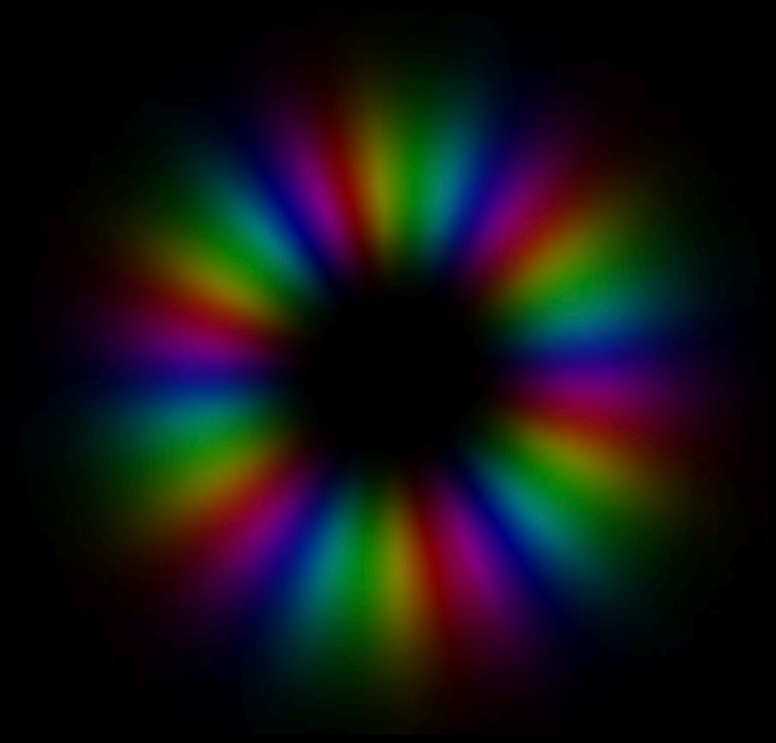
UNIVERSITÀ DI TRENTO
Dipartimento di Fisica



VI

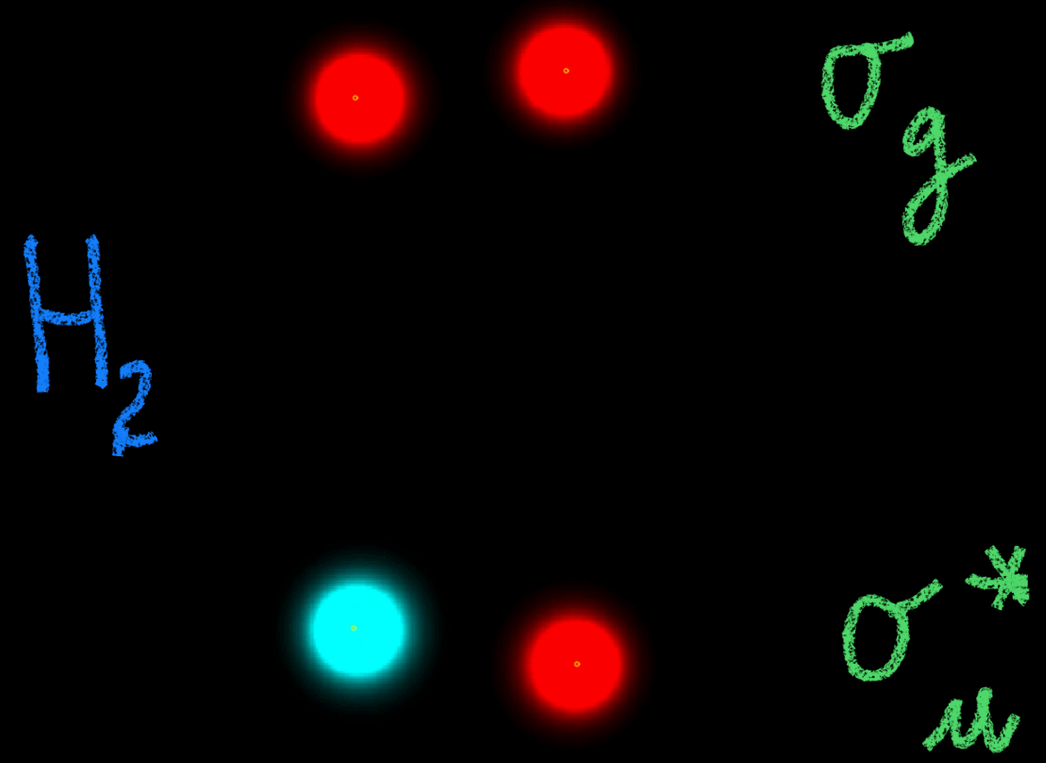
Il Lego della fisica

[due, molti, moltissimi atomi ...]

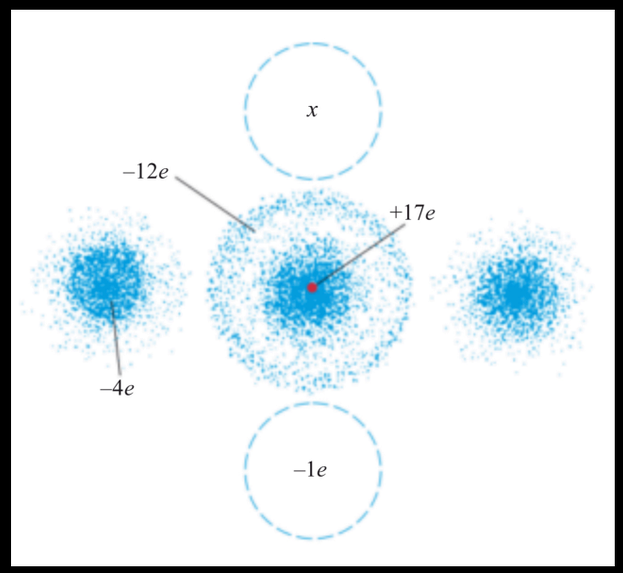
ELEMENTI di FISICA MODERNA

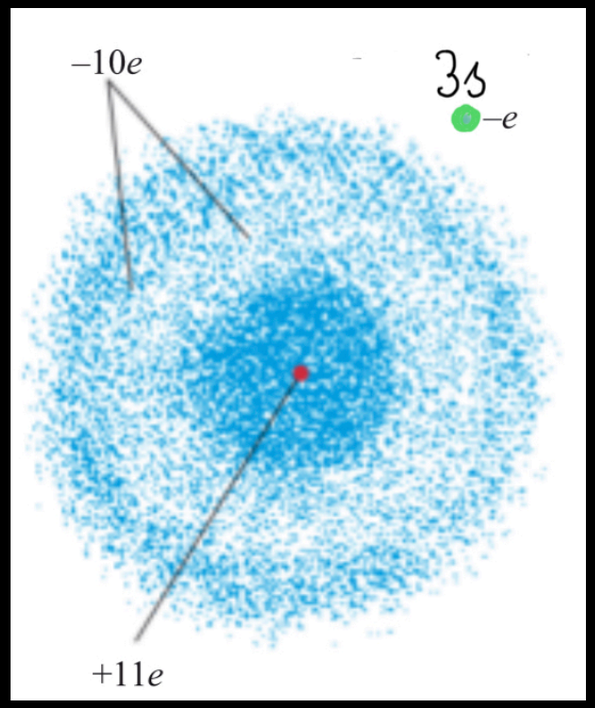
[e intelligenza artificiale] 2025

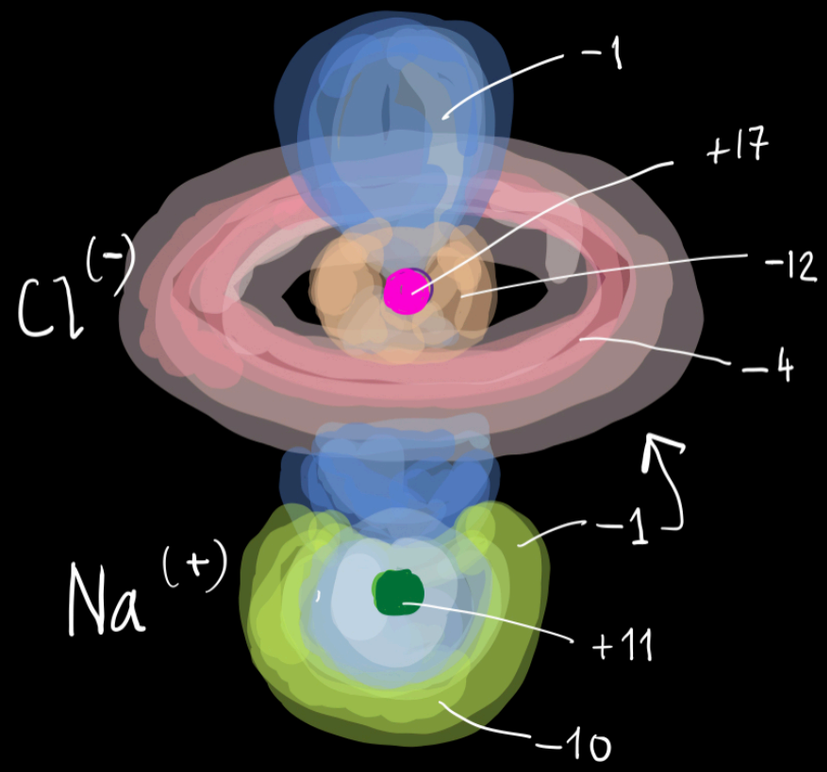
Legami covalenti e ionici: la colla molecolare



Legami covalenti e ionici: la colla molecolare

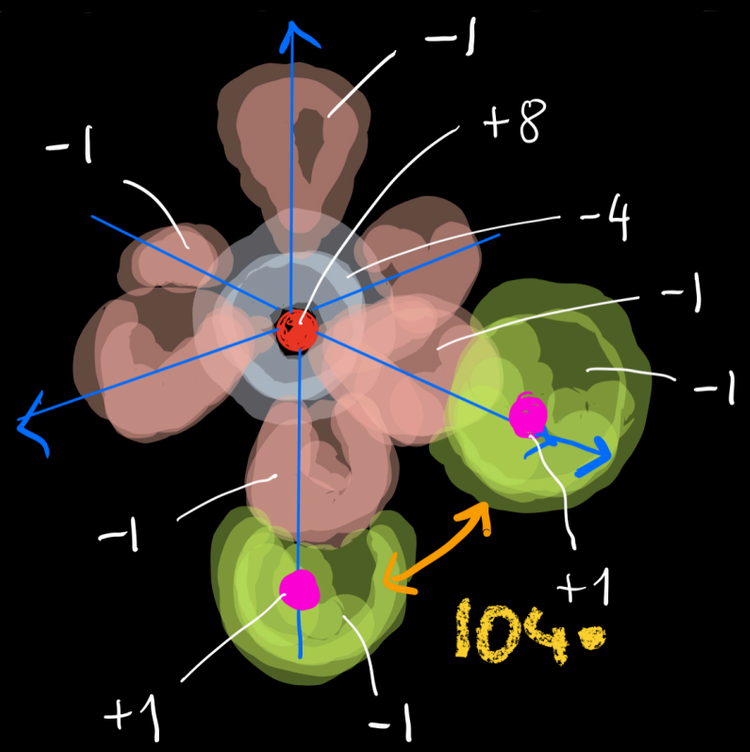


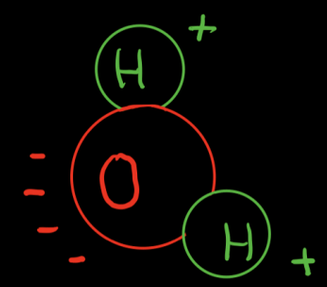




$Cl^{(-)}$ + $Na^{(+)}$

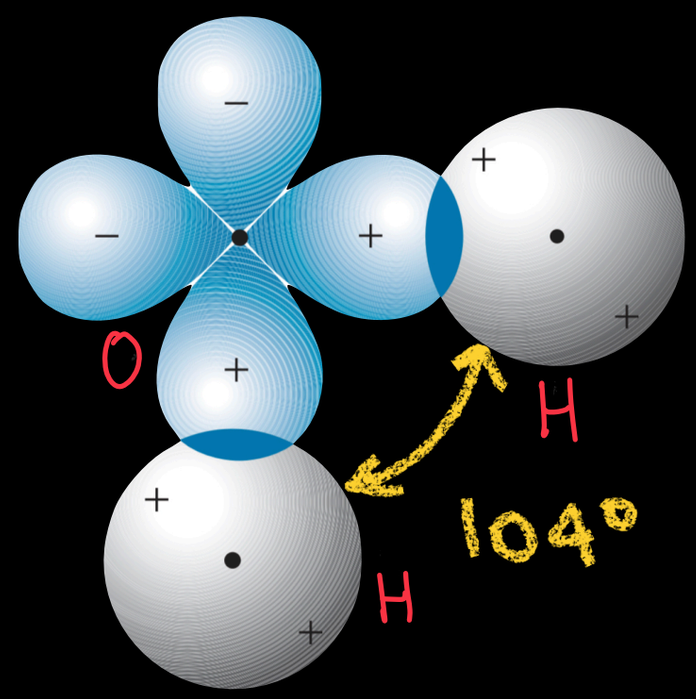
Legami covalenti e ionici: la colla molecolare



