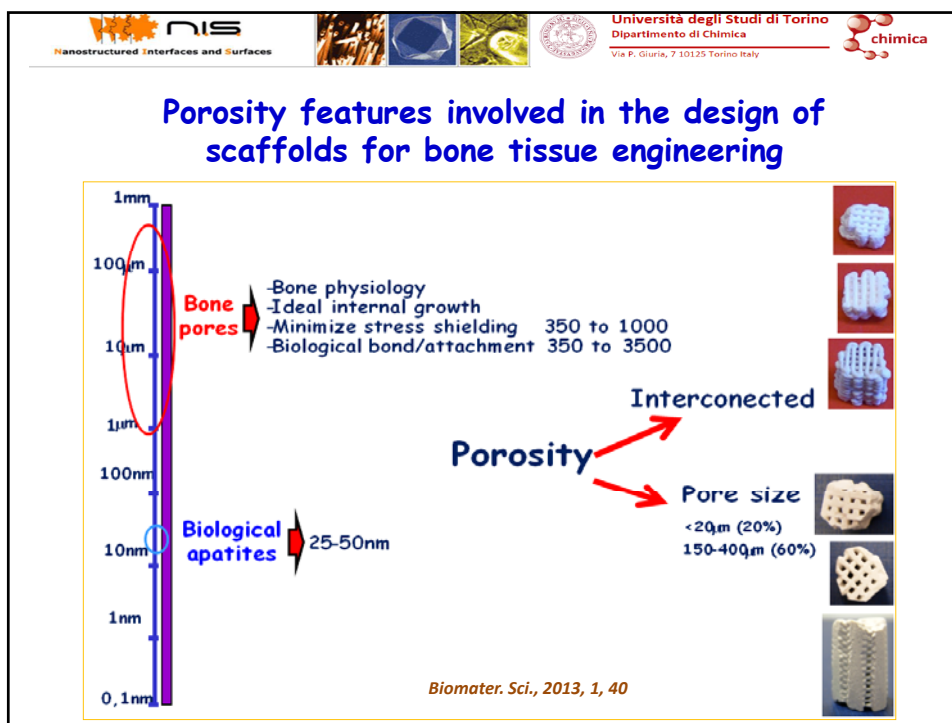
-Preparation of 3D porous scaffolds :

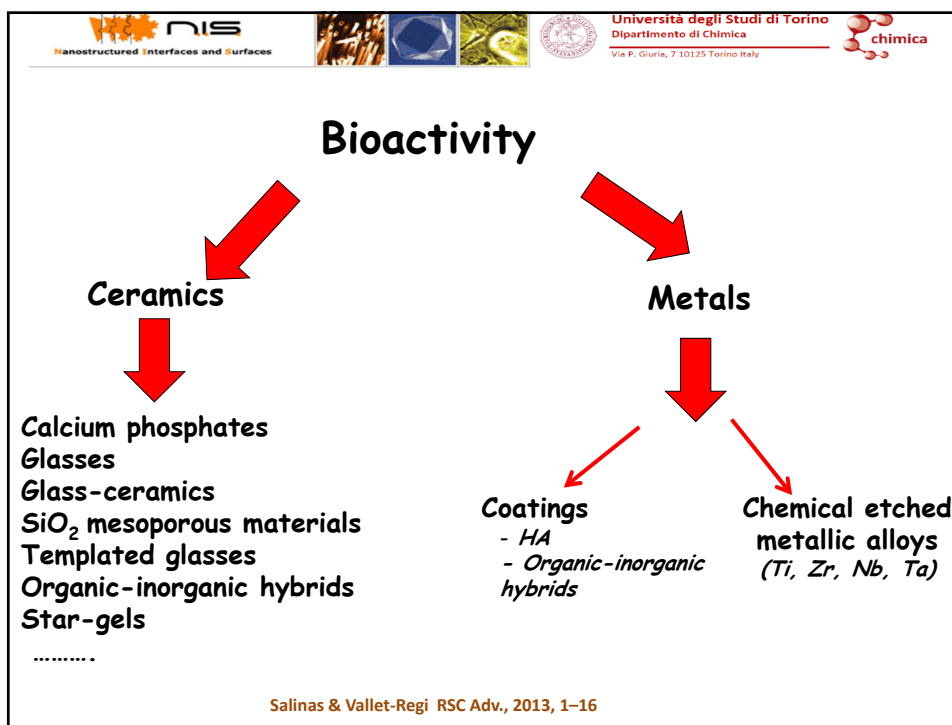
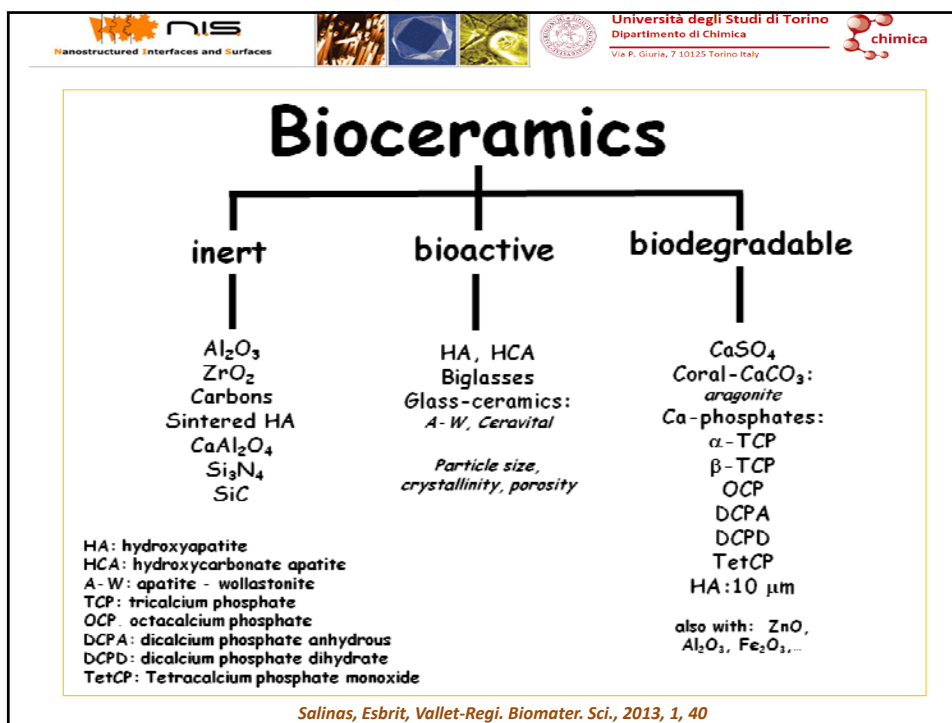
- Rapid type prototyping
- Foaming

