Bioingegnerizzazione di tessuti

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DIMP

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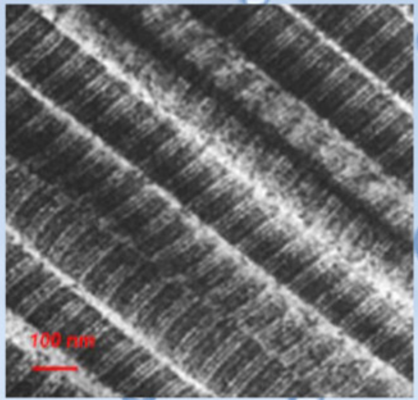
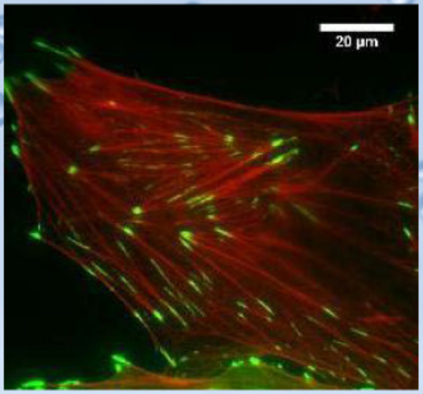
La Natura fornisce molteplici esempi di sistemi che si differenziano per

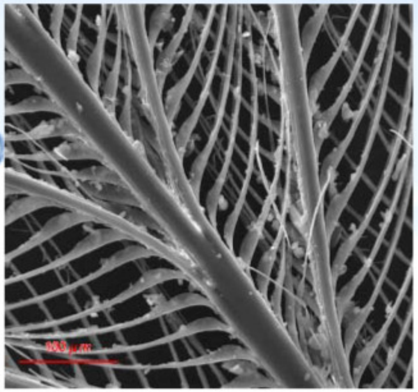
- ***Composizione***
- ***Microstruttura***
- ***Funzione***



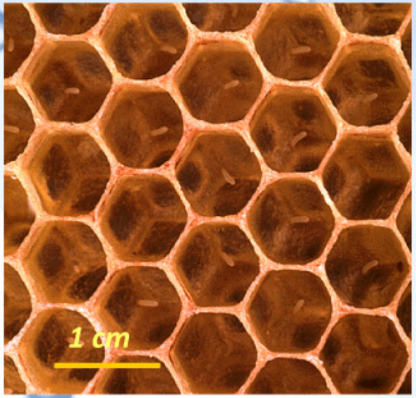
fibrille collagene



citoscheletro

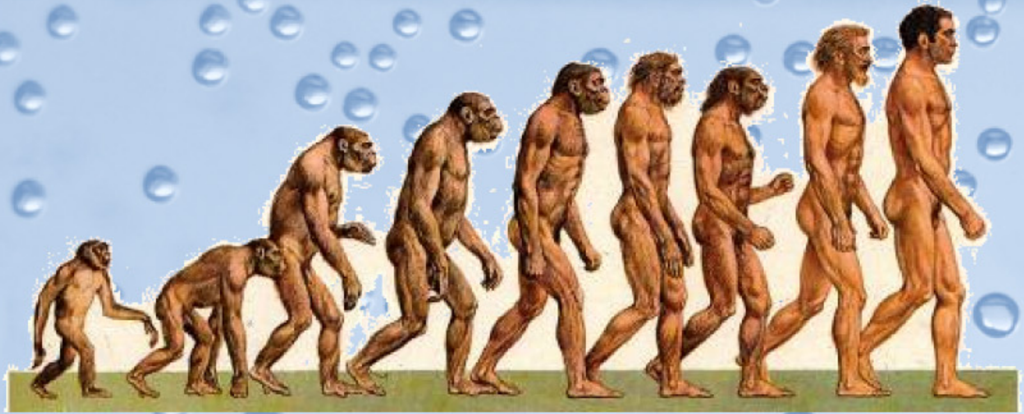


piuma



honeycomb

L'evoluzione biologica

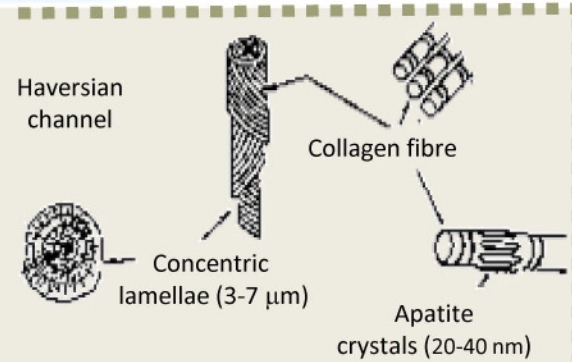


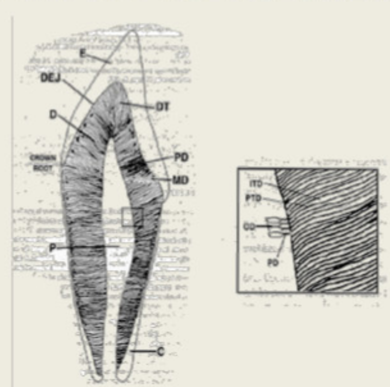
La selezione naturale agisce attraverso una procedura molto lenta ma estremamente efficiente che consiste nel sottoporre continuamente le strutture a verifiche basate sull'approccio <u>'trial and error'</u> allo scopo di sviluppare le strutture migliori per ogni prestazione funzionale

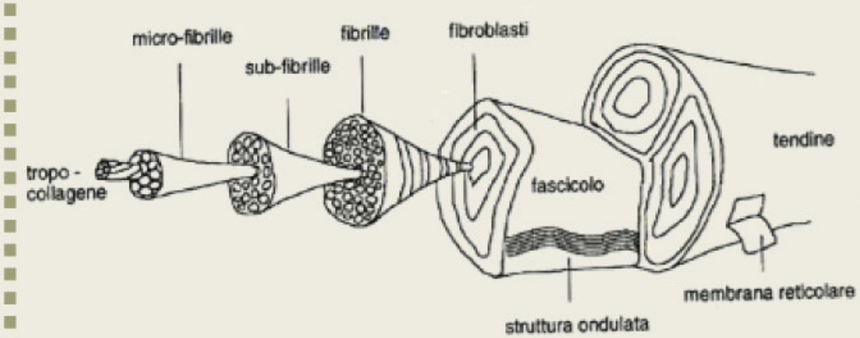
stadio evolutivo n → modifica

modifica di successo → stadio evolutivo n+1 → L'EVOLUZIONE PROSEGUE

modifica errata → ESTINZIONE



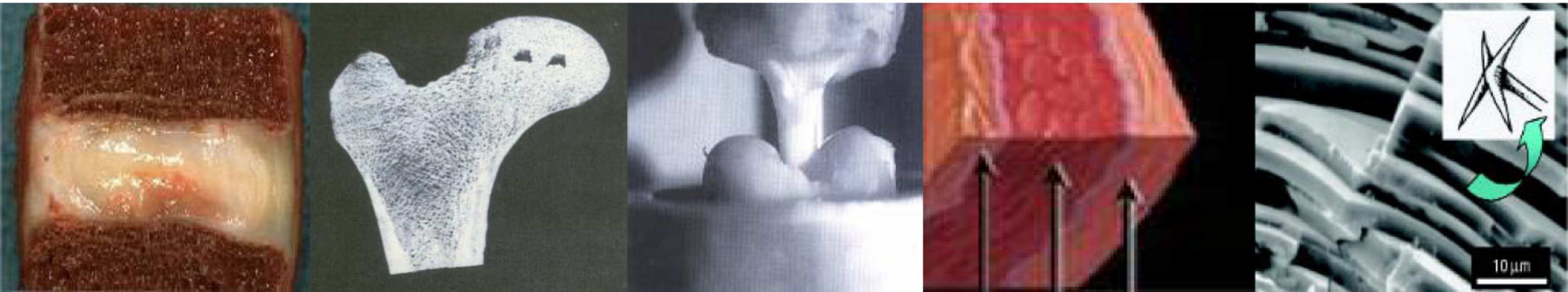




Caratteristiche dei tessuti naturali

Il processo di evoulzione ha conferito ai tessuti biologici proprietà uniche:

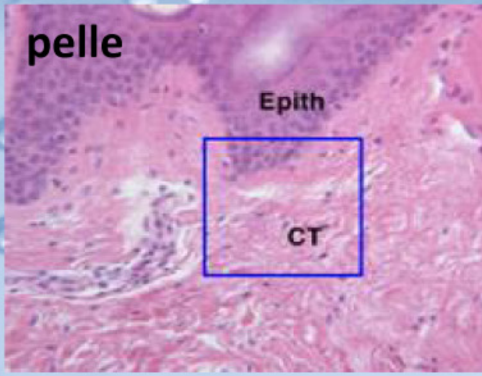
- **Eterogeneità**
- **Anisotropia**
- **Viscoelasticità**

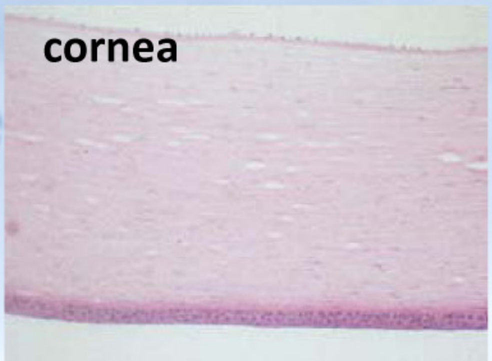


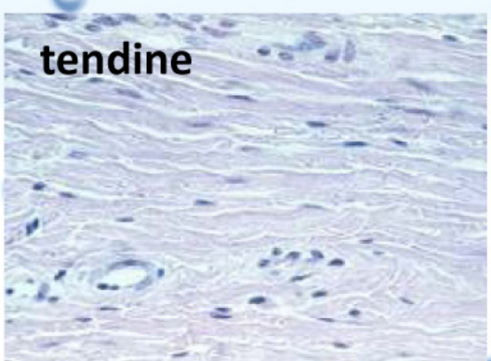
Eterogeneità

I tessuti sono costituiti da:

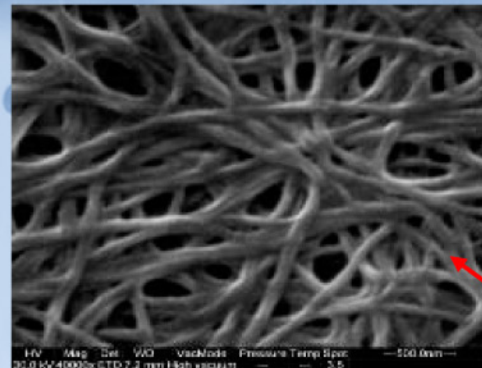
- Fase liquida
- Fase solida
- Fase cellulare