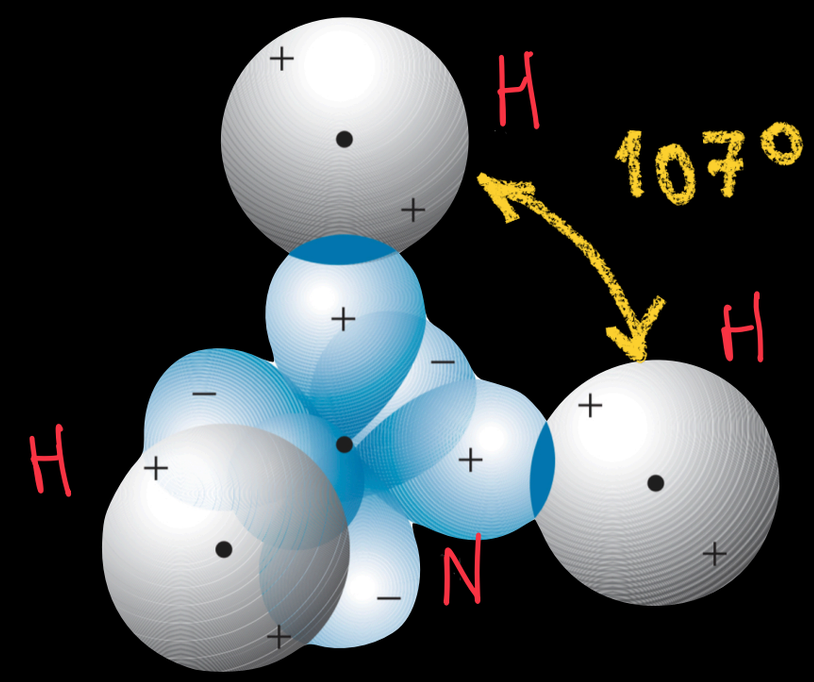


H_2O

Legami covalenti e ionici: la colla molecolare

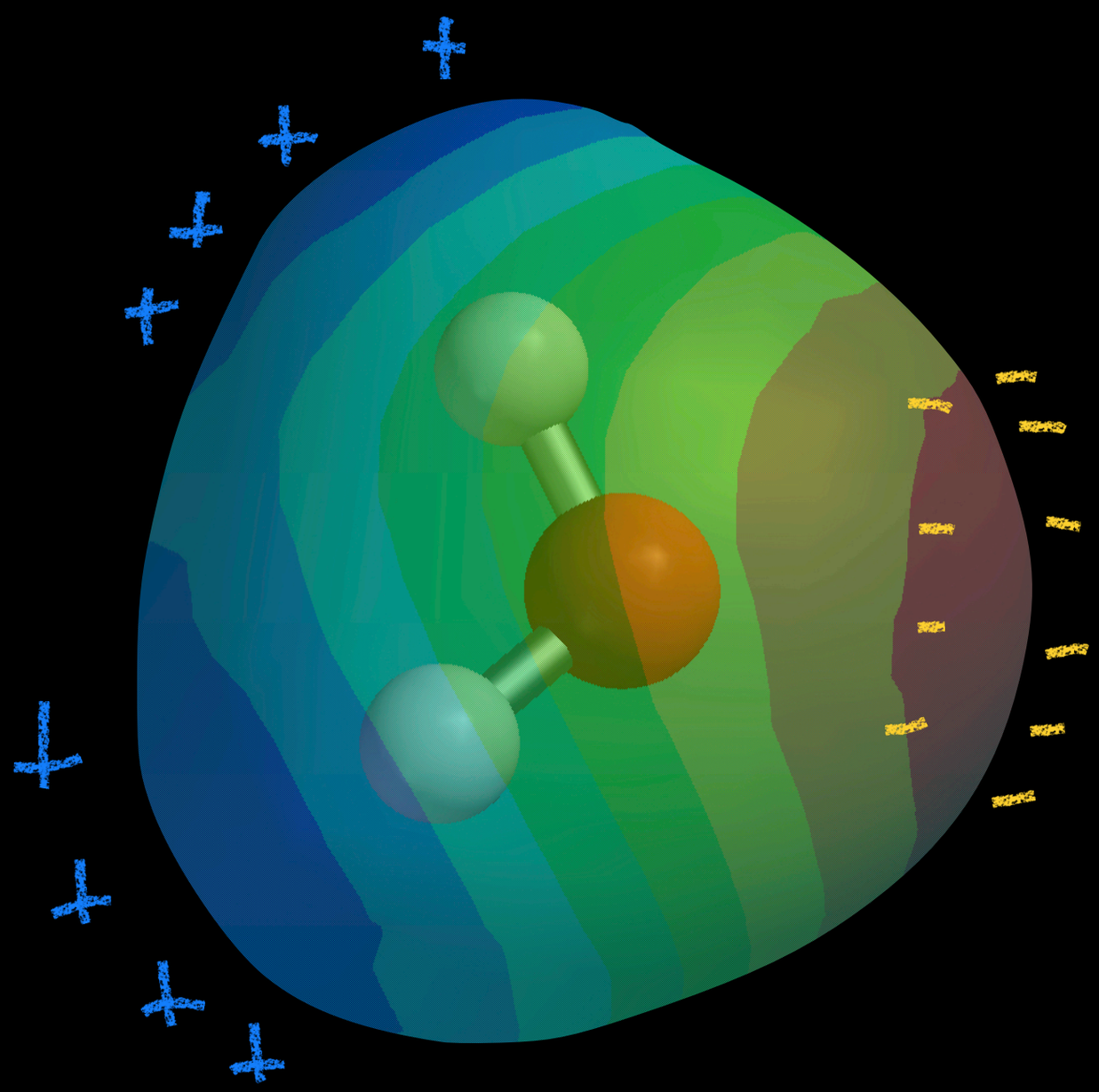


H_2O



NH_3

Legami deboli - Van der Waals



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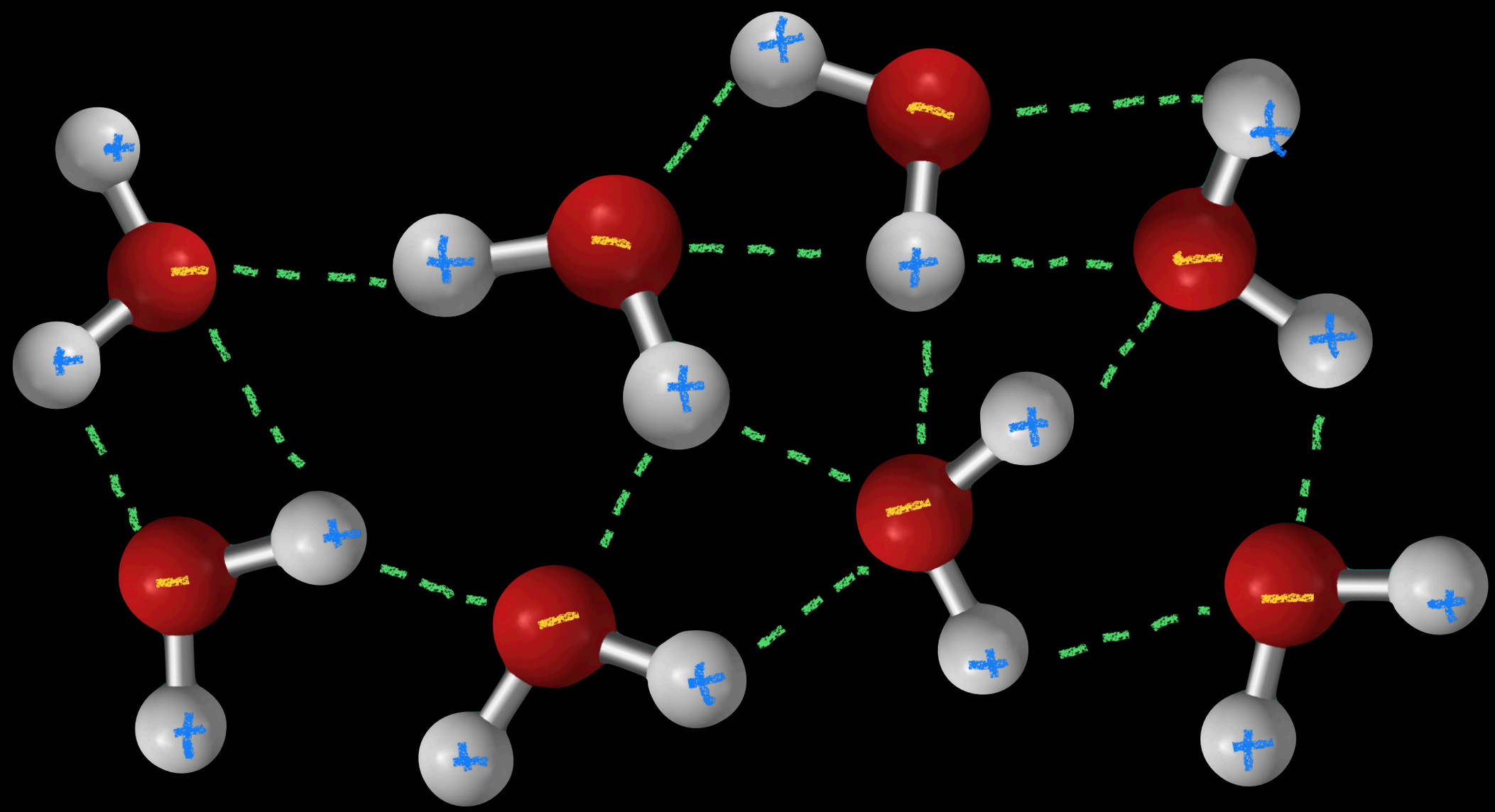
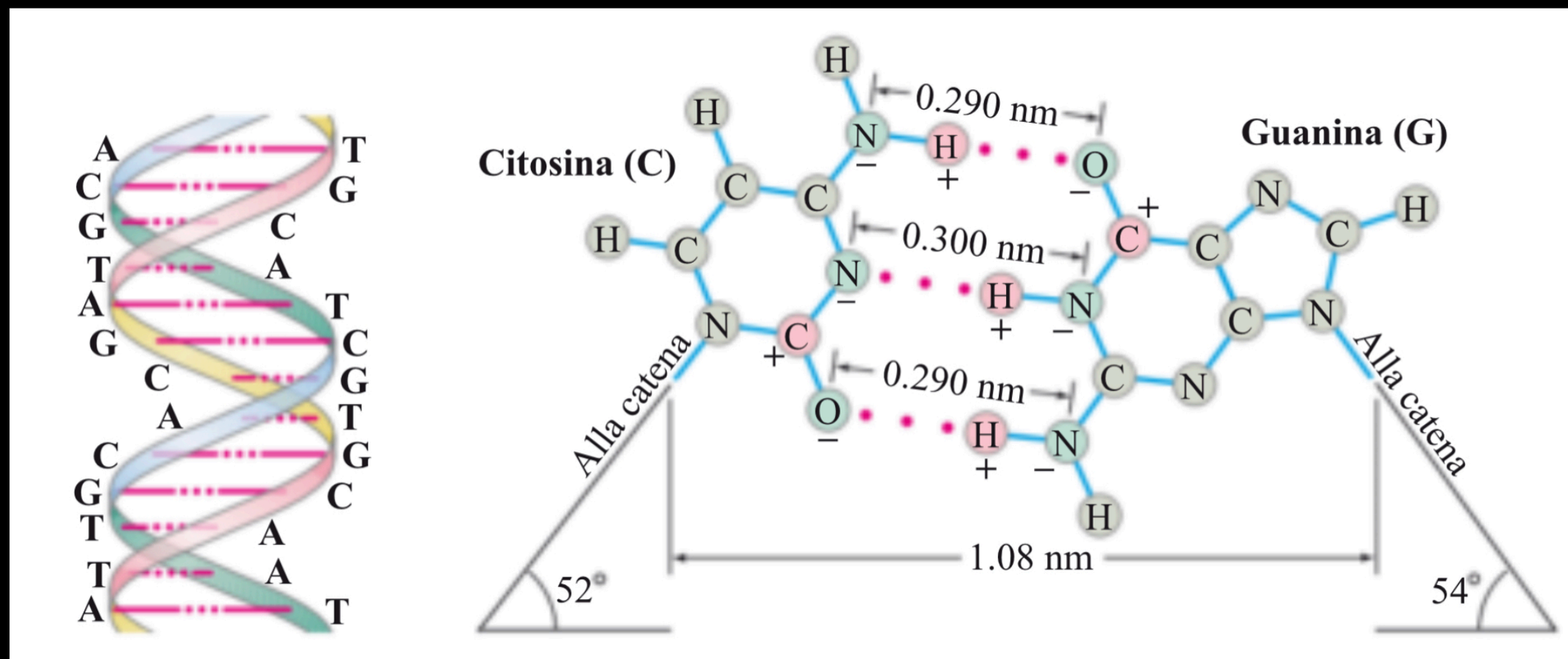
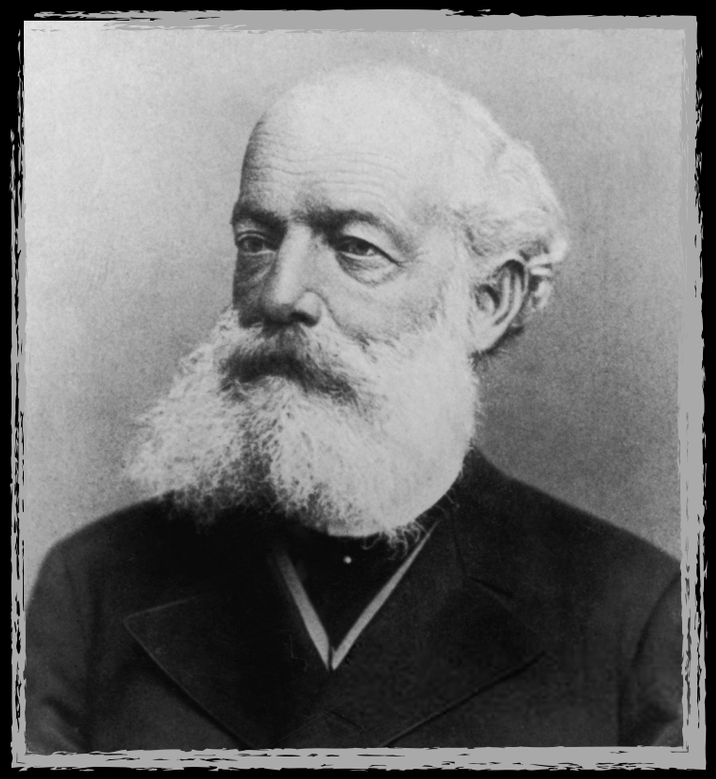


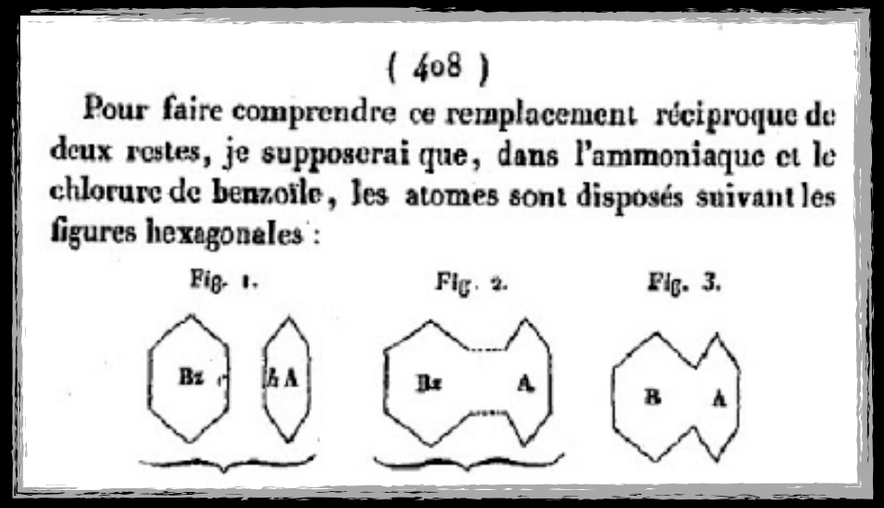
Legami deboli - Van der Waals



$k_B T \sim 0.03\,eV$

Orbitali Ibridi e la chimica organica



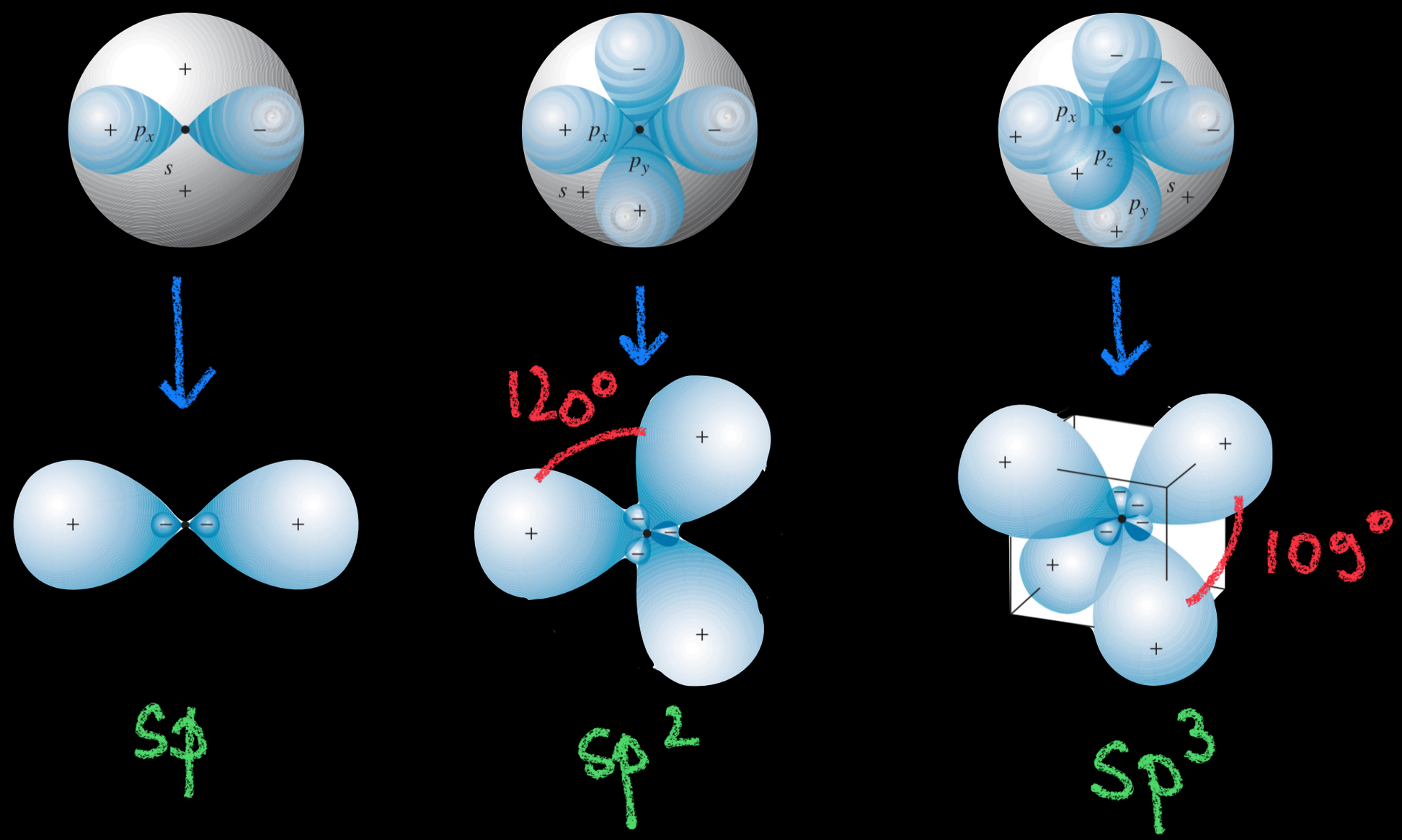


(408)

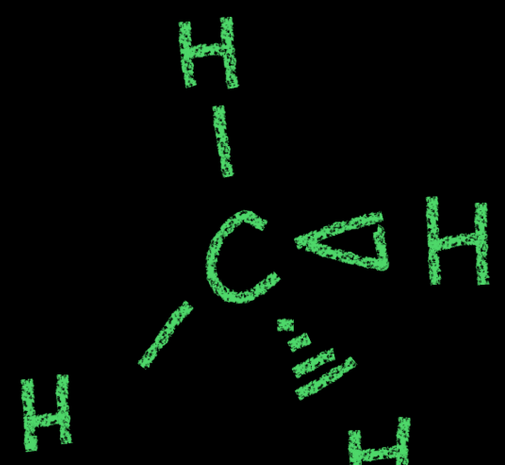
Pour faire comprendre ce remplacement réciproque de deux restes, je supposerai que, dans l'ammoniaque et le chlorure de benzoïle, les atomes sont disposés suivant les figures hexagonales :

Fig. 1. Fig. 2. Fig. 3.