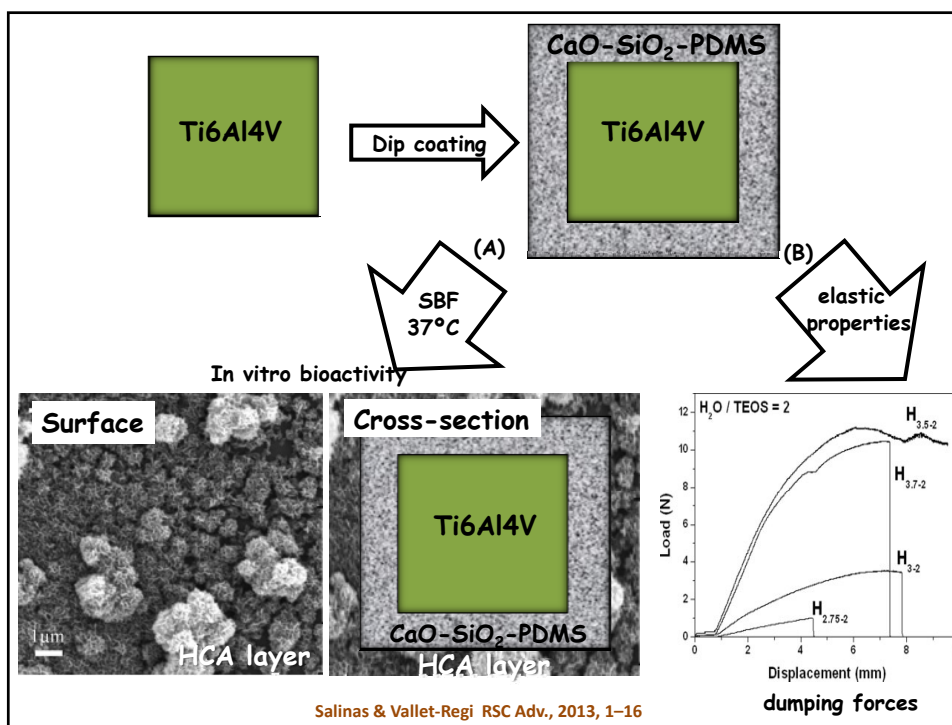
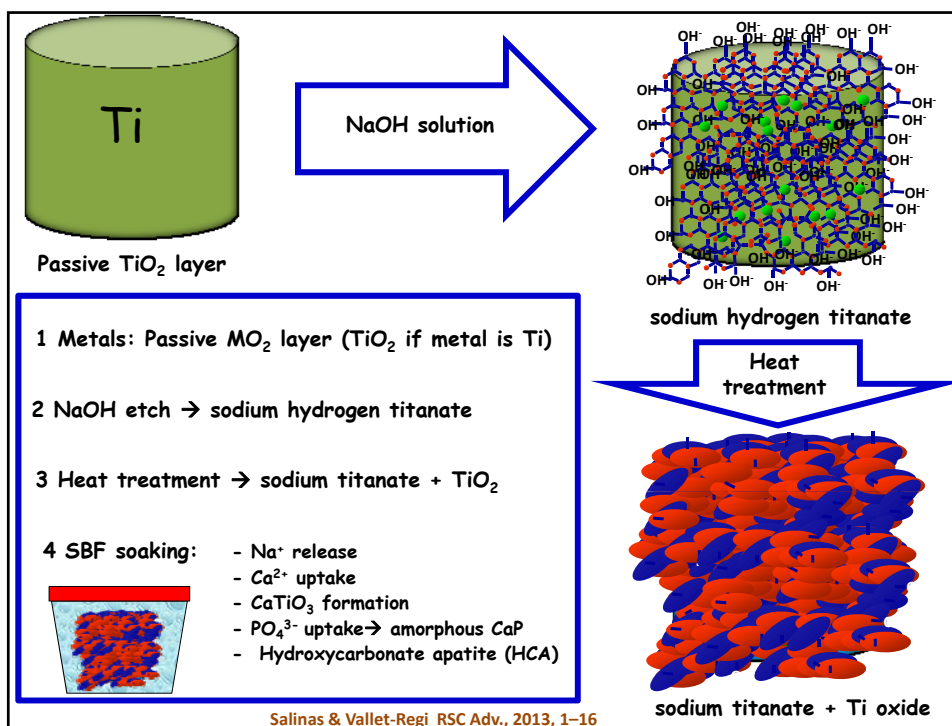
- Upgrading second generation bioceramics with:

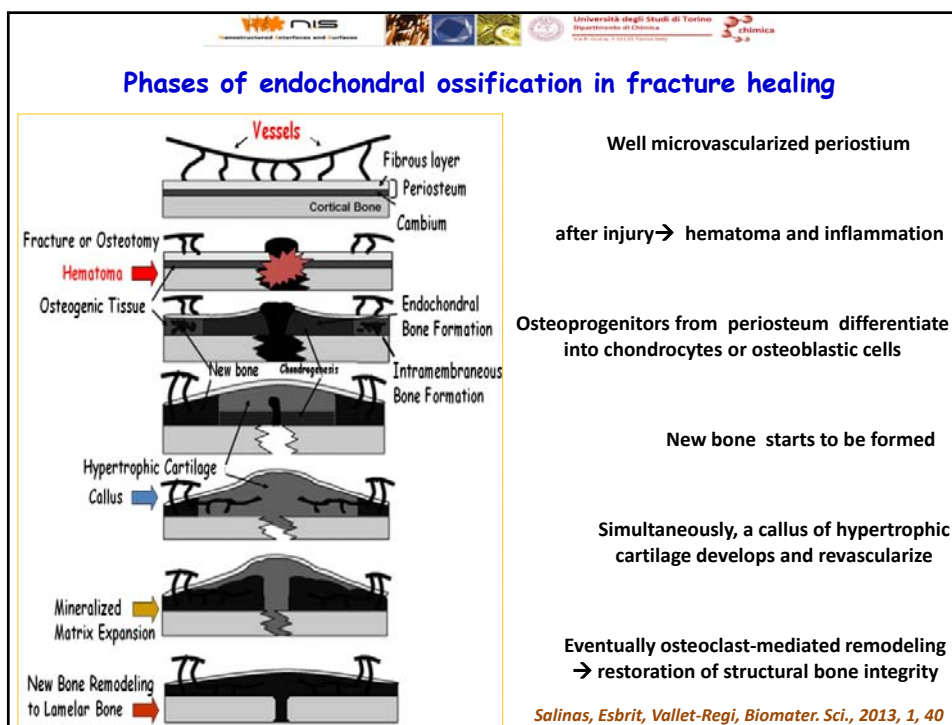
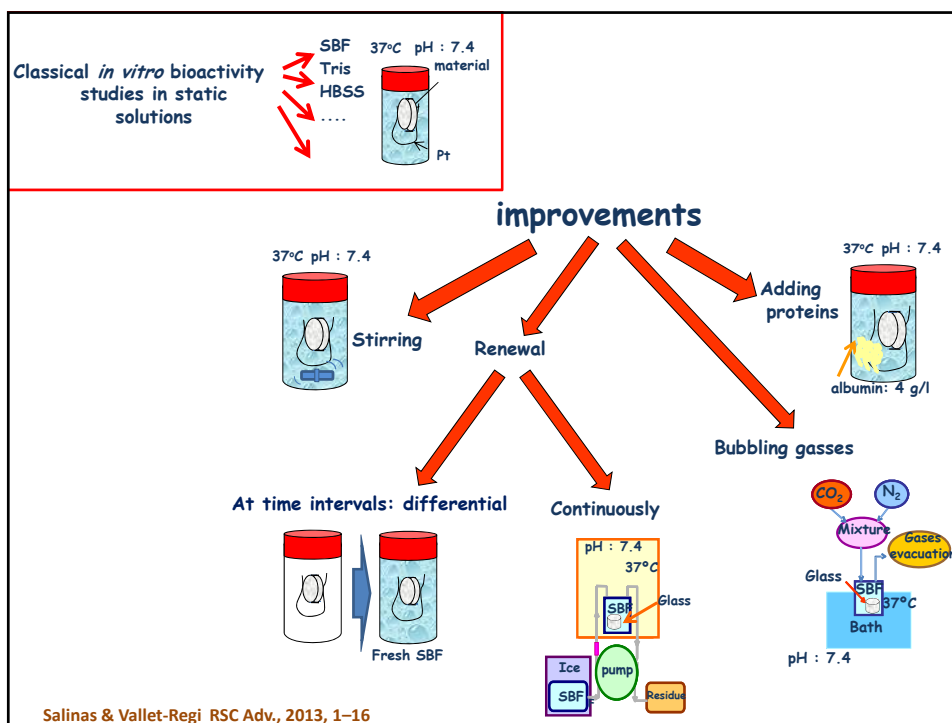
- Osteogenic factors: **osteostatin, DBM**
- Therapeutic Inorganic Ions: **Ga³⁺, Er³⁺, Zn²⁺, Si(IV)**

