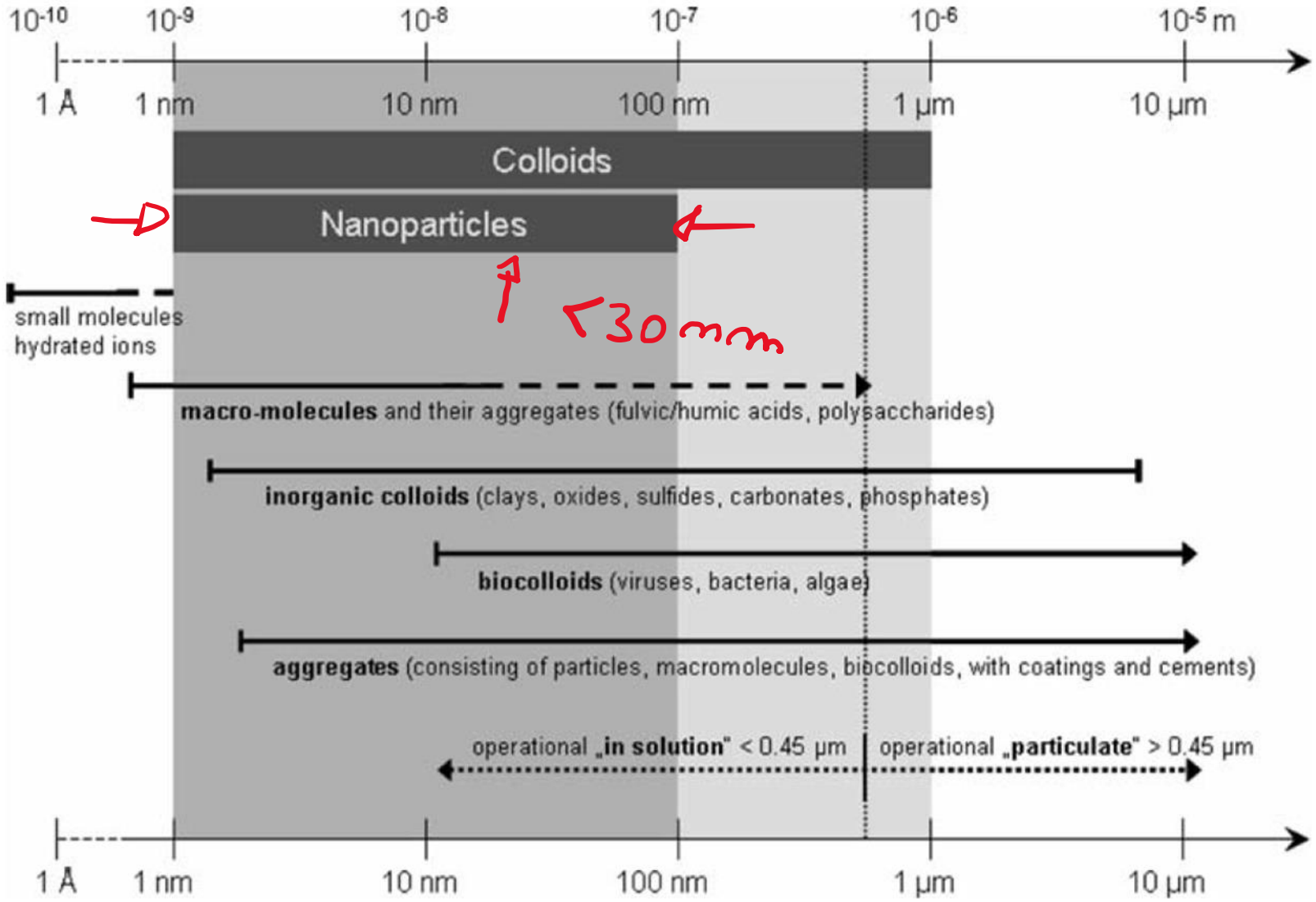
CEN0370

Propriedades dos Nanomateriais

- ❑ Interação com a luz
- ❑ Solubilidade
- ❑ Propriedades térmicas e mecânicas
- ❑ Propriedades elétricas e magnéticas
- ❑ Reatividade química

Fig. 1 Size domains and typical representatives of natural colloids and nanoparticles. Operationally defined cut-off is given for filtration at 0.45 µm



Propriedades dependentes do tamanho

PROPRIEDADES DE SOLUBILIDADE / DISSOLUÇÃO

POR QUE AS PROPRIEDADES APRESENTAM DEPENDÊNCIA DO TAMANHO

- ÁREA DE SUPERFÍCIE
- K_{PS} CONSTANTE DO PRODUTO DE SOLUBILIDADE
- MOLHABILIDADE X ESTRUTURA DOS MATERIAIS

PROPRIEDADES TÉRMICAS

COMO O CALOR É CONDUZIDO E ARMAZENADO NAS MATERIAS?