Orbitali Ibridi e la chimica organica



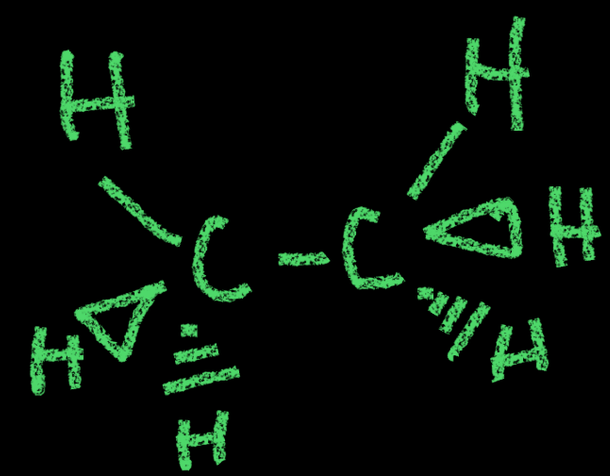
Orbitali Ibridi e la chimica organica



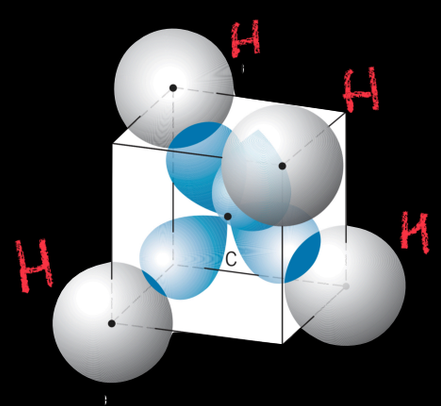
Metano

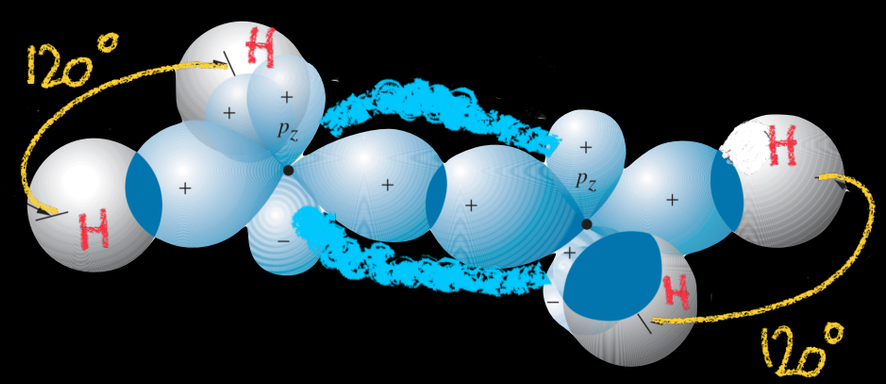
Etilene

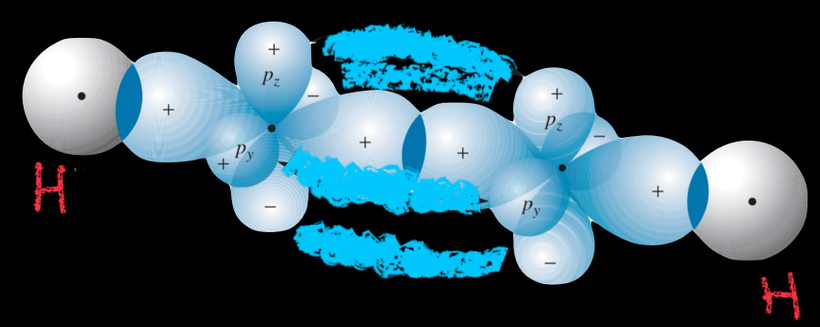
Acetilene



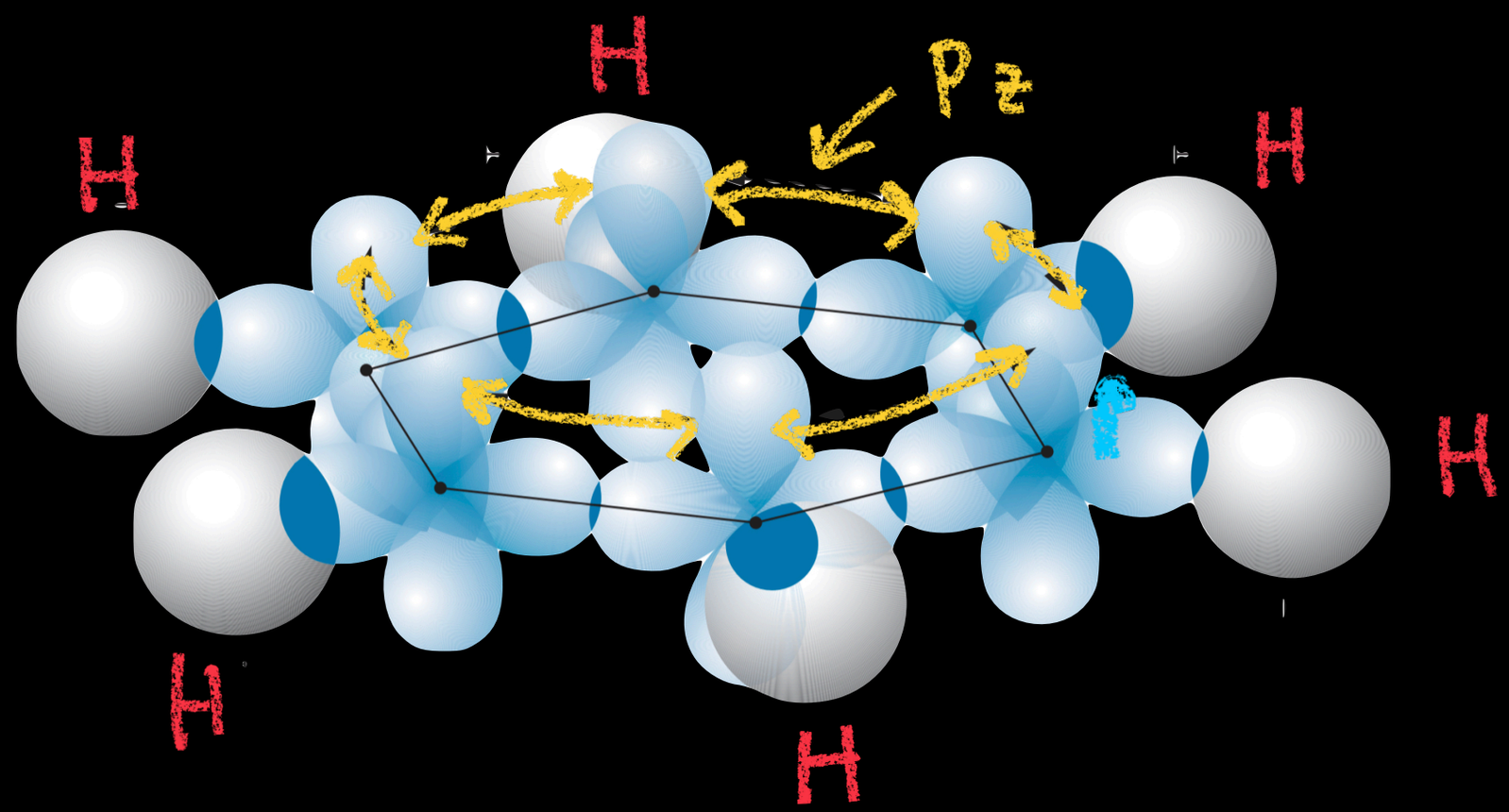
Etano

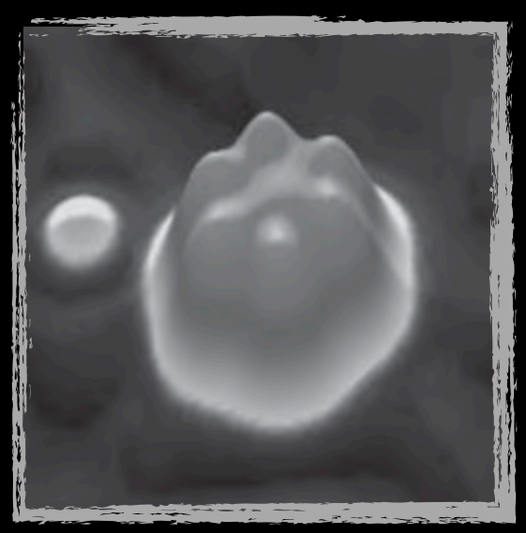






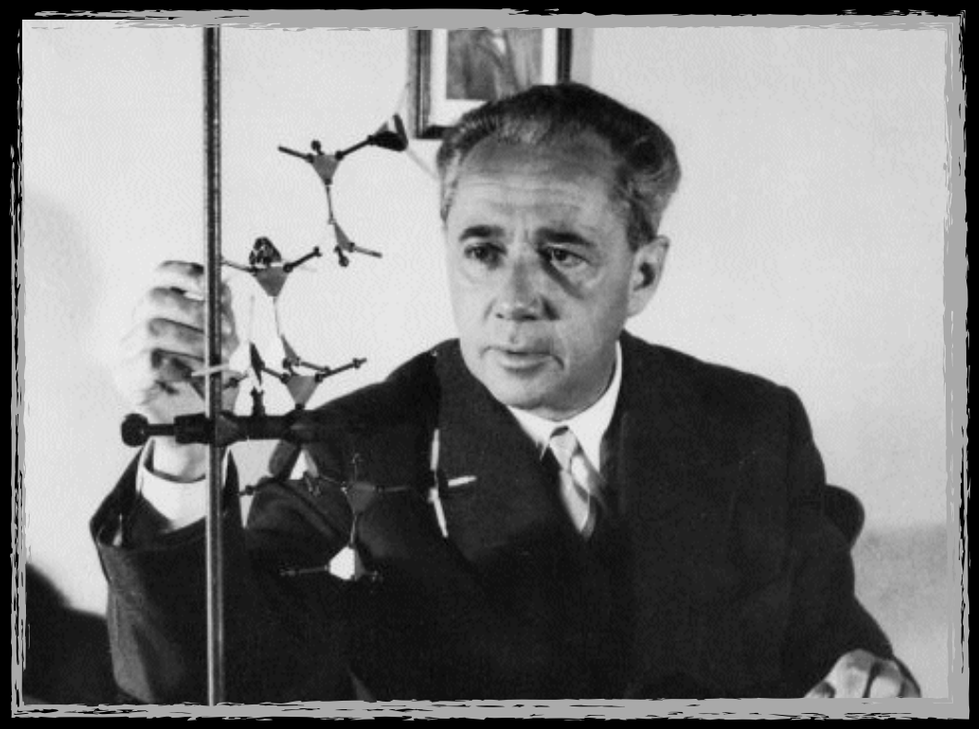
Orbitali Ibridi e la chimica organica





C_6H_6 - benzene

Polimeri



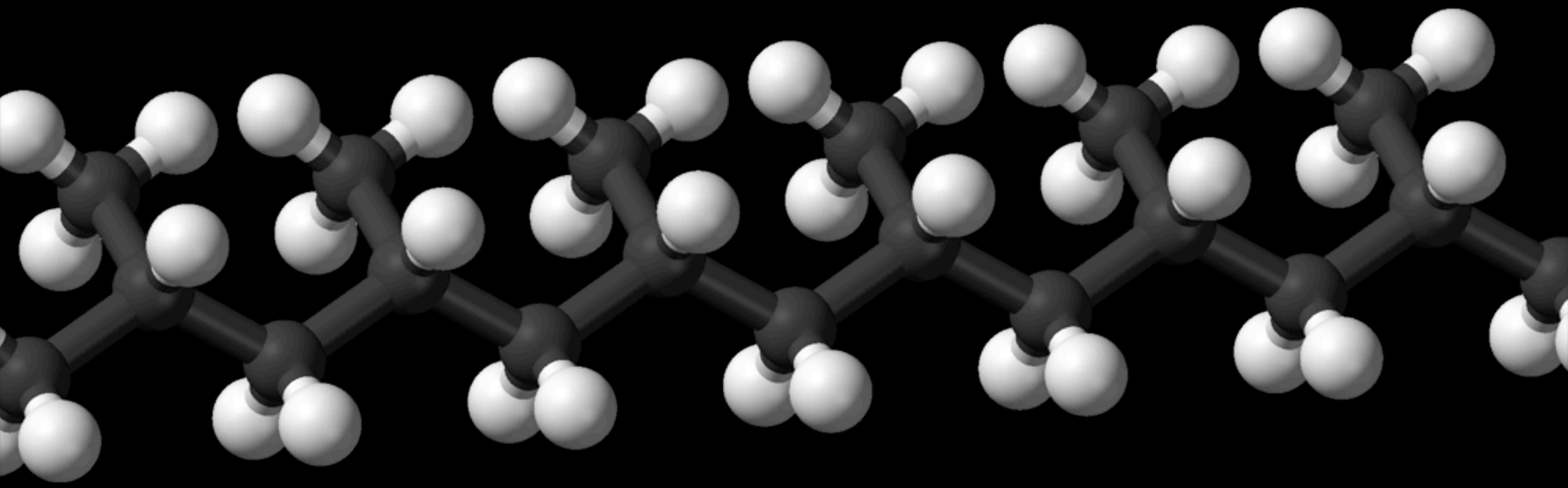
G. Natta

N. Chimica

1963

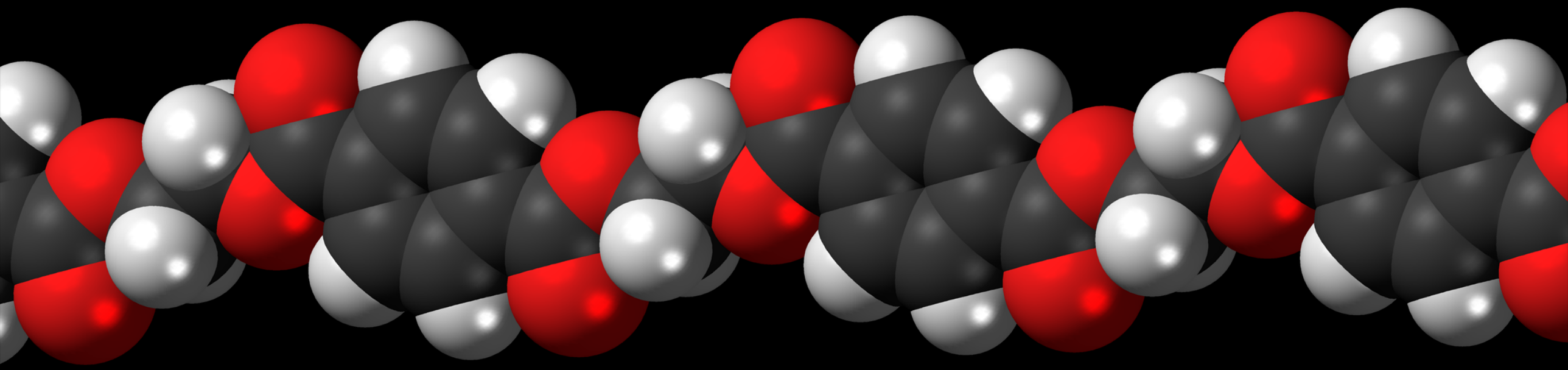
Moplen - Polipropilene Isotattico

Polimeri



Moplen- Polipropilene Isotattico

Polimeri



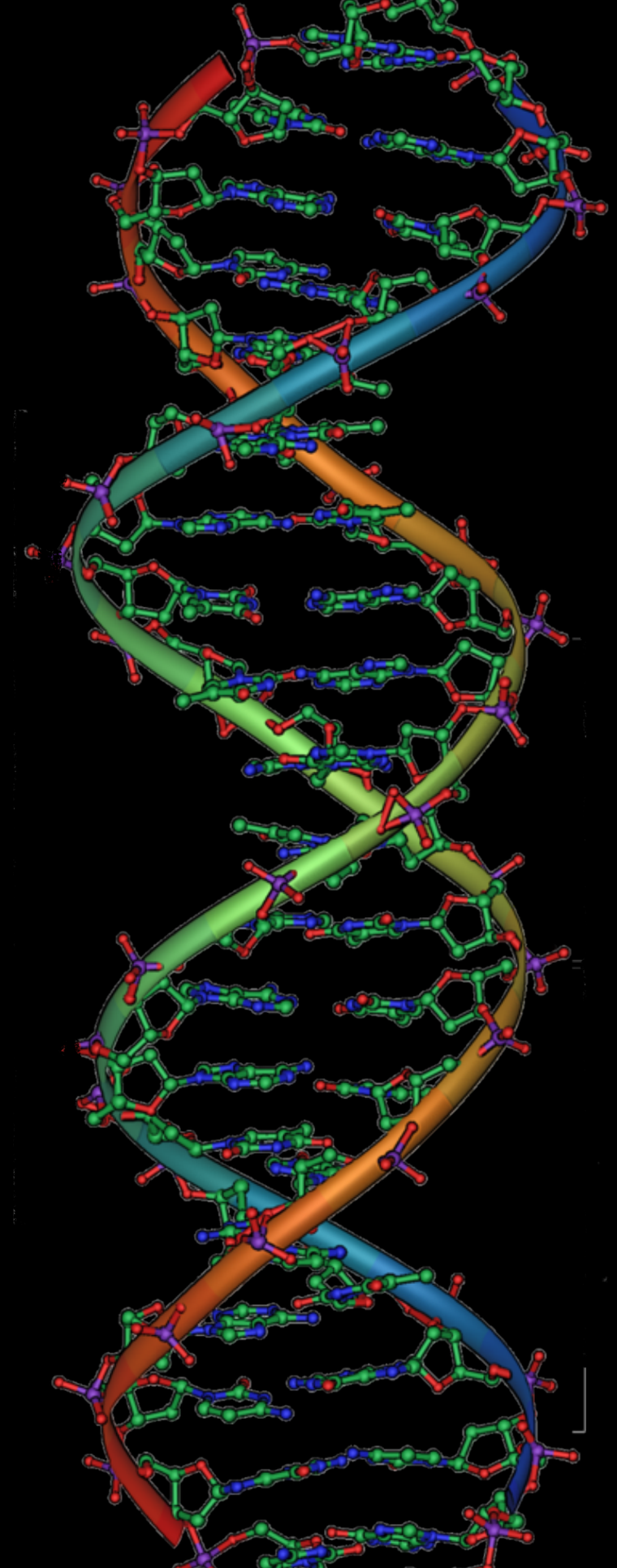
PET (polietilene tereftalato)

Polimeri

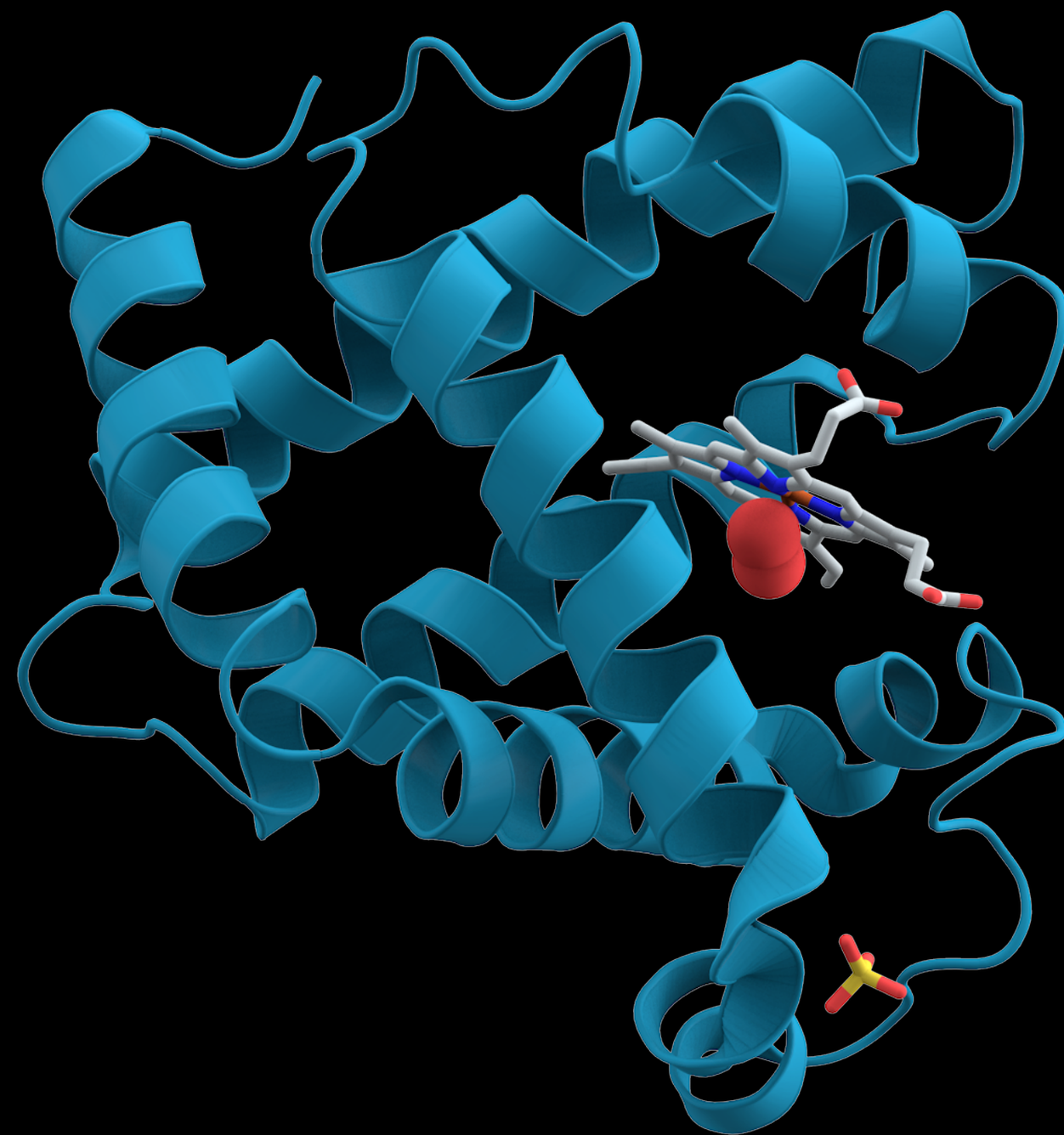
- CA – Acetato di cellulosa
- CAB – Acetobutirrato di cellulosa
- CN – Nitrato di cellulosa
- CP – Propionato di cellulosa
- EP – Epossidi
- MF – Melammina-formaldeide
- PA – Poliammidi
- PAI – Poliammidiimmide
- PAN – Poliacrilonitrile
- PB – Polibutene-1
- PBT – Polibutilentereftalato
- PC – Policarbonato
- PCTFE – Policlorotrifluoroetilene
- PDAP – Polidialliftalato
- PE – Polietilene
- PE-C – Polietilene clorurato
- PEI – Polieterimmide
- PEK – Polieterchetone
- PEEK – Polietereterchetone
- PES – Polietersolfoni
- PET – Polietilentereftalato
- PF – Fenolformaldeide
- PI – Poliimmide
- PIB – Poliisobutilene
- PMI – Polimetacrilimmide
- PMMA – Polimetilmetacrilato
- PMP – Poli-4-metilpentene-1
- POM – Poliossimetilene, Poliformaldeide, Poliacetale
- PP – Polipropilene
- PPE – Polifeniletere
- PPO – Polifenilenossido
- PPS – Polifenilensolfuro
- PS – Polistirene
- PSU – Polisolfone
- PT – Politiofene
- PTFE – Politetrafluoroetilene (Teflon)
- PUR – Poliuretano
- PVB – Polivinilbutirrale
- PVC – Polivinilcloruro
- PVC-C – Polivinilcloruro clorurato
- PVDC – Polivinildencloruro
- PVDF – Polivinildenfluoruro
- PVF – Polivinilfluoruro
- RC – Cellulosa rigenerata
- SI – Siliconi
- UF – Urea-formaldeide
- UP – Poliestere insaturo
- PDMS – Polidimetilsilossano