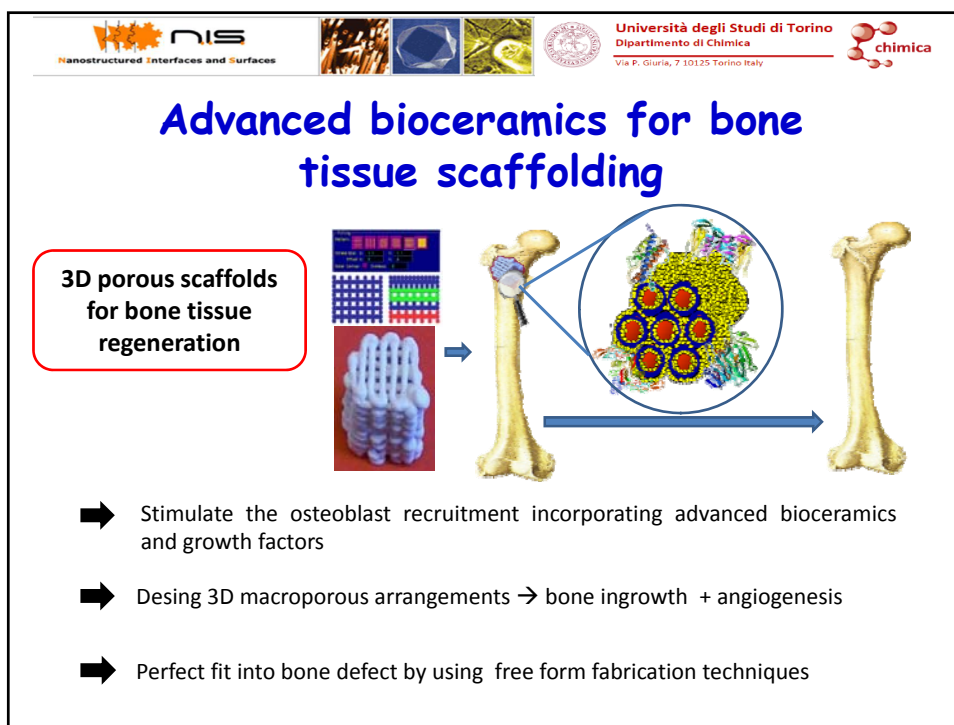
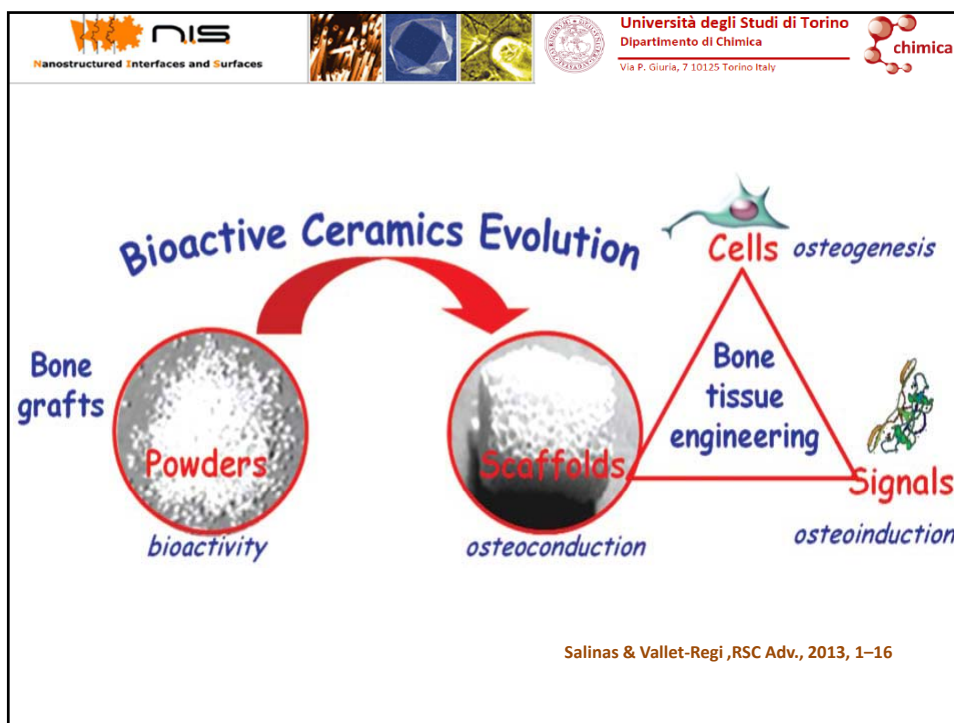










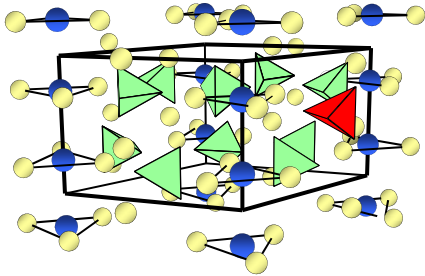





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Silicon substituted hydroxyapatite

➔ Composition $\text{Ca}_{10}(\text{PO}_4)_{5,7}(\text{SiO}_4)_{0,3}(\text{OH})_{1,7}$



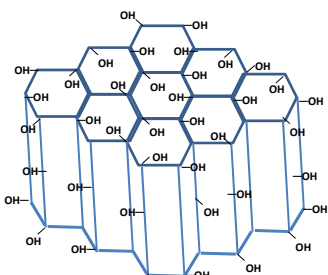

Vallet-Regí M, Arcos D. *J Mater Chem* (2005)

Improves in the in vivo response of
the implant with respect of
stoichiometric hydroxyapatite




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Mesoporous ordered materials:
pure amorphous-SiO₂