i) CONDUTIVIDADE TÉRMICA

ii) CALOR ESPECÍFICO

iii) PONTO DE FUSÃO

ESSAS PROPRIEDADES TAMBÉM SÃO DEPENDENTES DO TAMANHO

INTERAÇÃO COM LUZ

ABSORÇÃO

EMISSÃO

REFLEXÃO/DIFRAÇÃO DA LUZ

DEPENDEM DO TAMANHO DAS PARTÍCULAS,

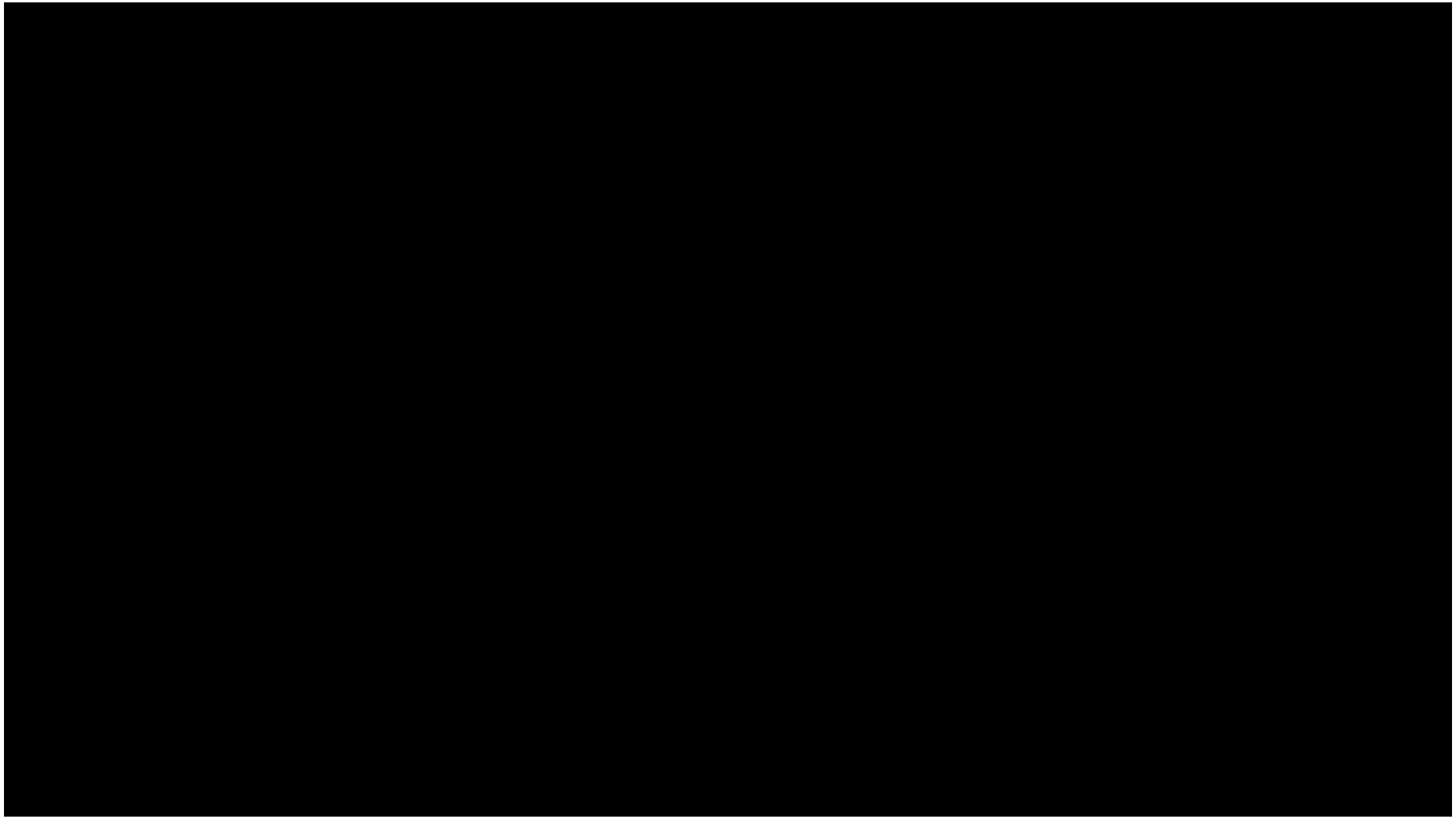
E DA ESTRUTURA

REATIVIDADE QUÍMICA

→ REAÇÕES QUE SE PASSAM NA SUPERFÍCIE DOS MATERIAIS

Nanomateriais e interação com a luz

A cor do camaleão

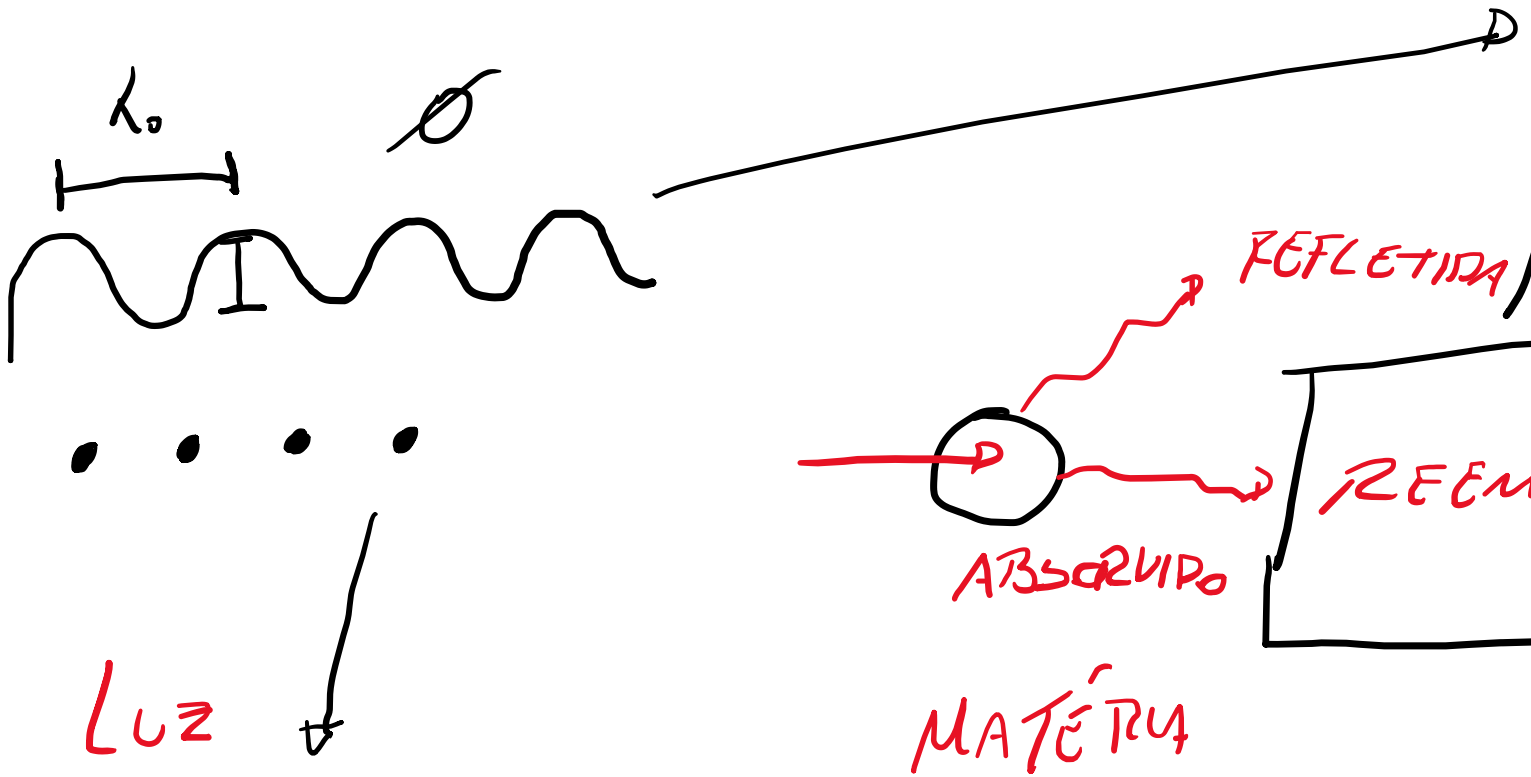


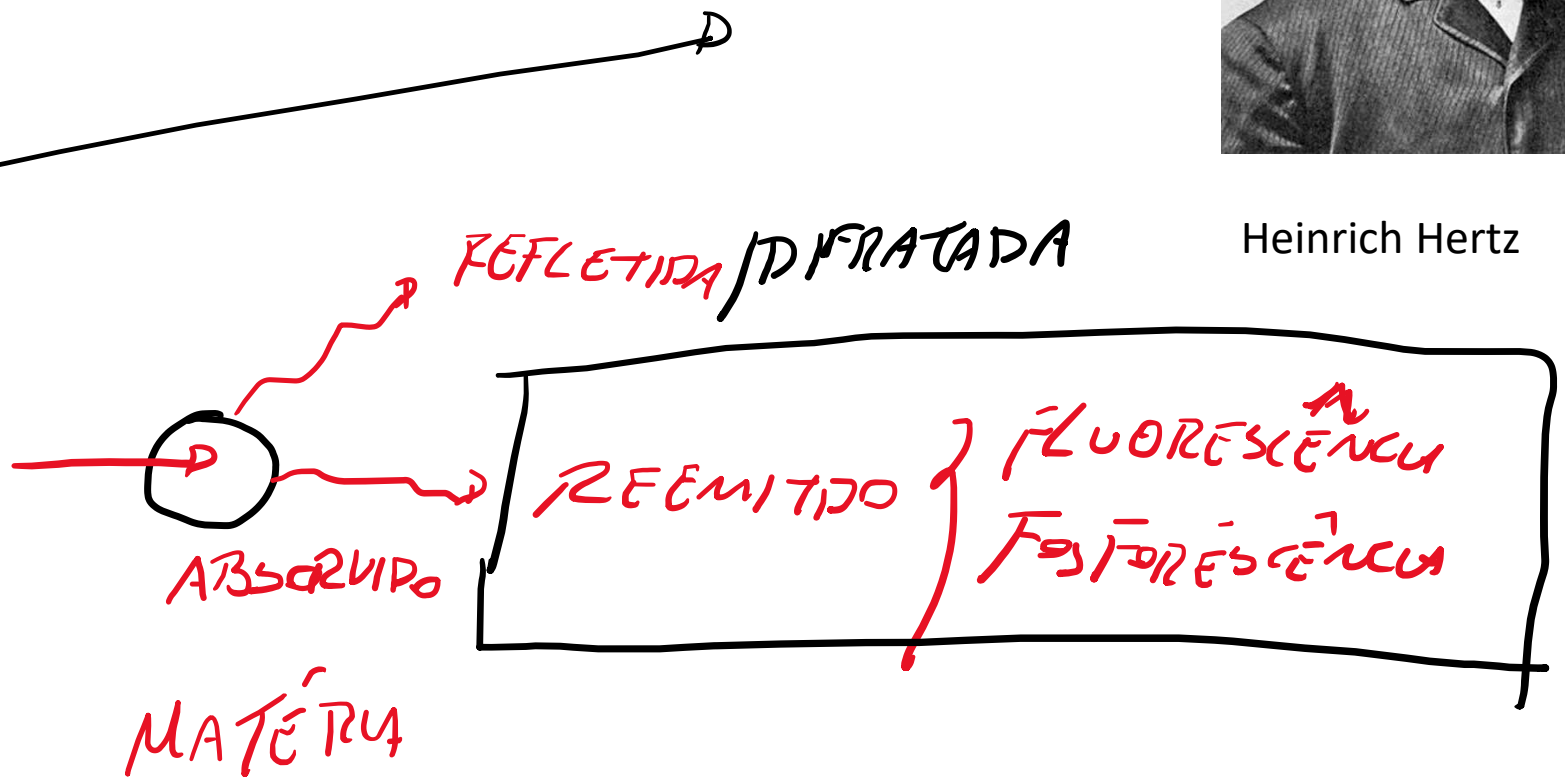
POR QUÉ ISSO OCORRE?

i) PROTEÍNA?

TEMPERATURA?

