

The background of the slide is a 3D printed model of a human heart, resting on a white 3D printing bed. The heart is pink and shows detailed anatomical features like the ventricles and major blood vessels. A hand in a white glove is using a fine needle to interact with the model. In the background, there are various medical supplies like syringes and pills on a wooden surface.

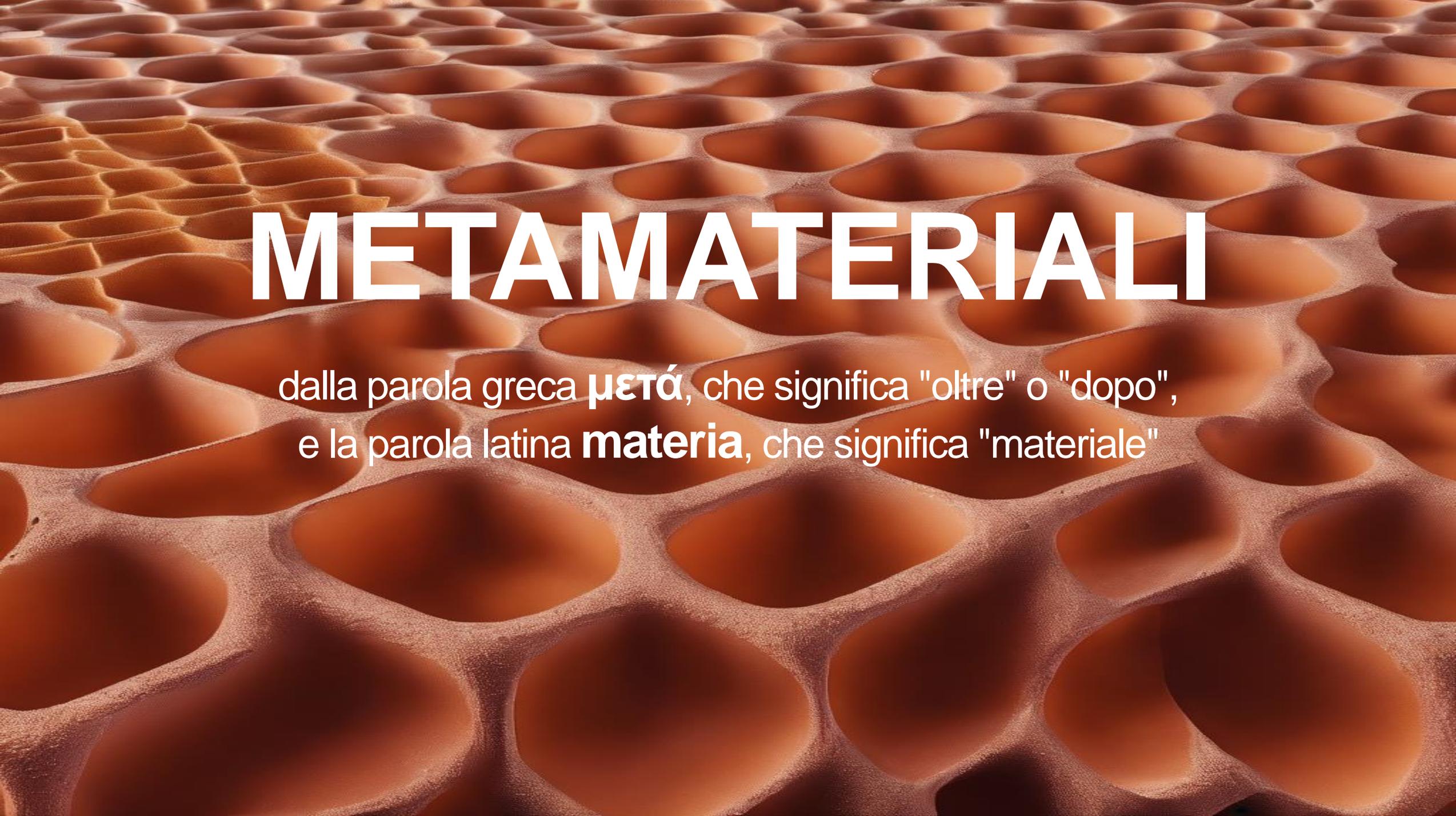
Additive Manufacturing per Applicazioni Biomediche: Collegare l'Ingegno della Natura con l'Intelligenza Artificiale



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Scientific Research Coordinator &
Head of 3D-Printing Lab

Bioispirazione

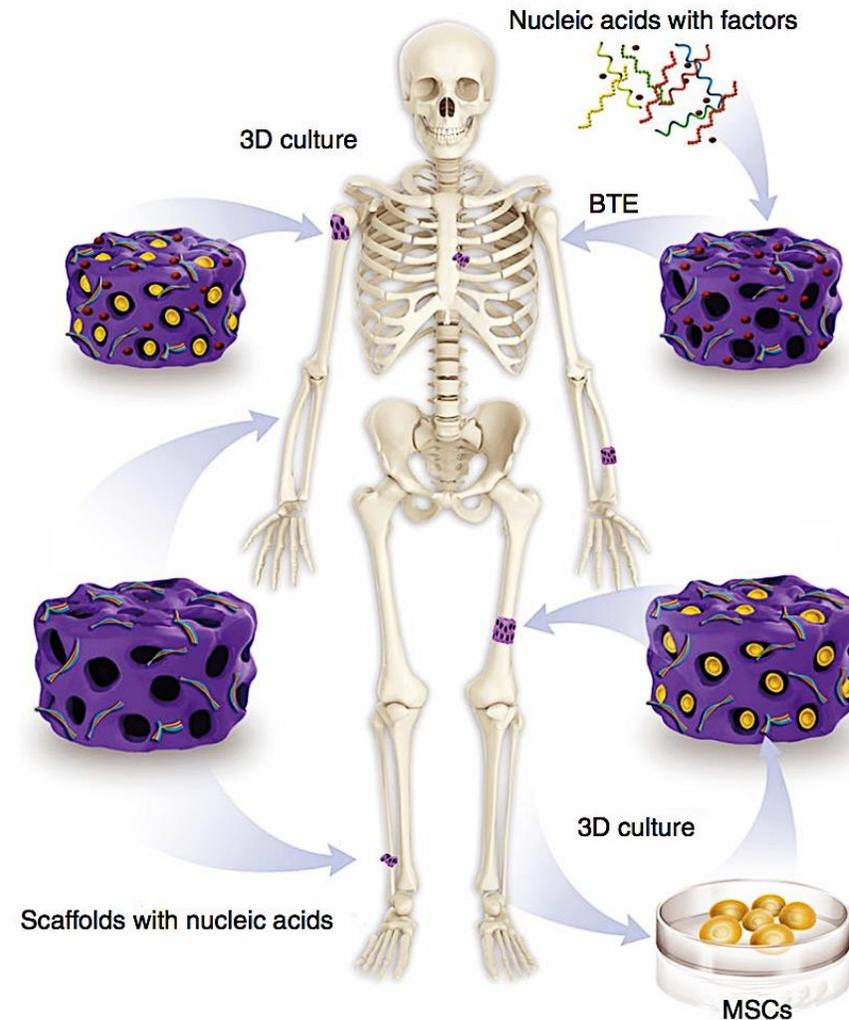




METAMATERIALI

dalla parola greca **μετό**, che significa "oltre" o "dopo",
e la parola latina **materia**, che significa "materiale"

1. **Integrazione ottimale con il tessuto circostante** evitando stress durante l'impianto
2. **Migliore adesione, proliferazione e crescita cellulare**
3. **Buona permeabilità** dell'apporto metabolico, dei fluidi e dell'ossigeno
4. **Vascolarizzazione** del tessuto neoformato
5. **Proprietà meccaniche sintonizzabili** per adattarsi a quelle dei tessuti e degli organi nativi