Polimeri

DNA

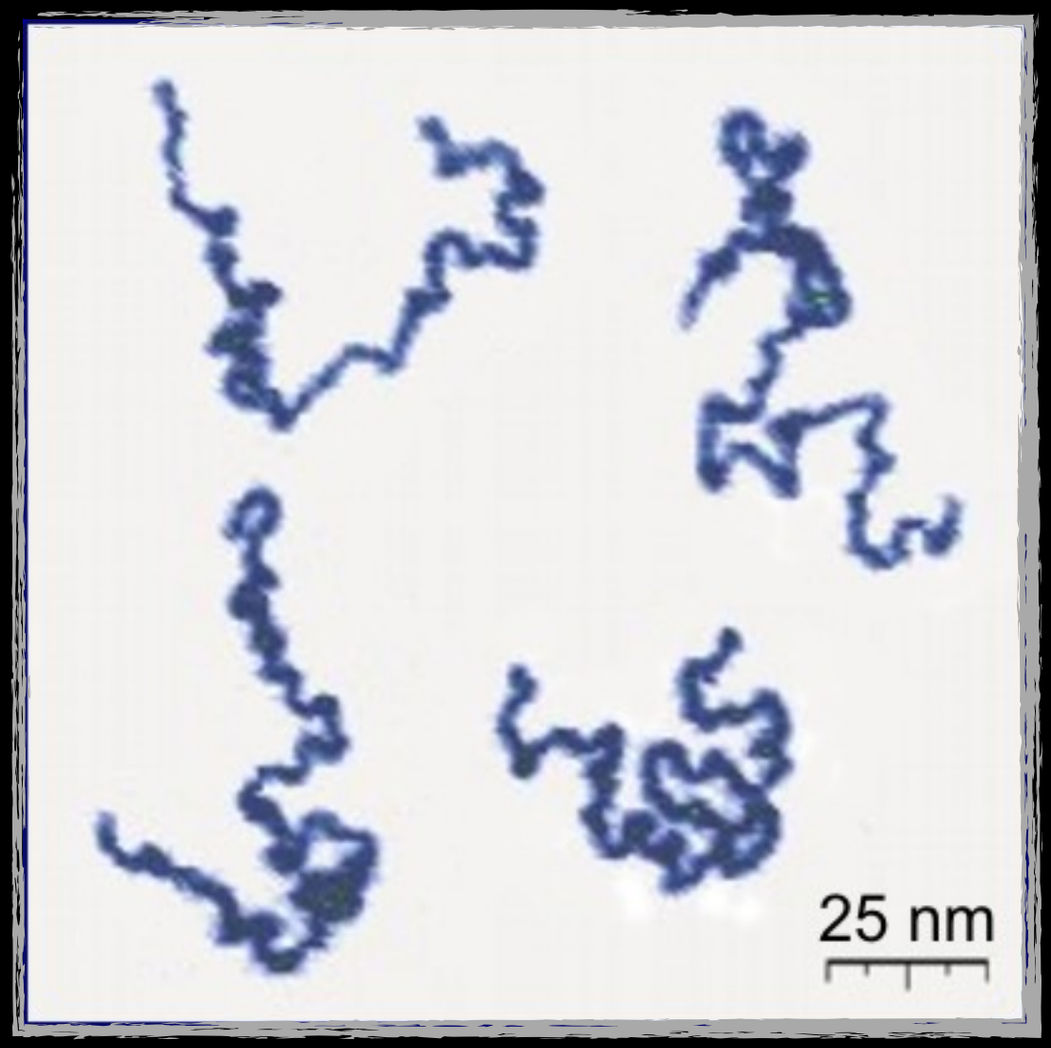


Polimeri

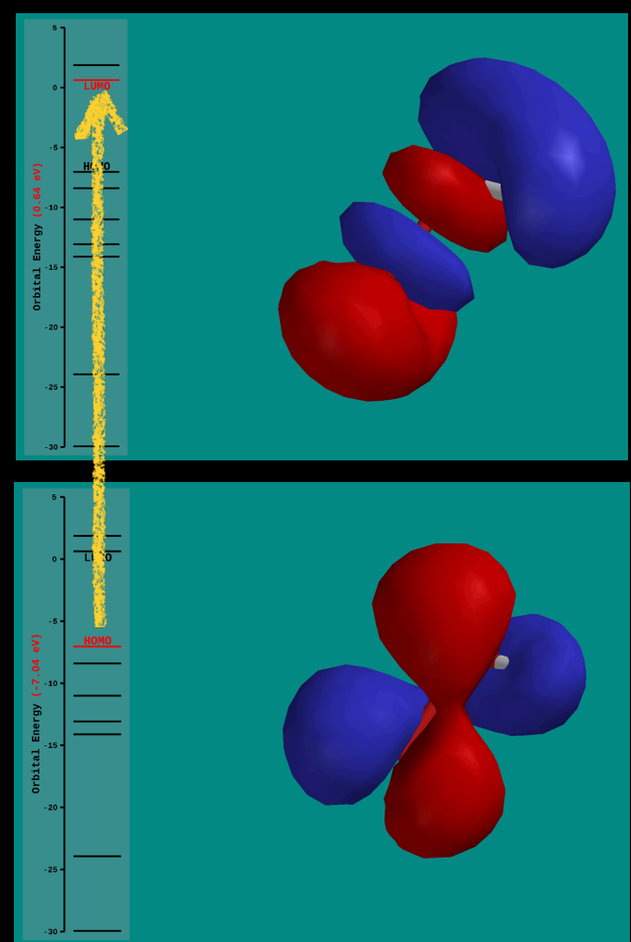


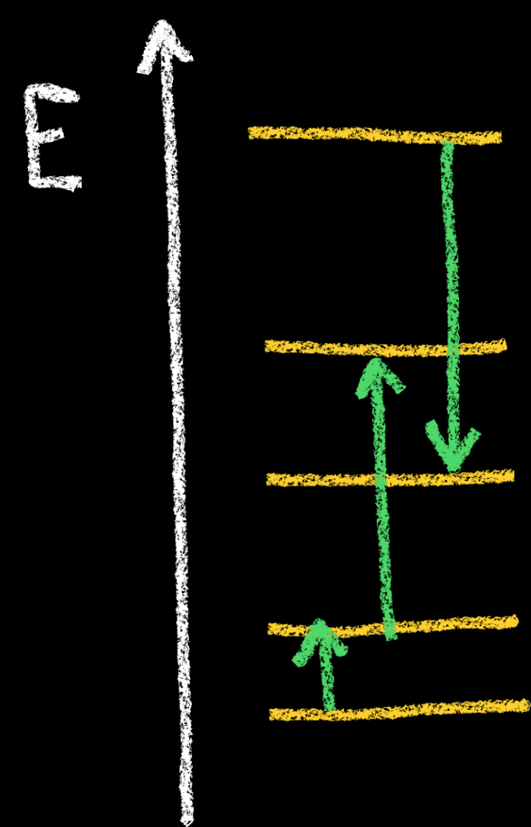
Mioglobina

Polimeri



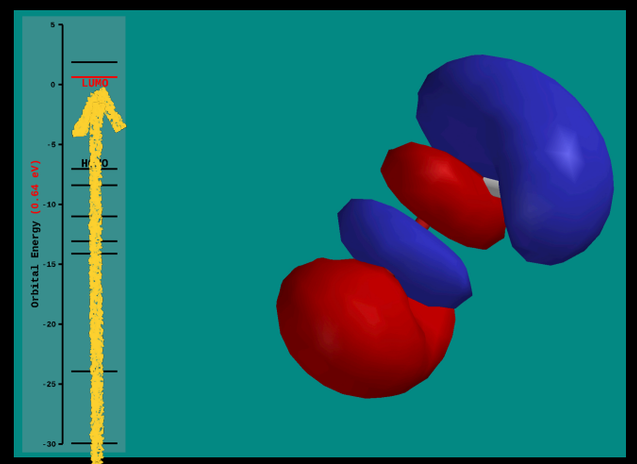
Spettri Molecolari

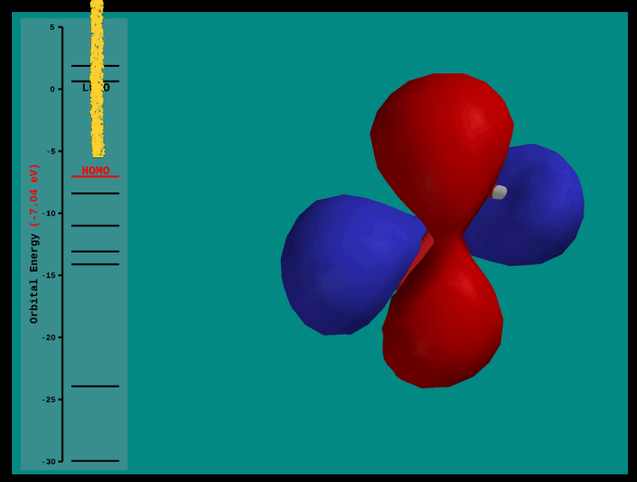


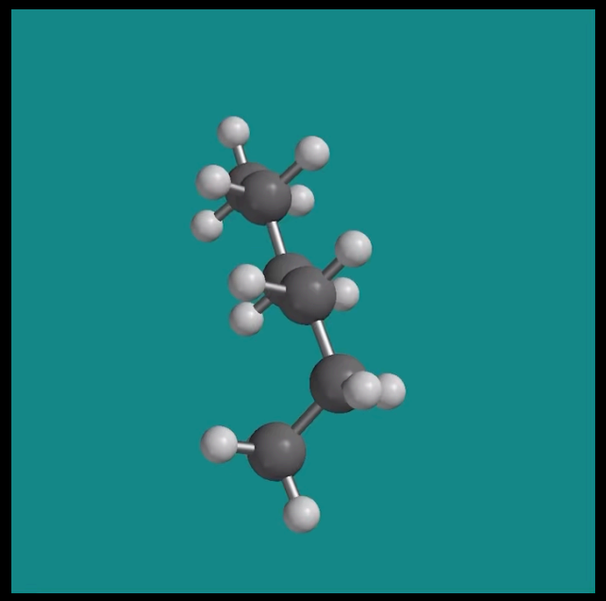


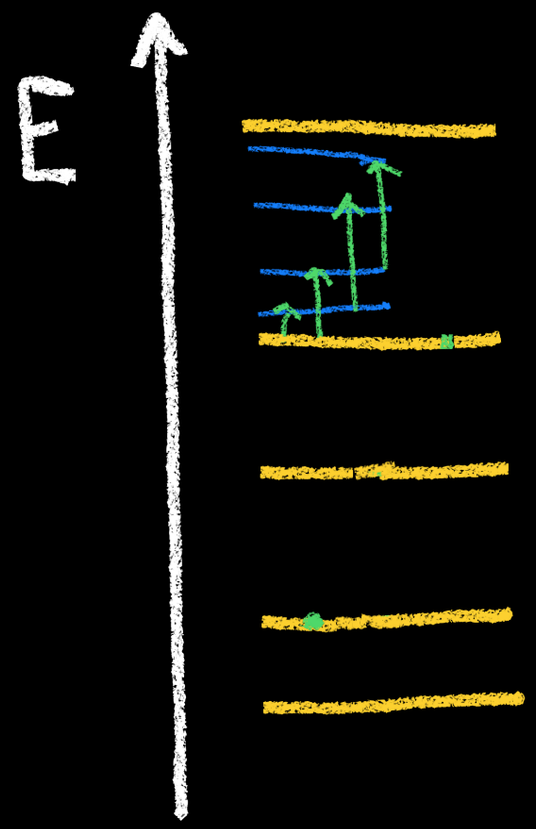
elettronico

Spettri Molecolari





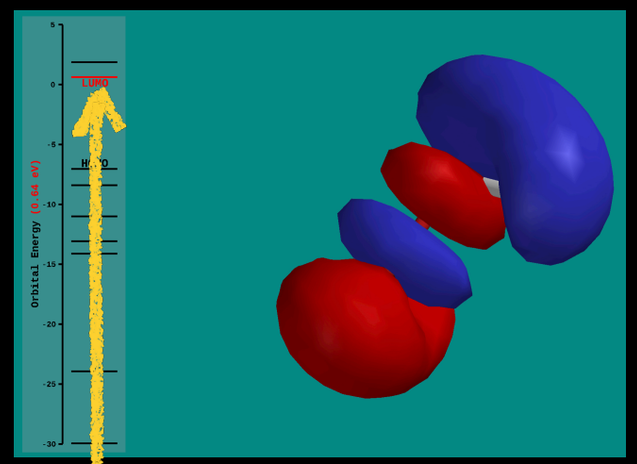


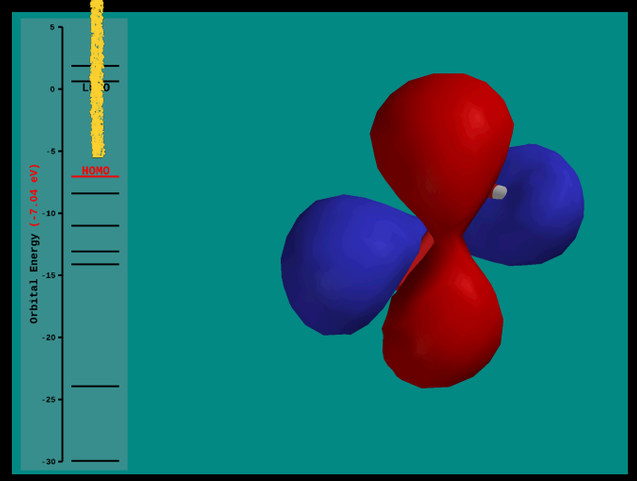


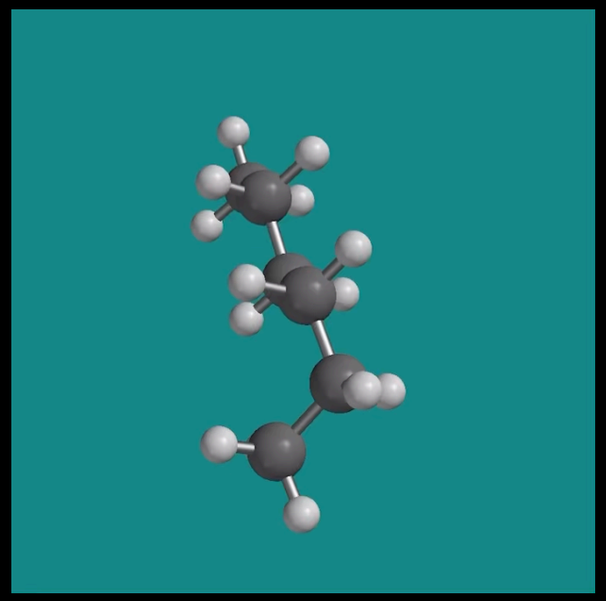
elettronico

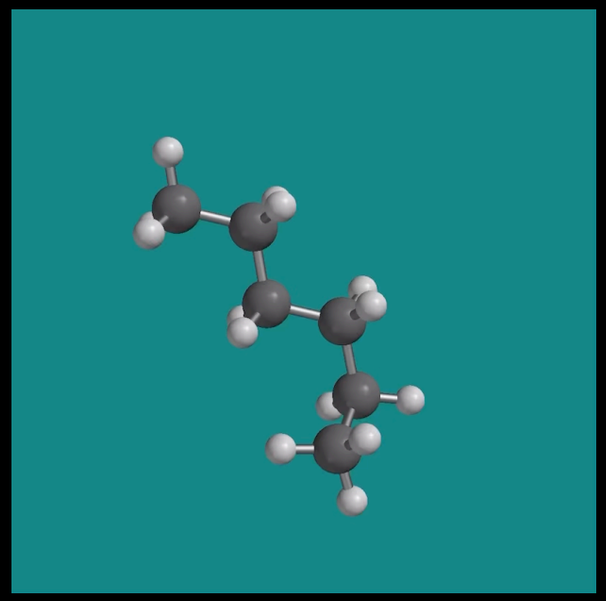
vibrazionale

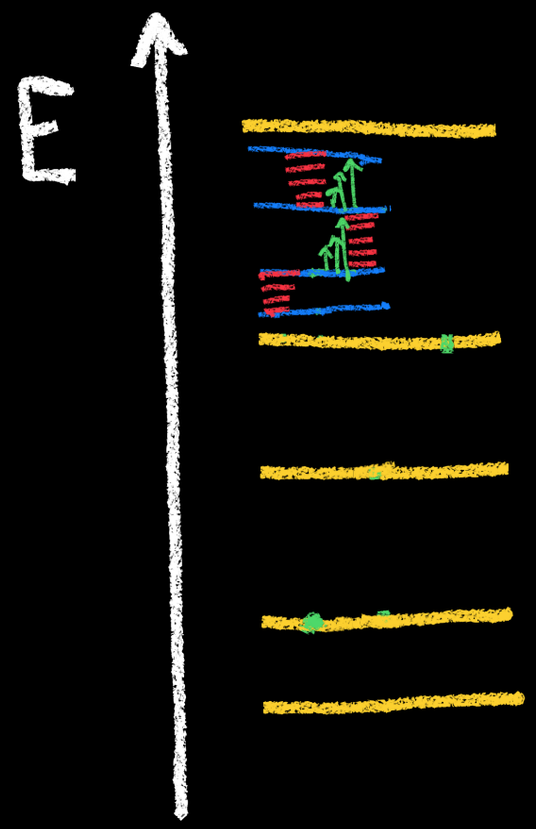
Spettri Molecolari











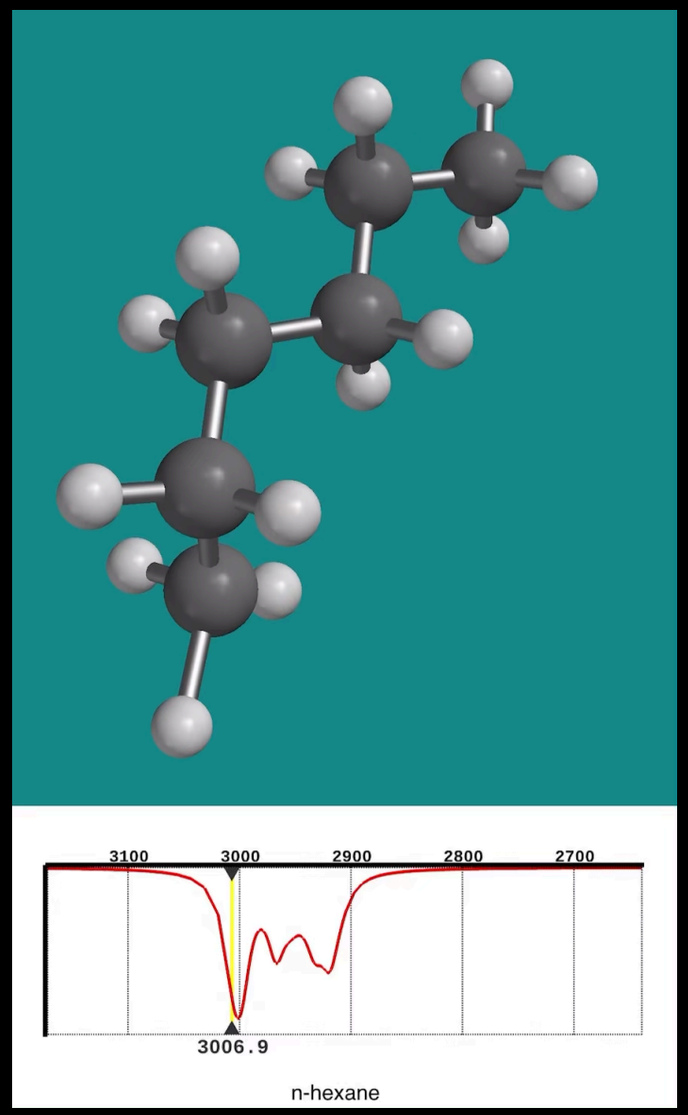
