

# Oltre il visibile: laboratorio di microscopia scansione

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DIPARTIMENTO  
DI ECCELLENZA  
MIUR

Istituto dei Materiali per l'Elettronica e il  
Magnetismo del CNR

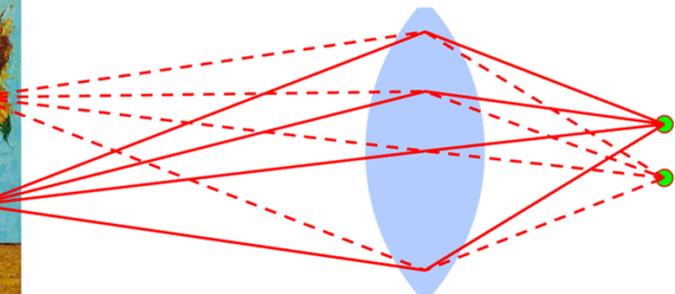
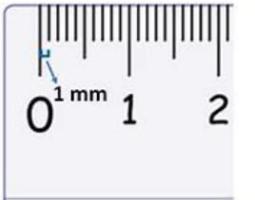


Perché vediamo  
gli oggetti?

Perché c'è luce....  
...e perché abbiamo gli occhi.



I nostri occhi distinguono punti separati fra loro da più di 0.1 mm.



E per oggetti più piccoli e vicini? Microscopio!

# La microscopia ottica dal medioevo a oggi

721 a.C  
Lente di  
Nimrud  
(Assiria)



Medioevo:  
lenti da vista



1595: Hans e Zackarias Jansen (costruttori di lenti olandesi) costruiscono il primo microscopio assemblando lenti diverse in serie.

1609: Galileo perfeziona l'idea di usare più lenti  
Telescopio



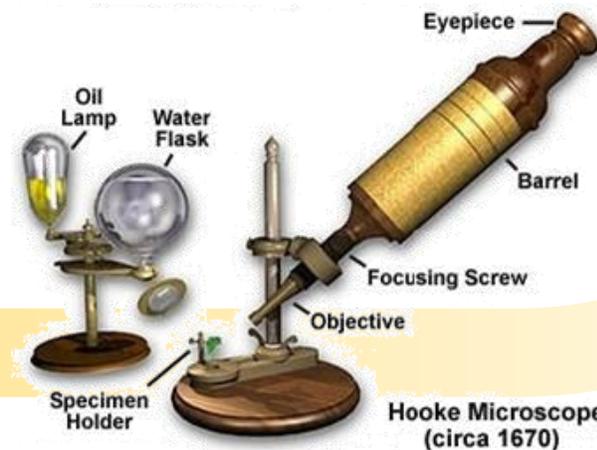
2020



1857



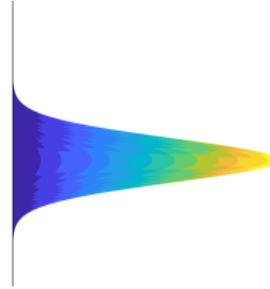
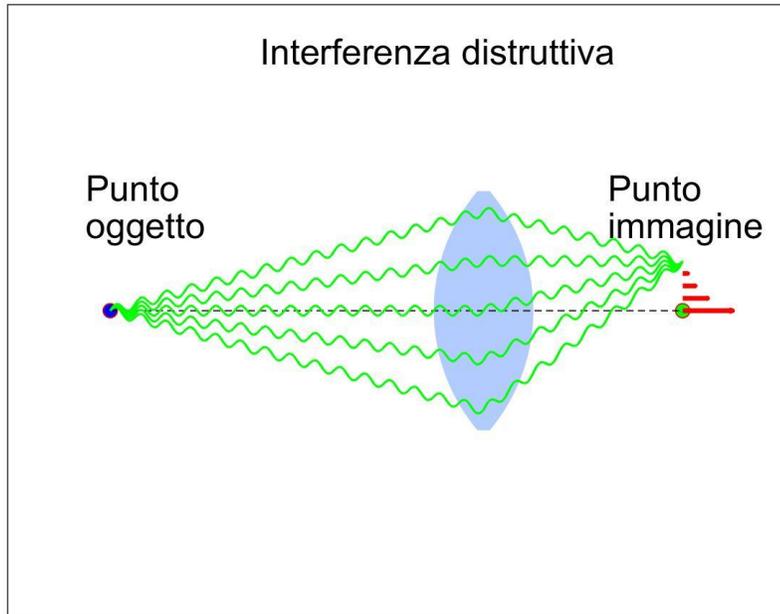
1850: Zeiss ed Adobe sviluppano il microscopio moderno.



1665: Hooke pubblica la 'Micrografia'. Conia il nome «cellula».