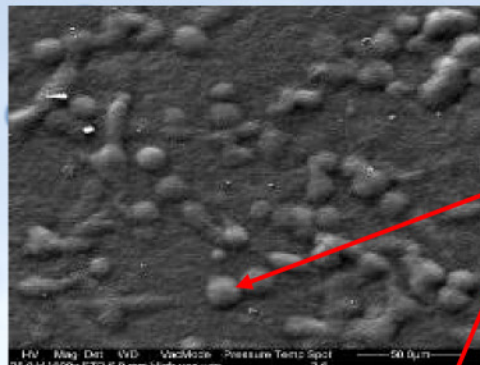


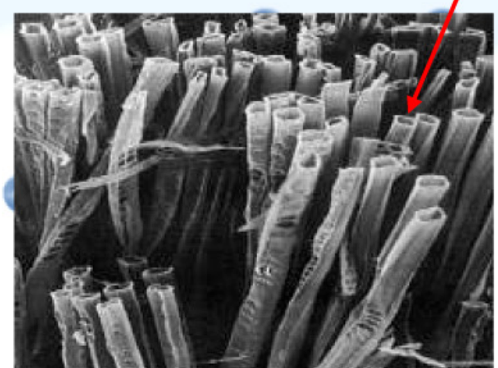




Microscopia ottica

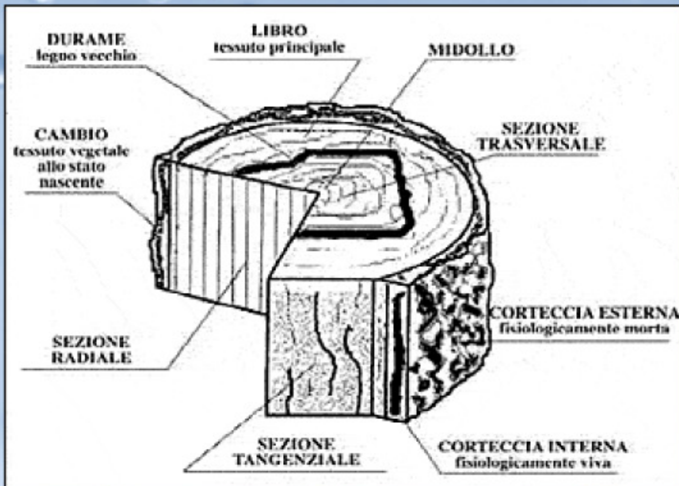


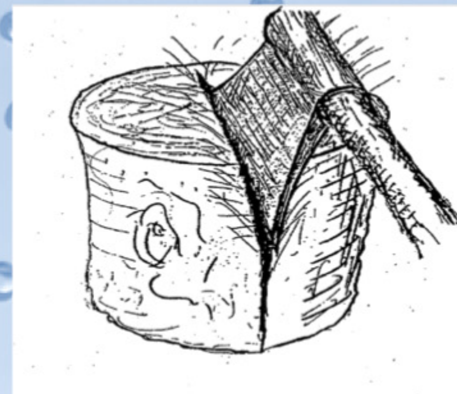


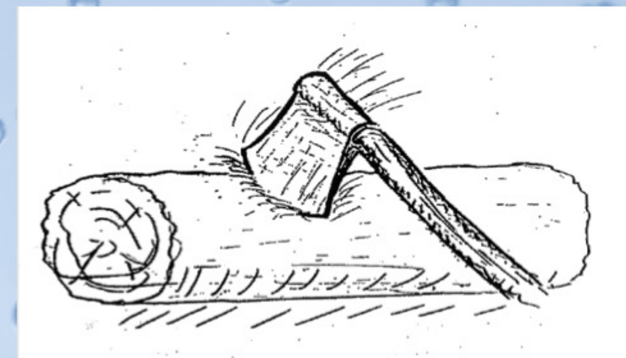


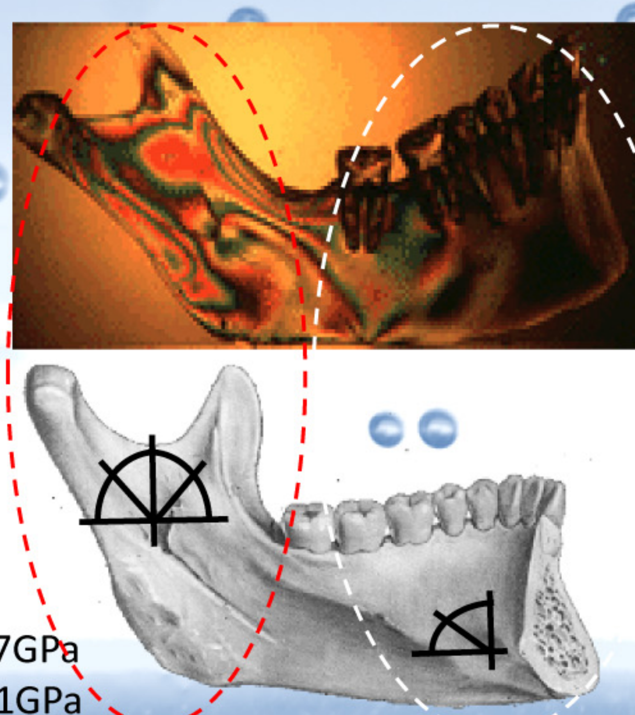
Microscopia elettronica

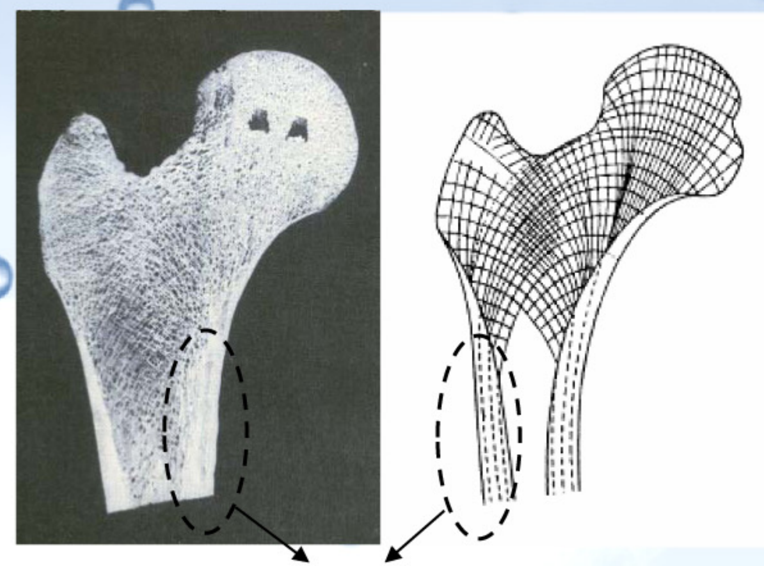
Anisotropia







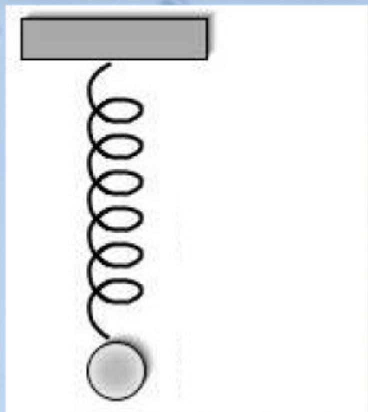




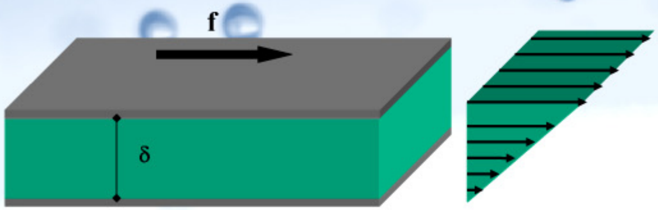
Ramo
45° E=17GPa
135° E=11GPa

Mandibola anteriore
0° E=21GPa
90° E=12GPa

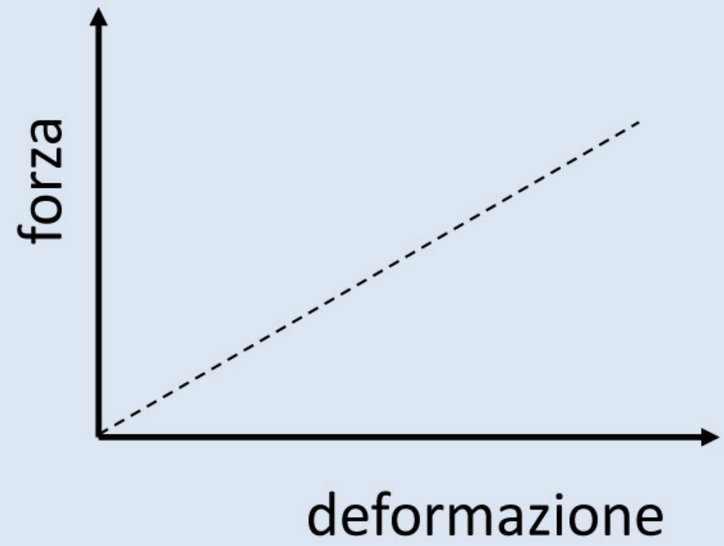
Femore
$E_{longitudinale}$ = 20GPa
$E_{radiale}$ = 12GPa