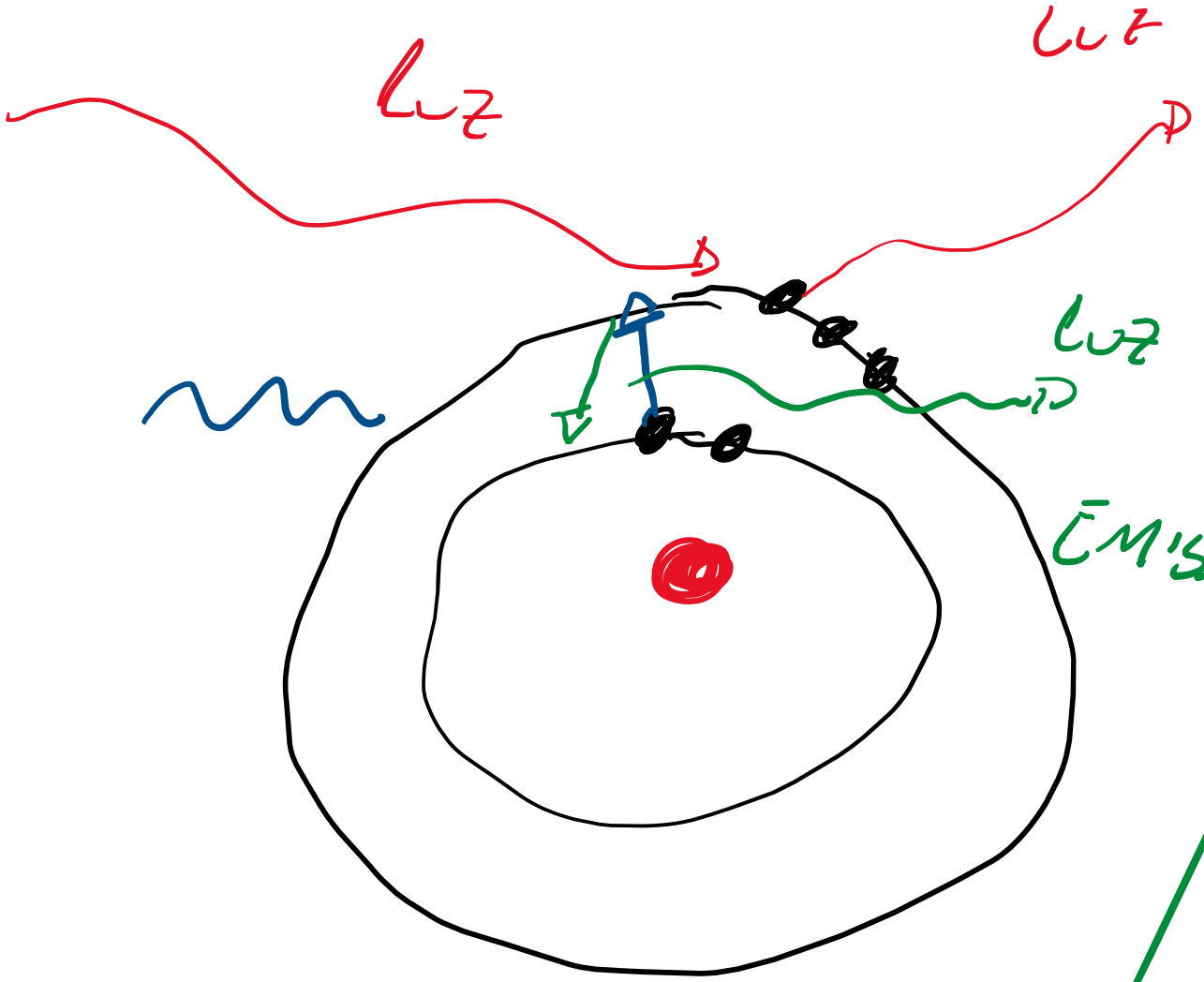
Heinrich Hertz





EINSTEIN

EFEITO FOTOELÉTRICO



REFLEXÃO / MUDANÇA DE DIREÇÃO

MUDANÇA DE FASE

MESMA ENERGIA

EMISSÃO

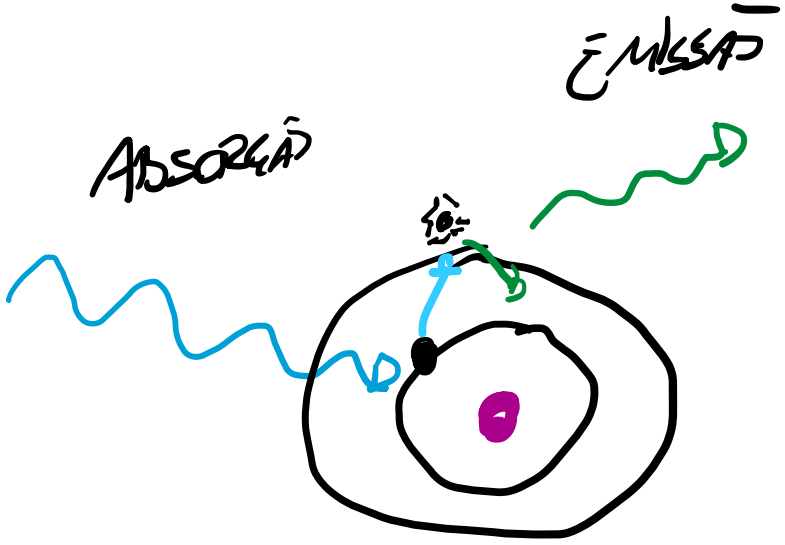
TRANSIÇÃO ELETRÔNICA

MUDANÇA DE DIREÇÃO

MUDANÇA DE ENERGIA

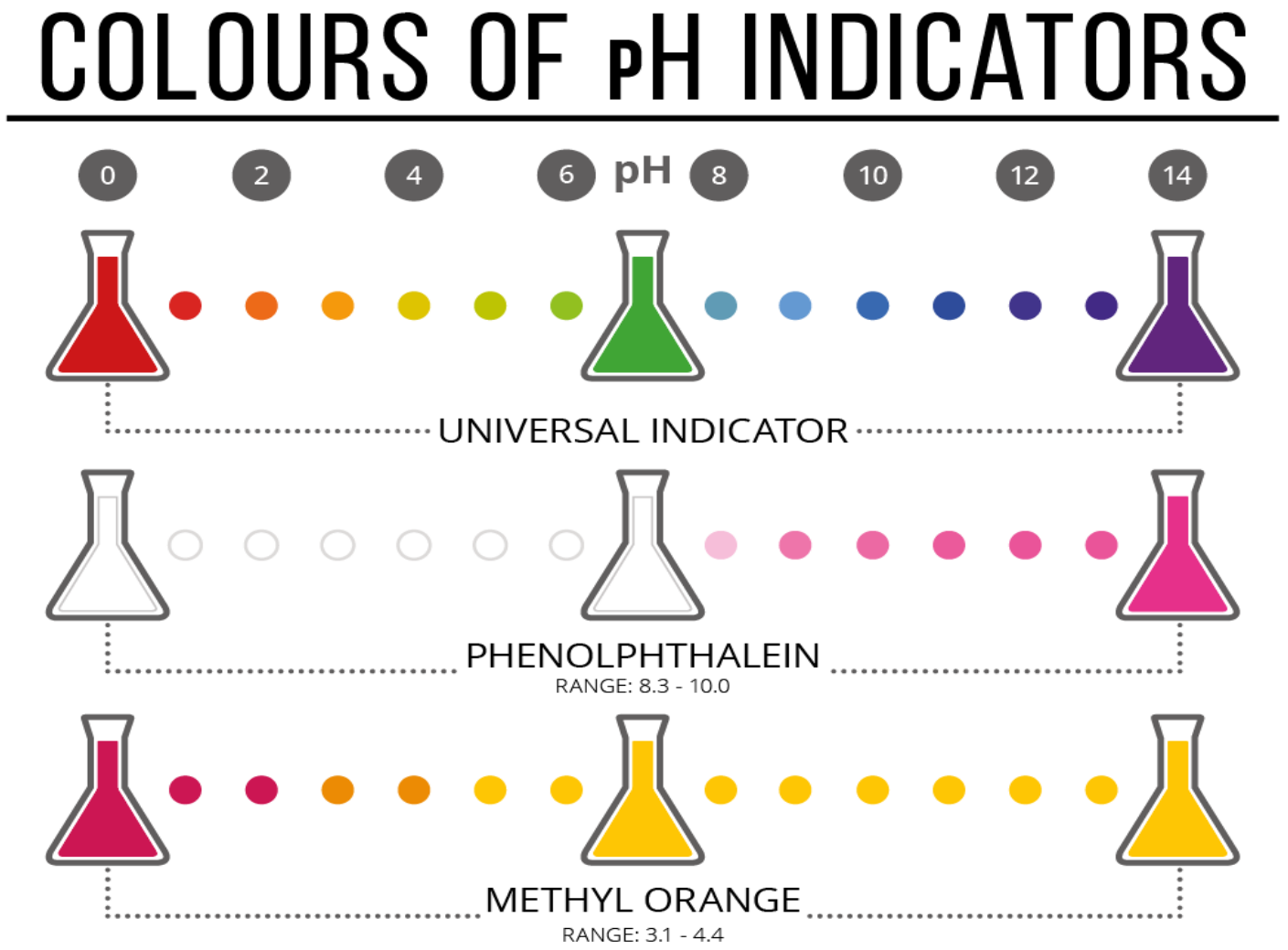
POR QUE A COR DO CAMALEÃO SE MODIFICA

i) CROMÓFOROS → Molécula que muda de cor em função de um estímulo | pH / temperatura

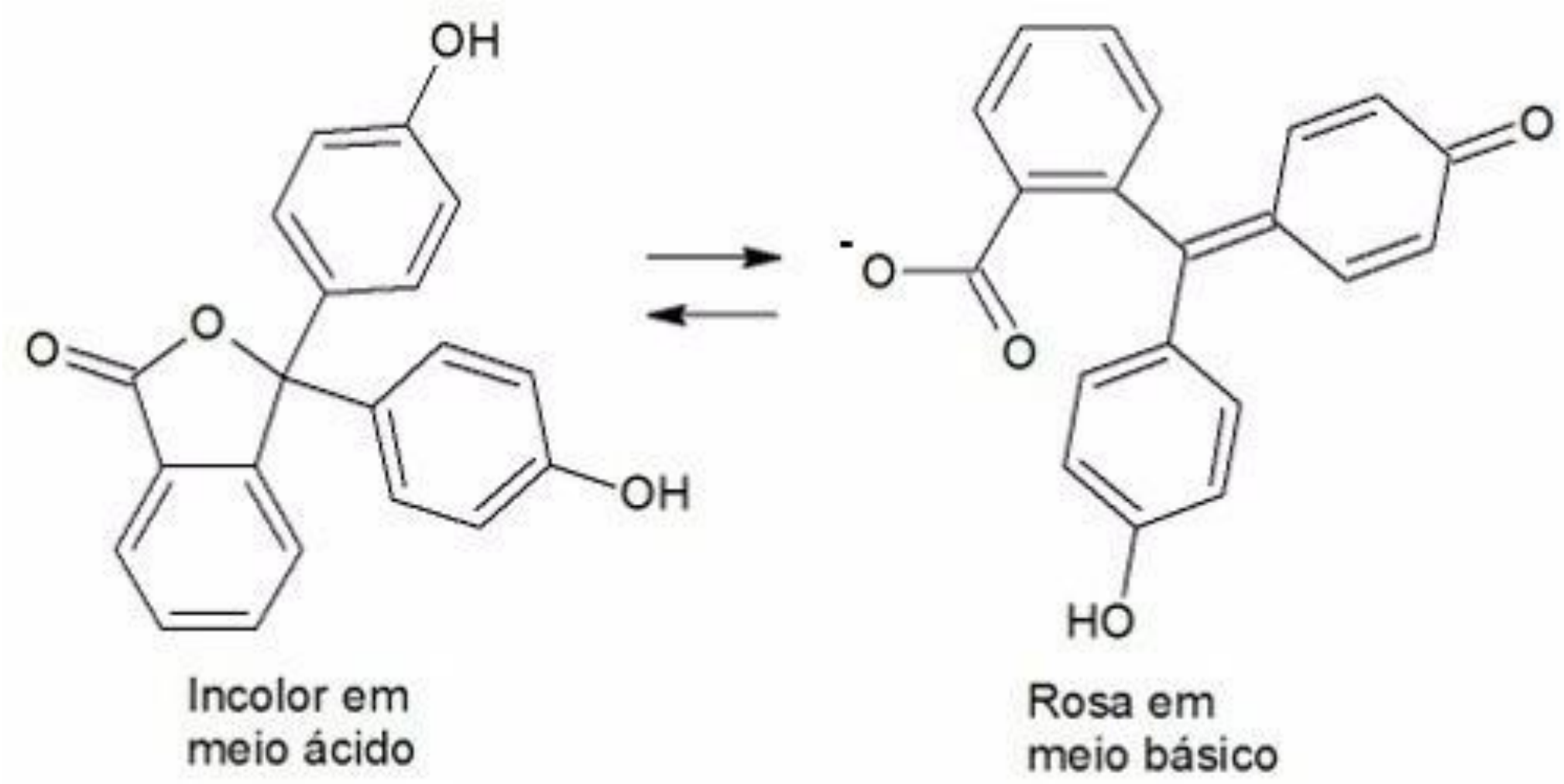


ii) O comprimento de onda que será absorvido e emitido depende da estrutura do material