# Il microscopio ottico: risoluzione

Il microscopio è formato da lenti, che hanno il compito di far convergere i raggi nel punto immagine.

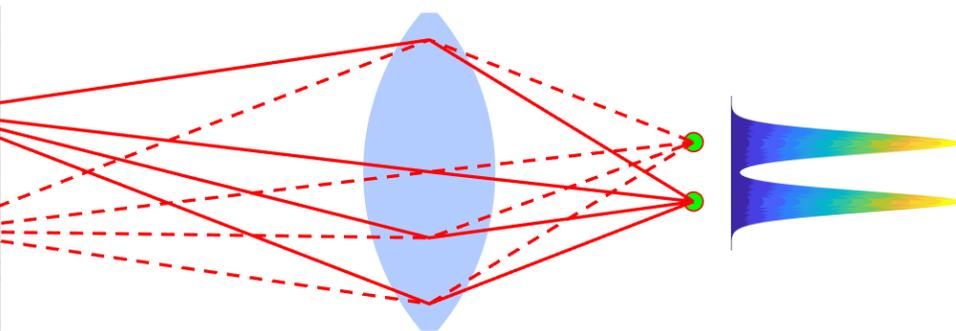
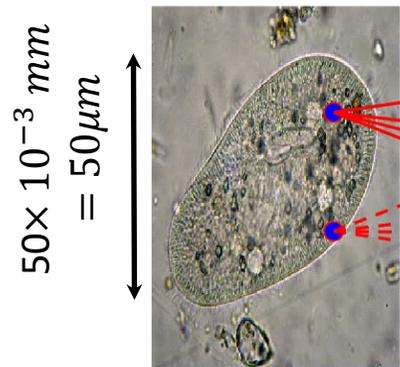


$$\lambda \sim 0.5 \times 10^{-3} \text{ mm} = 0.5 \mu\text{m}$$

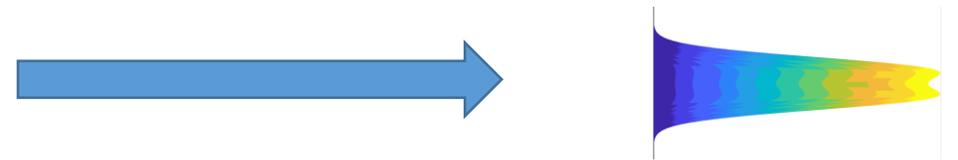
Larghezza del punto immagine pari a  $\lambda$ .

→ **anche per un microscopio ideale, limite all'ingrandimento!**

## Paramecium-caudatum



Le immagini di punti distanza  $< \lambda$  indistinguibili.