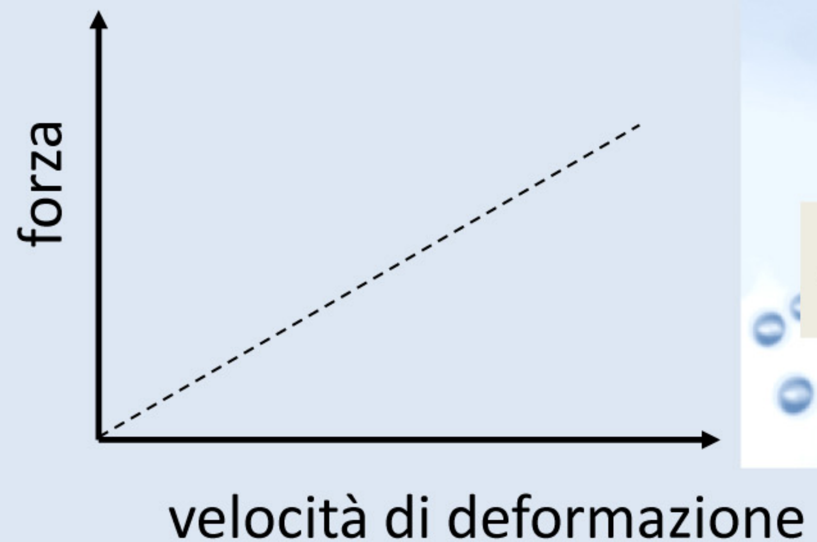
Solido Elastico



Liquido viscoso

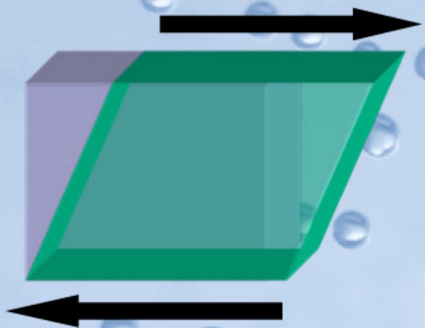


$$\sigma = E\,\varepsilon$$



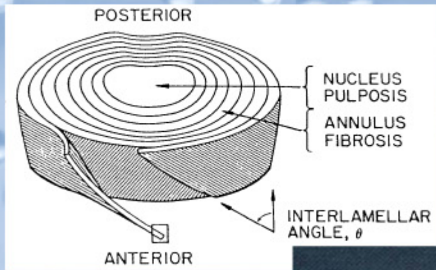
$$\tau = \eta\,\dot{\varepsilon}$$

Viscoelasticità

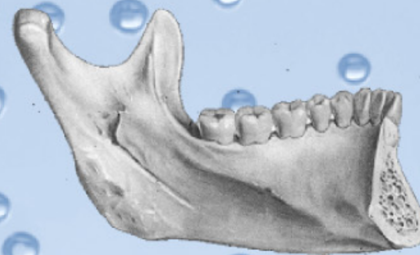


$\tau =$ Componente elastica $+$ Componente viscosa

Protesi composite

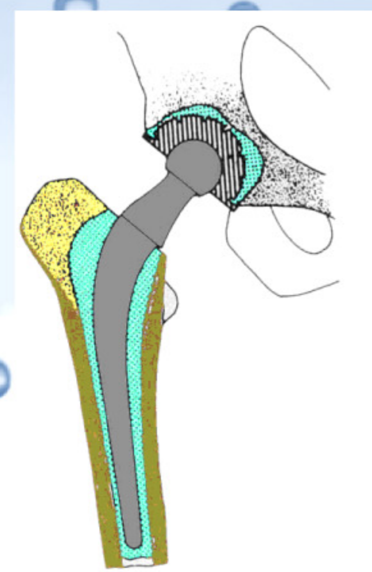


Disco intervertebrale



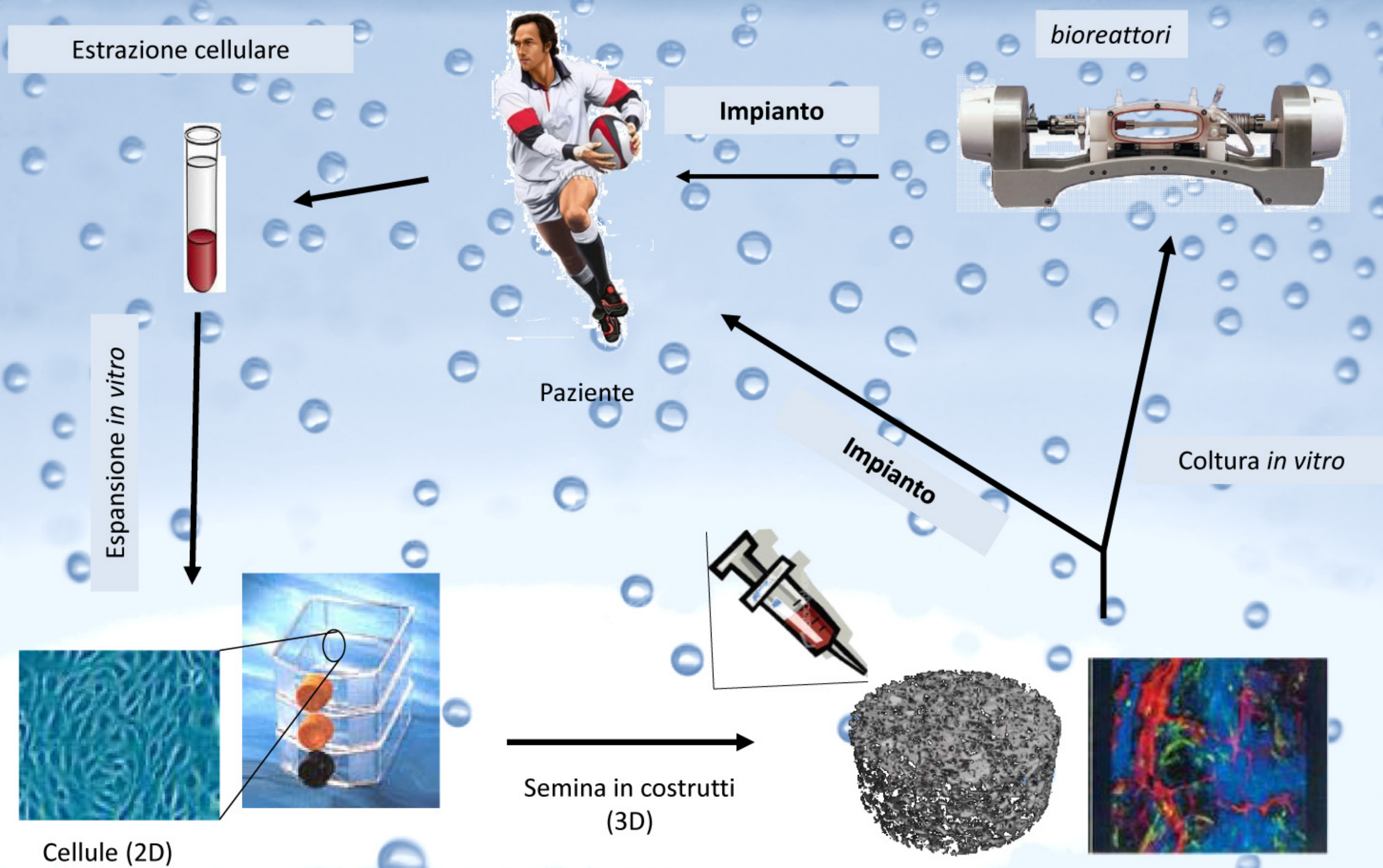
Mandibola

Tendini e legamenti



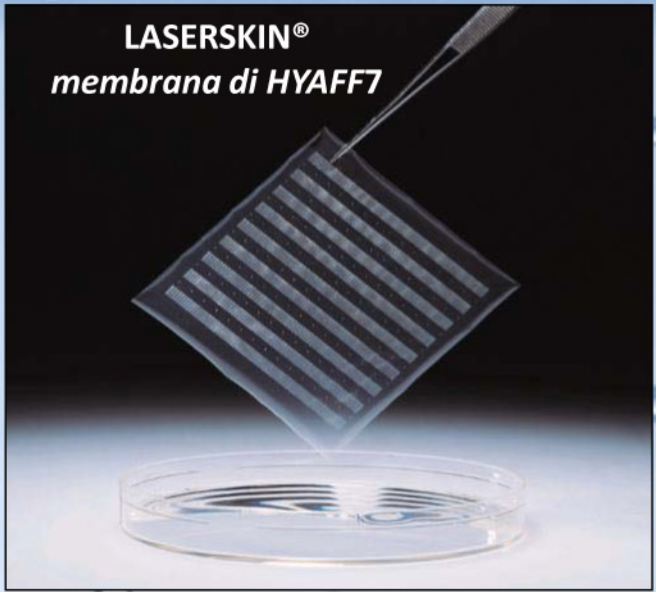
Anca

Ingegneria dei Tessuti