http://i.ytimg.com/vi/rX-YiYHahoo/maxresdefault.jpg



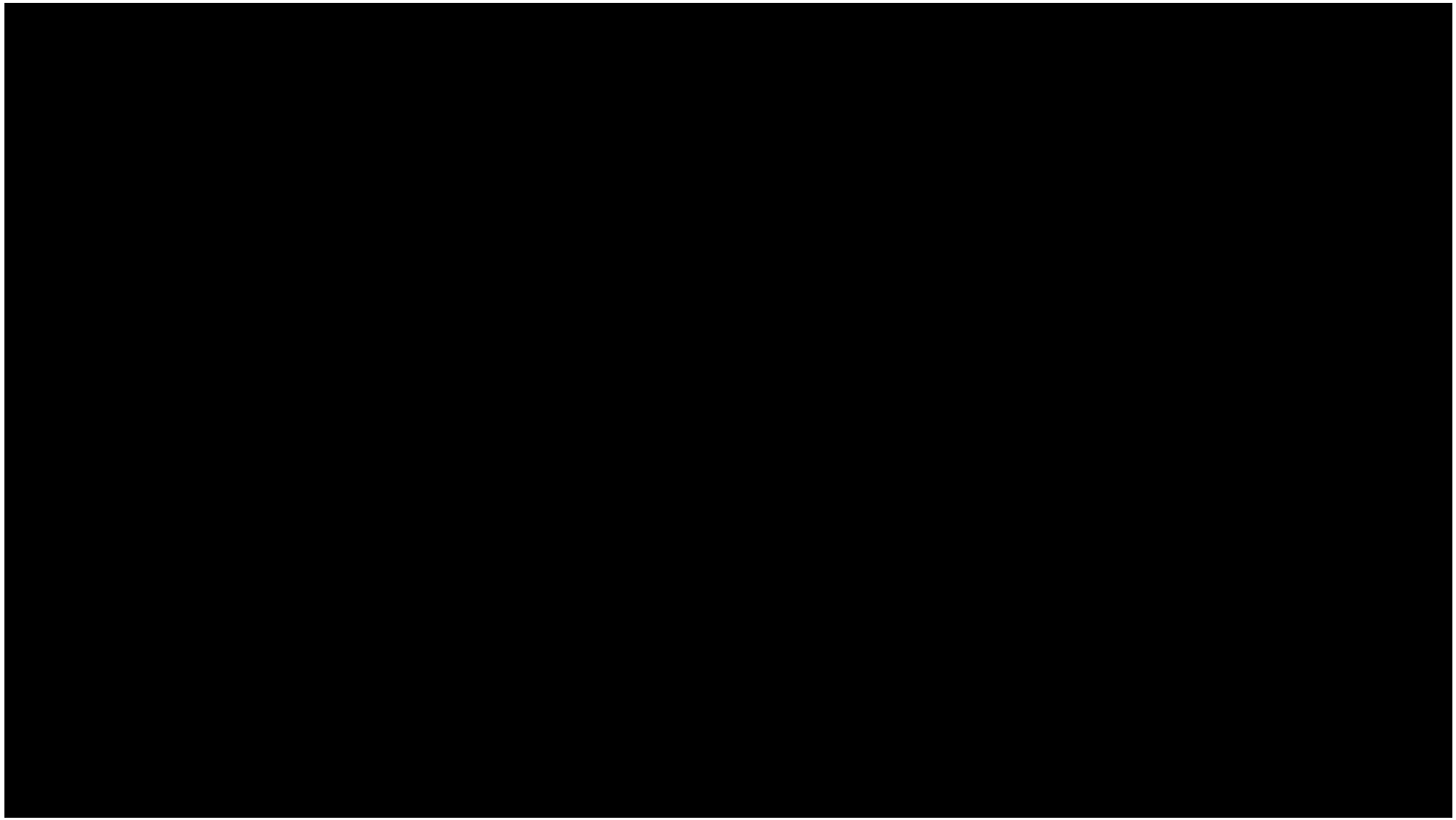
http://www.compoundchem.com/wp-content/uploads/2014/04/Colours-of-pH-Indicators-POST.png



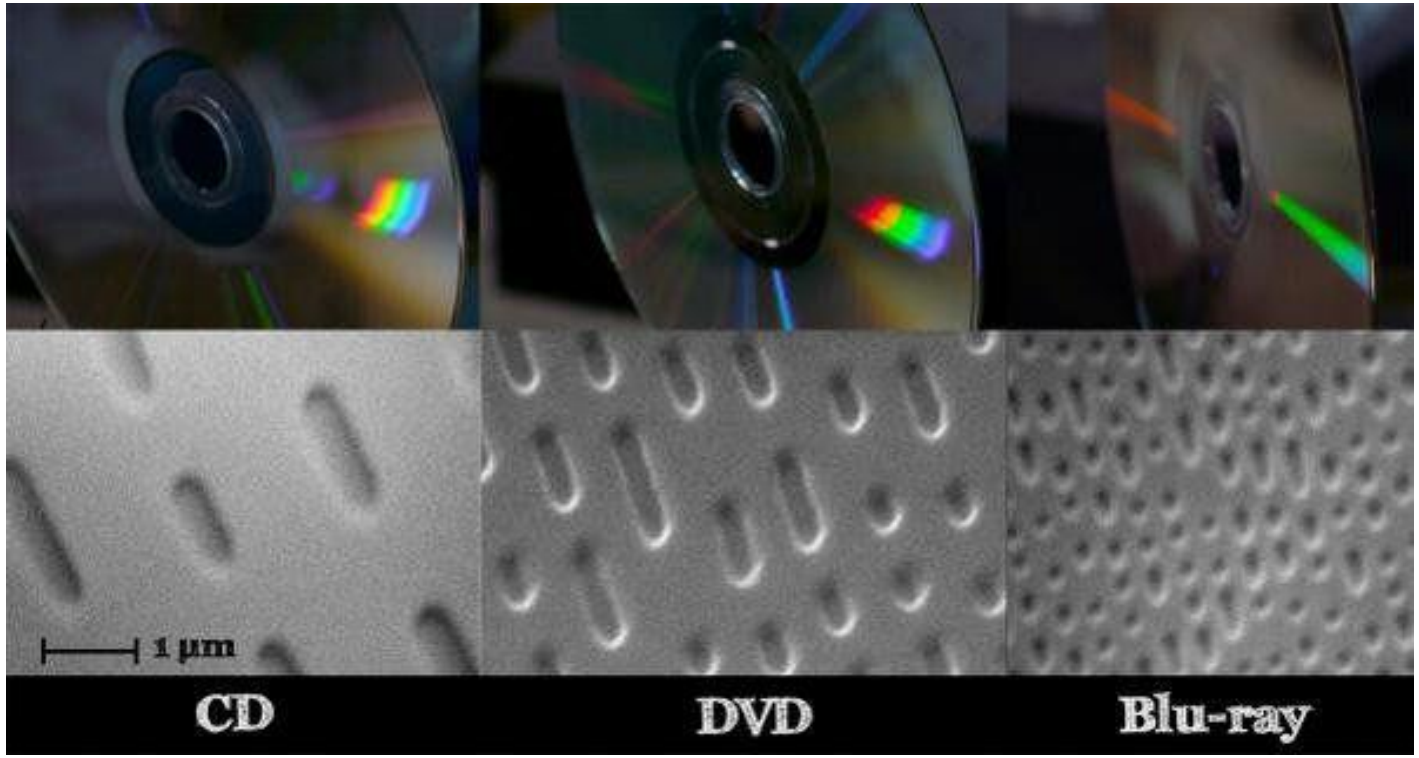
https://produto.mercadolivre.com.br/MLB-1190885988-fenolftaleina200ml-indicador-universal-ph-100-_JM

- Monitoramento da cor de uma única célula
- Estímulo: Variação da pressão osmótica

Nature Commun. 6, 6368 (2015)