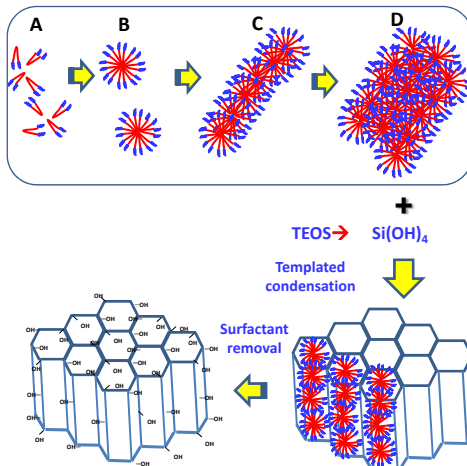
Controlled
drug release

Functionalize to
control the drug
release

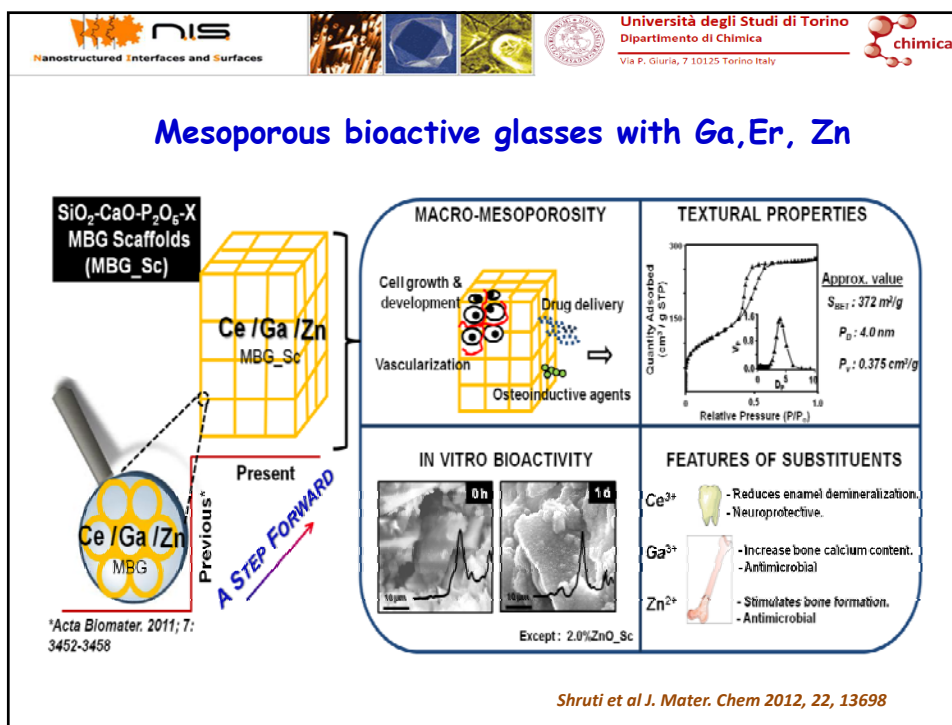
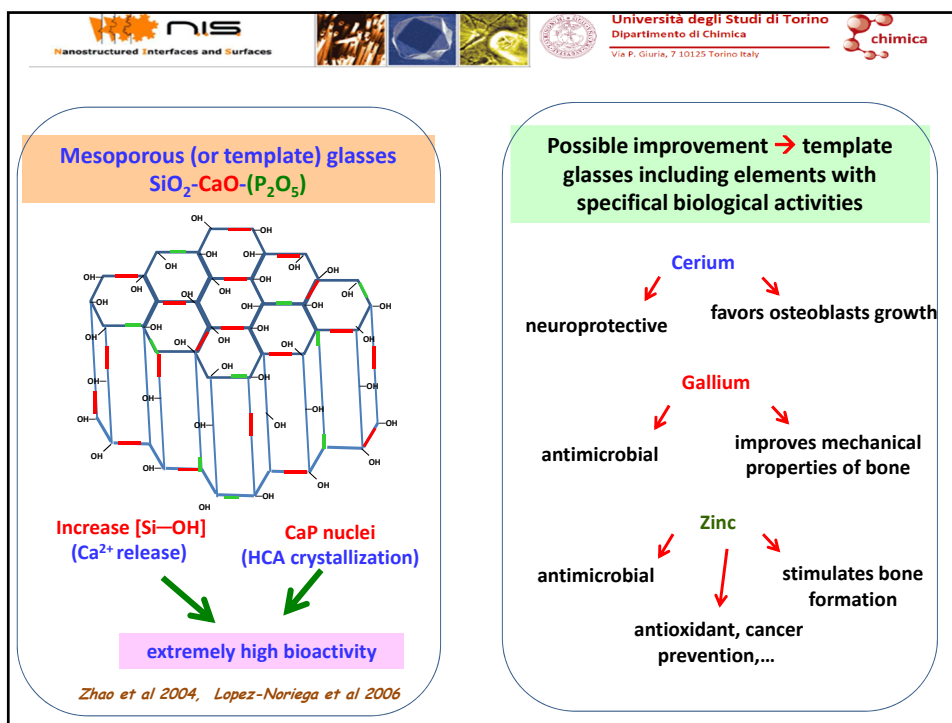
Moderate
bioactive
response

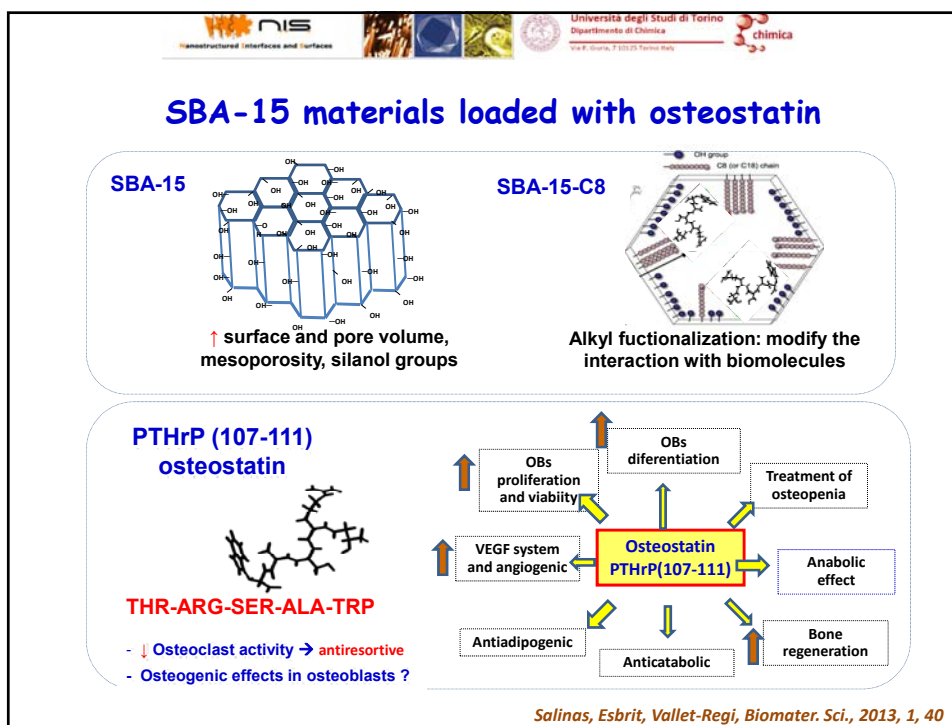
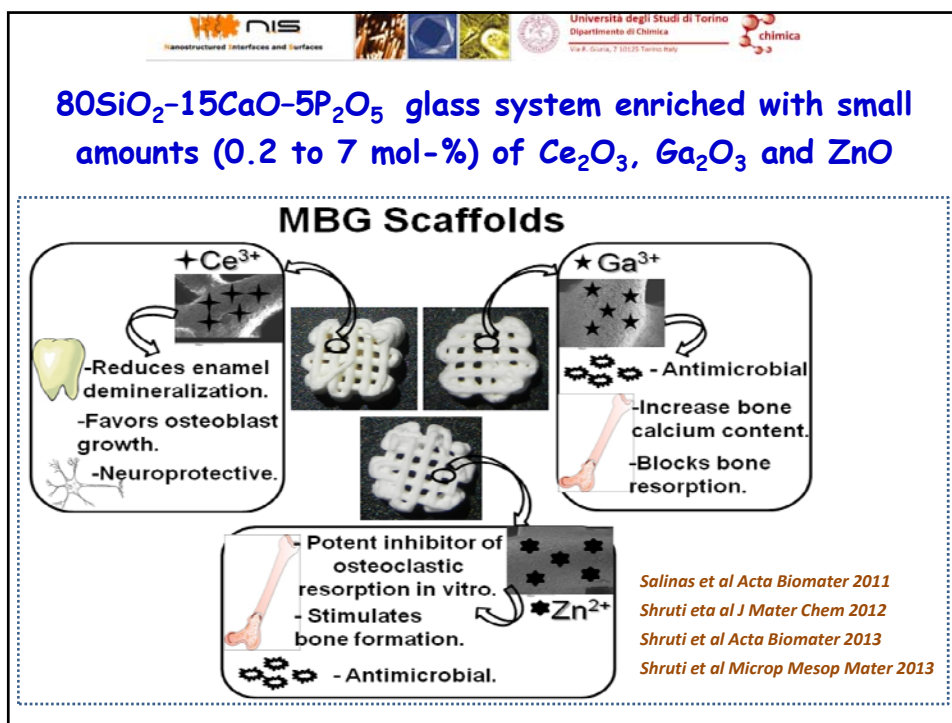
Vallet-Regí et al, Chem Mater 2001