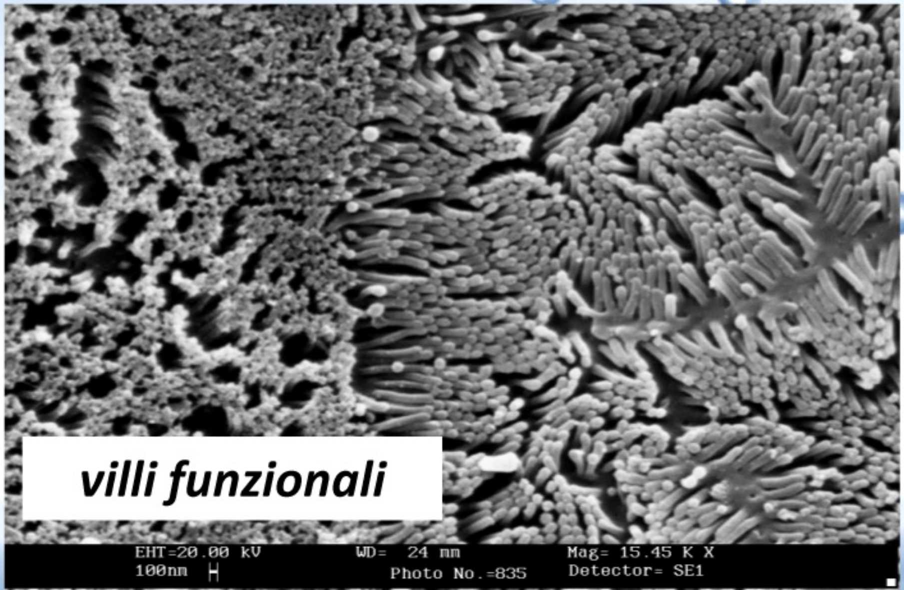


effetto del materiale sulla risposta cellulare

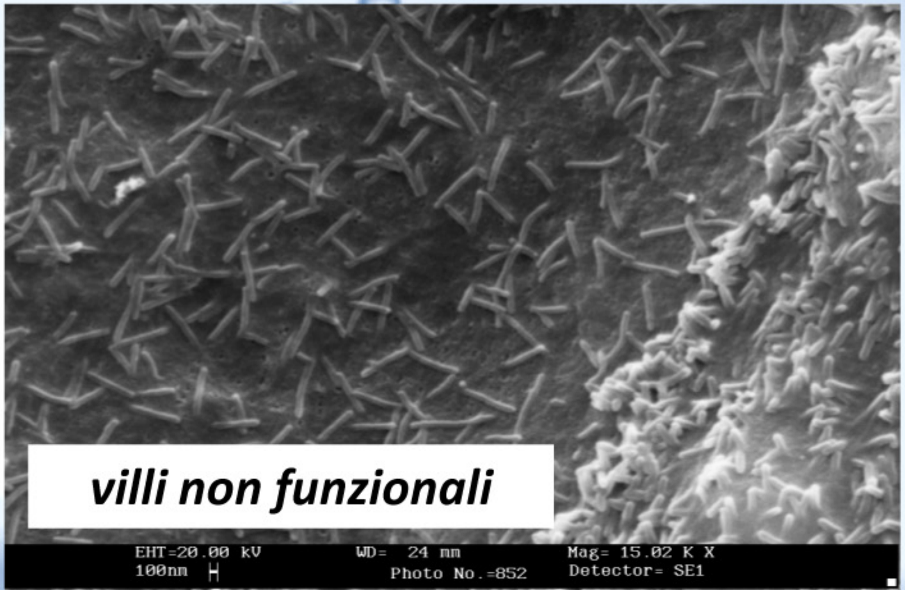
Cellule stabilizzate di intestino
CaCo2



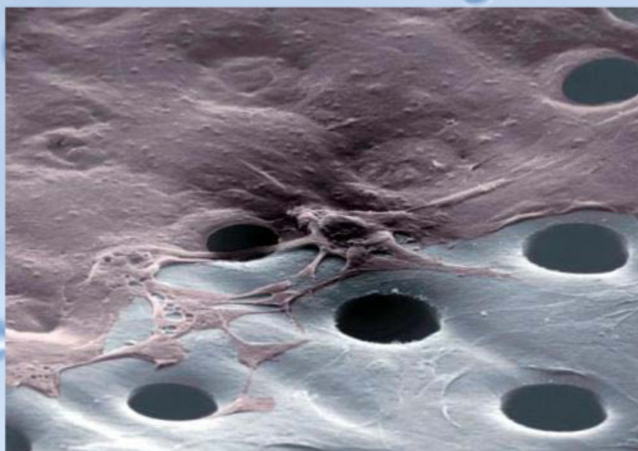
38 giorni di coltura su *Laserskin*



38 giorni di coltura su poliuretano

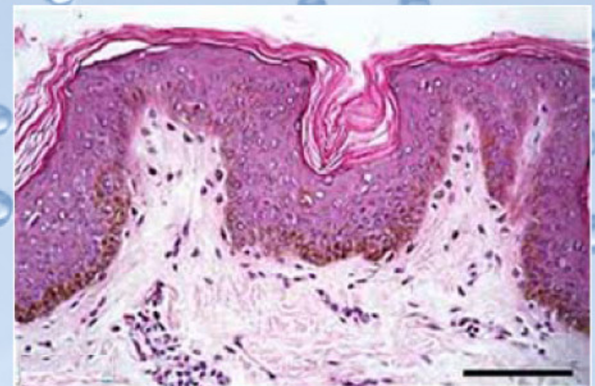


Rigenerazione della pelle

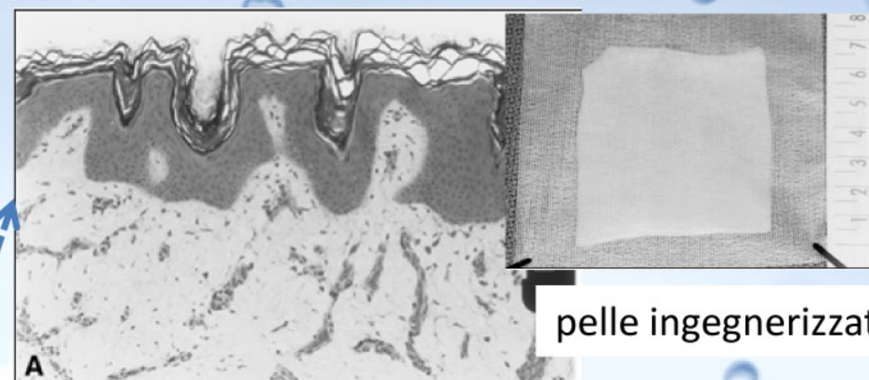


epidermide *in vitro*: cheratinociti su scaffold in Hyaff11

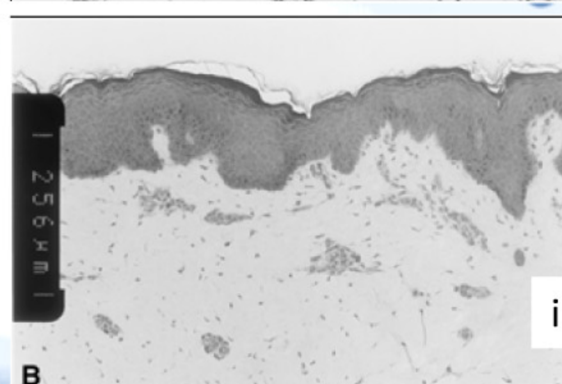
pelle *in vitro*: Co-coltura di cheratinociti e fibroblasti in scaffold di collagene e glicosamminoglicani