elettronico

vibrazionale

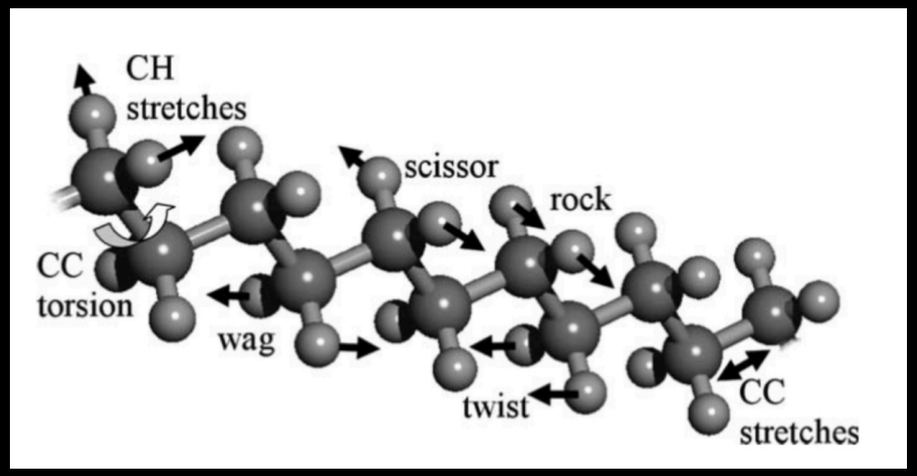
rotazionale

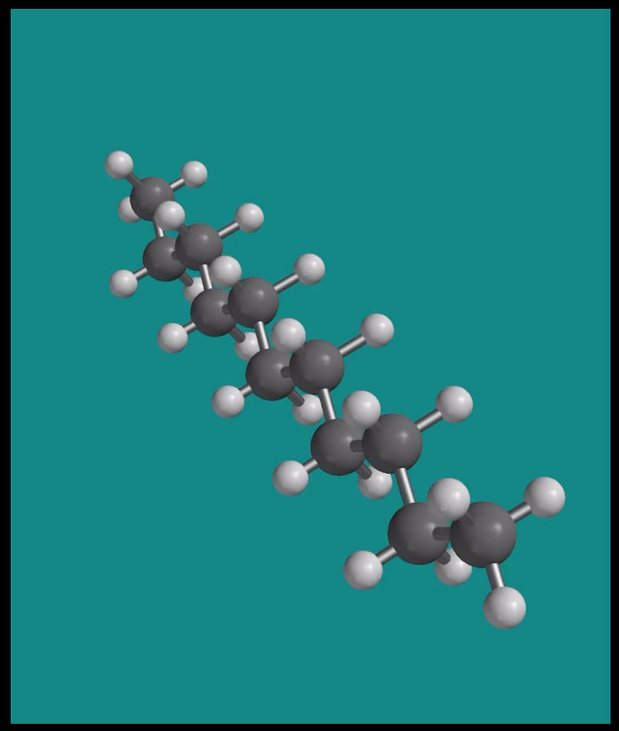
Spettri Molecolari

impronte digitali vibrazionali

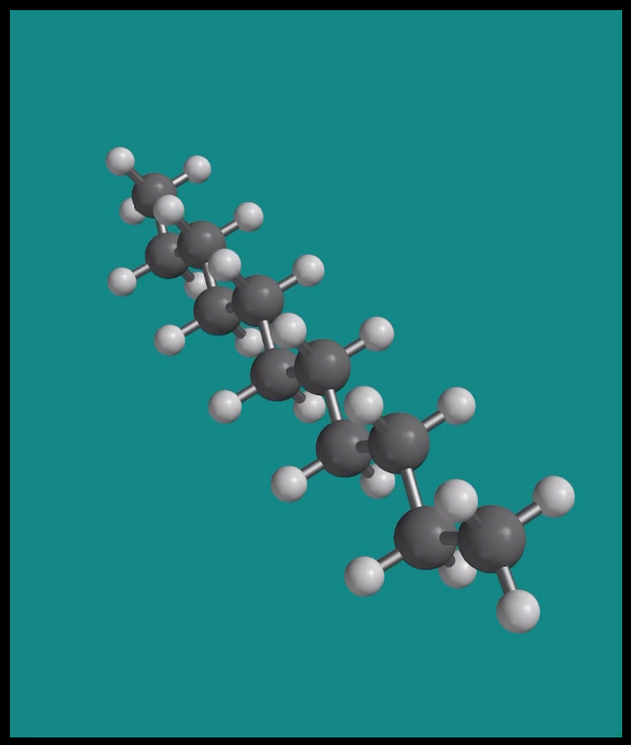


la ginnastica del polimero

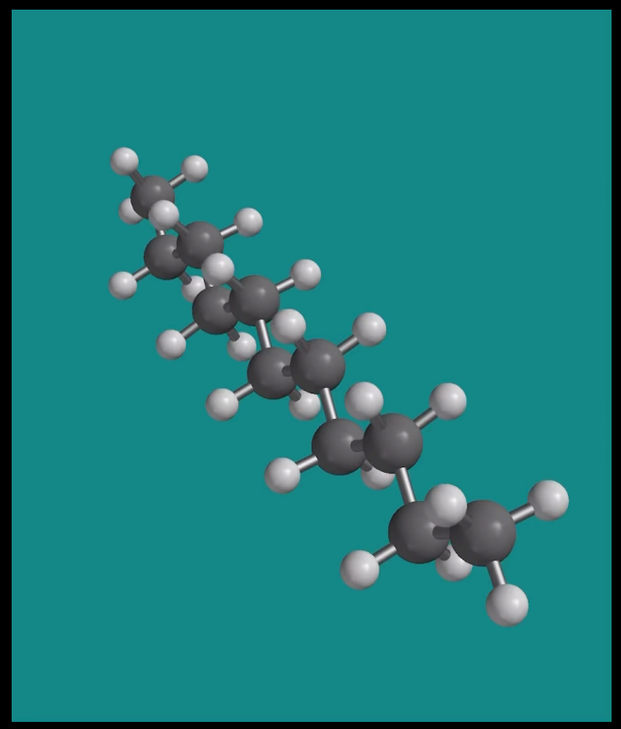




stretch



twist



scissor

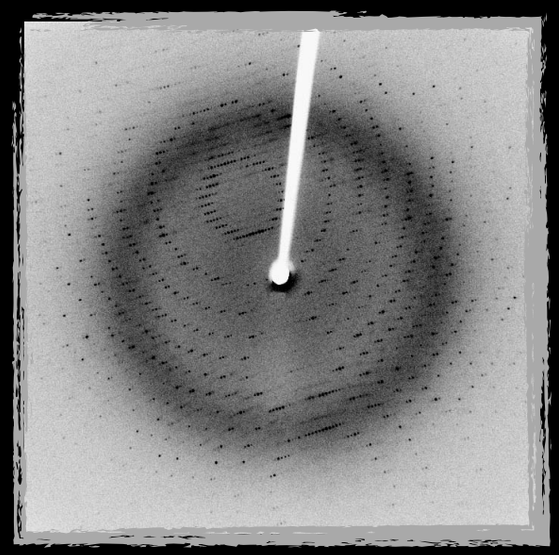
MOLTISSIMI ATOMI :
la fisica dello stato SOLIDO

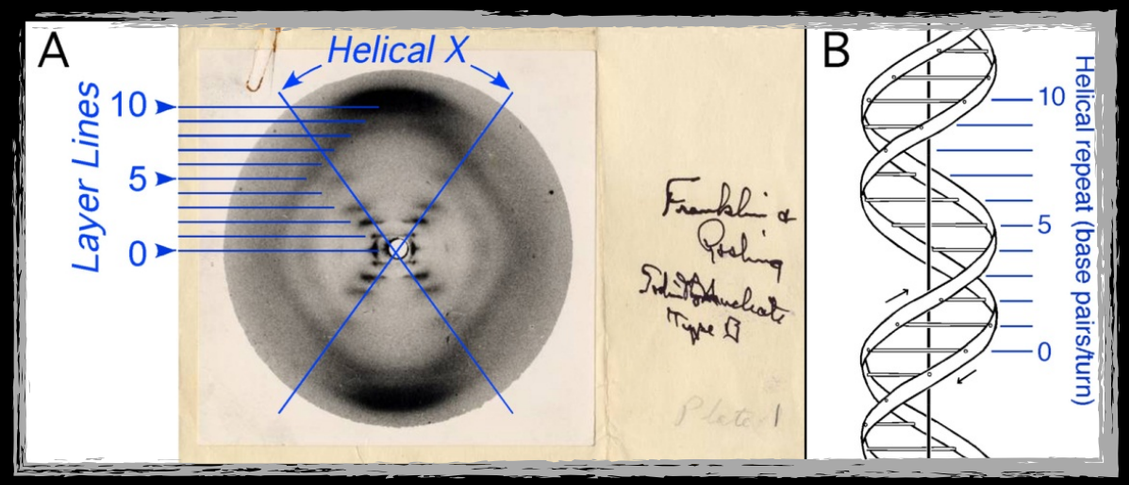
SOLIDI
- AMORFI
- CRISTALLINI
  - IONICI
  - COVALENTI
  - MOLECOLARI
  - METALLICI

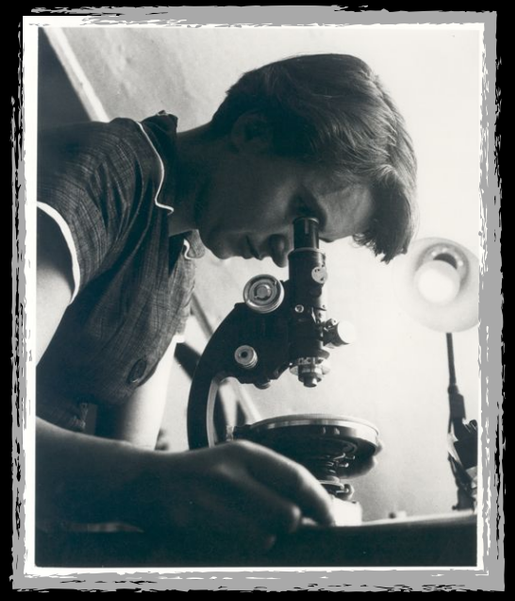
c'è anche la fisica dei fluidi

I reticoli cristallini e i raggi X

[difrattometria atomica]