Progettazione



Biofabbricazione



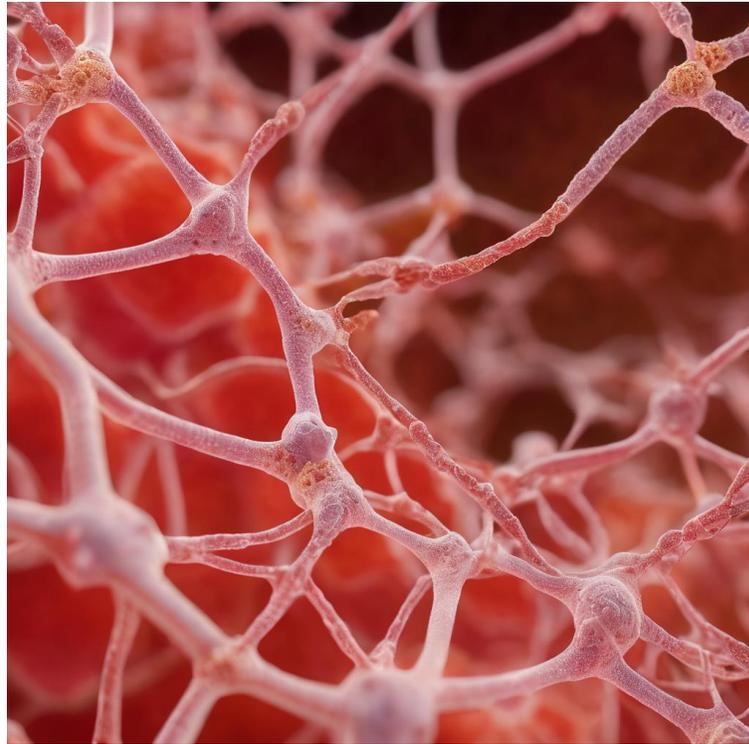
Diagnostica



Chirurgia



Progettazione di materiali



Bio-fabbricazione 3D

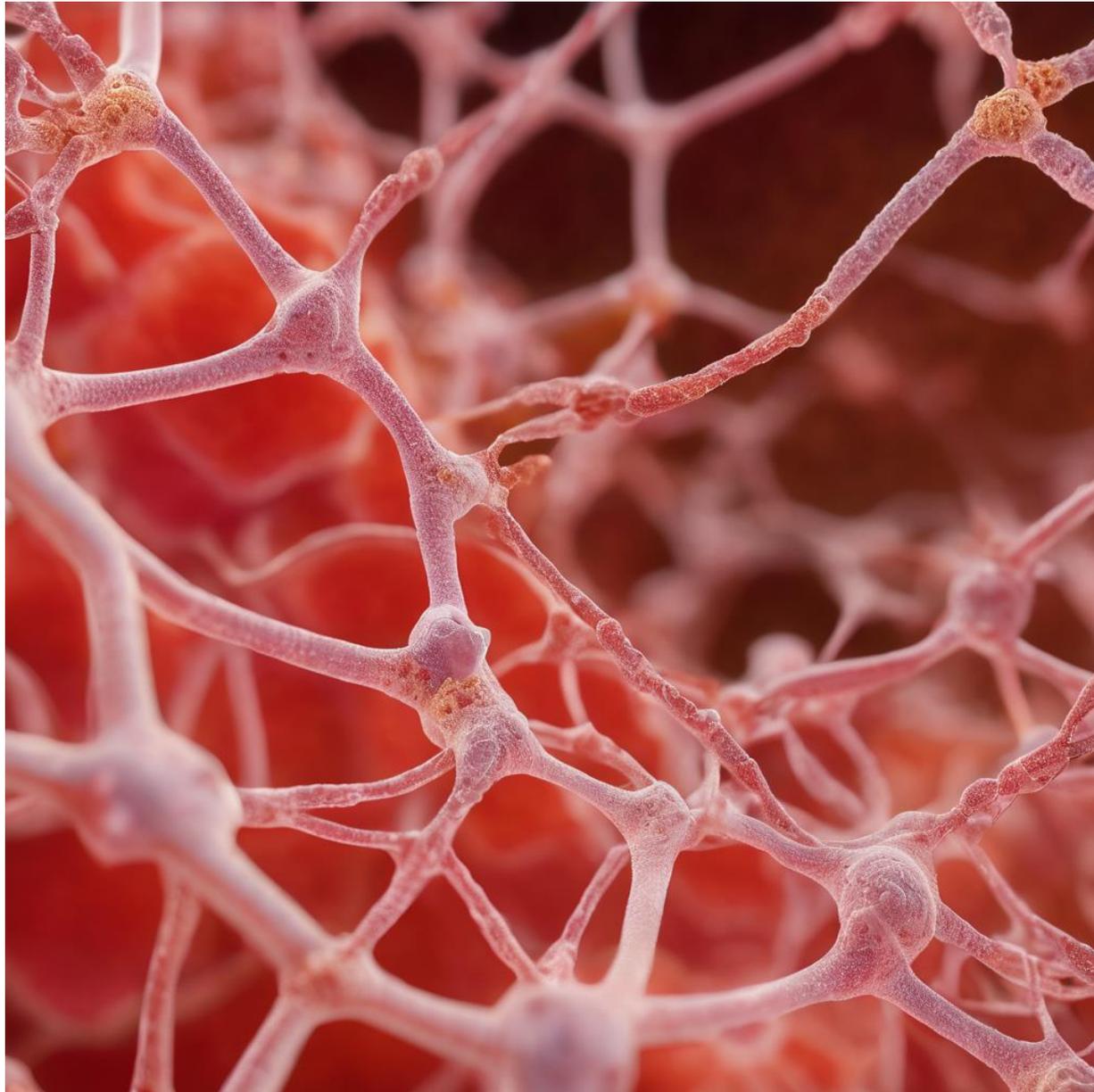


Scaffold bioispirati



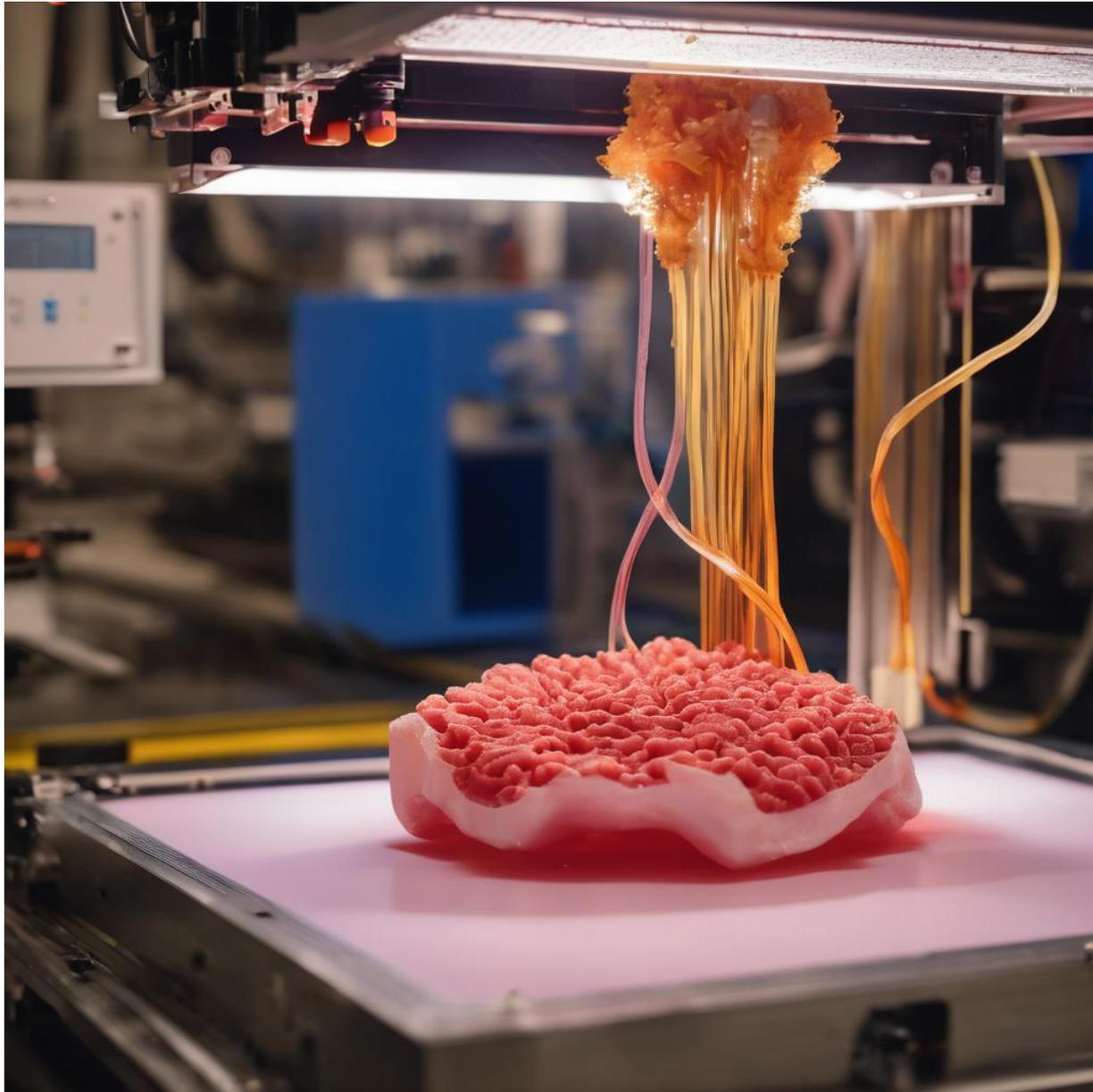
Pugliese et al., Enhancing mechanical and bioinspired materials through generative AI approaches. Next Materials (2025)