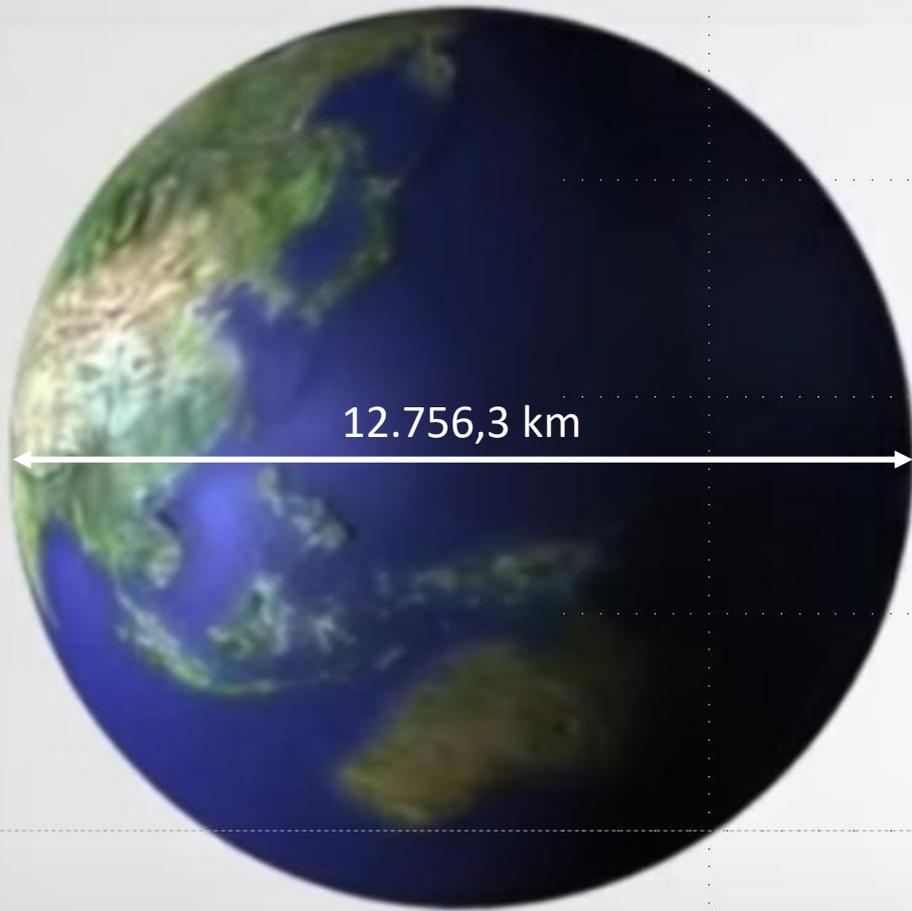
1 km =  $10^3$  m

1 m

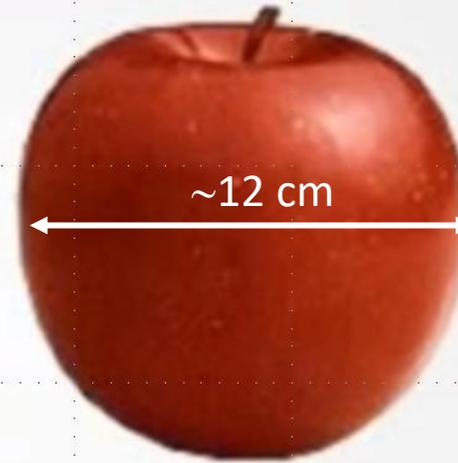
1 mm =  $10^{-3}$  m

1  $\mu$ m =  $10^{-6}$  m

1 nm =  $10^{-9}$  m    1 Å =  $10^{-10}$  m



: 100.000.000



: 100.000.000



Buckyball, C<sub>60</sub>  
~1nm

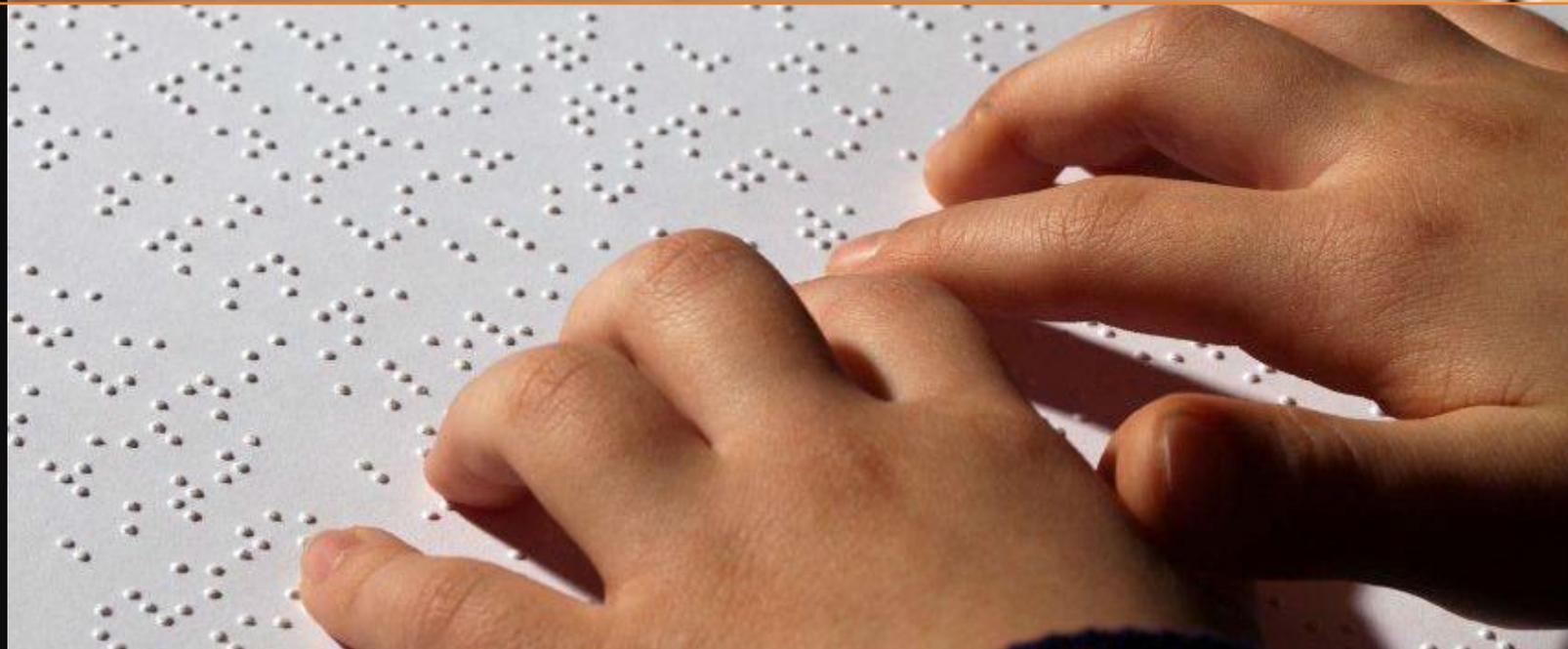
Ci sono cose più piccole da vedere.....