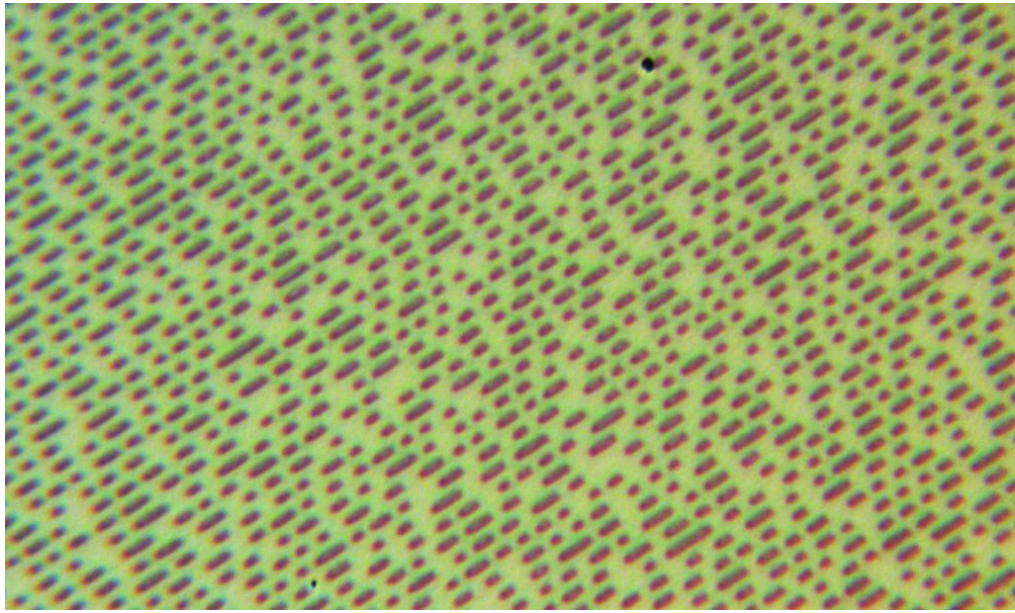


https://www.amazon.com/Rainbow-Cutout-Party-Accessory-count/dp/B0019I1C9U

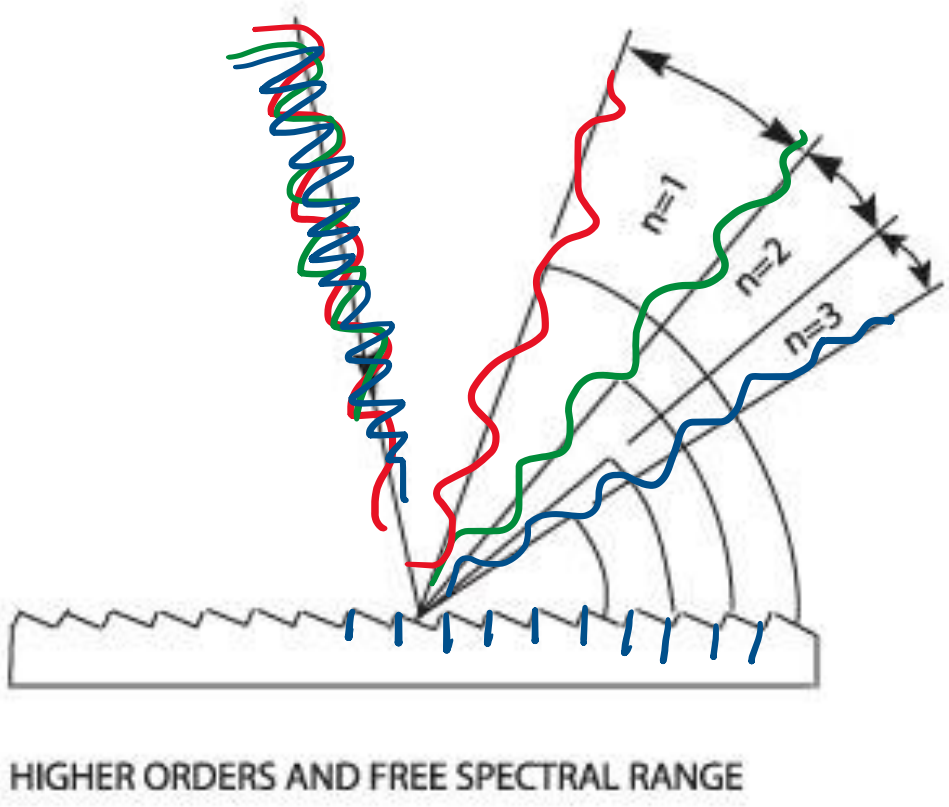


https://br.pinterest.com/pin/8122664827736136 20/

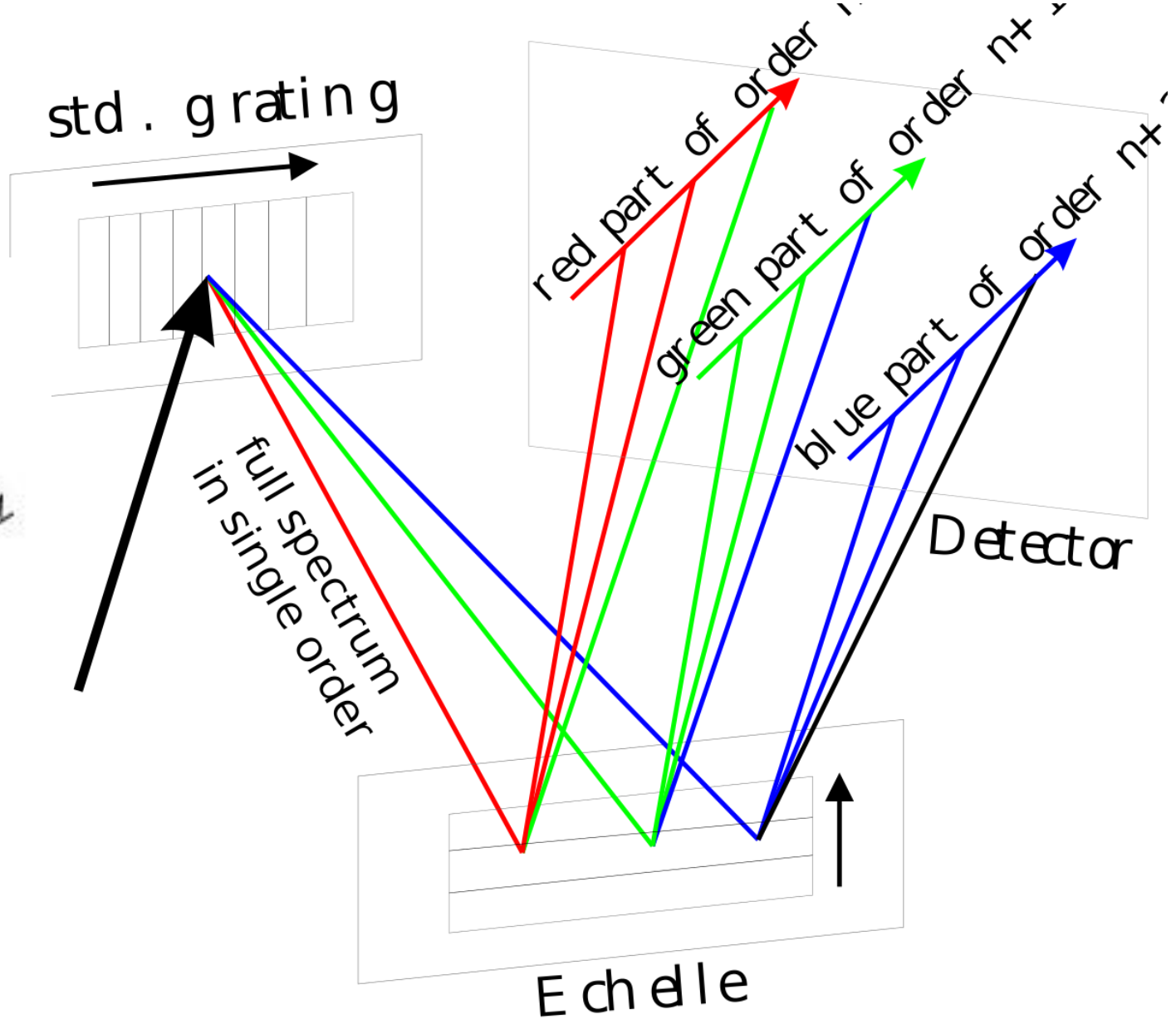
https://3.14.by/en/read/cd-dvd-microscope



https://3.14.by/en/read/cd-dvd-microscope



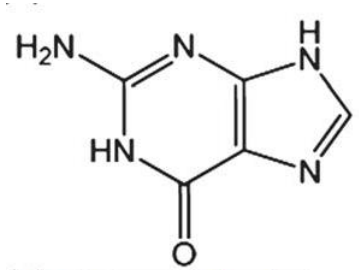
HIGHER ORDERS AND FREE SPECTRAL RANGE



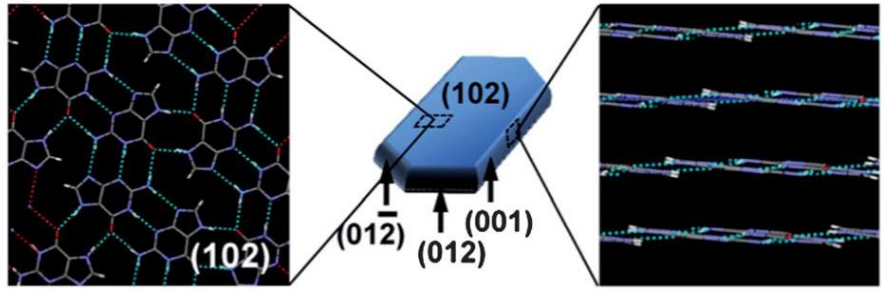
O Mistério do Camaleão

- Nanocristais de guanina

Tamanho : 127.4±17.8 nm

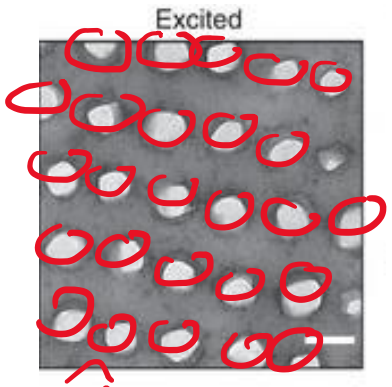


Guanina

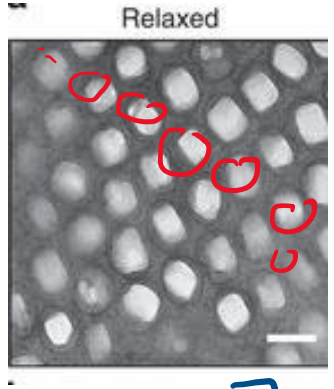


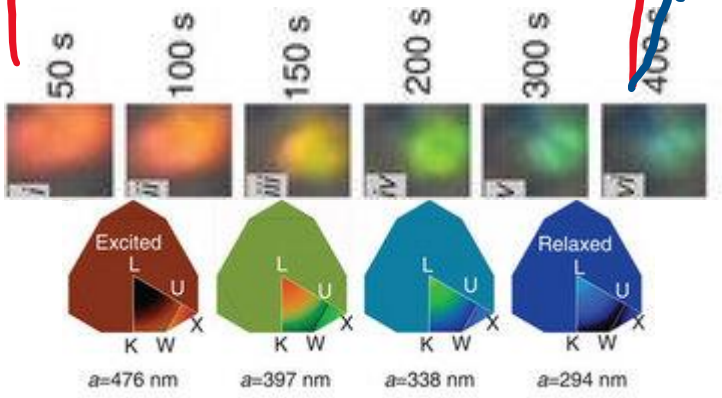
J. Mater. Chem. 22, 22686 (2012)