pelle normale



pelle ingegnerizzata



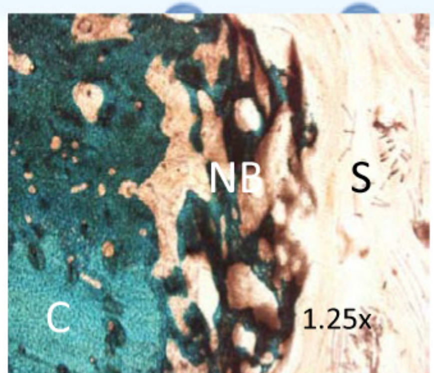
innesto autologo

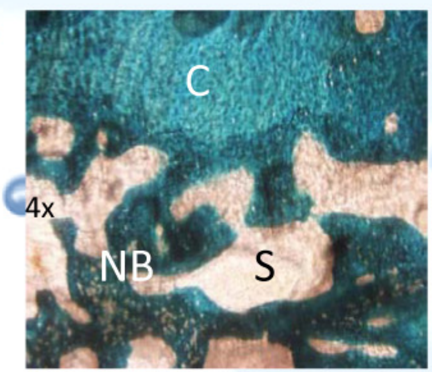
Rigenerazione del tessuto osseo

Scaffold poroso in PCL / PLA

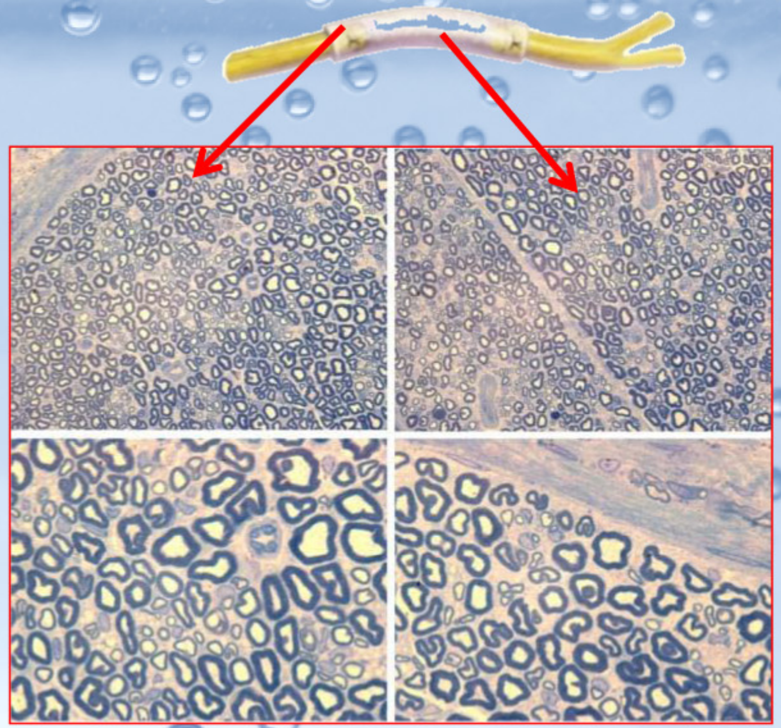
Impianto in vivo

Formazione di tessuto osseo ed assenza di capsula fibrotica

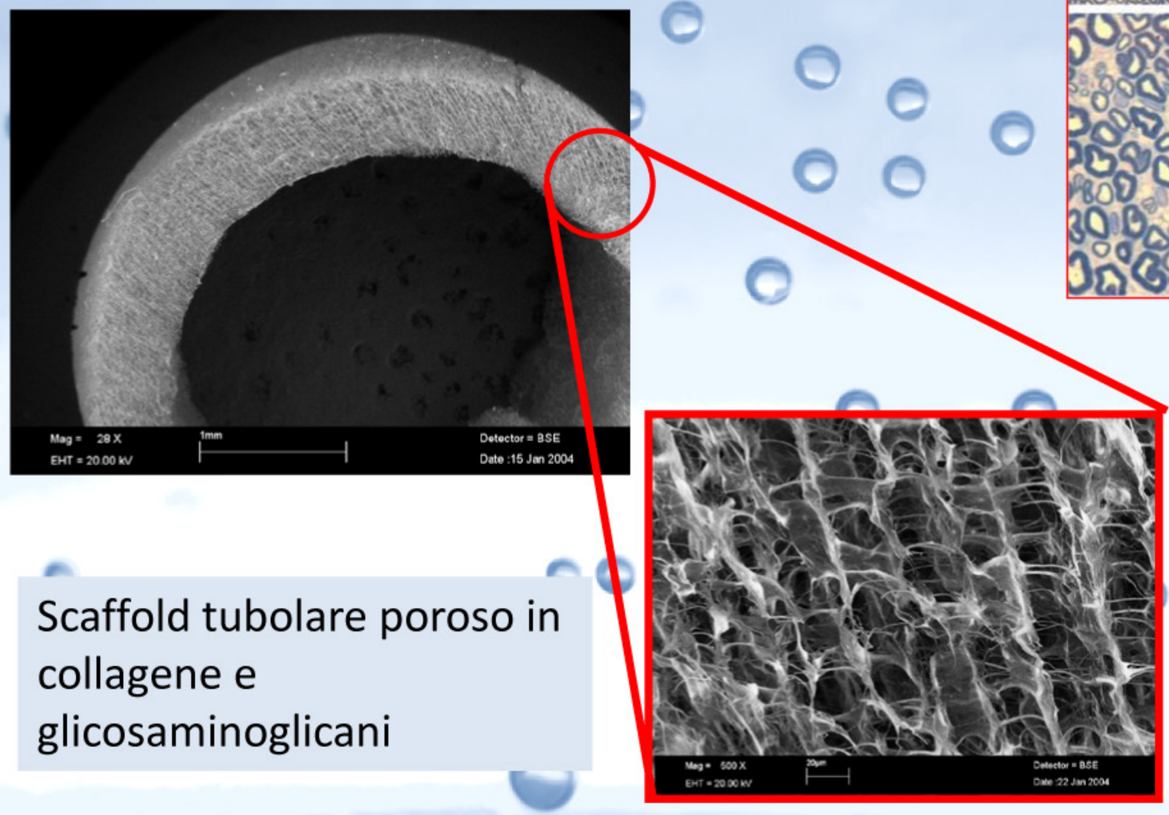




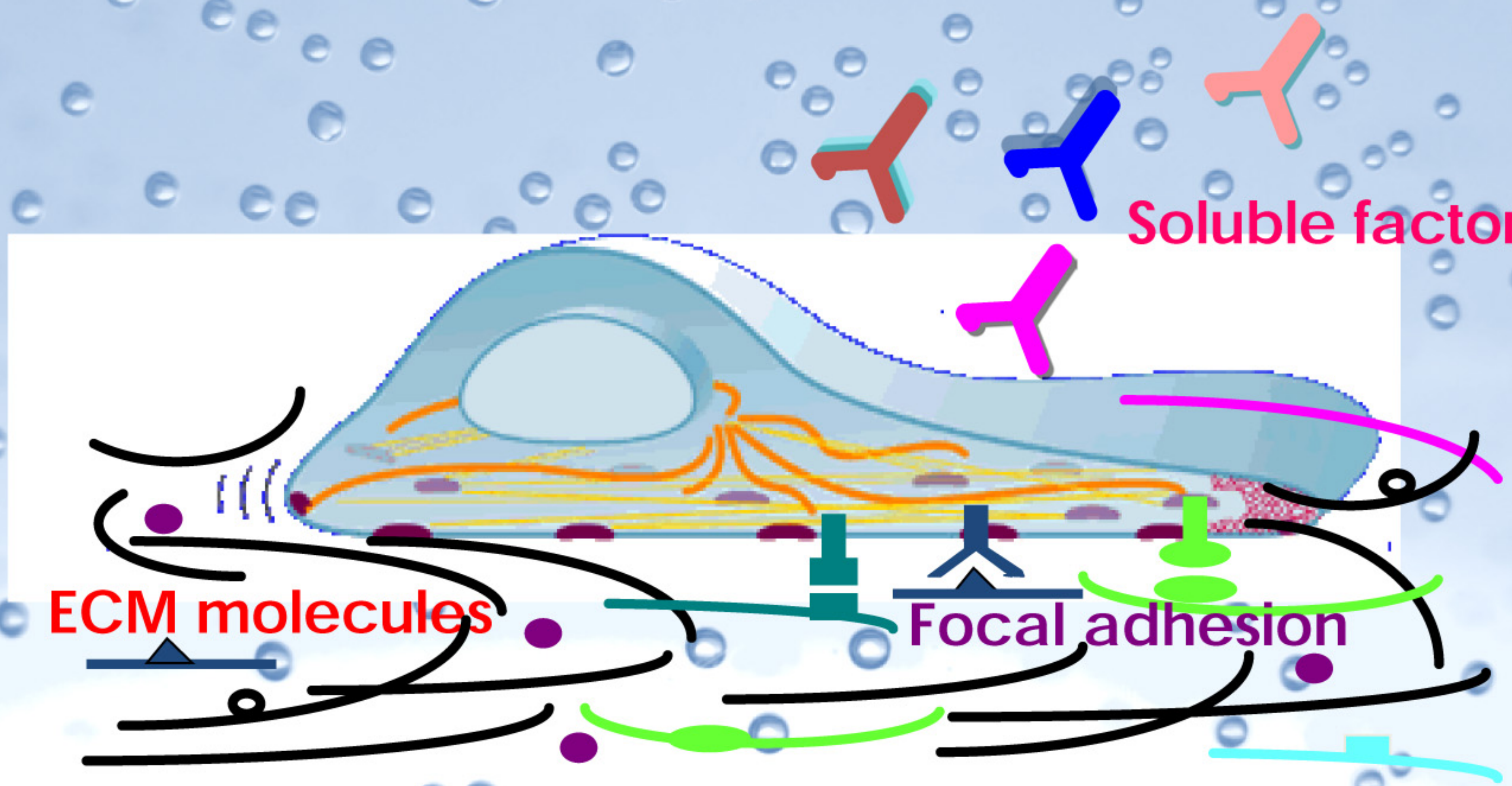
Rigenerazione del tessuto nervoso



Adeguata mielinizzazione dei fasci nervosi



Scaffold tubolare poroso in collagene e glicosaminoglicani