....bisogna cambiare metodo.

VISTA → TATTO



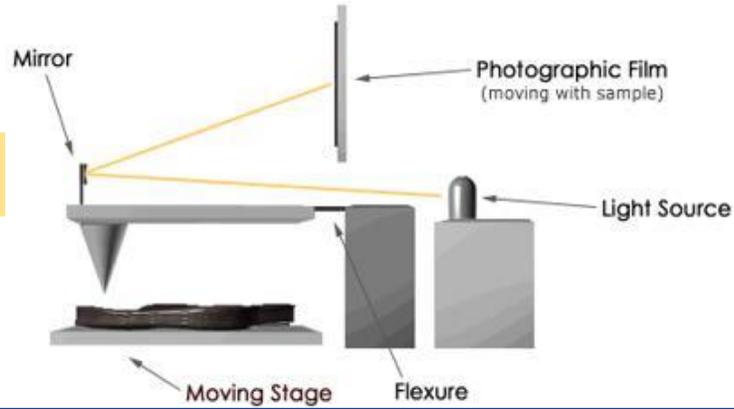
Stampa → Braille



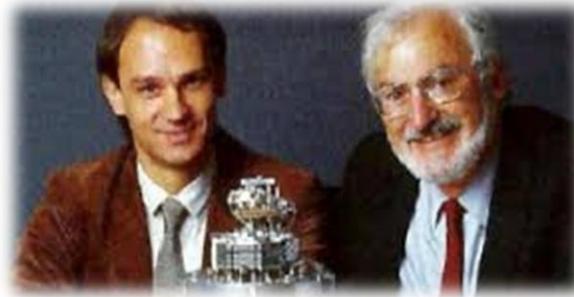
# La microscopia a scansione di sonda SPM



1877: Edison inventa il fonografo

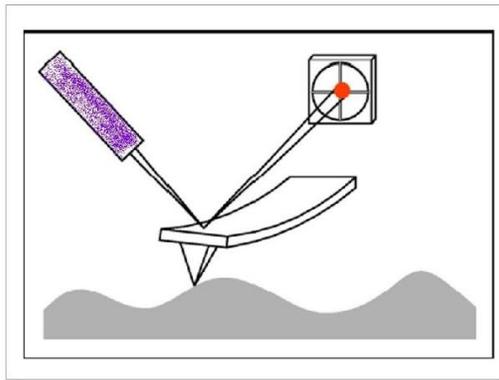


1929: Stylus profiler. Primo esempio di microscopio a scansione di sonda (Schmalz).

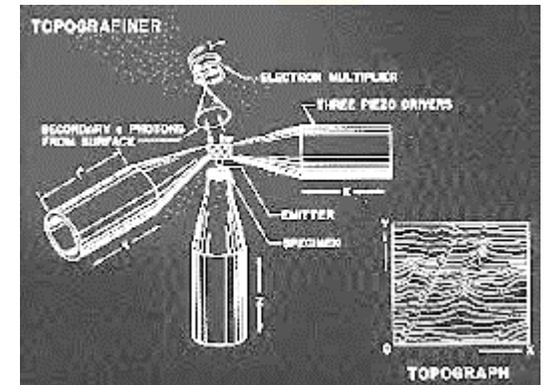
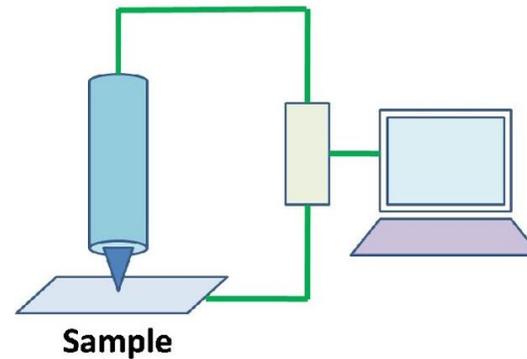


G. Binnig and H. Rohrer  
Nobel Prize 1986

Microscopio a forza atomica  
(1986)