excitado



relaxado





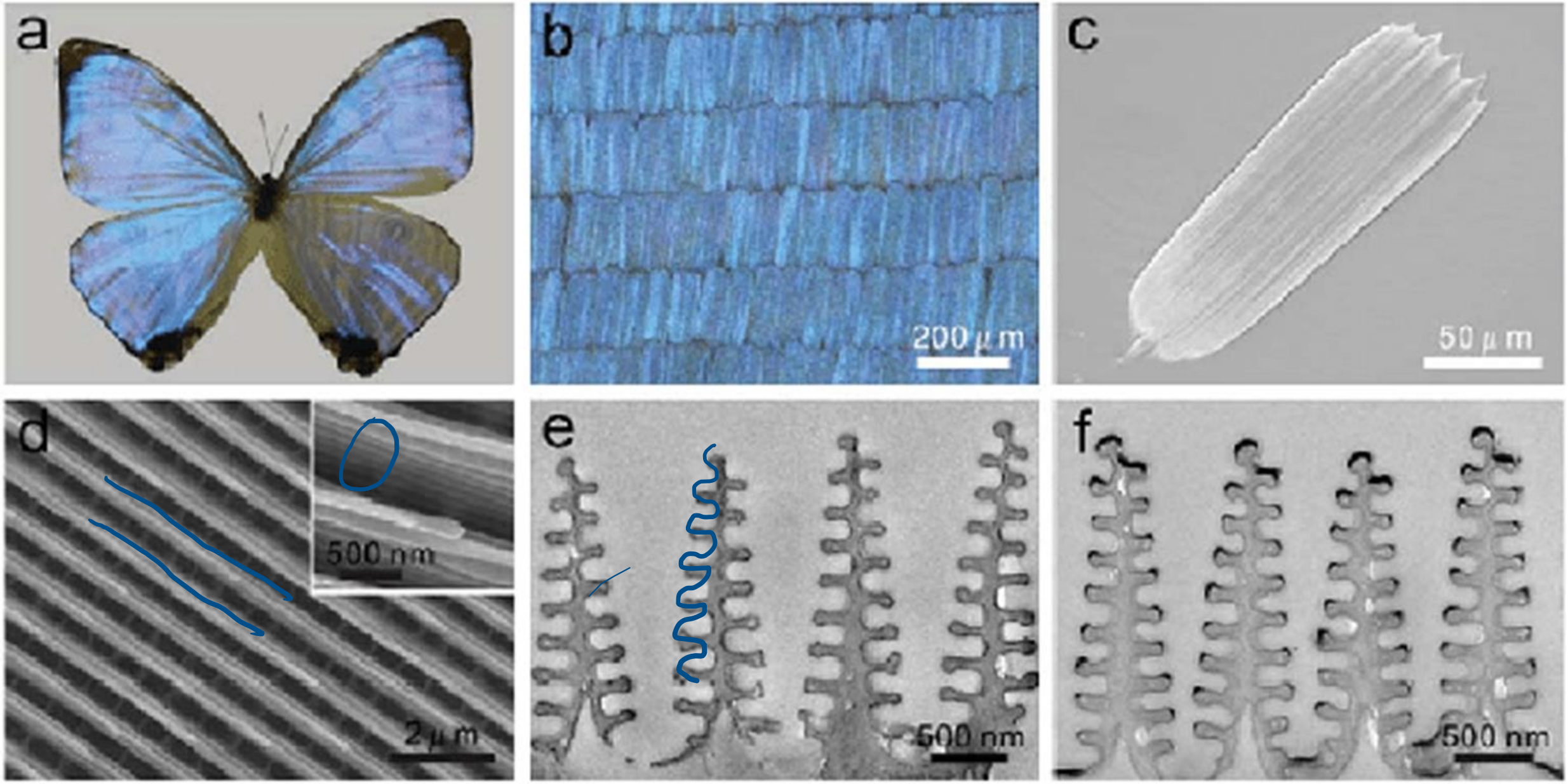
Osmolaridade de 236 to 1.416 mOsm

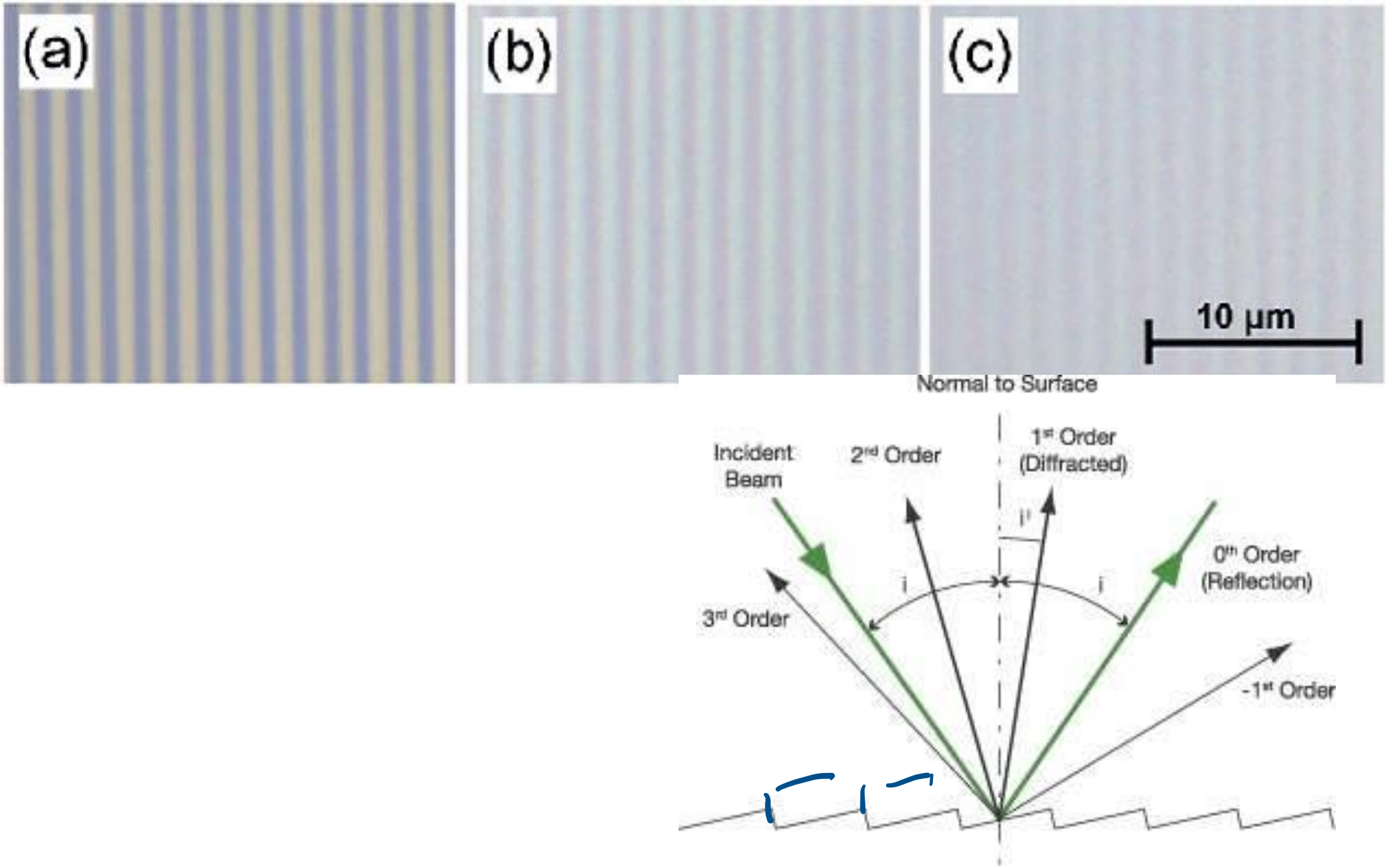
Nature Commun. 6, 6368 (2015)

VAGALUME

LE CROMÓFORO

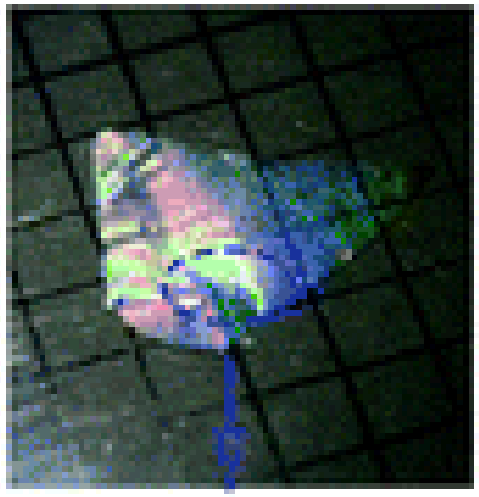

a

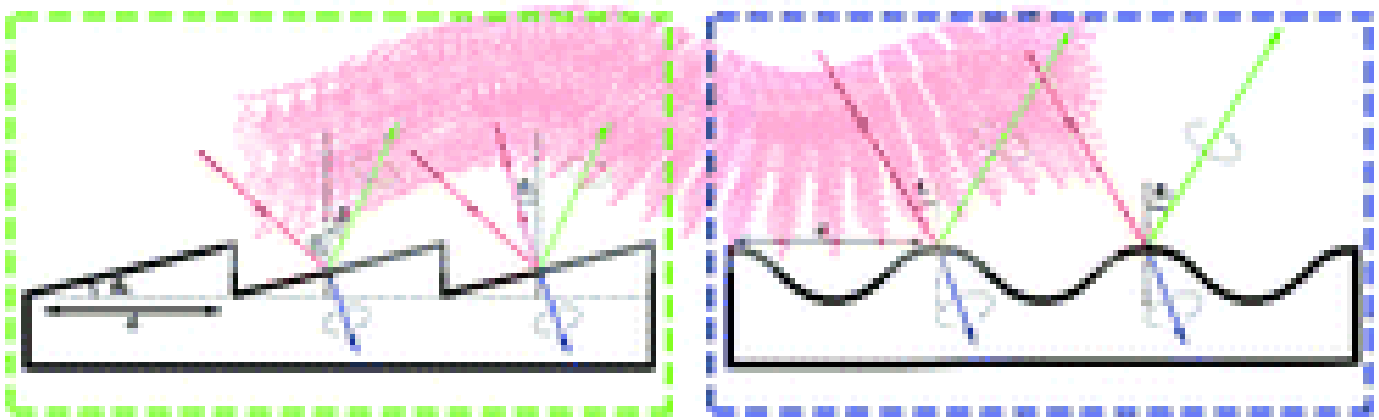

a
b
200 μm
c
50 μm
d
500 nm
2 μm
e
500 nm
f
500 nm

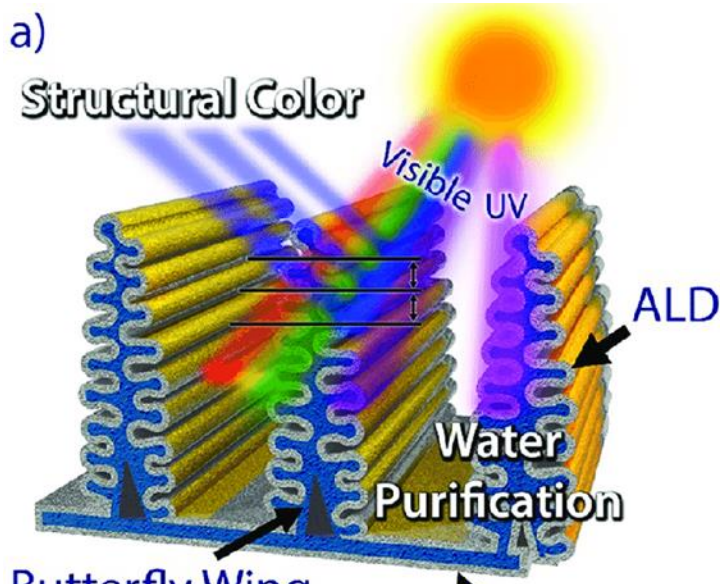

(a)
(b)
(c)
10 µm
Normal to Surface
Incident Beam
2nd Order
1st Order (Diffracted)
i'
0th Order (Reflection)
i
i
3rd Order
-1st Order