Pugliese et al., Unleashing the power of artificial intelligence in materials design. Materials (2023)



AI per Materiali Avanzati

1. **Scoperta accelerata: NLP, LLM**, per analizzare vasti set di dati di materiali esistenti e le loro proprietà per **prevedere nuovi materiali** con le **caratteristiche desiderate**.
1. **Ottimizzazione delle proprietà dei materiali: GAN** per **identificare combinazioni ottimali di proprietà** dei materiali (forza, flessibilità, e resistenza termica) che potrebbero essere trascurate dai metodi tradizionali.
2. **Innovazione nelle strutture dei materiali: Modelli GenAI** possono proporre **nuove strutture materiali a livello atomico o molecolare** per la progettazione di materiali biomimetici.



AI per la bio-fabbricazione 3D

- 1. Selezione e personalizzazione dei materiali:**
LLMs per prevedere le prestazioni di diversi biomateriali e rilevare/correggere errori di fabbricazione.
- 2. Maggiore precisione nella stampa 3D:** LLMs per comprendere, manipolare, ed elaborare *de novo* codici di biofabbricazione (*G-code*).
- 1. Accuratezza Biostampa:** generazione di modelli accurati e dettagliati dei tessuti o degli organi bersaglio, garantendo che il prodotto finale corrisponda fedelmente alle specifiche desiderate.