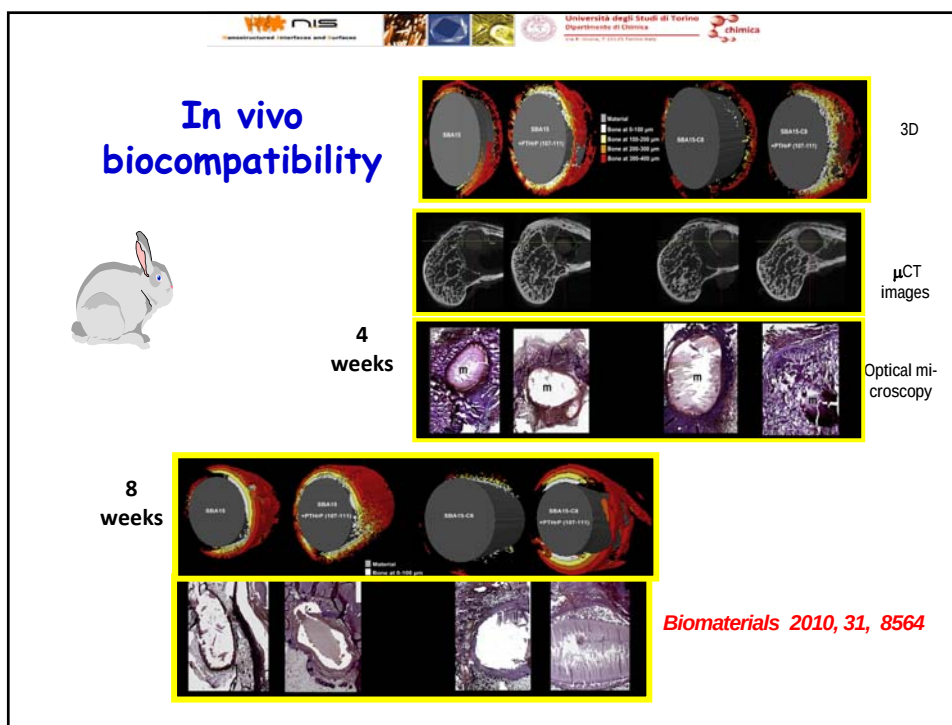
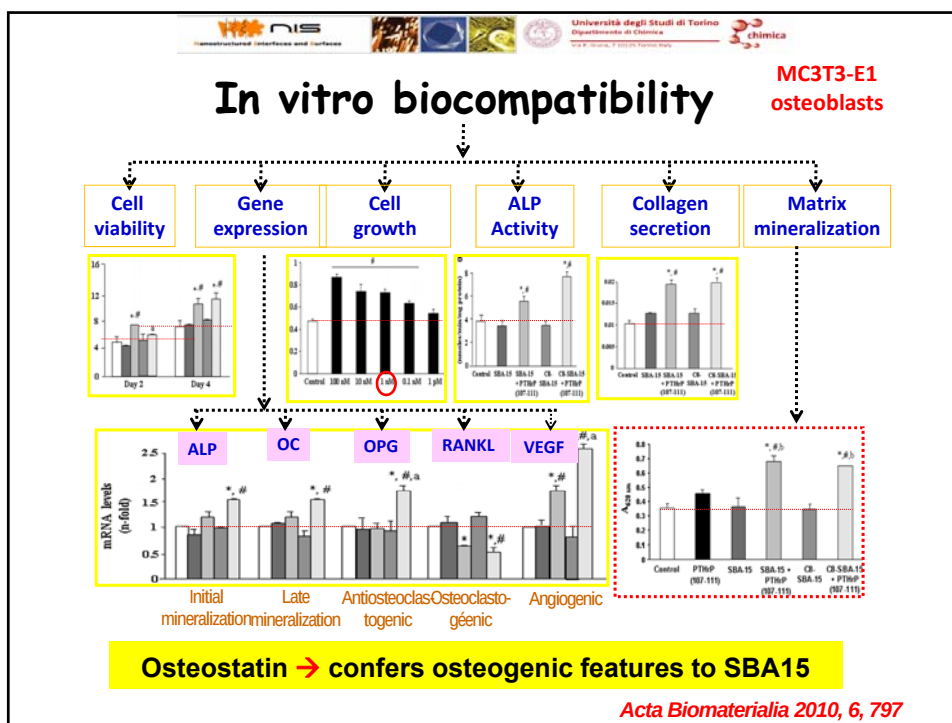
$\text{HO}(\text{CH}_2\text{CH}_2\text{O})_{20}(\text{CH}_2\text{CH}(\text{CH}_3)\text{O})_{70}(\text{CH}_2\text{CH}_2\text{O})_{20}\text{H}$
 [Pluronic 123]

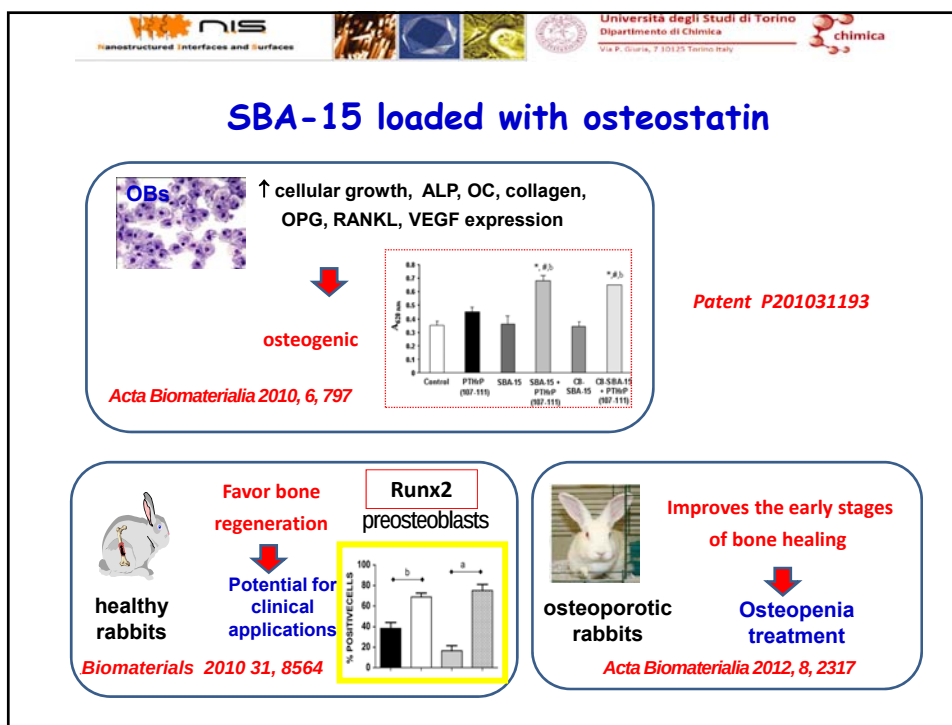
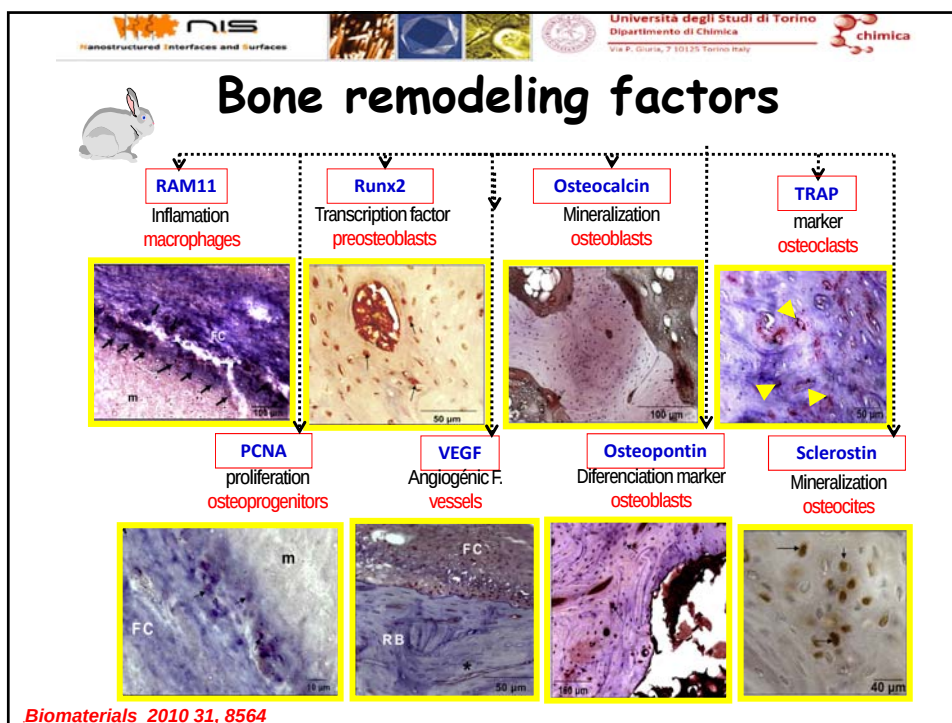