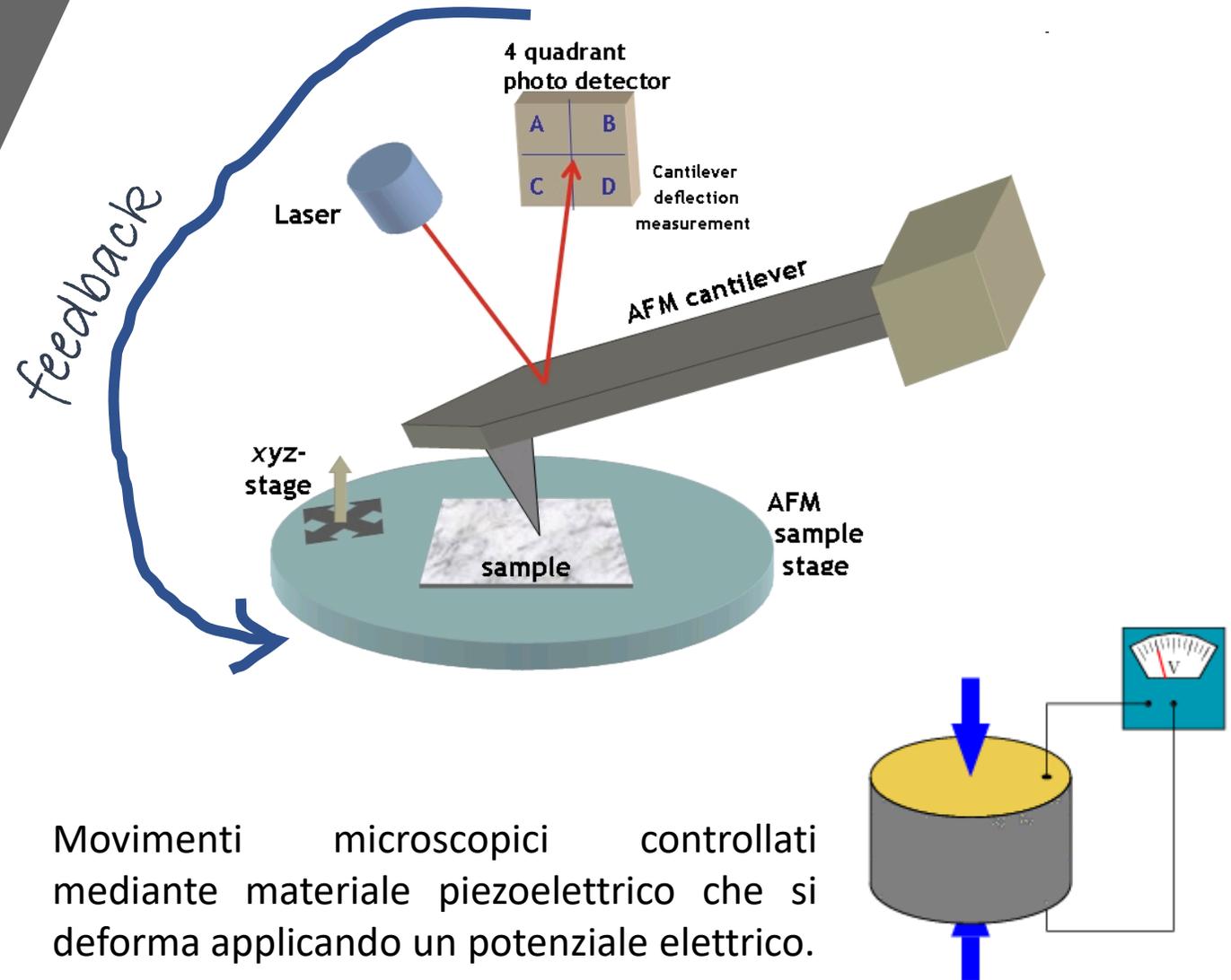


Microscopio a effetto tunnel  
(1981)