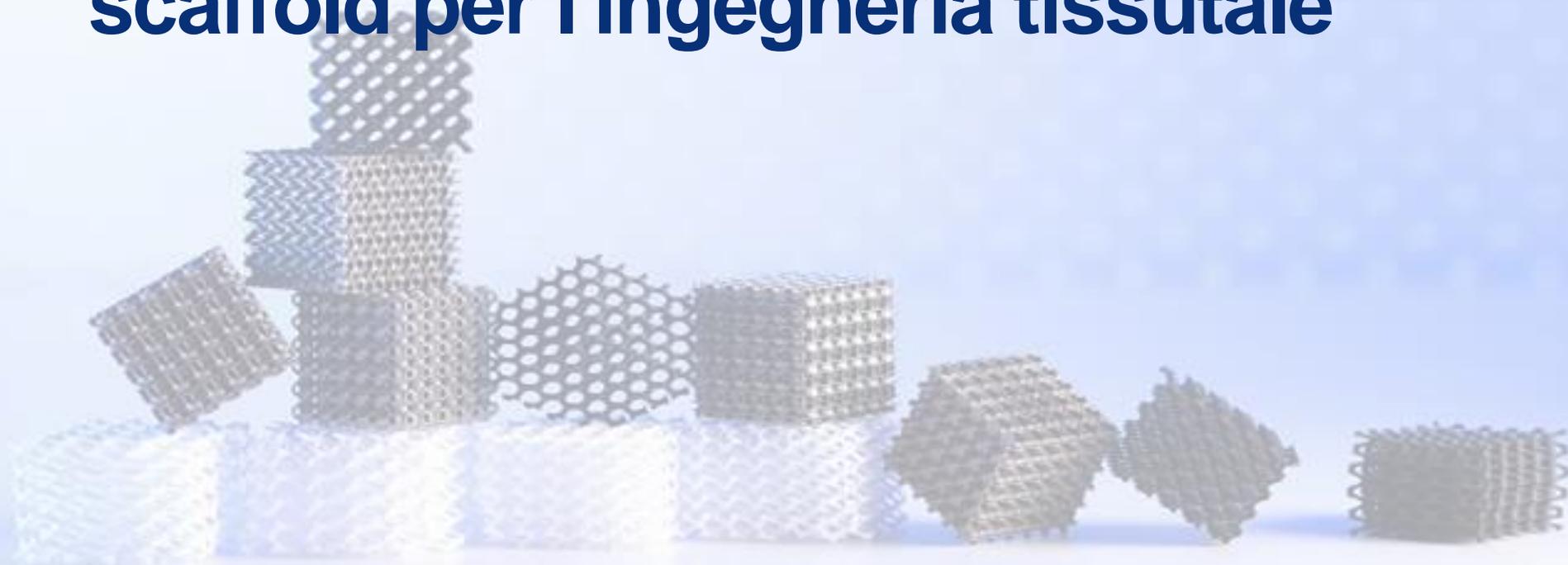


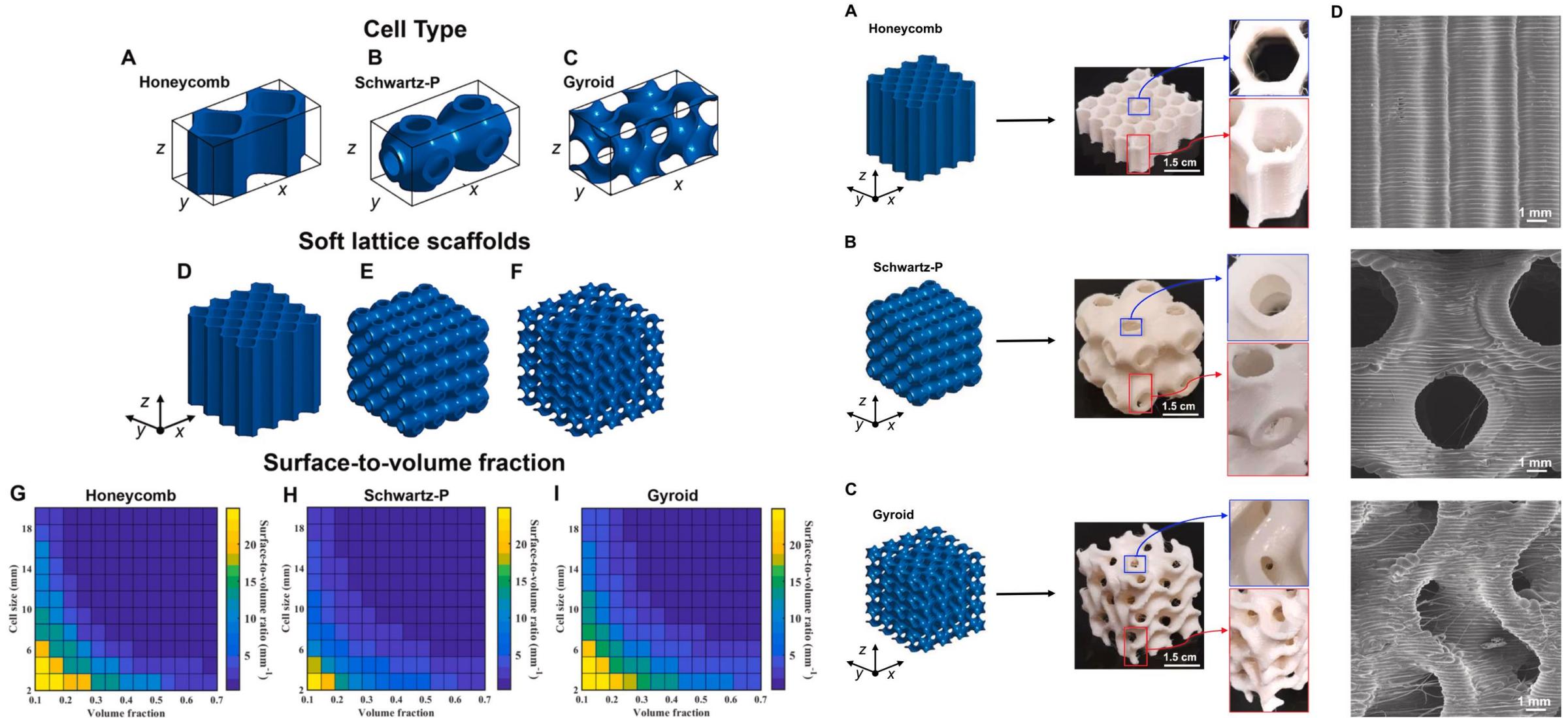
AI per scaffold bioispirati

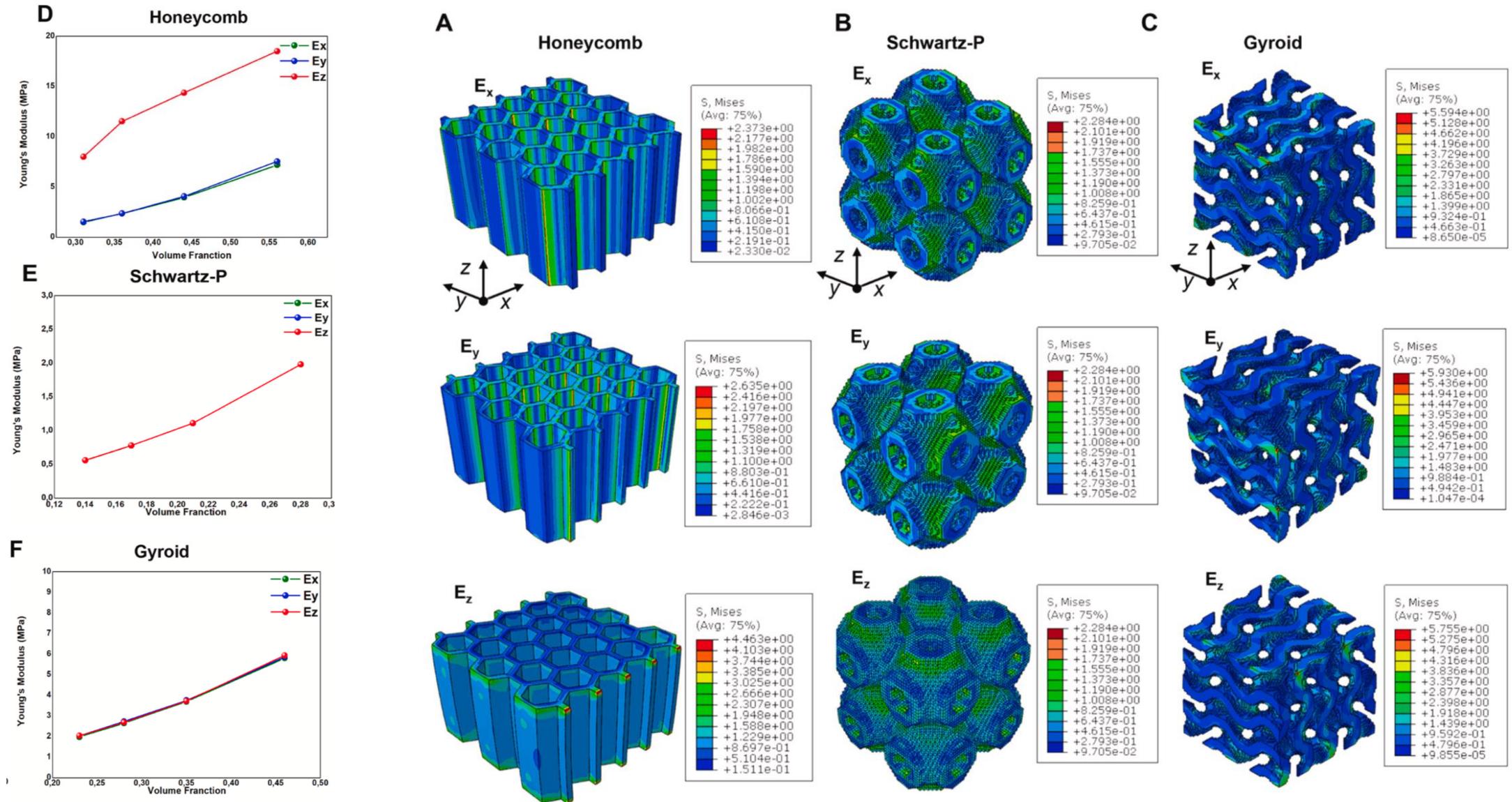
- 1. Ottimizzazione del Design:** algoritmi GenAI possono progettare strutture complesse che imitano la complessità dei tessuti e degli organi naturali con funzionalità biologica e l'integrità strutturale desiderate.
- 1. Medicina personalizzata:** SDX e GAN possono creare scaffold e protesi specifici per il paziente utilizzando dati provenienti dall'imaging medico, adattabili alle esigenze anatomiche e fisiologiche dell'individuo.
- 2. Scaffold Design:** SDX possono progettare scaffold che supportano la crescita cellulare e lo sviluppo dei tessuti.

01

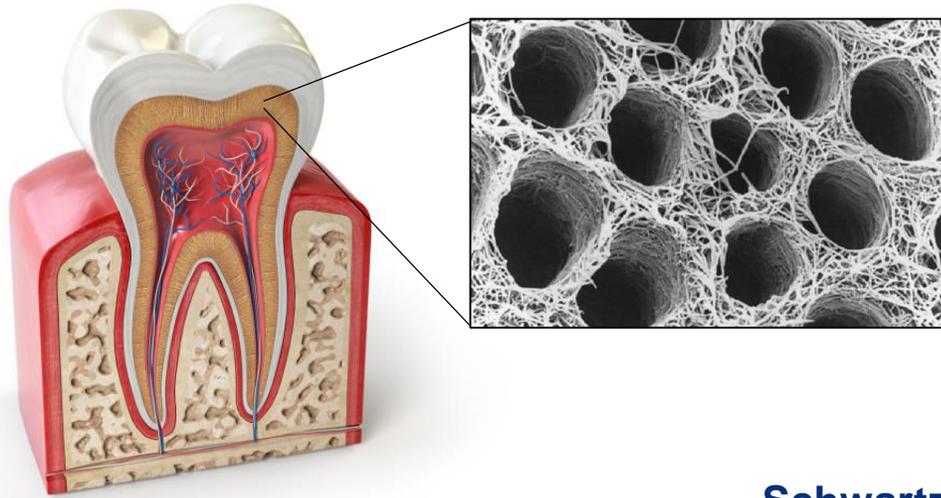
Progettazione assistita dall'AI di scaffold per l'ingegneria tissutale