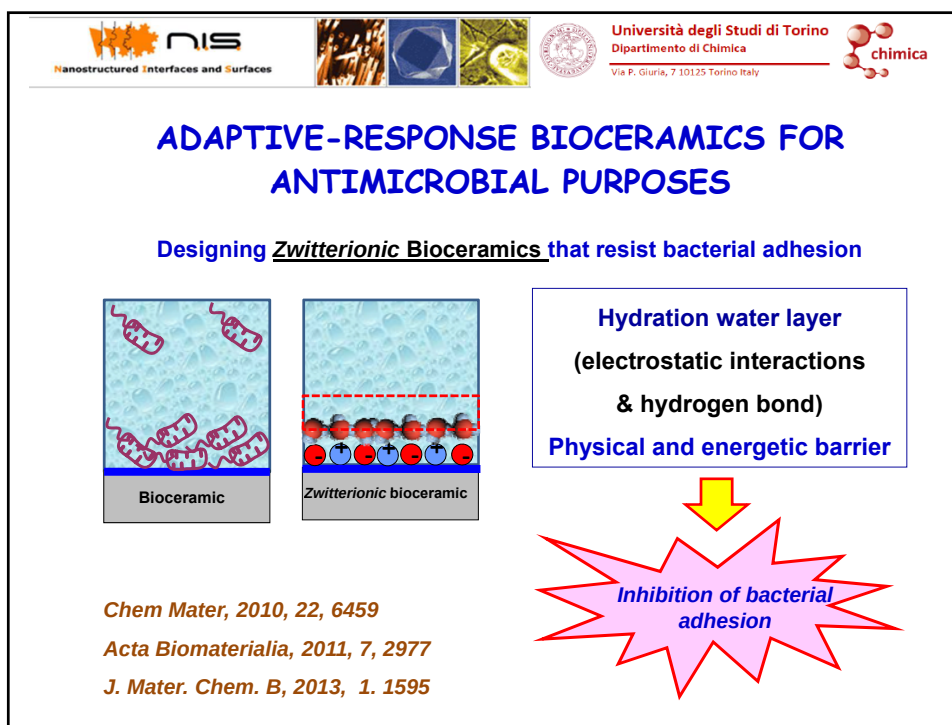
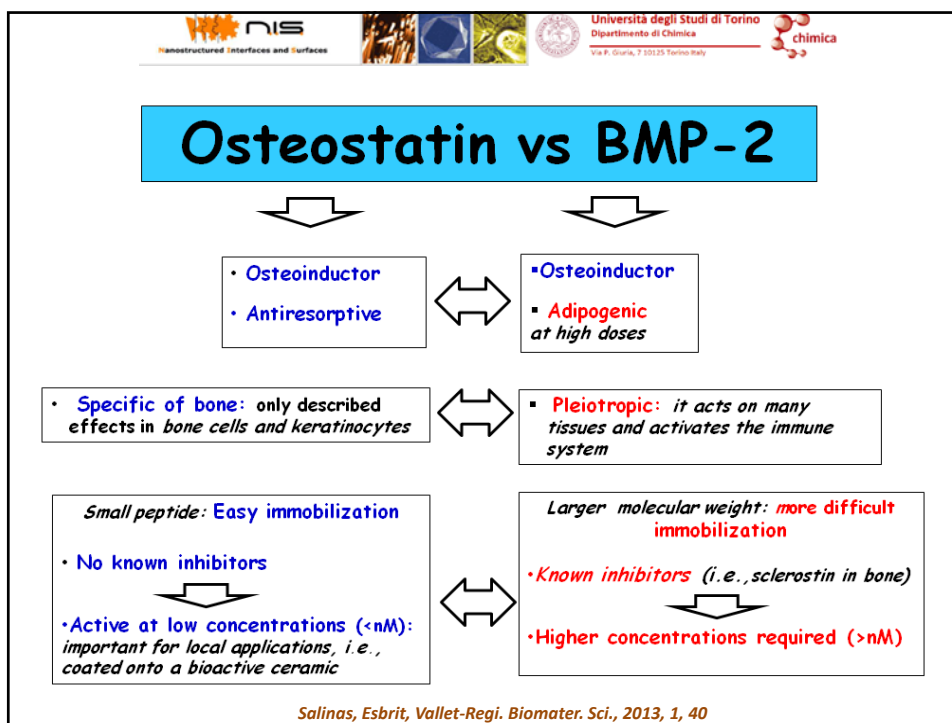
SBA-15, MCM-41,...