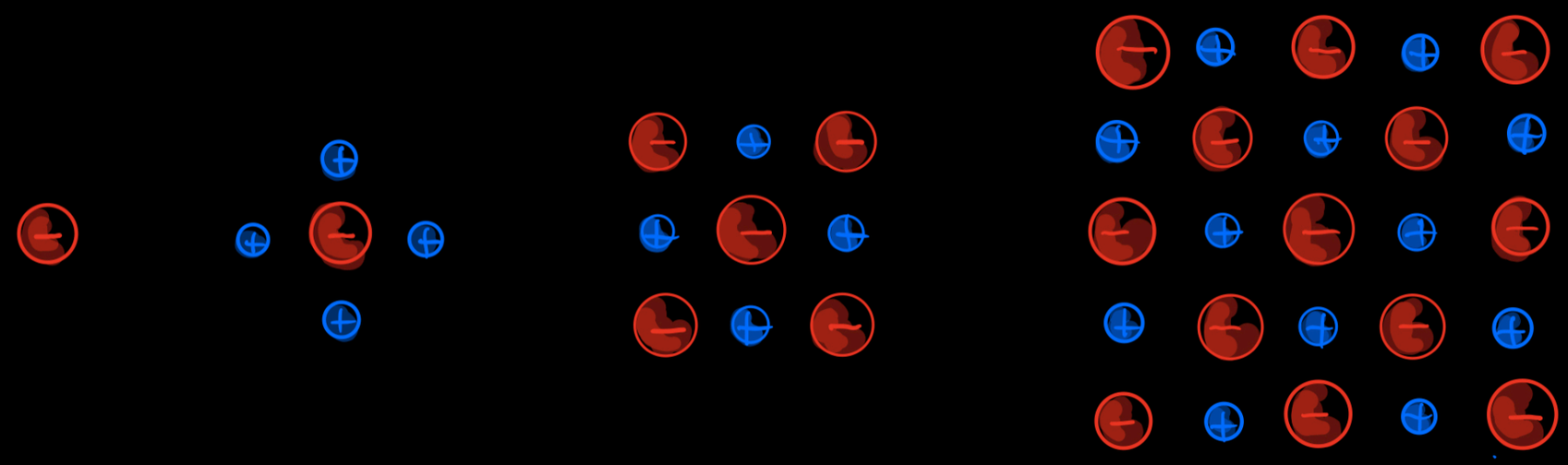




R. Franklin

Cristalli Ionici

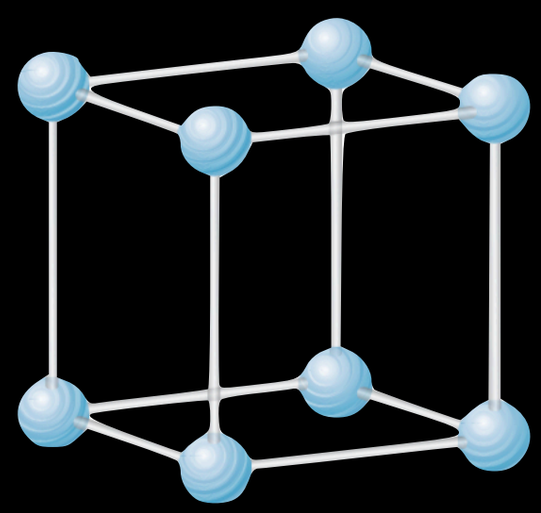
regolarità e meccanica quantistica



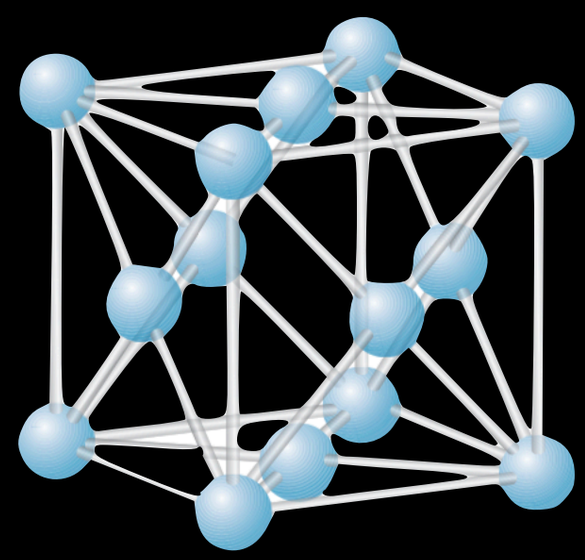
Cristalli Ionici

regolarità e meccanica quantistica

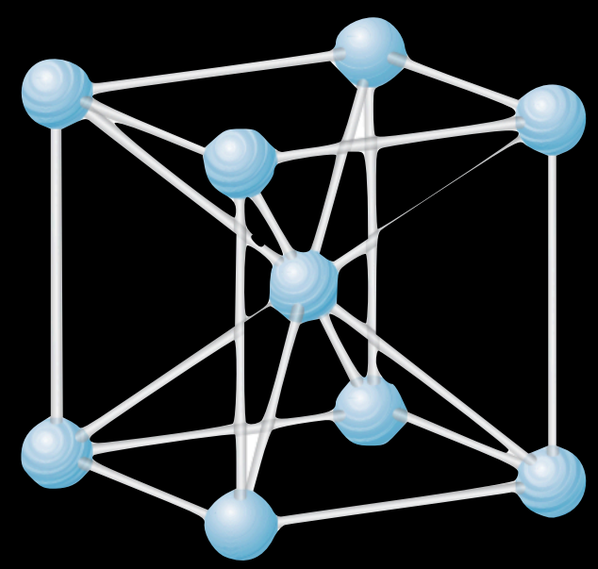
geometrie



Cubica Semplice



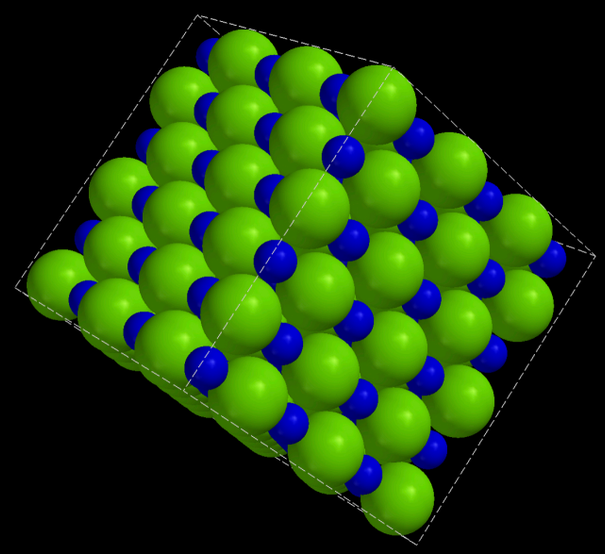
cubica facce centrate



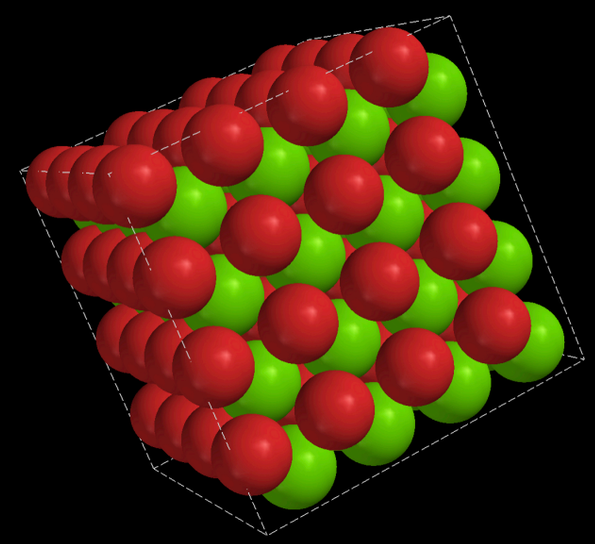
cubica corpo centrato

Cristalli Ionici

regolarità e meccanica quantistica



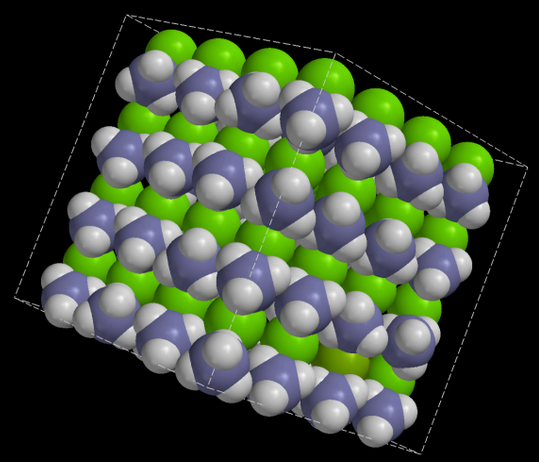
NaCl
f.c.



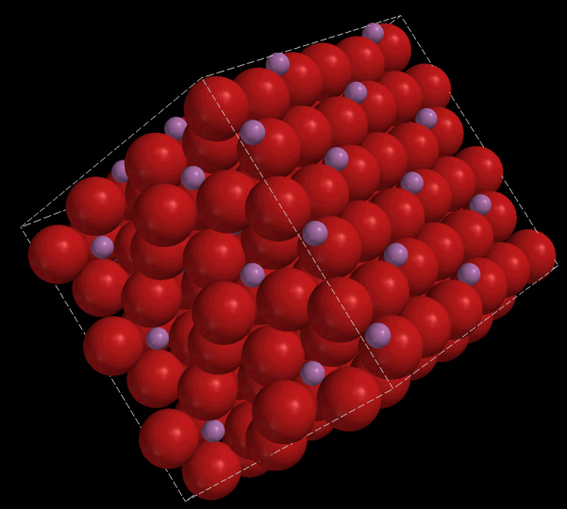
CsCl
c.c.

Cristalli Ionici

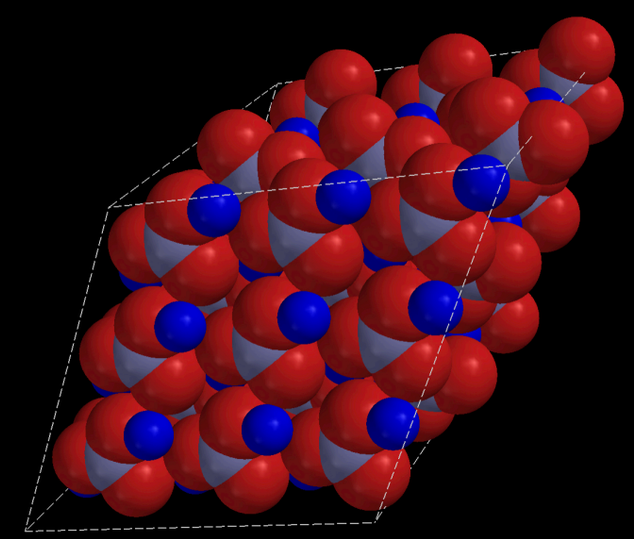
regolarità e meccanica quantistica



NH_4Cl



Al_2O_3



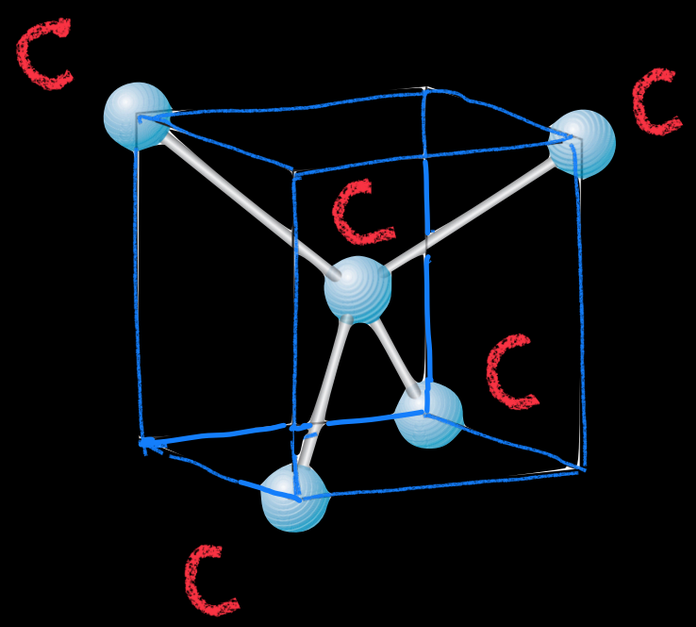
$NaNO_3$

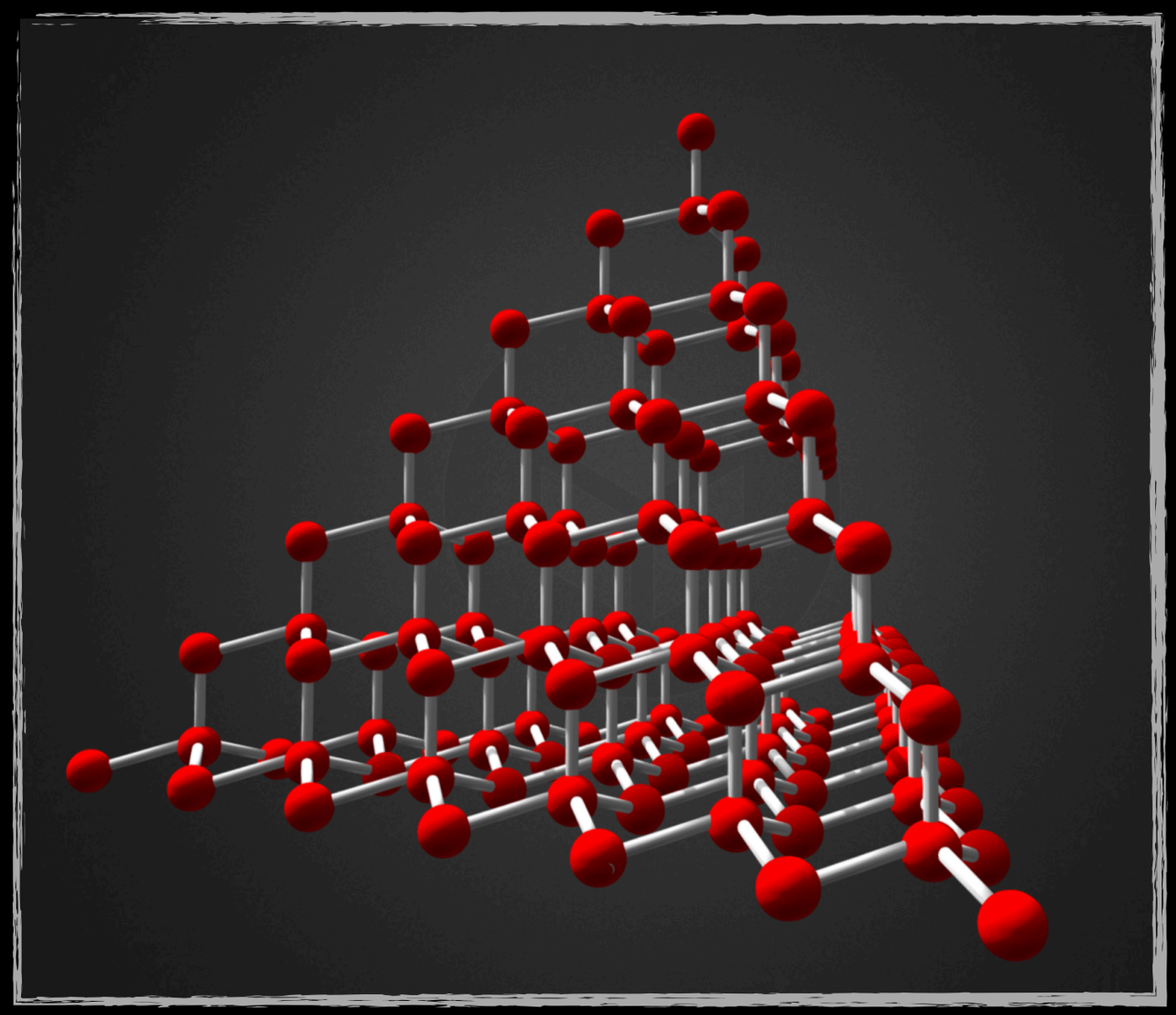
Cristalli Ionici

regolarità e meccanica quantistica

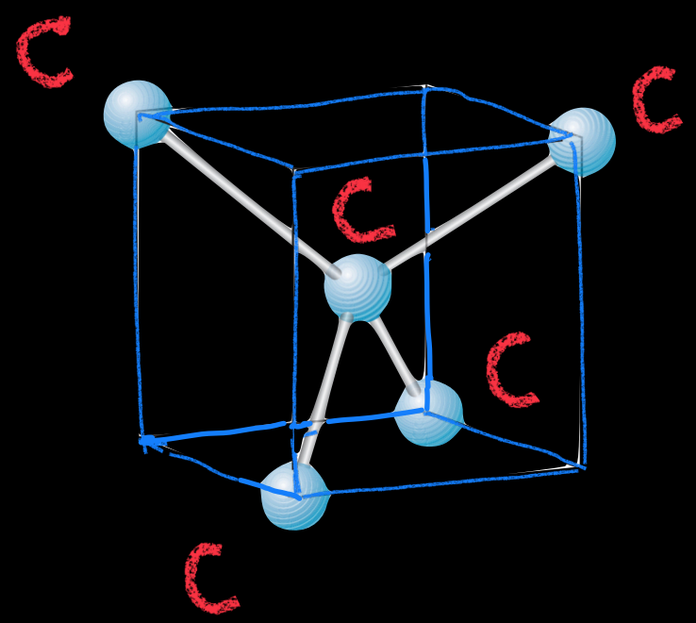
durezza meccanica
bassa conducibilità
alta temperatura di fusione
trasparenza alla luce
opacità all'infrarosso
solubilità polare