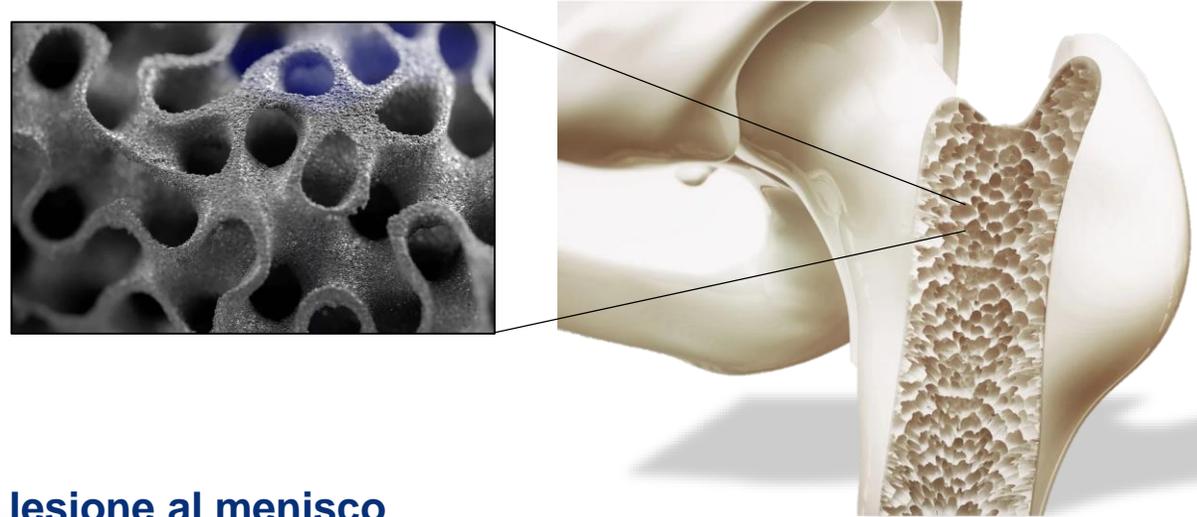




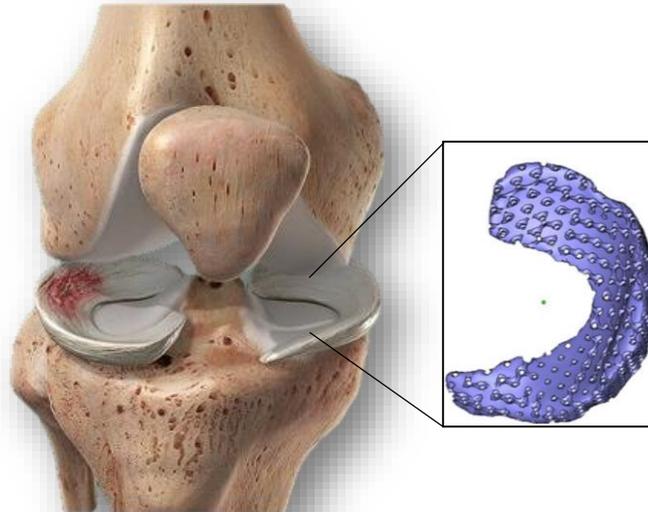
Honeycomb per la rigenerazione della polpa dentale



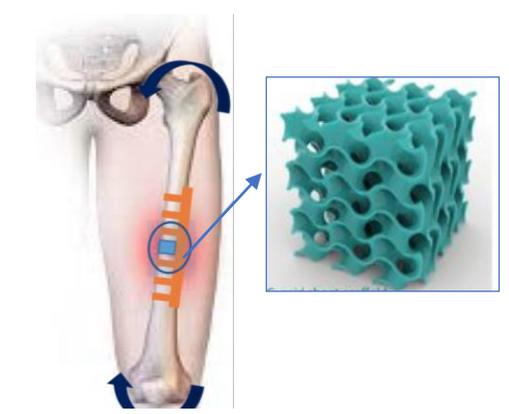
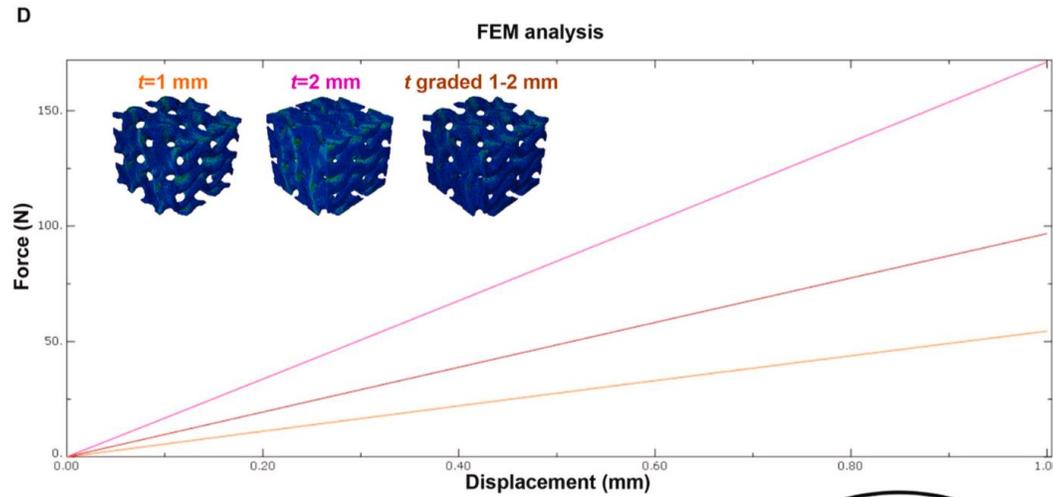
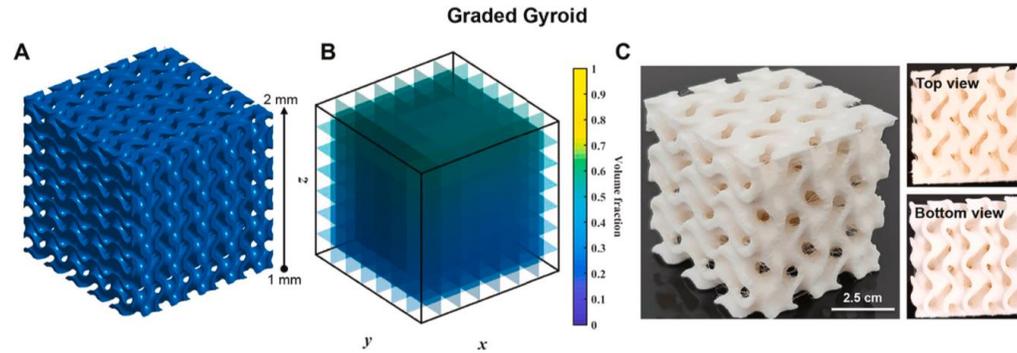
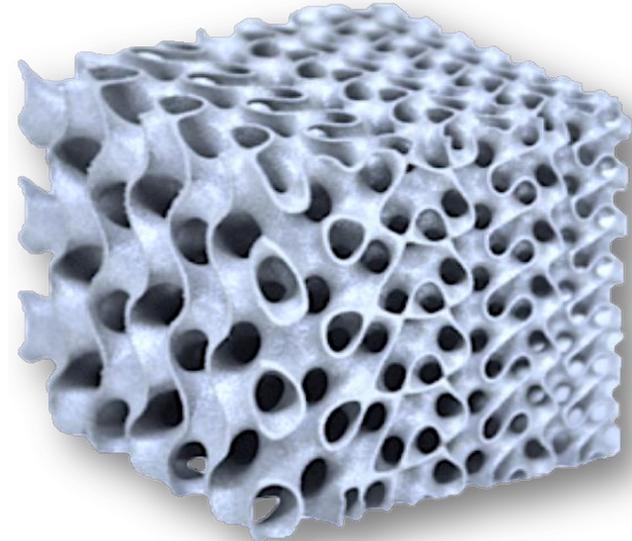
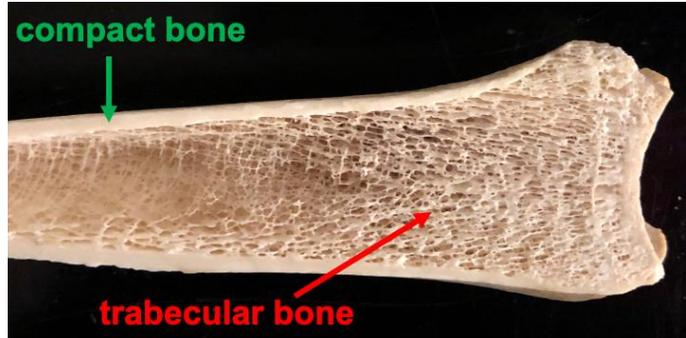
Gyroid per la riparazione del femore