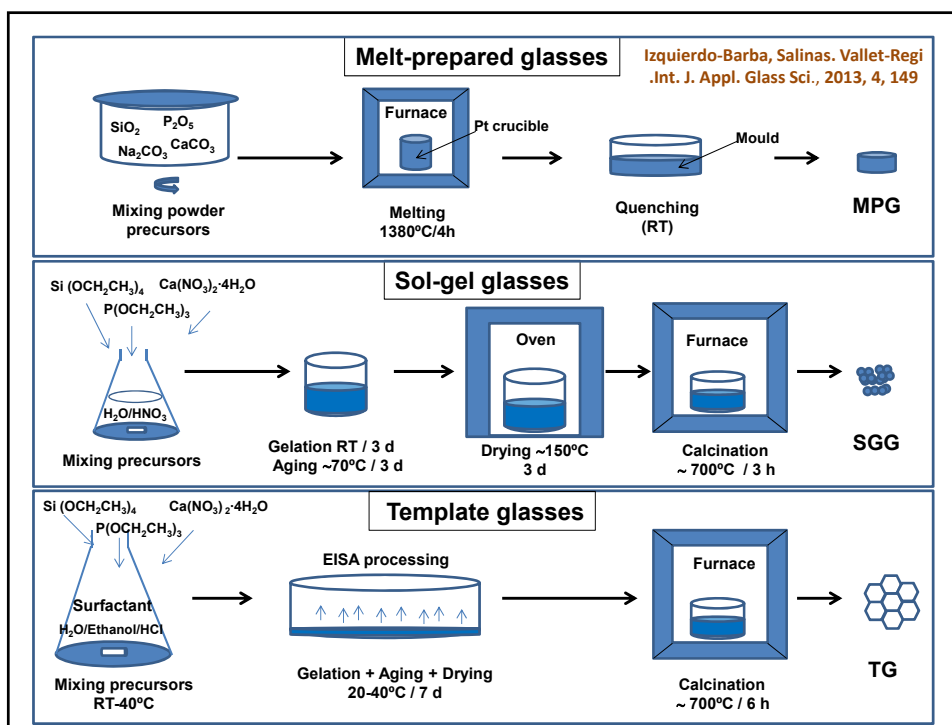
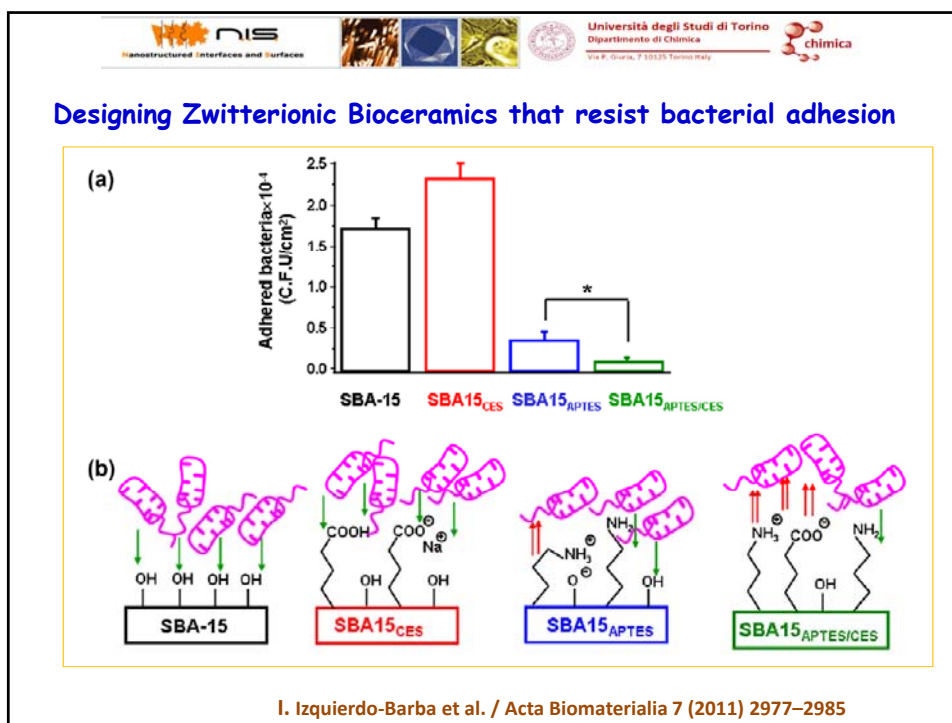


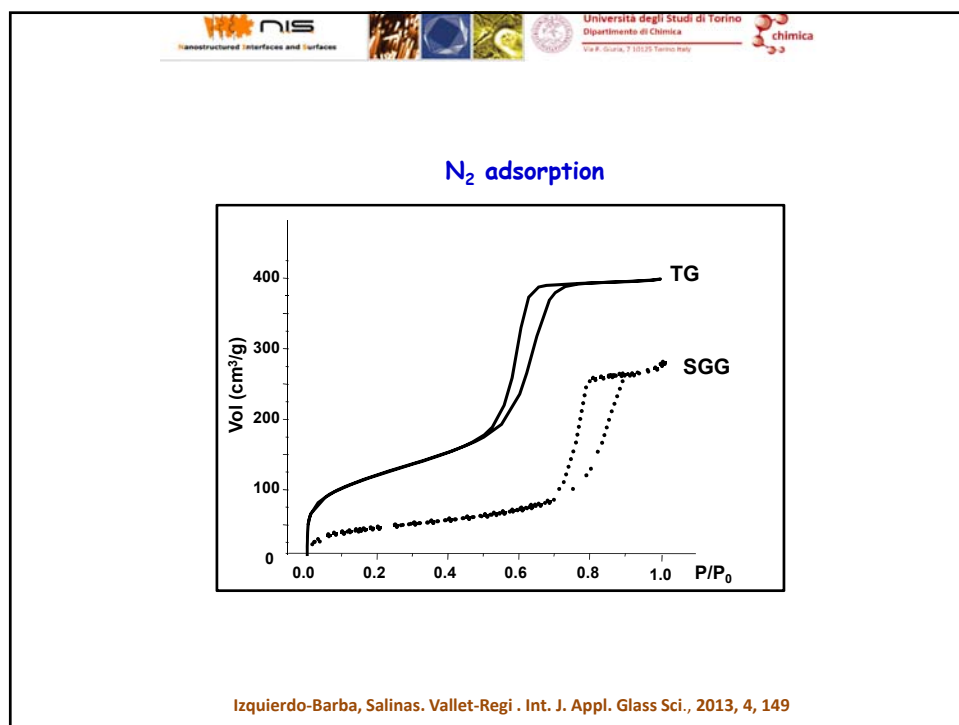
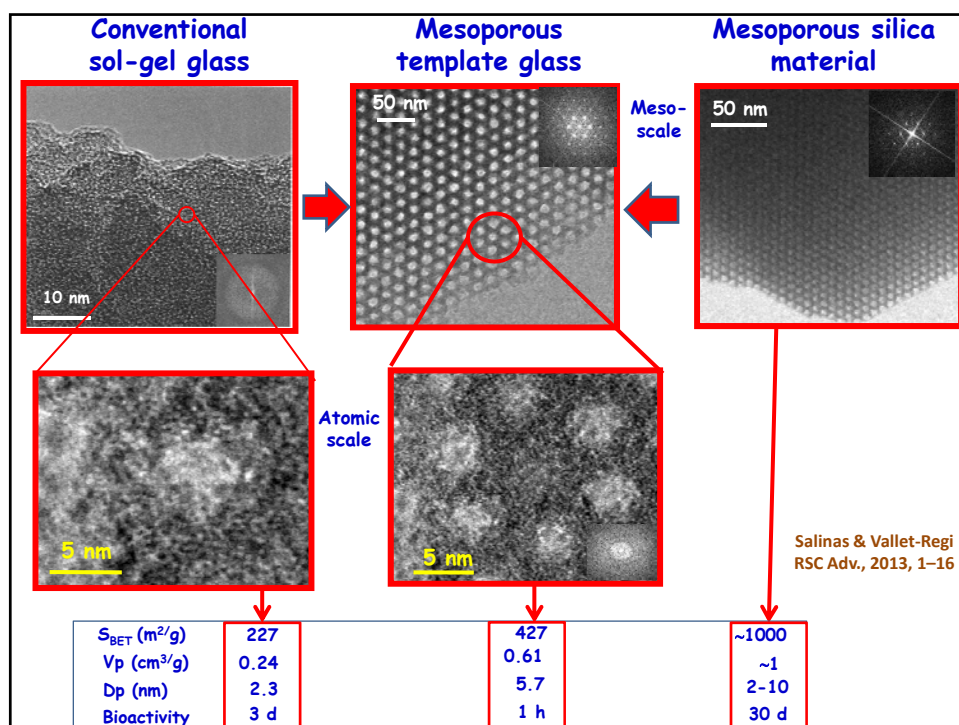