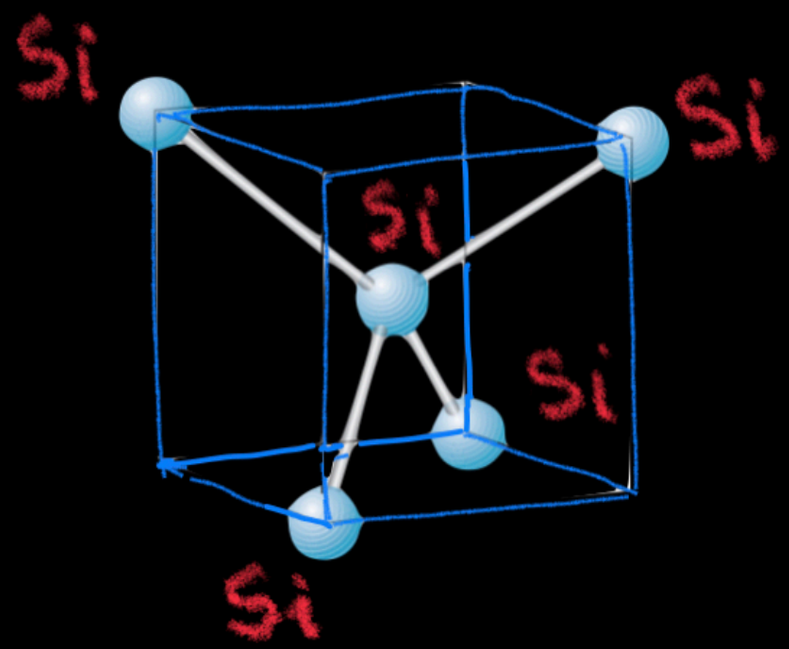
Cristalli Covalenti





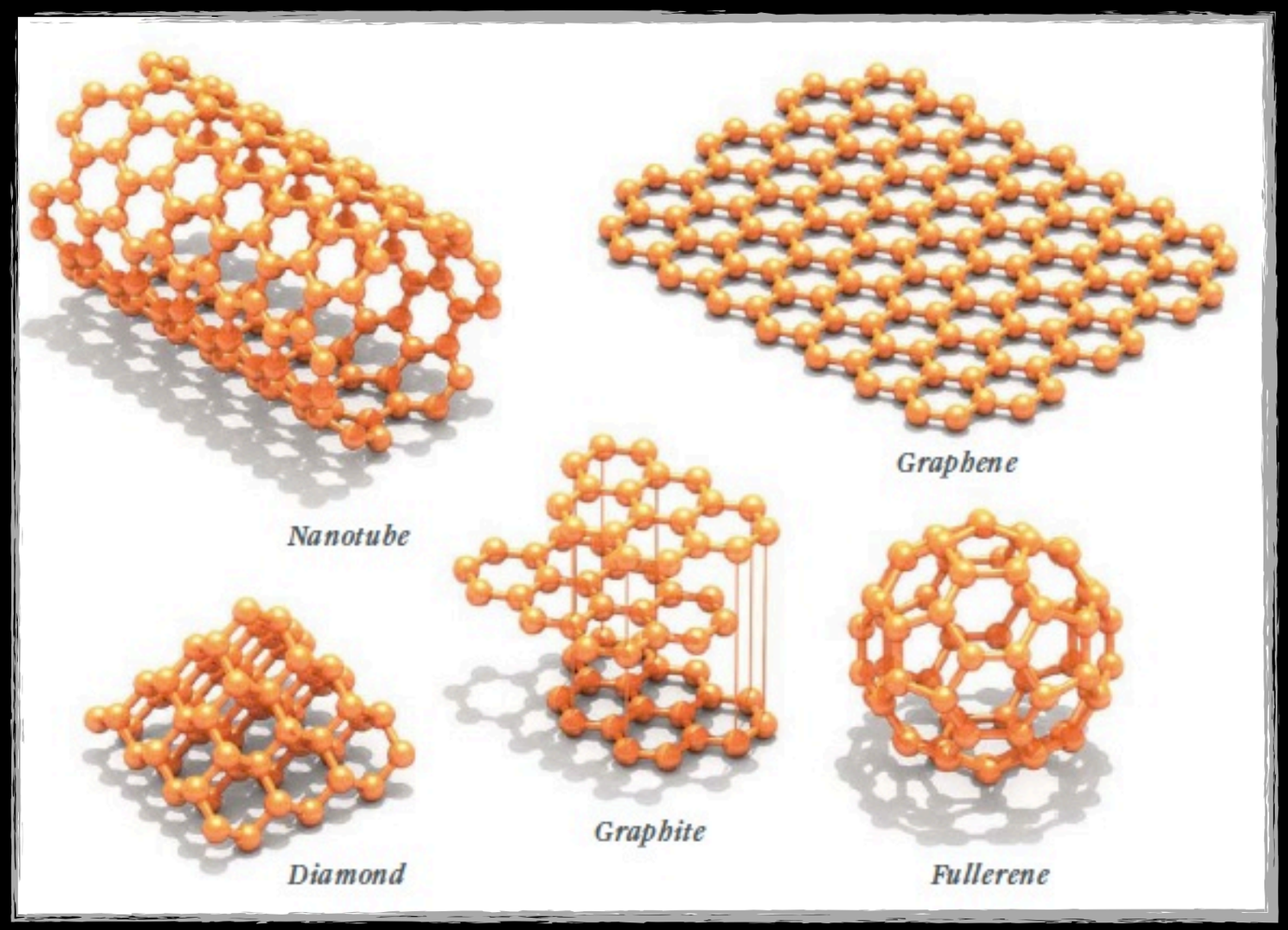
Cristalli Covalenti



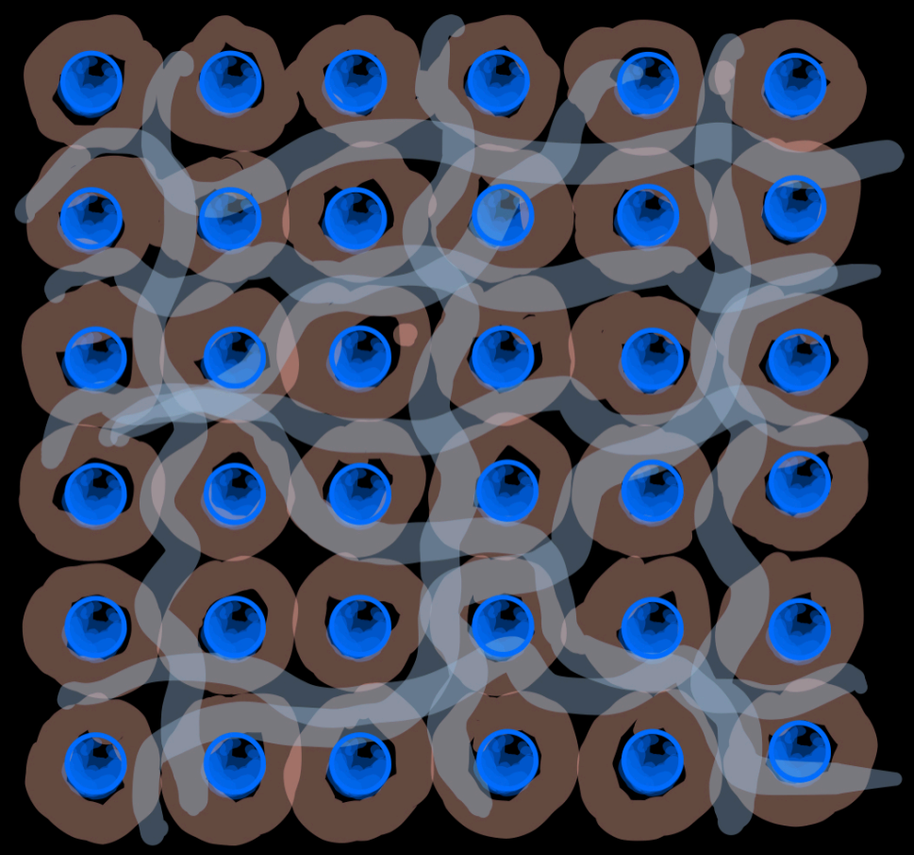


Cristalli COVALENTI

nano-strutture



Solidi Metallici

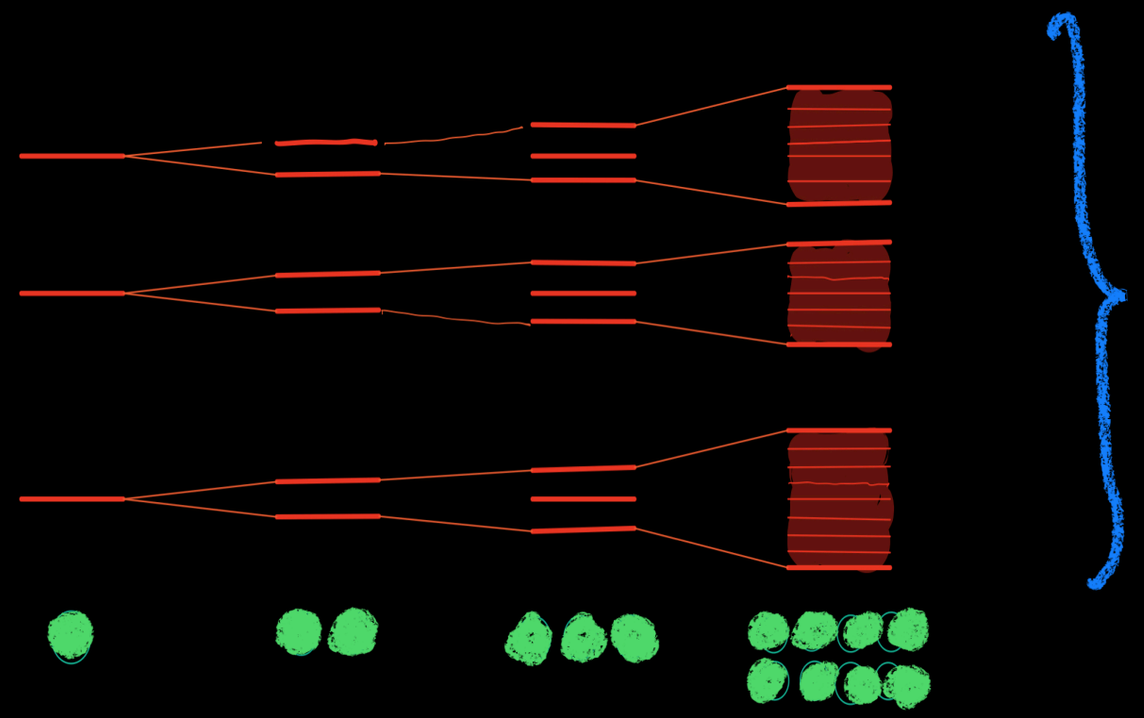


Il «mare» di Fermi

Solidi Metallici

teoria delle bande

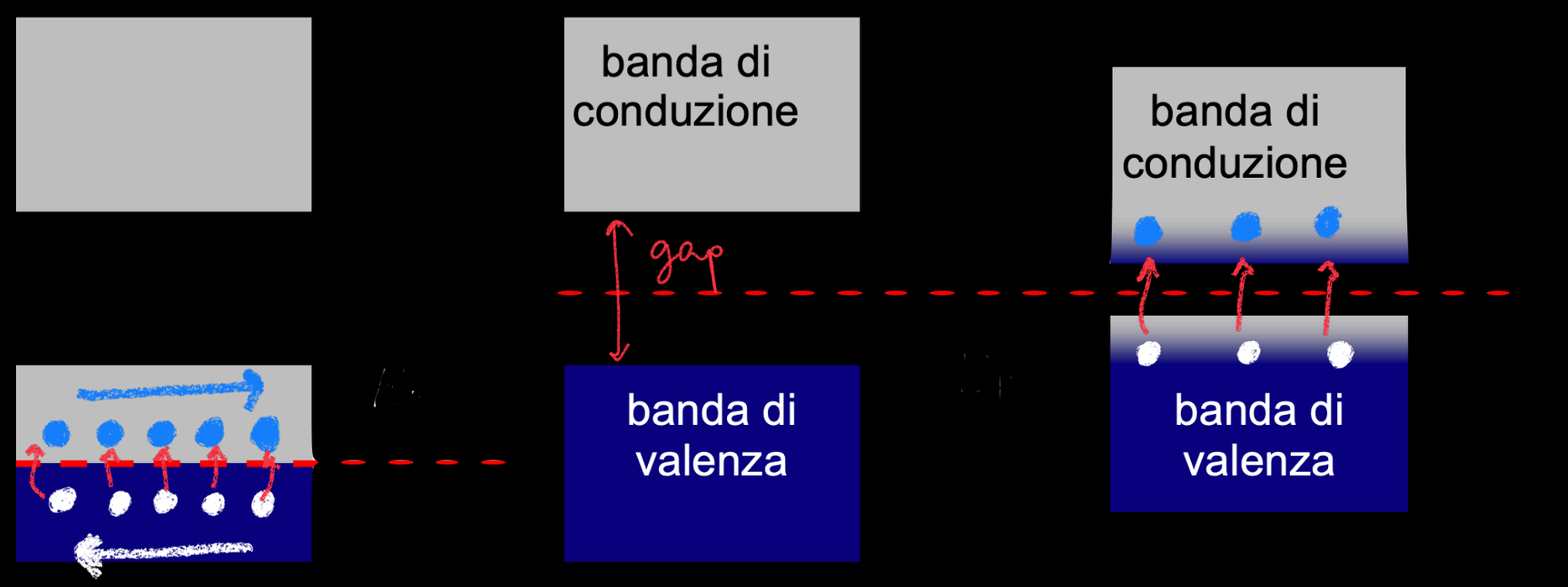
livelli atomici



bande energetiche

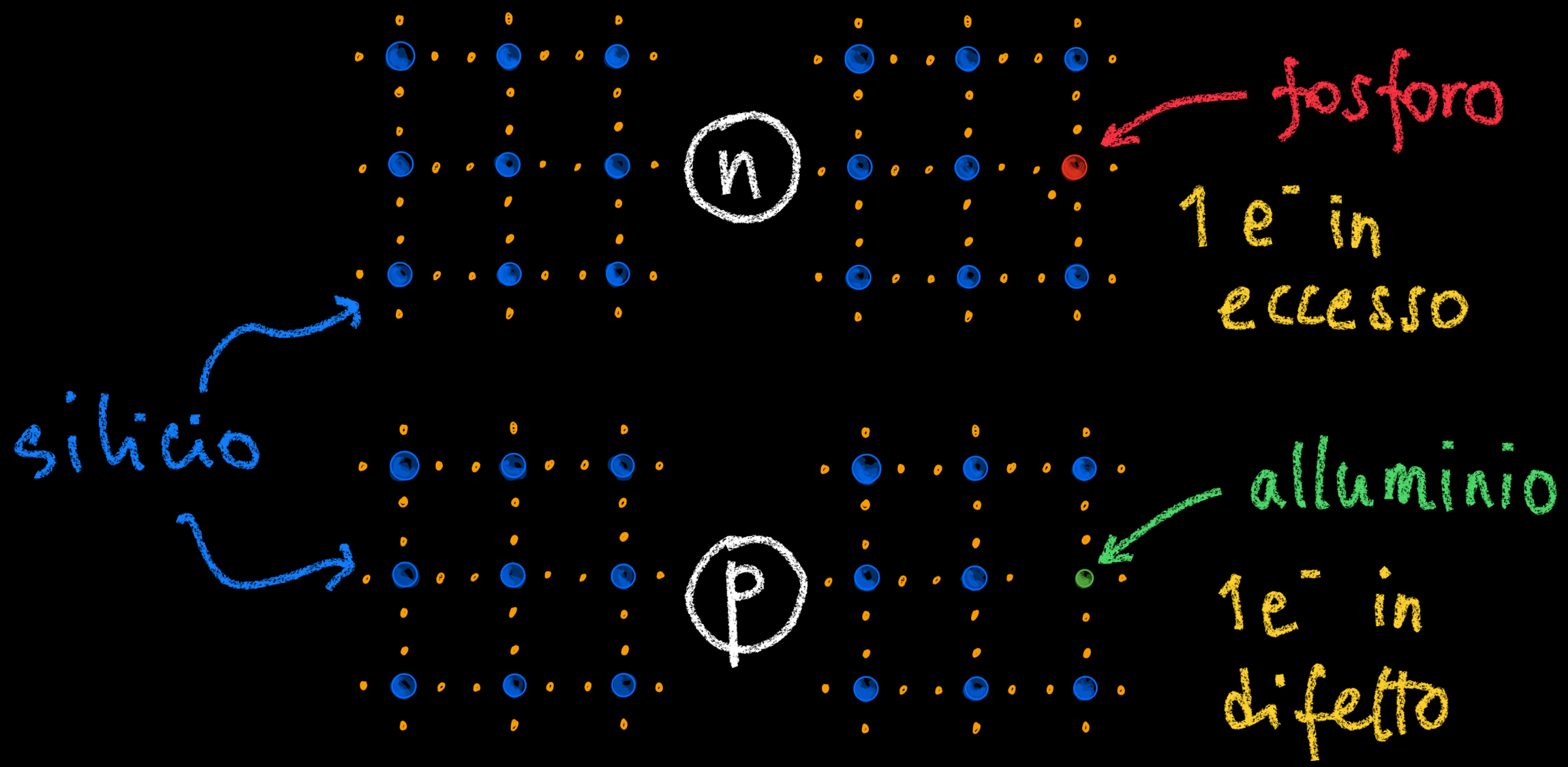
Solidi Metallici

teoria delle bande

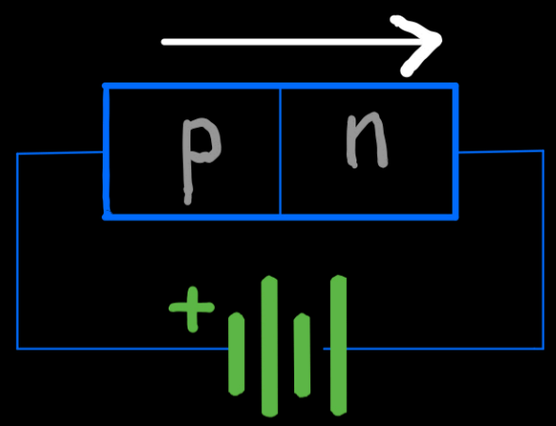


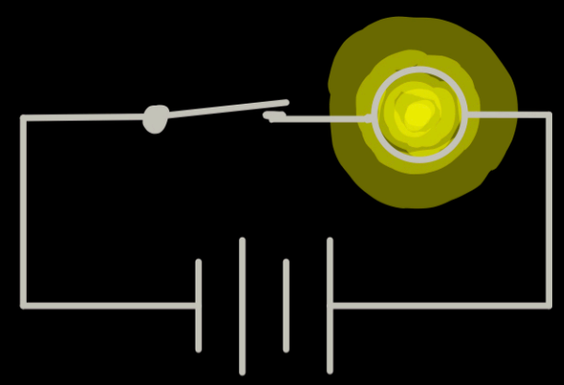
Conduttore Isolante Semiconduttore

Semiconduttori { intrinseci / drogati



giunzione p-n: il diodo





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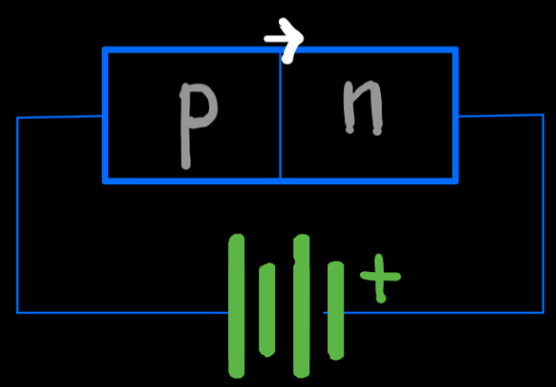
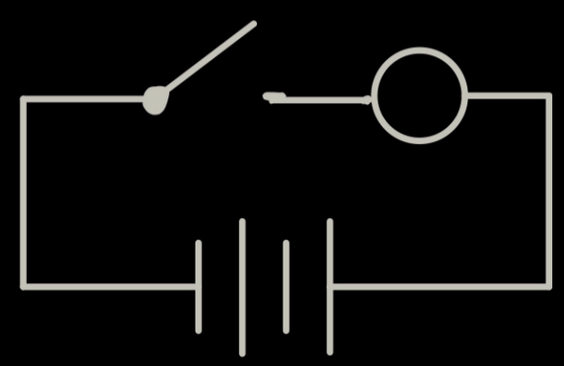
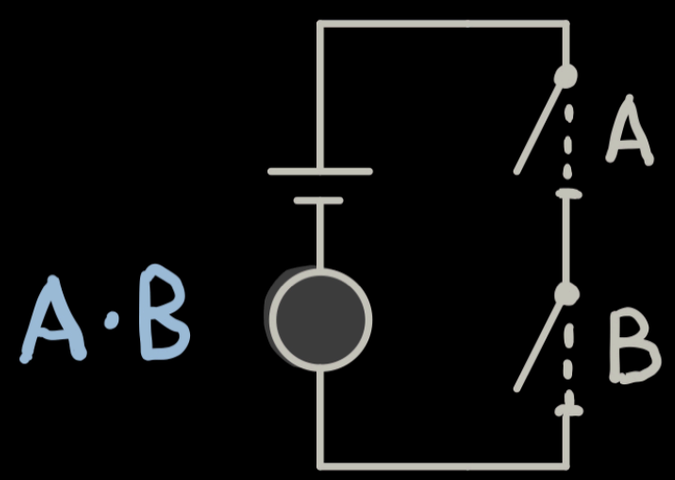