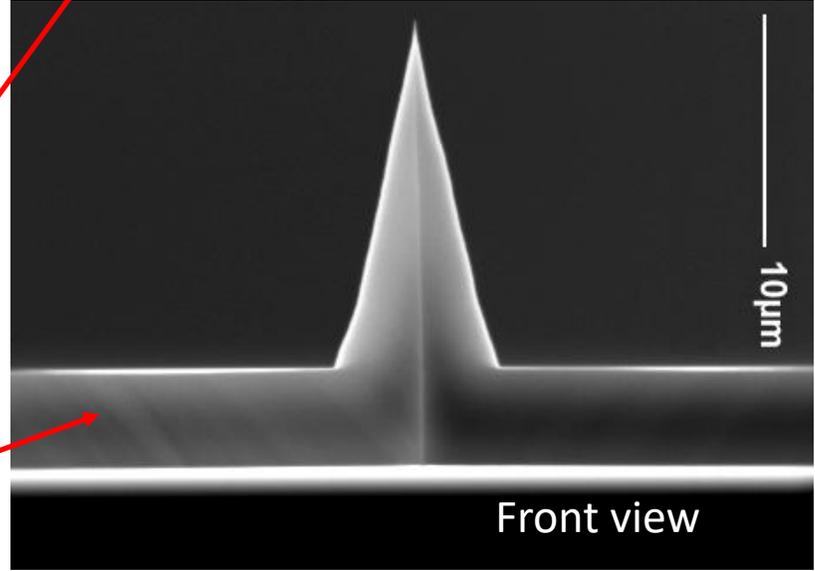
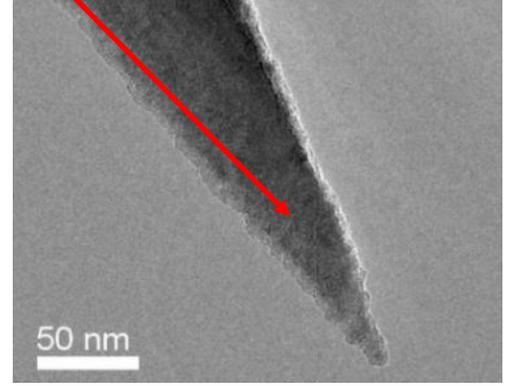
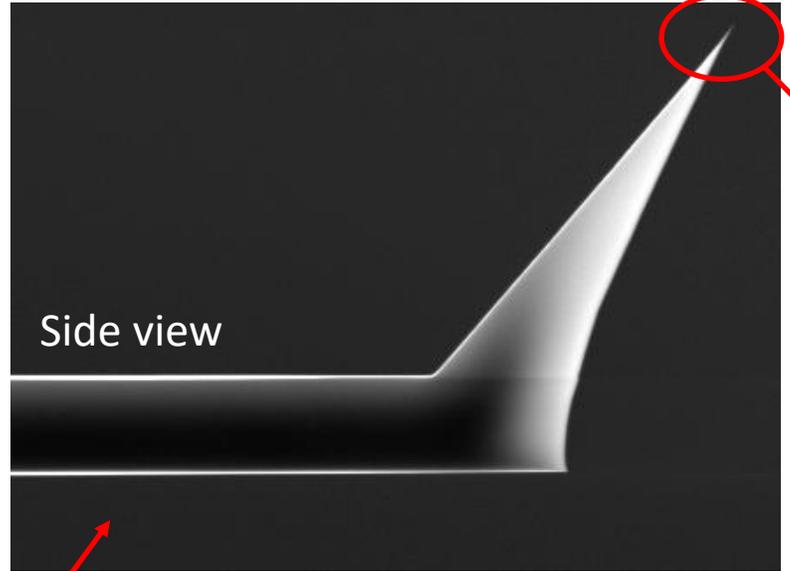
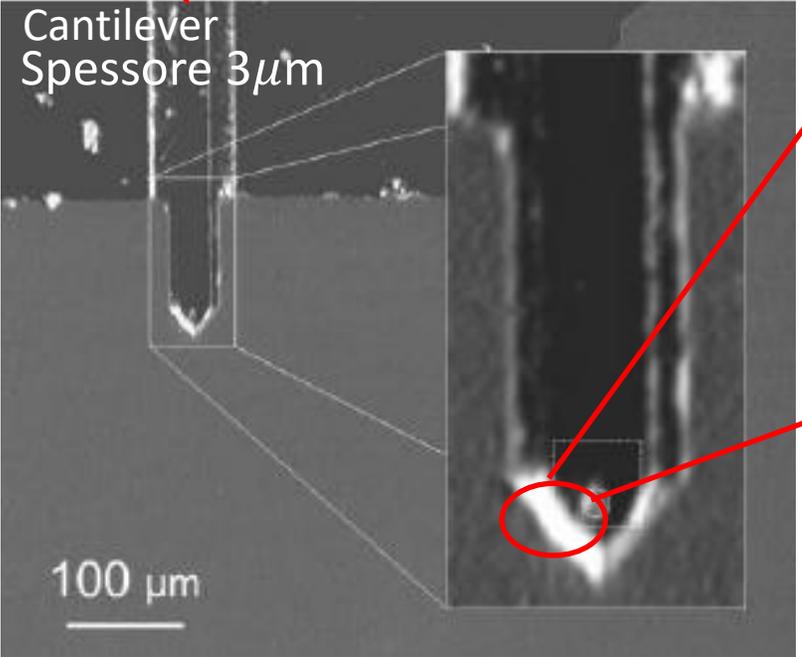
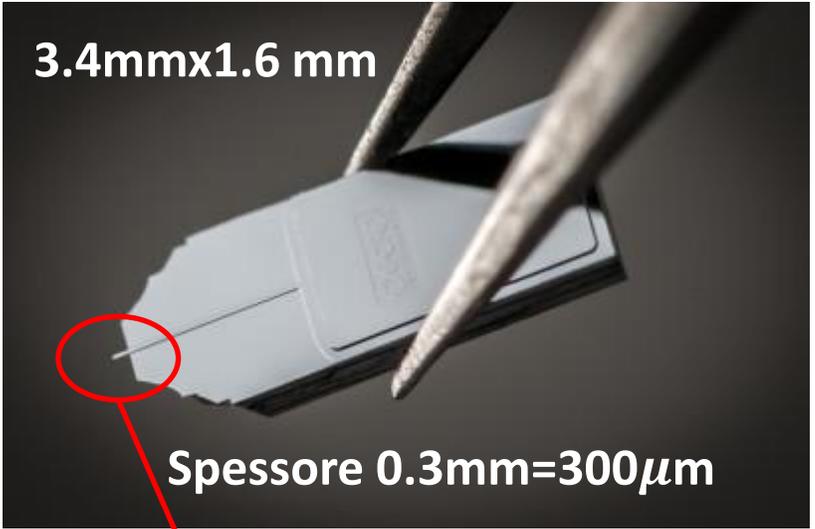
1971: Topographiner –  
Non-contact stylus profiler  
(Young, Ward, Scire).