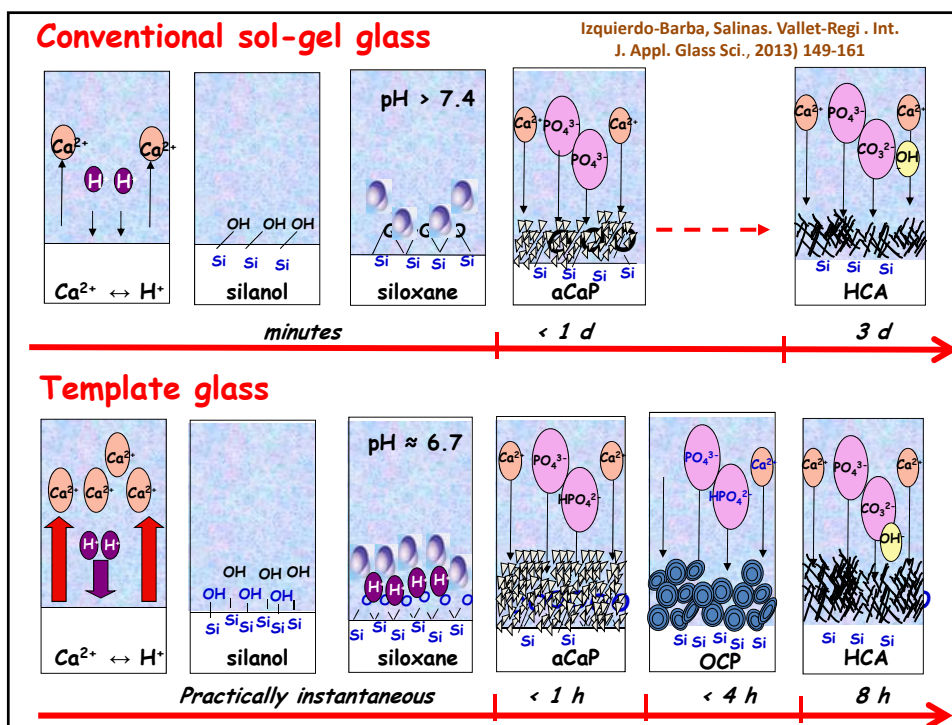
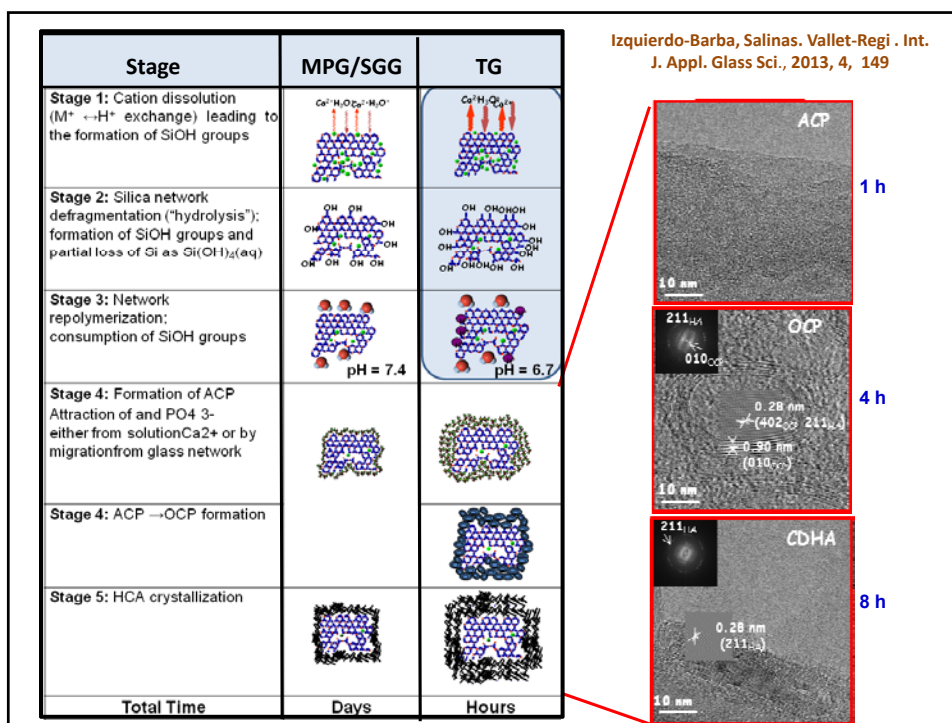


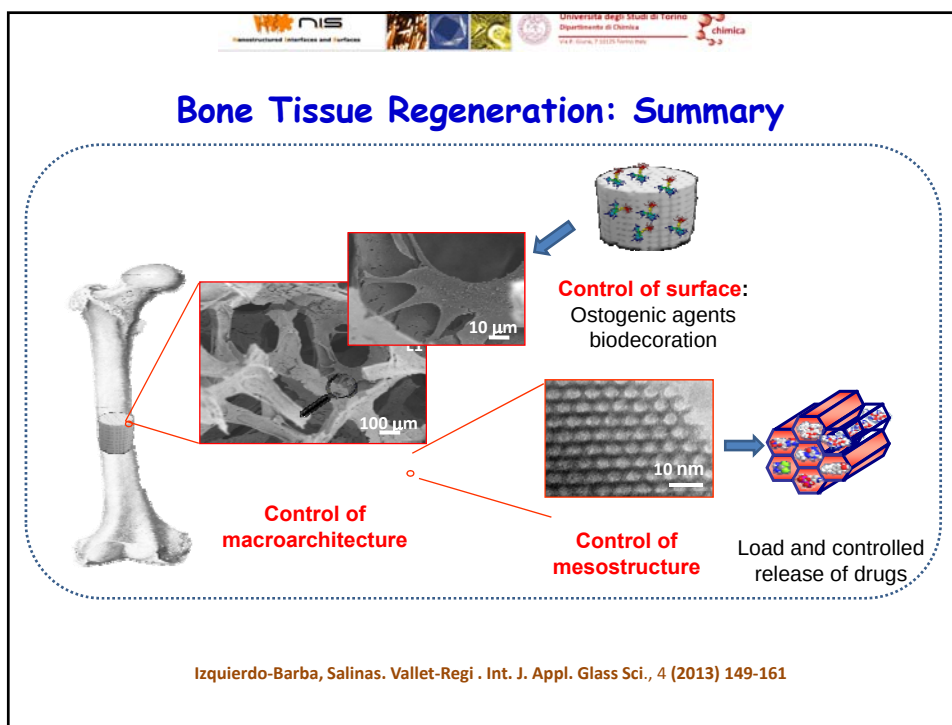
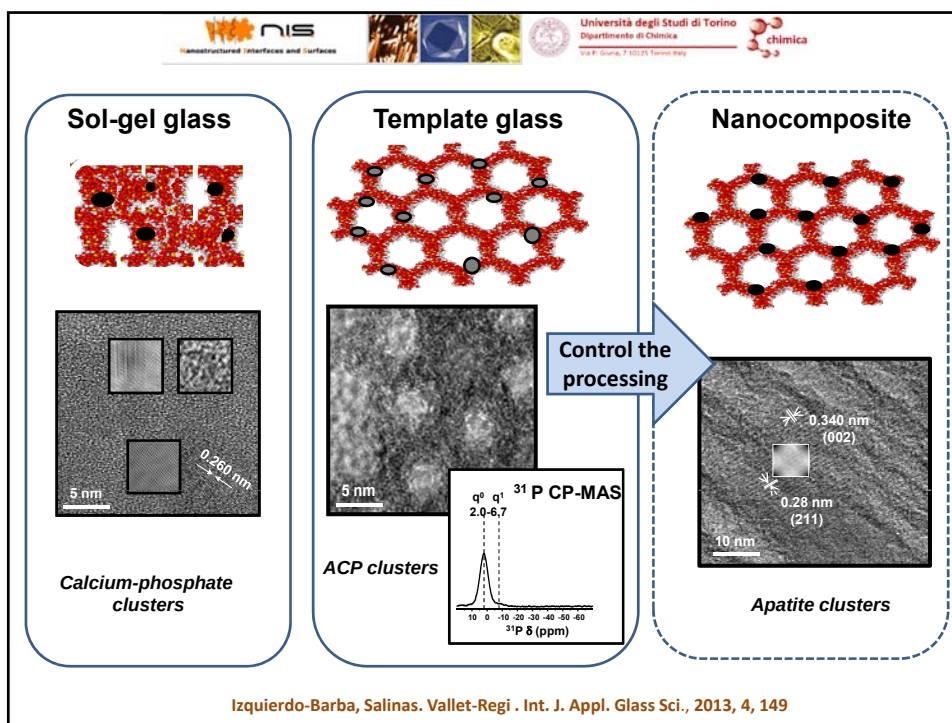












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