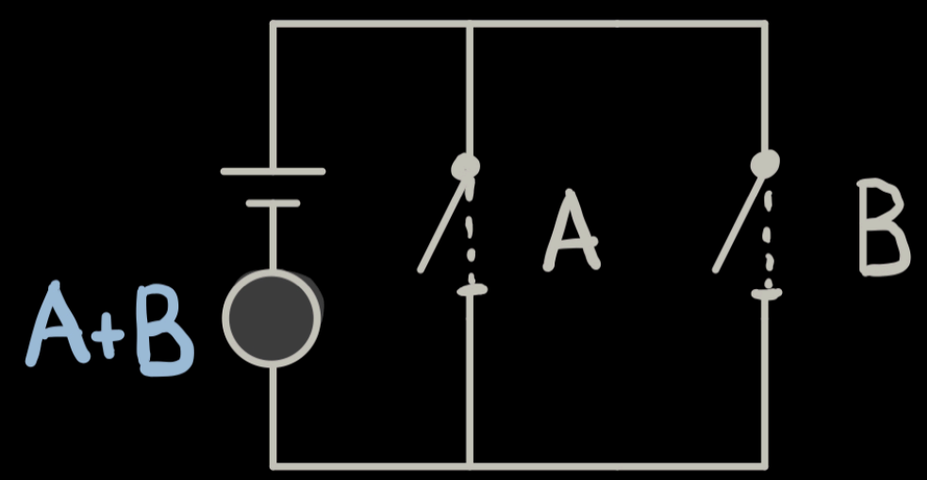


0 F

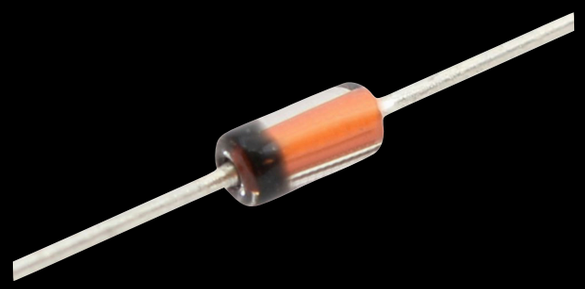
giunzione p-n: il diodo

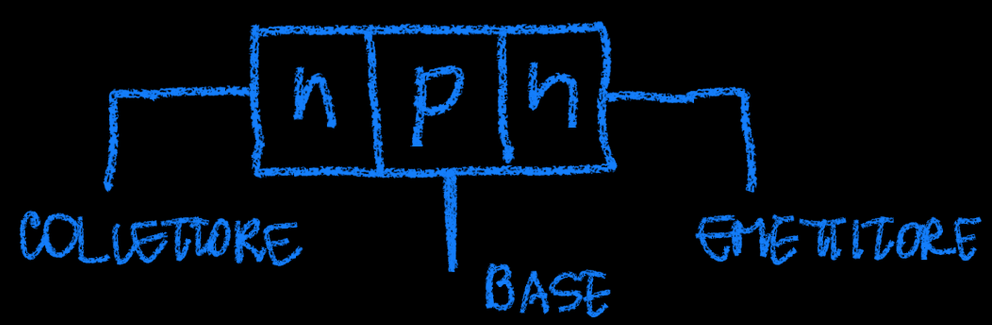
e l'algebra booleana





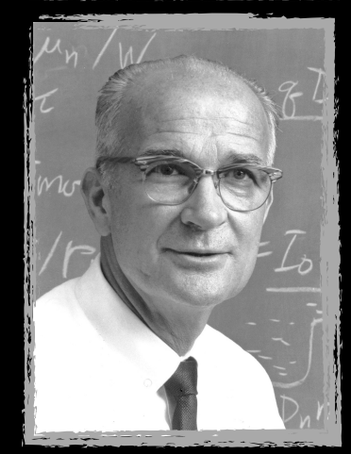
diodi & transistor



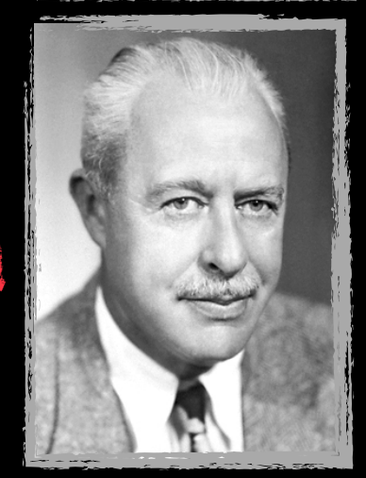


Bardeen

Shockley

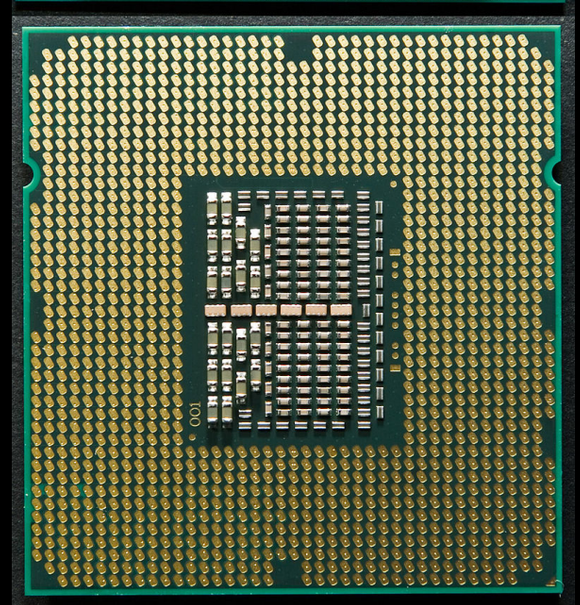


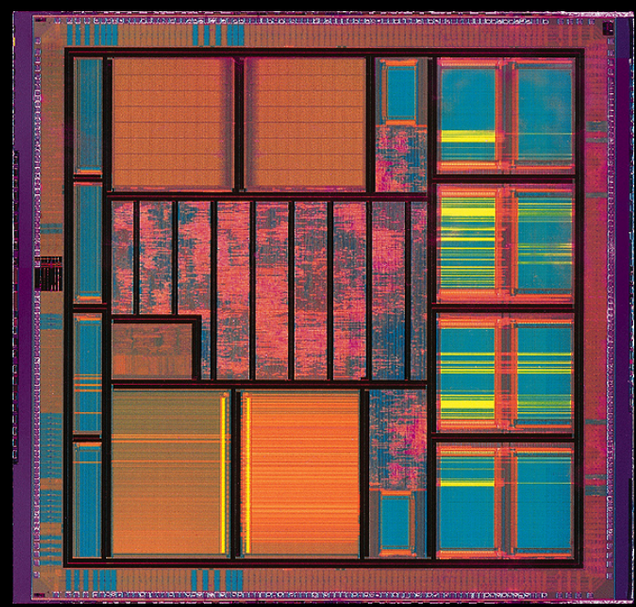
Brattain



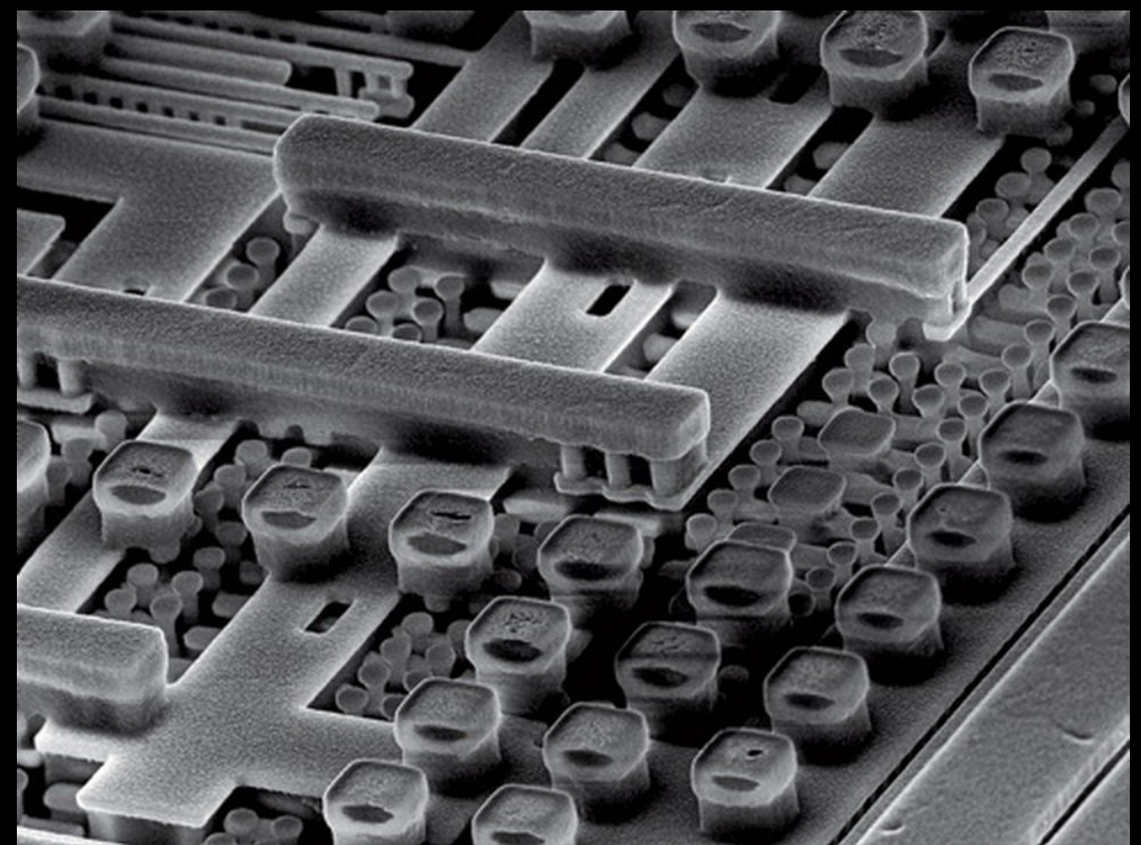
N. 1956

Very Large Scale Integration



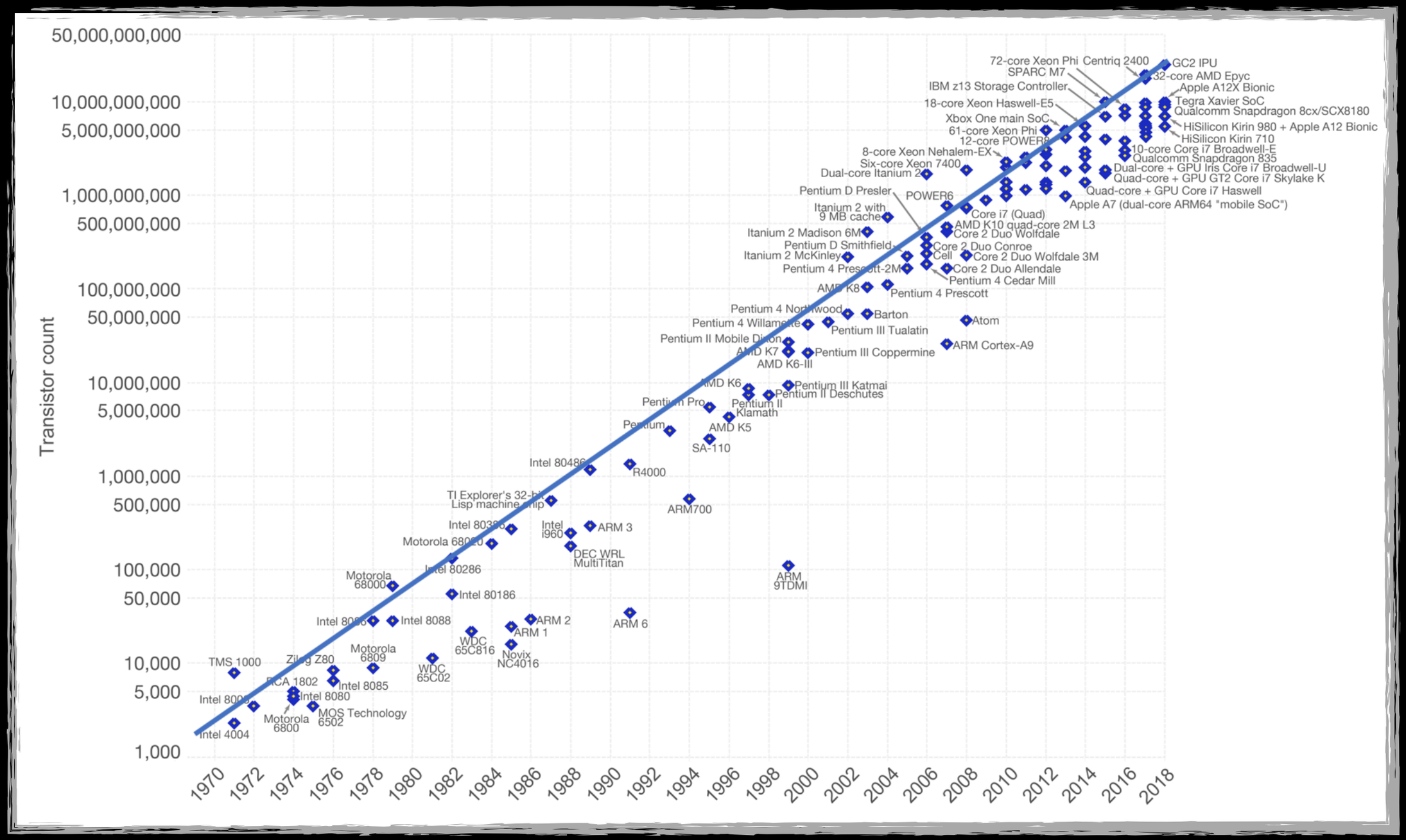


50.000.000.000
transistor

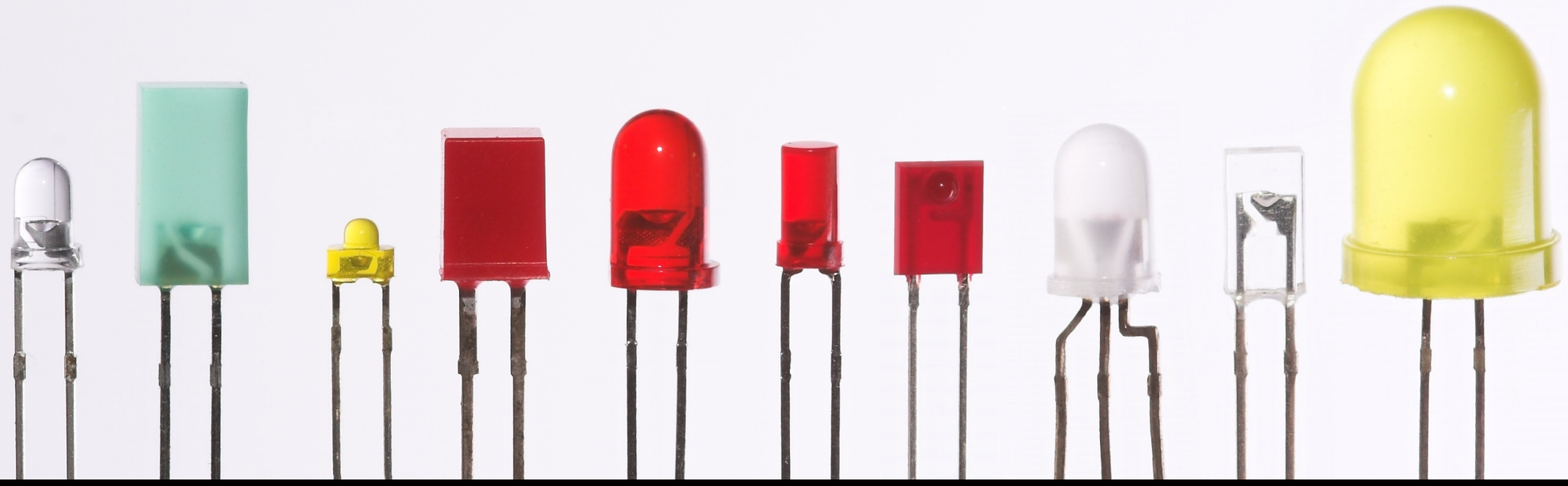


~30 nm

Legge di Moore

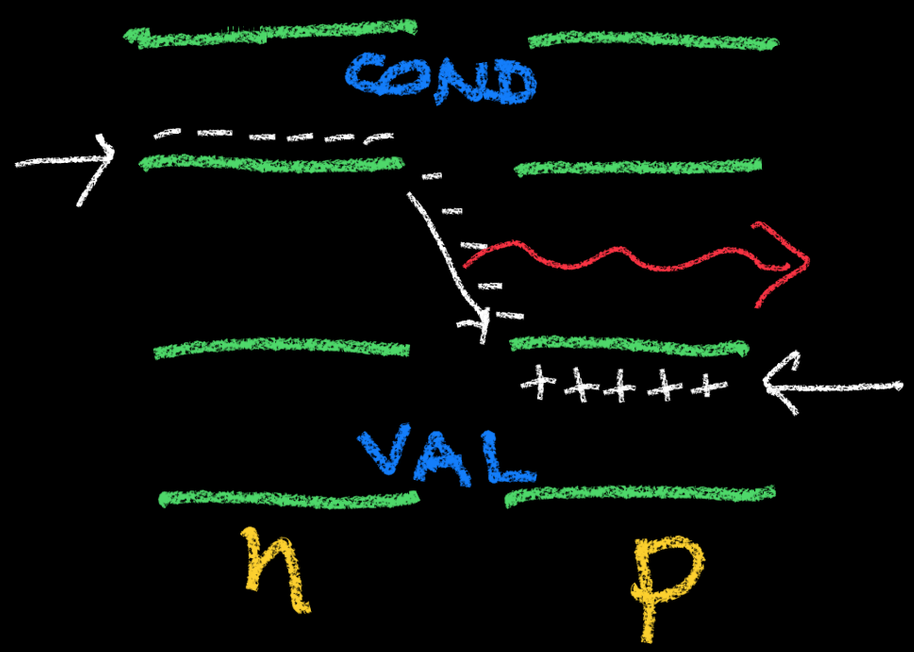


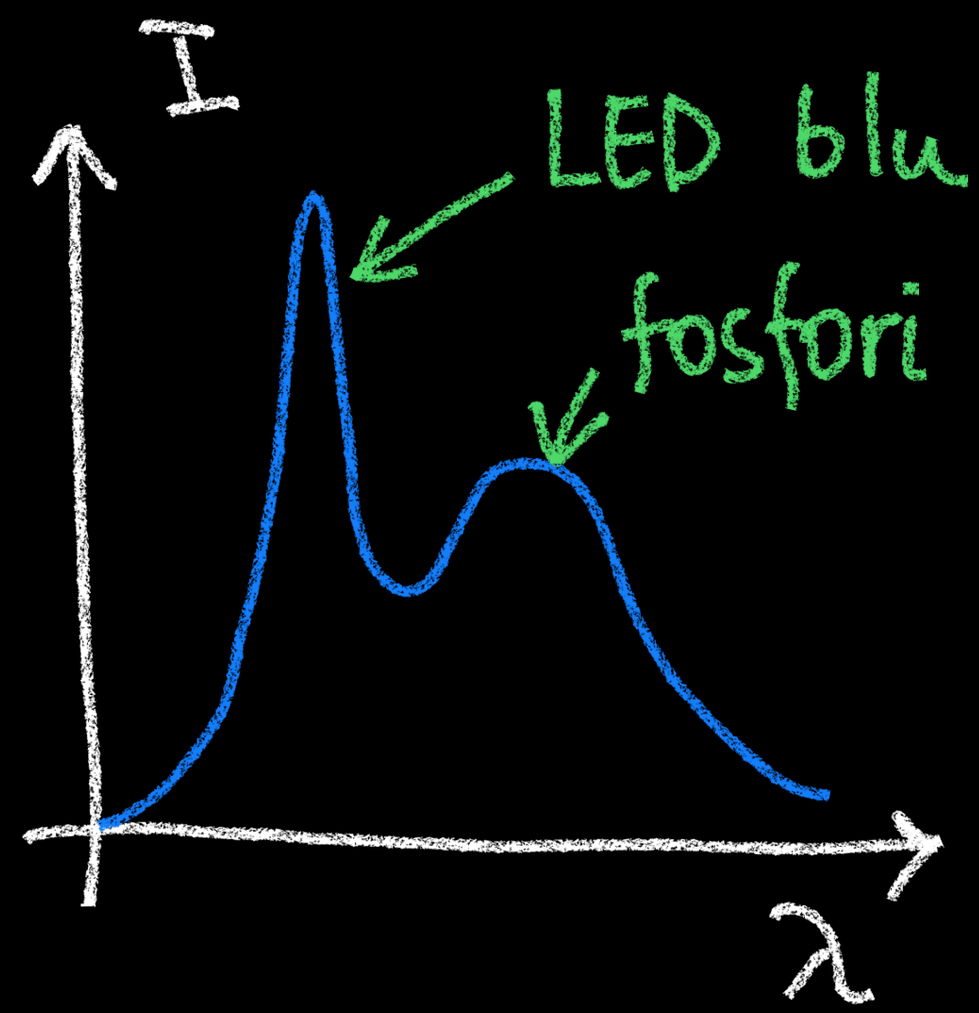
Light Emitting Diode : LED



Light Emitting Diode : LED

N. 2014





... e molto altro ...