# Microscopio a Forza Atomica (AFM)



Movimenti microscopici controllati mediante materiale piezoelettrico che si deforma applicando un potenziale elettrico.

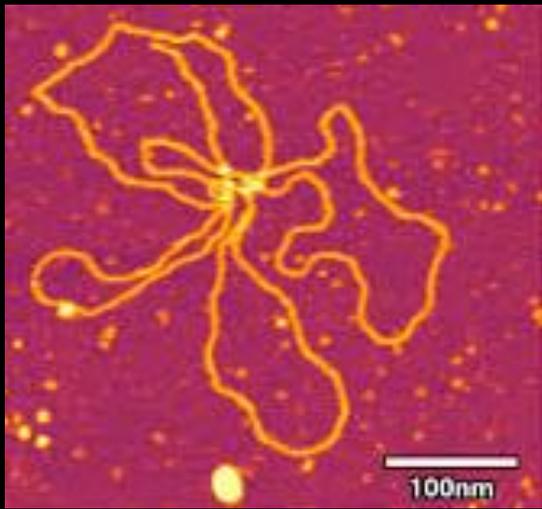
# La sonda: punta e cantilever



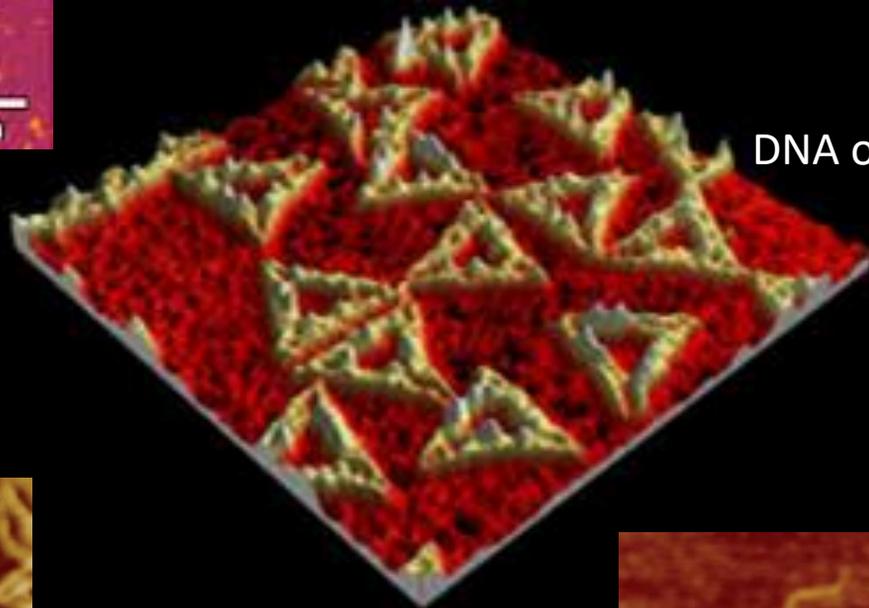
# Atomic Force Microscope

# AFM Gallery

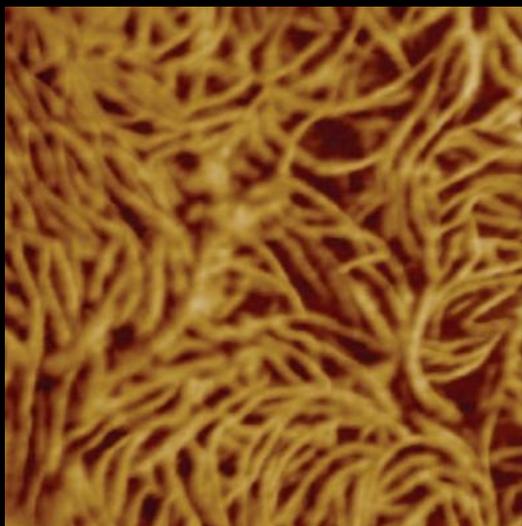