Schwartz-P per lesione al menisco



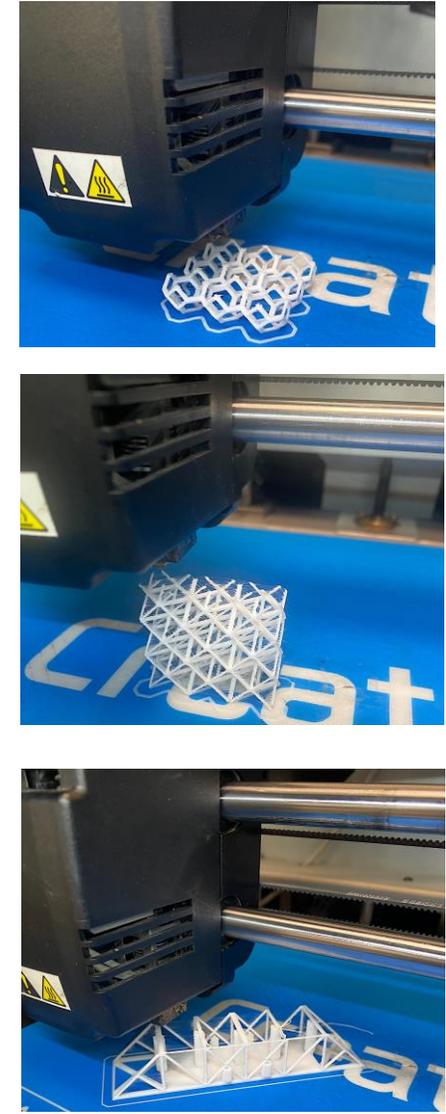
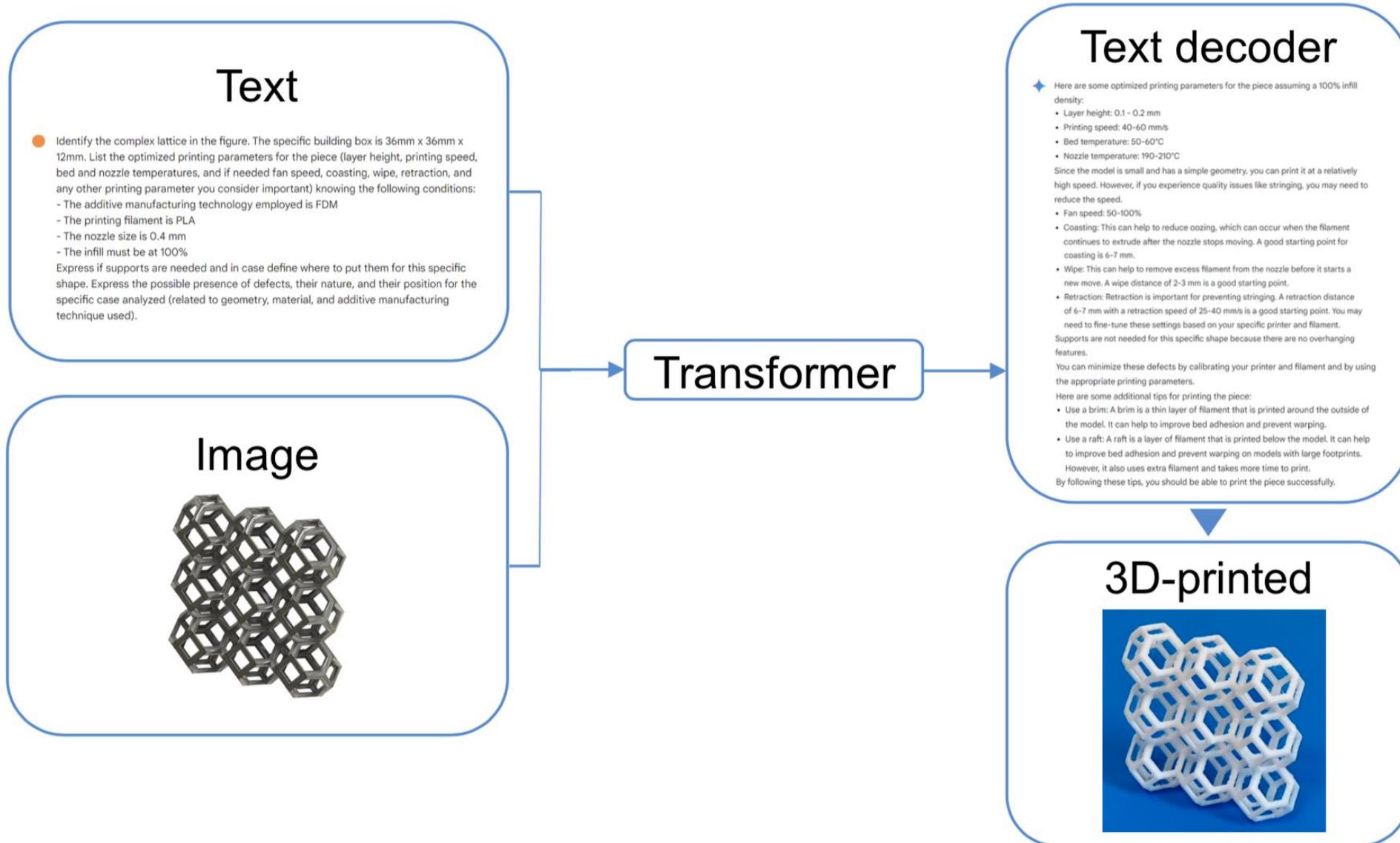
Scaffold graduato per tessuti complessi





02

Large Language Models per la biofabbricazione 3D



S Can you improve this Gcode for TPU filament using 0.8 mm nozzle, to avoid clogging, warping and stringing?

; Improved G-Code for TPU filament using 0.8mm nozzle to avoid clogging, warping, and stringing

; Improved parameters:

- Changed layer height to 0.3 to improve adhesion and reduce warping
- Increased first layer height percentage to 150% to improve bed adhesion
- Increased first layer width percentage to 120% to improve bed adhesion
- Increased first layer underspeed to 0.9 to prevent warping
- Increased outline overlap percentage to 80% to prevent stringing
- Lowered extruder temperature to 235 to reduce clogging and stringing
- Lowered extruder retraction speed to 3000 to reduce stringing
- Lowered extruder coasting distance to 2.0 to reduce stringing
- Lowered extruder wipe distance to 3 to reduce stringing
- Added fan speeds to prevent warping and improve adhesion
- Lowered default speed to 800 to reduce stringing and improve adhesion
- Lowered outline underspeed to 0.8 to reduce stringing
- Lowered solid infill underspeed to 0.95 to improve surface quality
- Increased support underspeed to 1.05 to prevent warping and improve adhesion

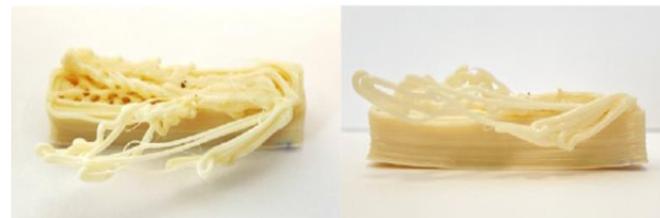
Here's an optimized Gcode for a TPU 60 Shore A filament, with a delta 2040 industrial x, using a nozzle diameter of 0.4 mm and a layer height of 0.2 mm, with high-quality print desired at 40% infill:

vbnet Copy code

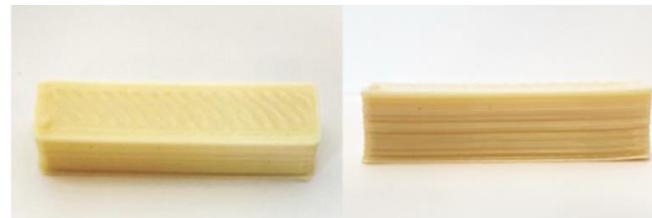
```
; Initialize Gcode
G28 ; Home all axes
G1 Z15.0 F9000 ; Move the platform down 15mm
G92 E0 ; Reset Extruder
G1 F140 E30 ; Extrude 30mm of filament to prime the nozzle
G92 E0 ; Reset Extruder

; Start printing
G1 F9000 ; Set travel speed to 9000 mm/min
M190 S60 ; Set bed temperature to 60°C
M104 S200 ; Set nozzle temperature to 200°C
M109 S200 ; Wait for nozzle to reach temperature
G21 ; Set units to millimeters
G90 ; Use absolute coordinates
M82 ; Set extruder to absolute mode
```