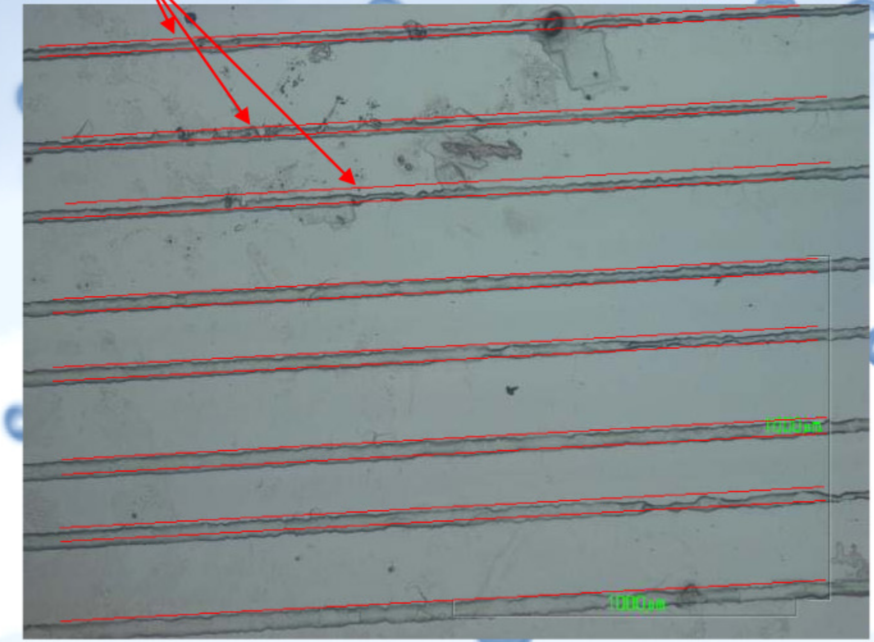
Le cellule *comunicano* con i materiali usando un *linguaggio* molecolare basato su segnali biochimici (*biological recognition)*

La comprensione del linguaggio cellulare apre nuove frontiere per l'ingegnerizzazione di piattaforme bioattive per il controllo dell'attività cellulare

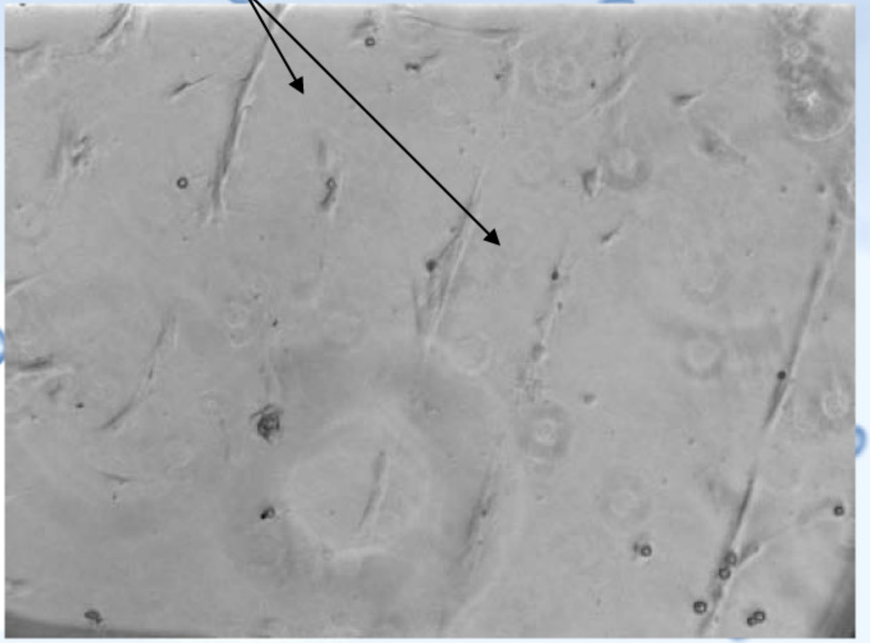
micro-patterning con *laminina* per il controllo dell'adesione e migrazione cellulare

(in collaborazione con Francesco Valle ISMN CNR Bologna)