Dal micro al nano



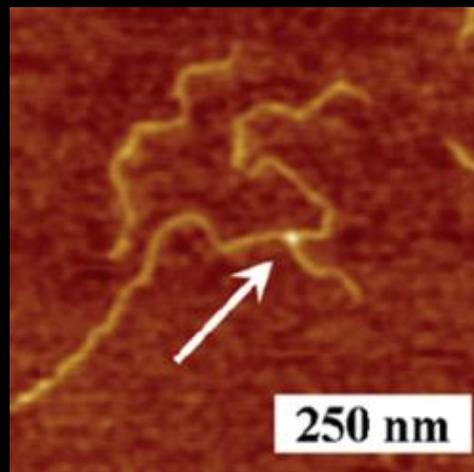
Filamento di DNA



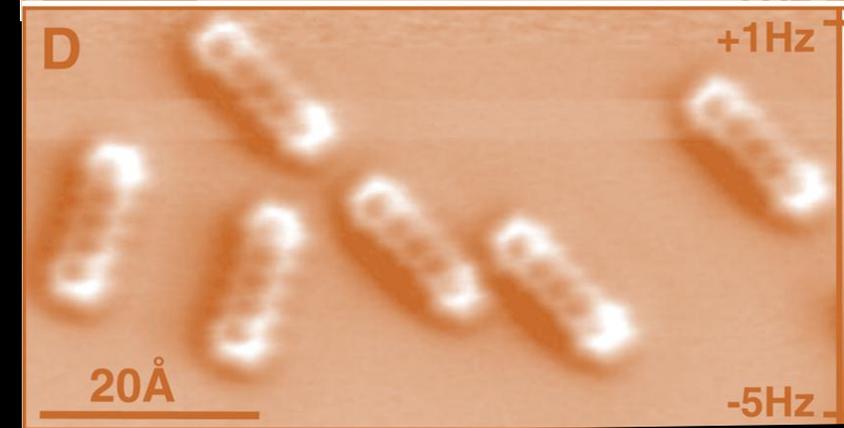
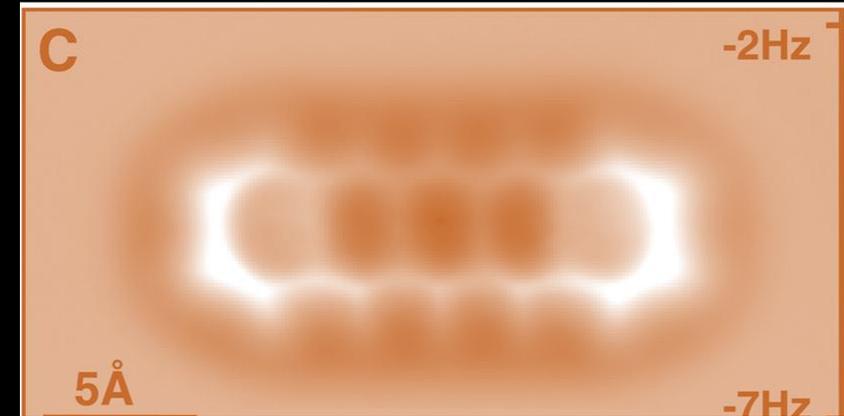
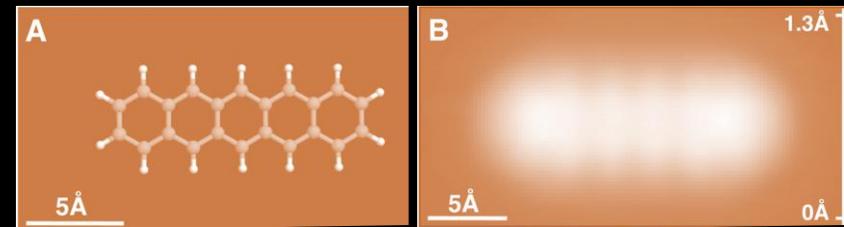
DNA origami



Polietilene lineare a bassa densità (LLDPE)



Copolimero



Molecole di Pentacene