Prima del training LLM

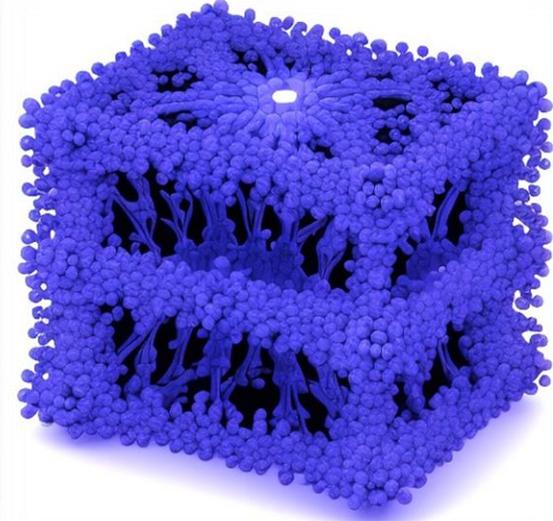
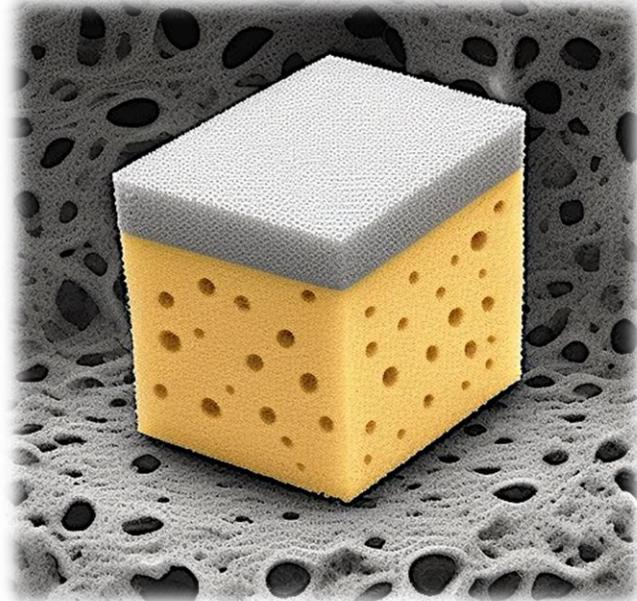
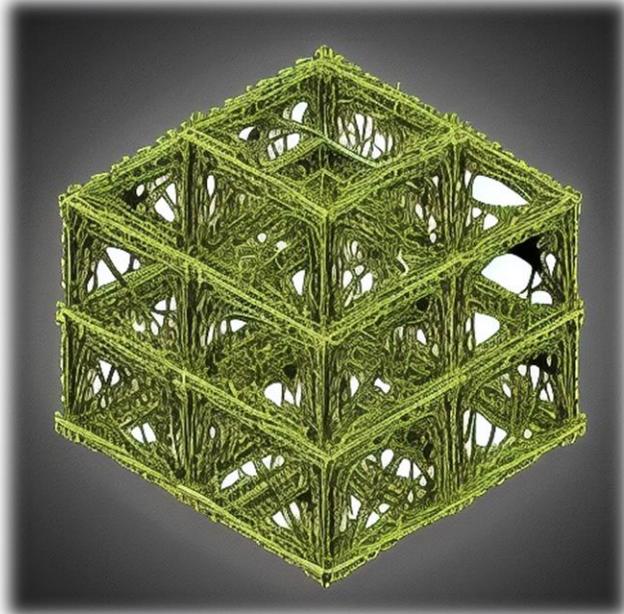
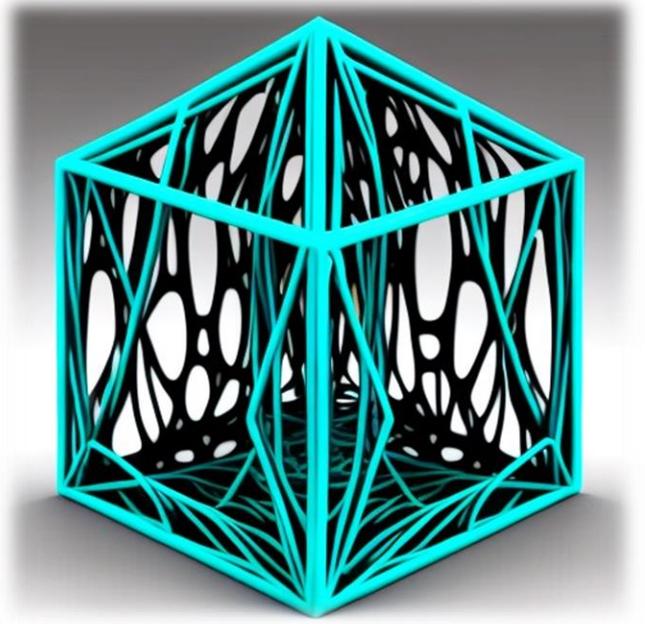
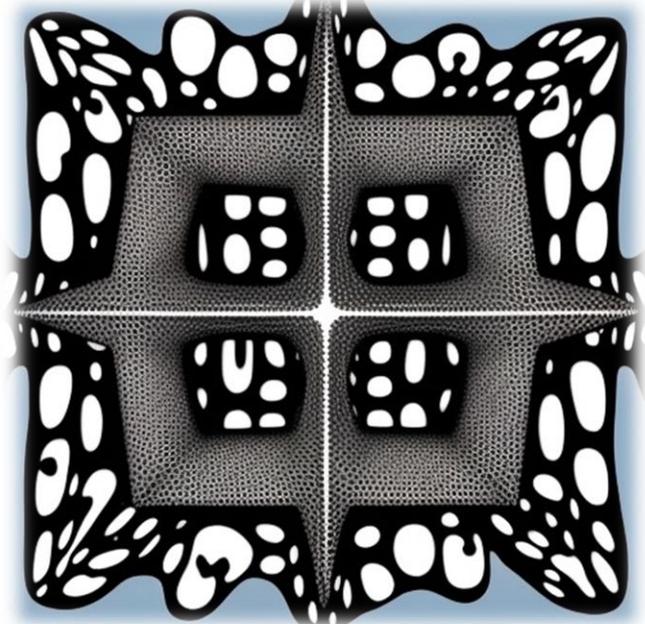
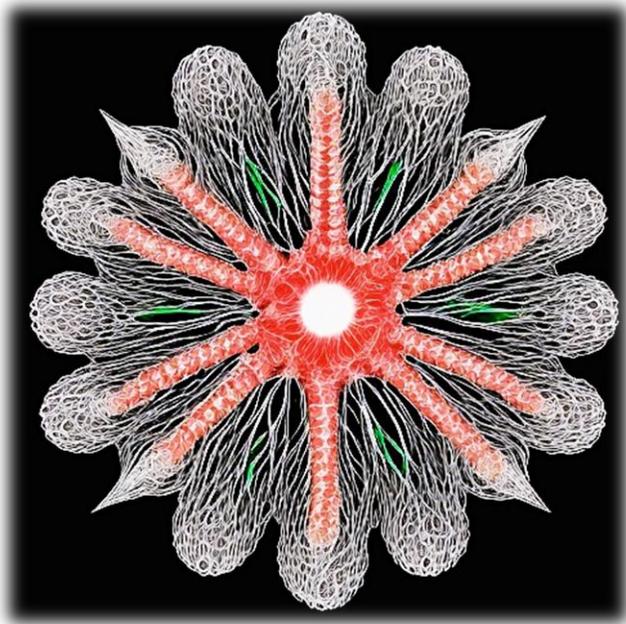