Strisce di laminina



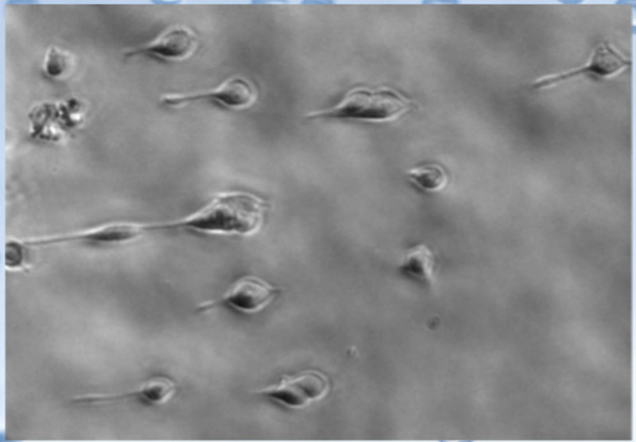
fibroblasti

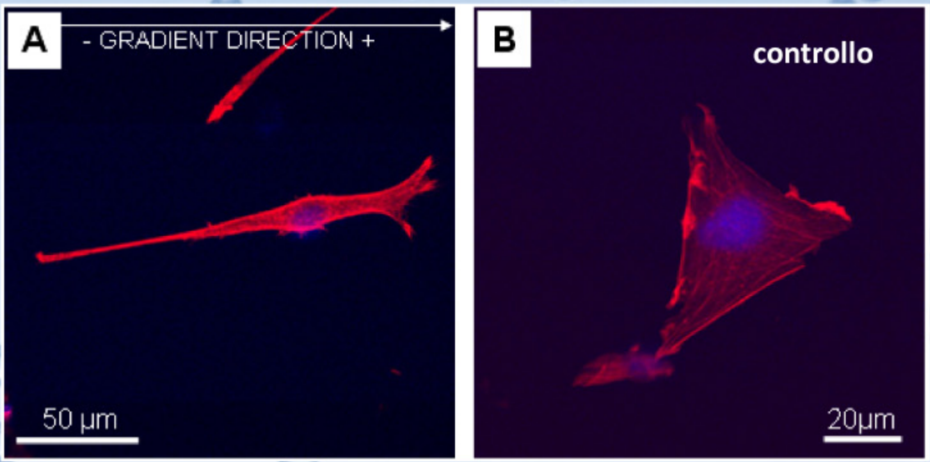


materiali bioattivi – biological recognition

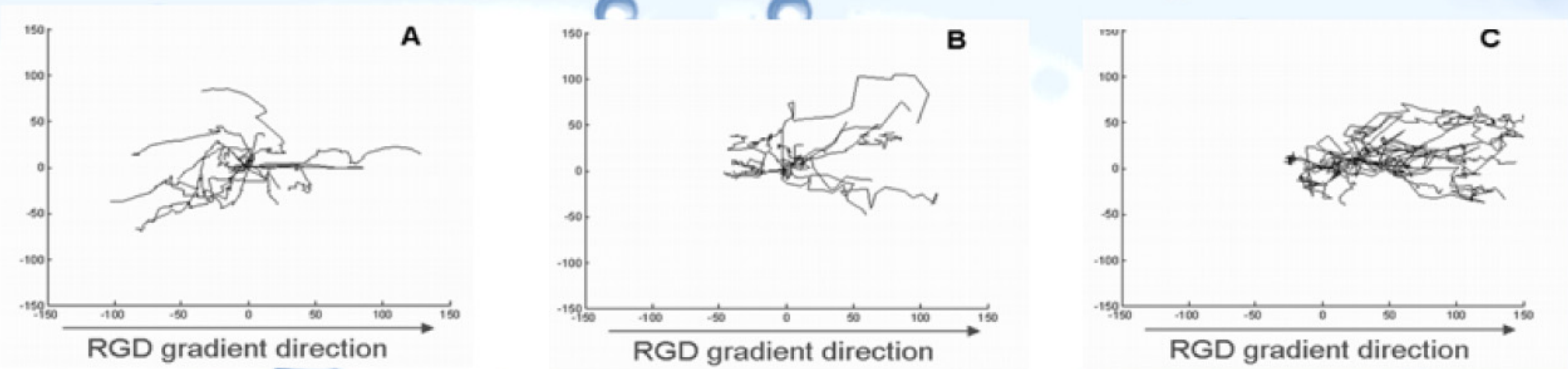
Adesione su substrati di PEG funzionalizzati – effetto del gradiente del tripeptide RGD

Sviluppo di modelli sperimentali per controllare e guidare la risposta cellulare in scaffold bioattivi

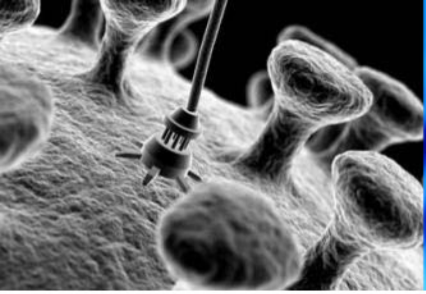
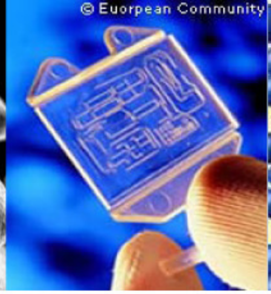


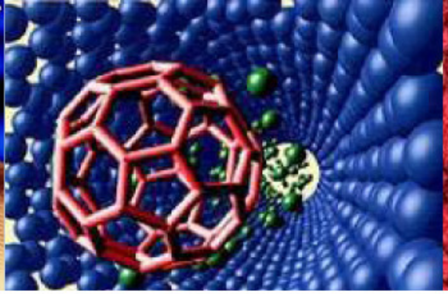
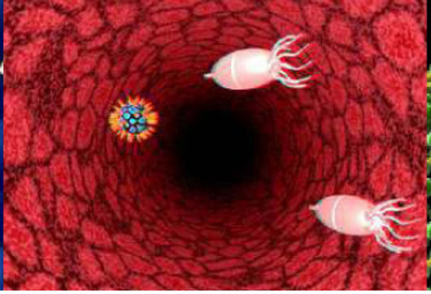
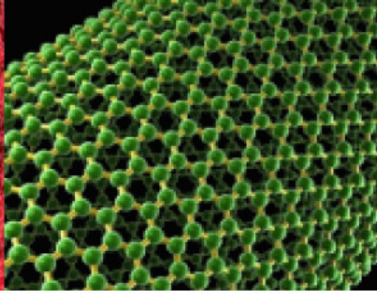


Traiettorie cellulari



Aumento della pendenza del gradiente di segnale

Conoscenze avanzate del *signaling* molecolare

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La possibilità di disegnare materiali con risoluzione nanometrica

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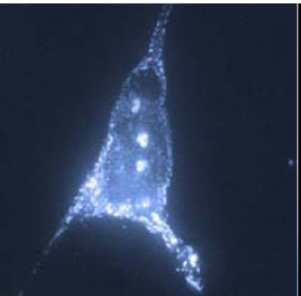
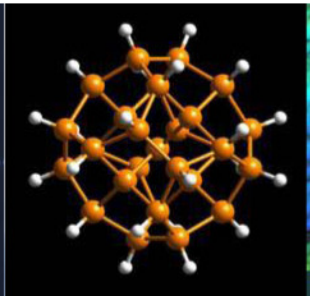
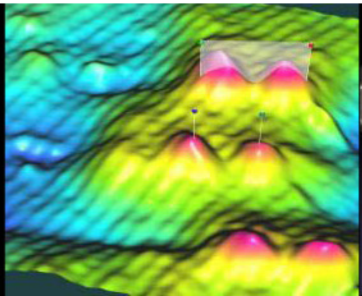
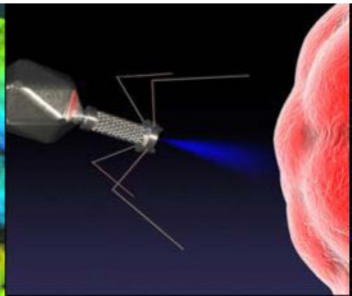
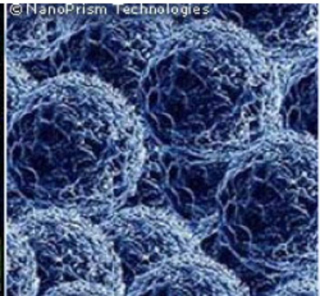
replicare dispositivi nanostrutturati altamente funzionali



Nell'ultimo trentennio il concetto
di materiale ha subito una trasformazione notevole
passando da *materiale quasi inerte*
a *materiale quasi vivente* capace di interagire con
l'ambiente e reagire in risposta a stimoli

Integrazione di conoscenze

- *Chimica*
- *Bioscienze*
- *Nanotecnologia*
- *Tecnologia dell'informazione*
- *Scienze cognitive*
- *Medicina*
- *Fisica*
- *Ingegneria*
- *Bioetica*