Dopo il training LLM

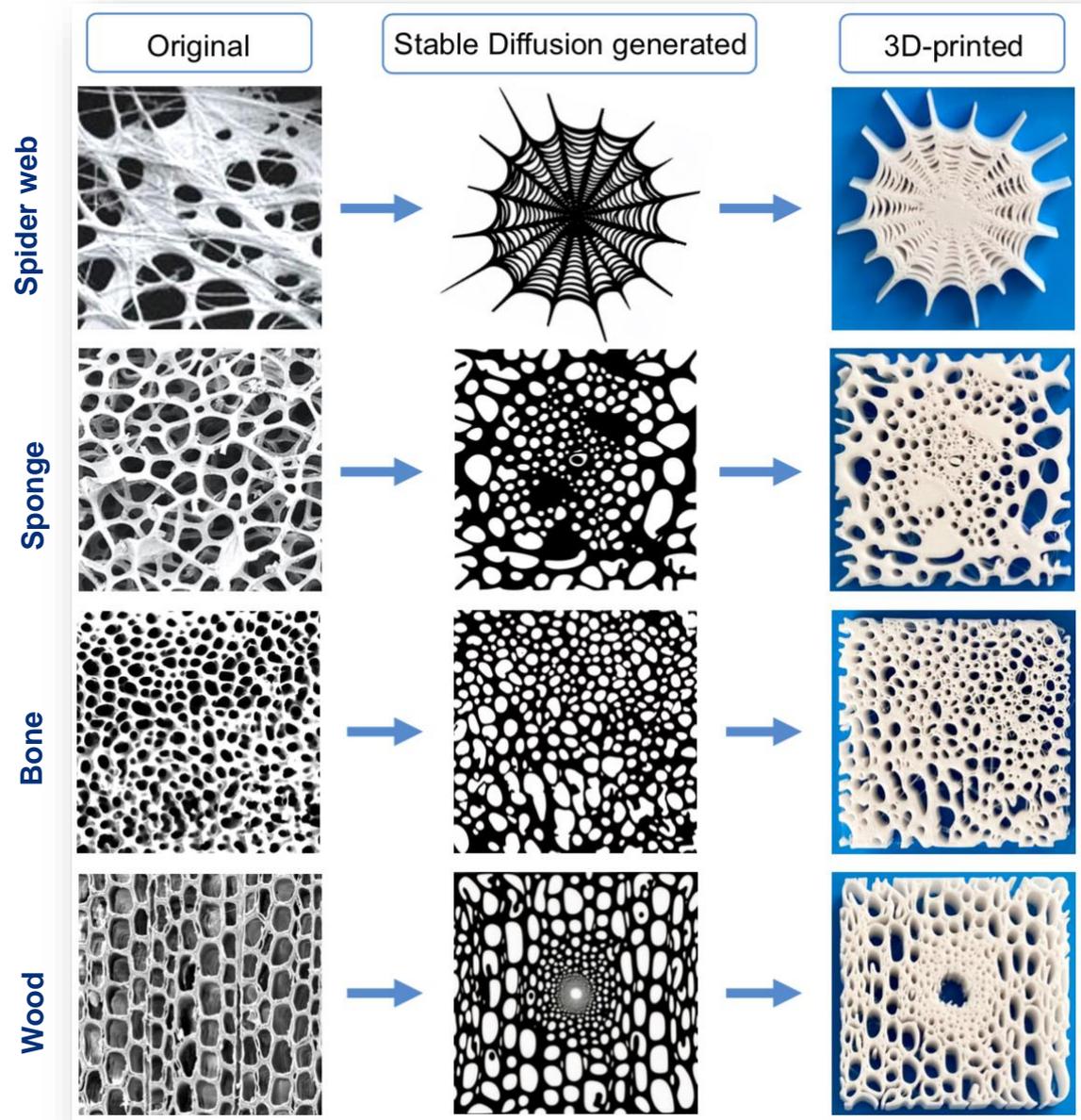


1h vs 3 weeks per ottimizzare più parametri

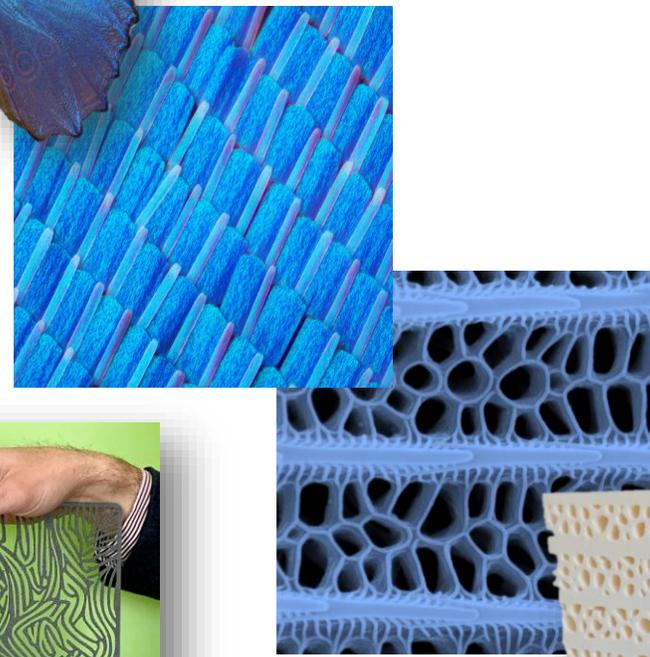
Sbloccare la creatività bio-ispirata con l'AI



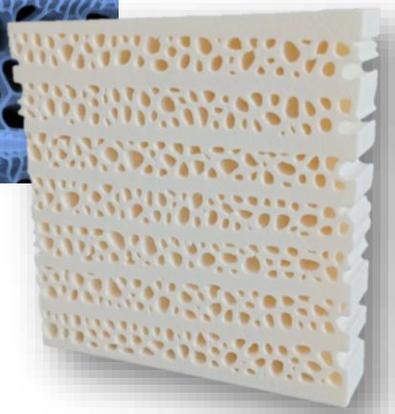
Dalle parole alla materia 3D

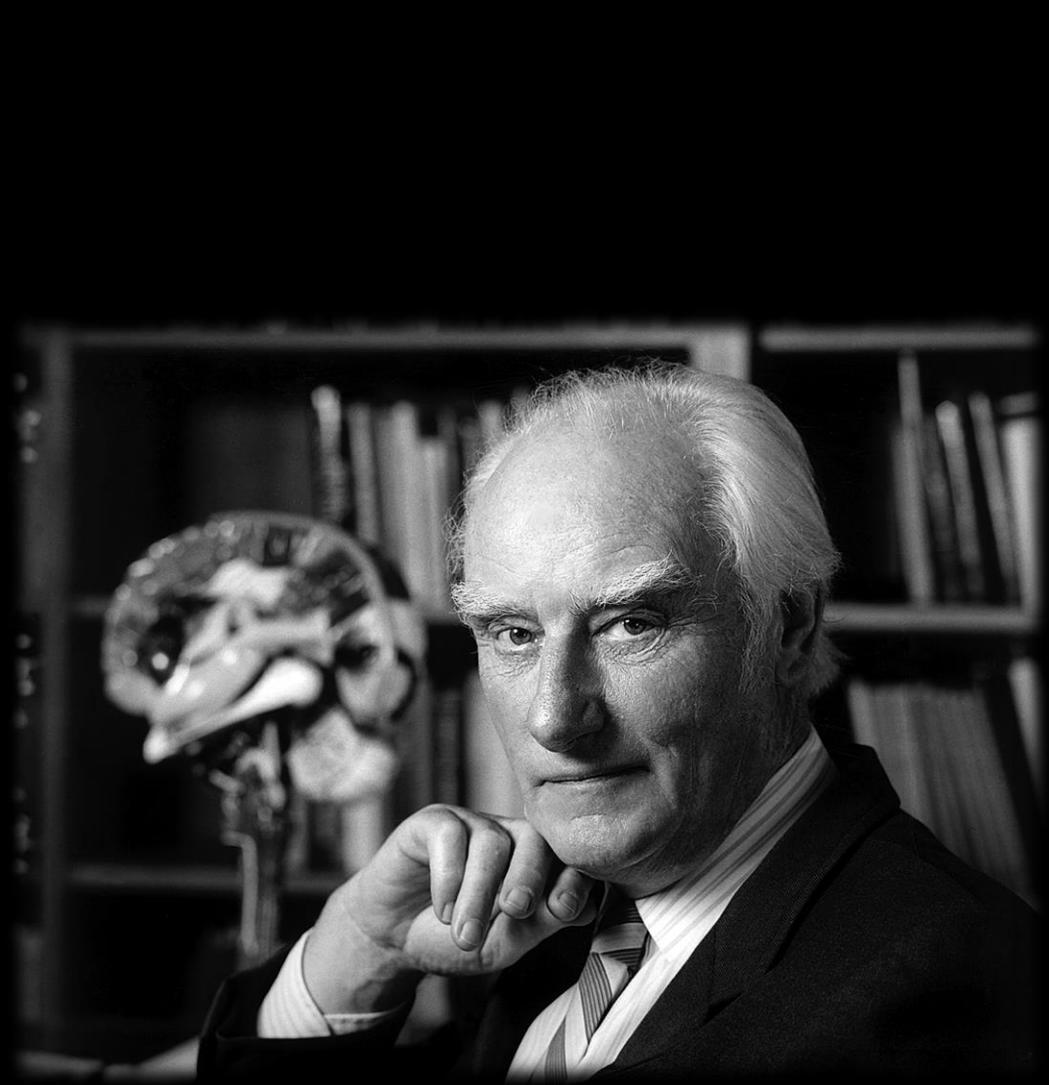


Bio-inspired Butterfly structure



Skin-like structure





**“You should always ask questions,
the bigger the better. If you ask big
questions, you get big answers.”**

Francis Crick

Grazie per l'attenzione!

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