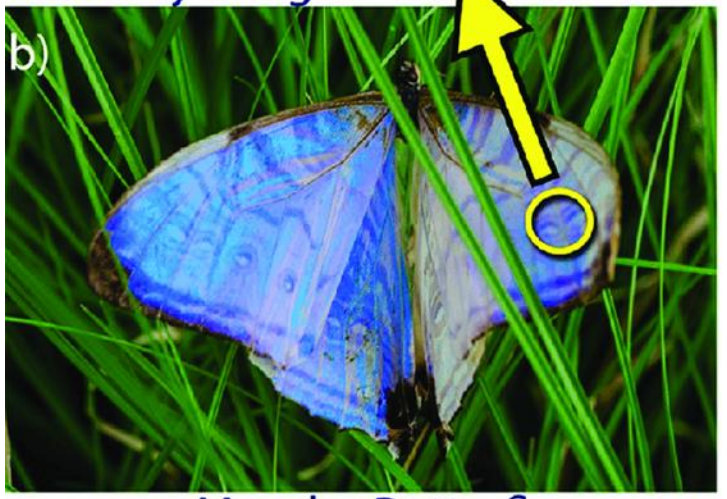
Photonic Coupled Cholesteric Grating

Inspired



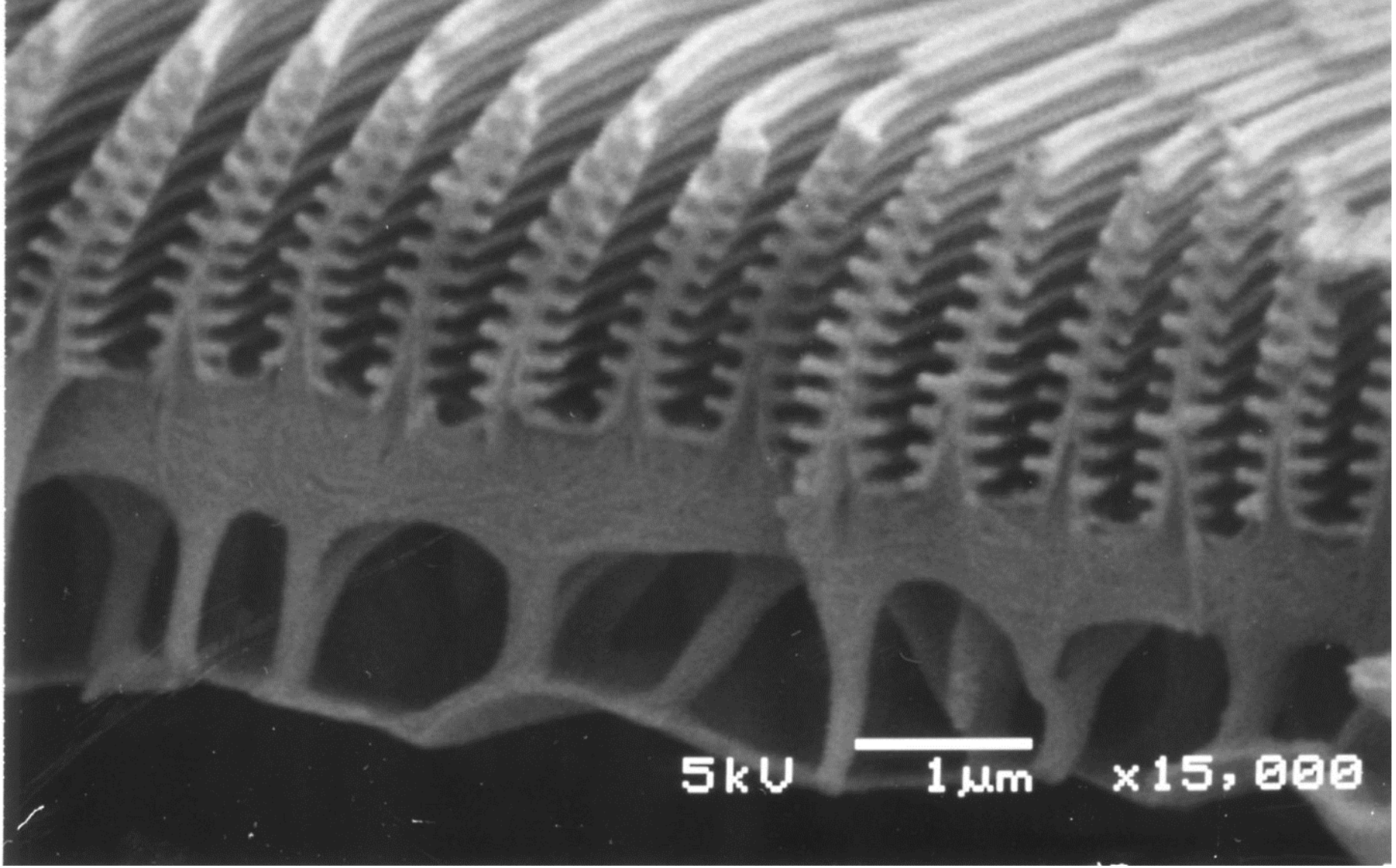




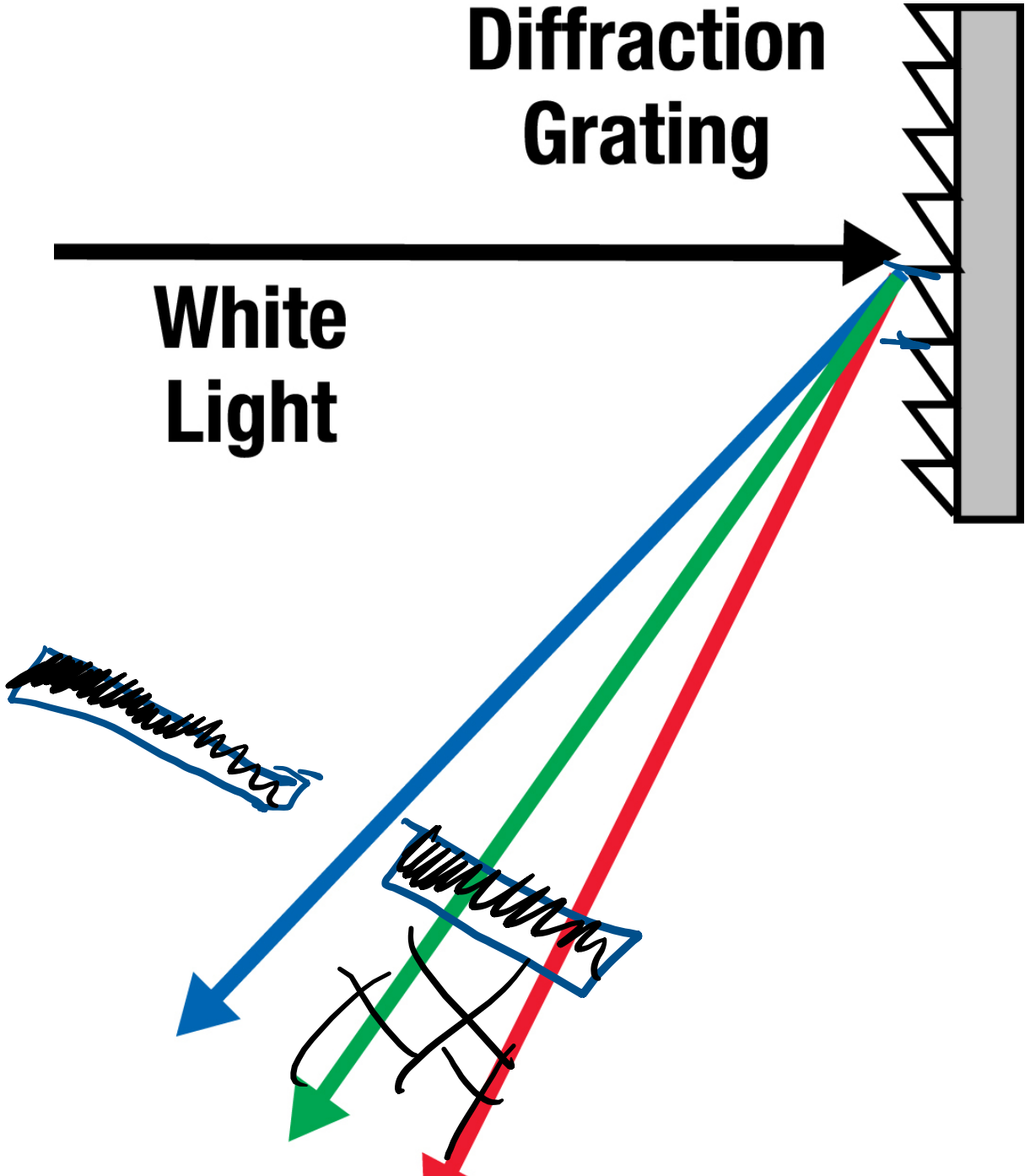


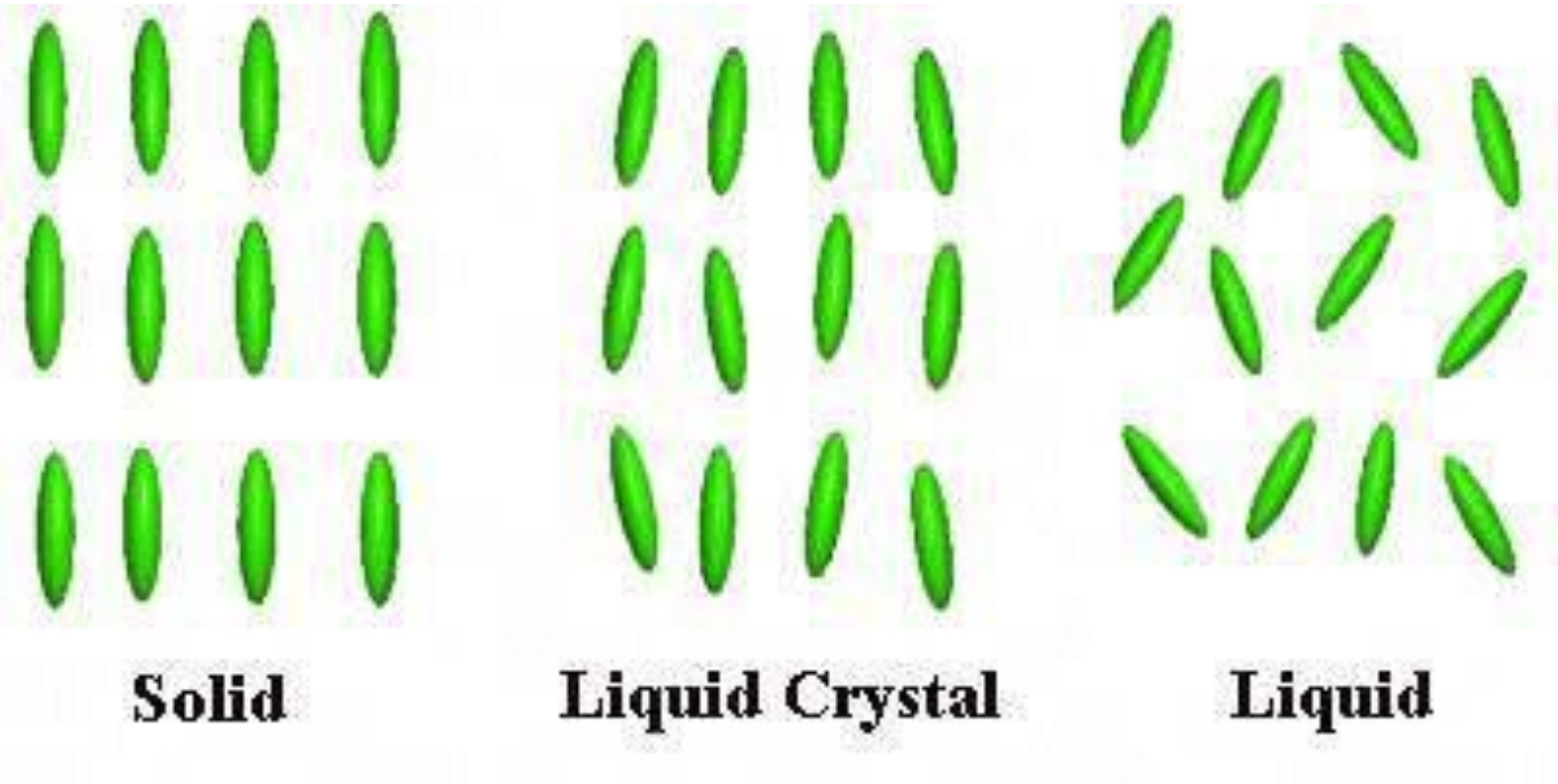
Morpho Butterfly

https://www.google.com/search?q=butterfly+wing+structure&tbm=isch&ved=2ahUKEwiUn6K30vLrAhVHNLkGHXlJDywQ2-cCegQIABAA&oq=butterfly+wing+stru&gs_lcp=CgNpbWcQARgAMgQIABATMggIABAFEB4QEzIICAAQBRAeEBMyCAgAEAgQHhATOgcIABCxAxBDOgQIABBDOgUIABCxAzoCCAA6BAgAEB5Q4mBYx7sBYJbCAWgCcAB4AIABXYgBigiSAQIxMpgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=xZ9kX9SoE8fo5OUP-ZK94AI&bih=969&biw=1920&rlz=1C1GCEU_pt-BRBR821BR822&hl=pt-BR#imgrc=HQcUc20i1eWwsM

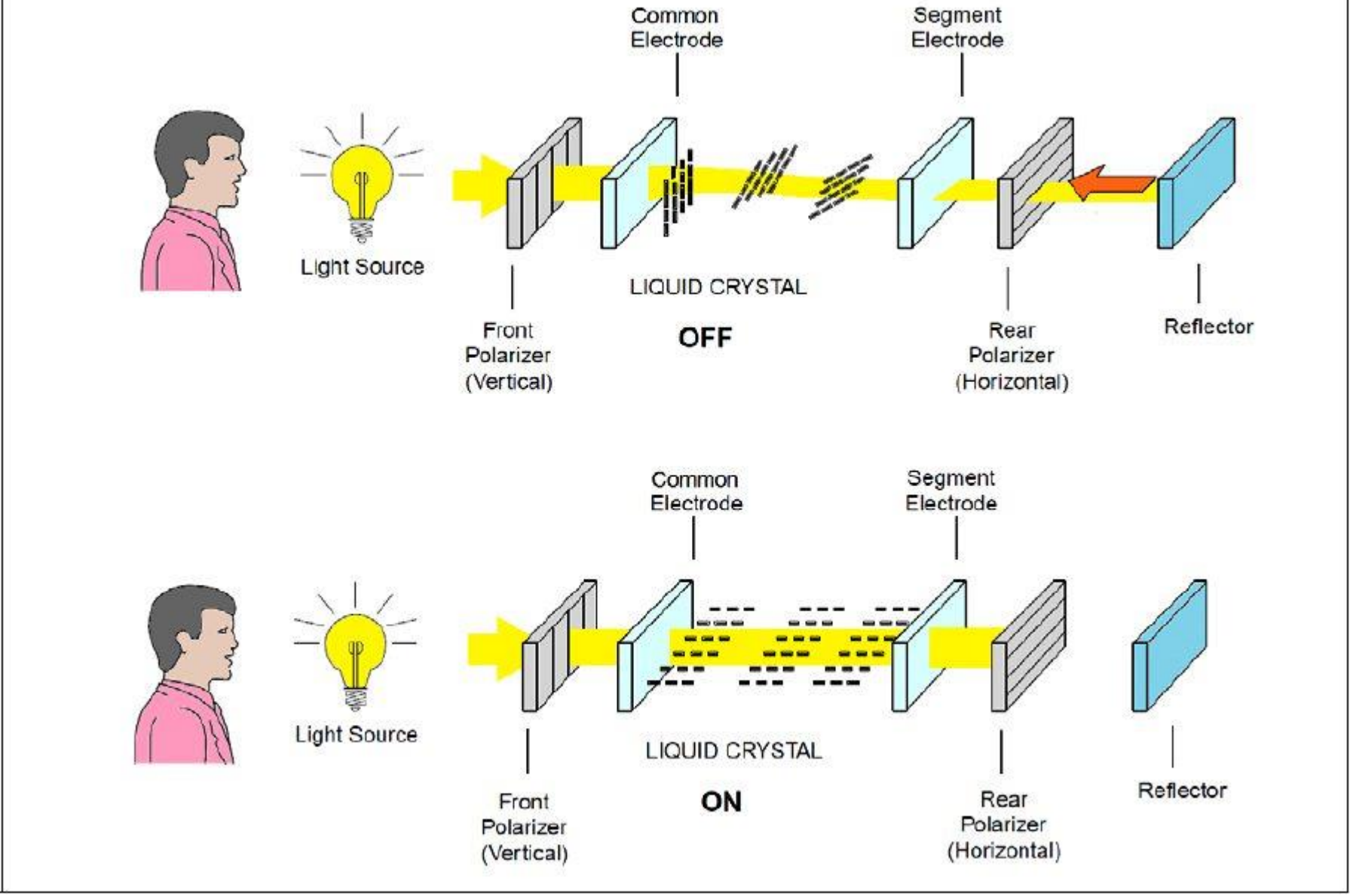


https://br.pinterest.com/pin/3771765375132915 93/

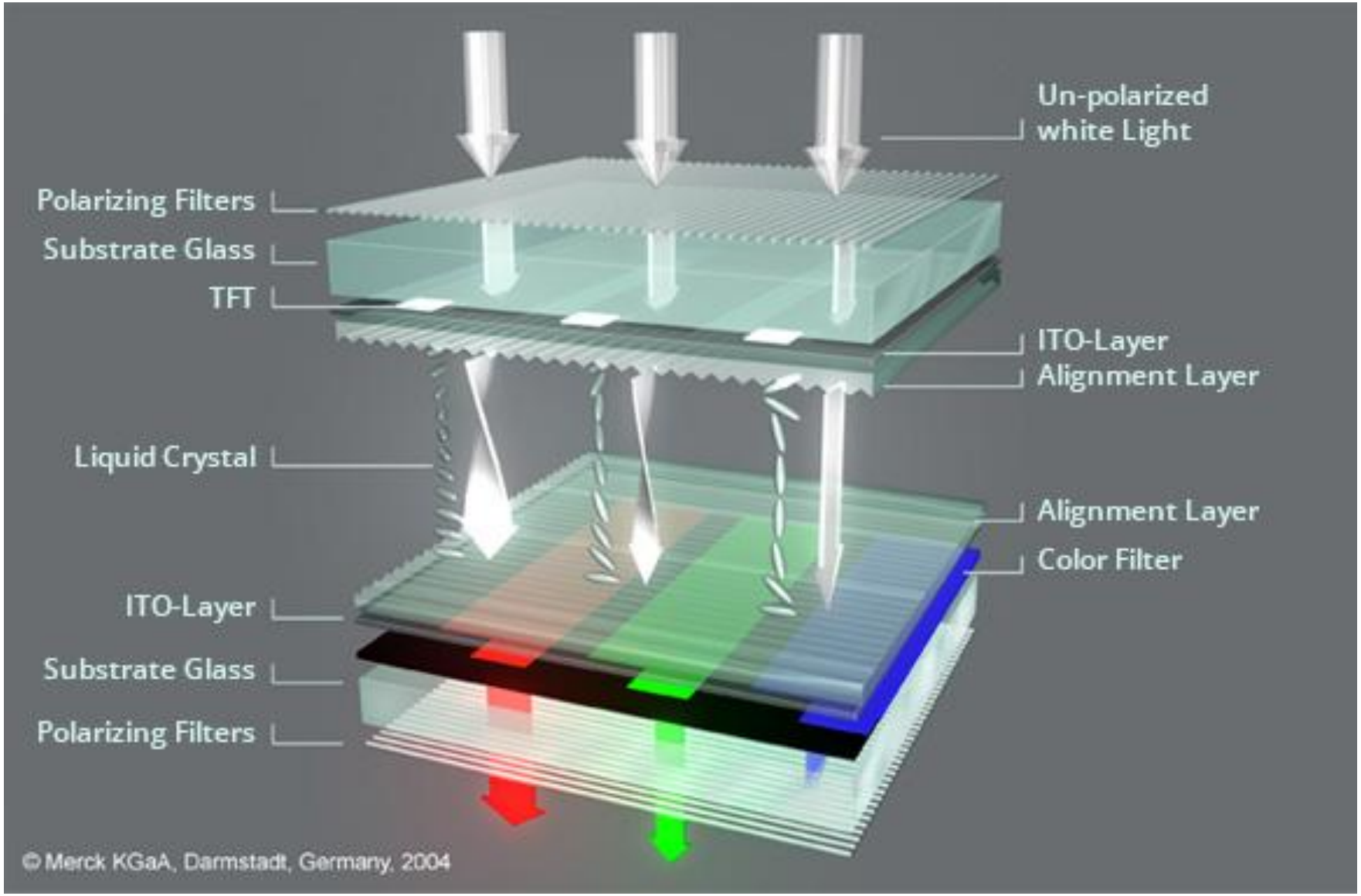

Diffraction
Grating
White
Light

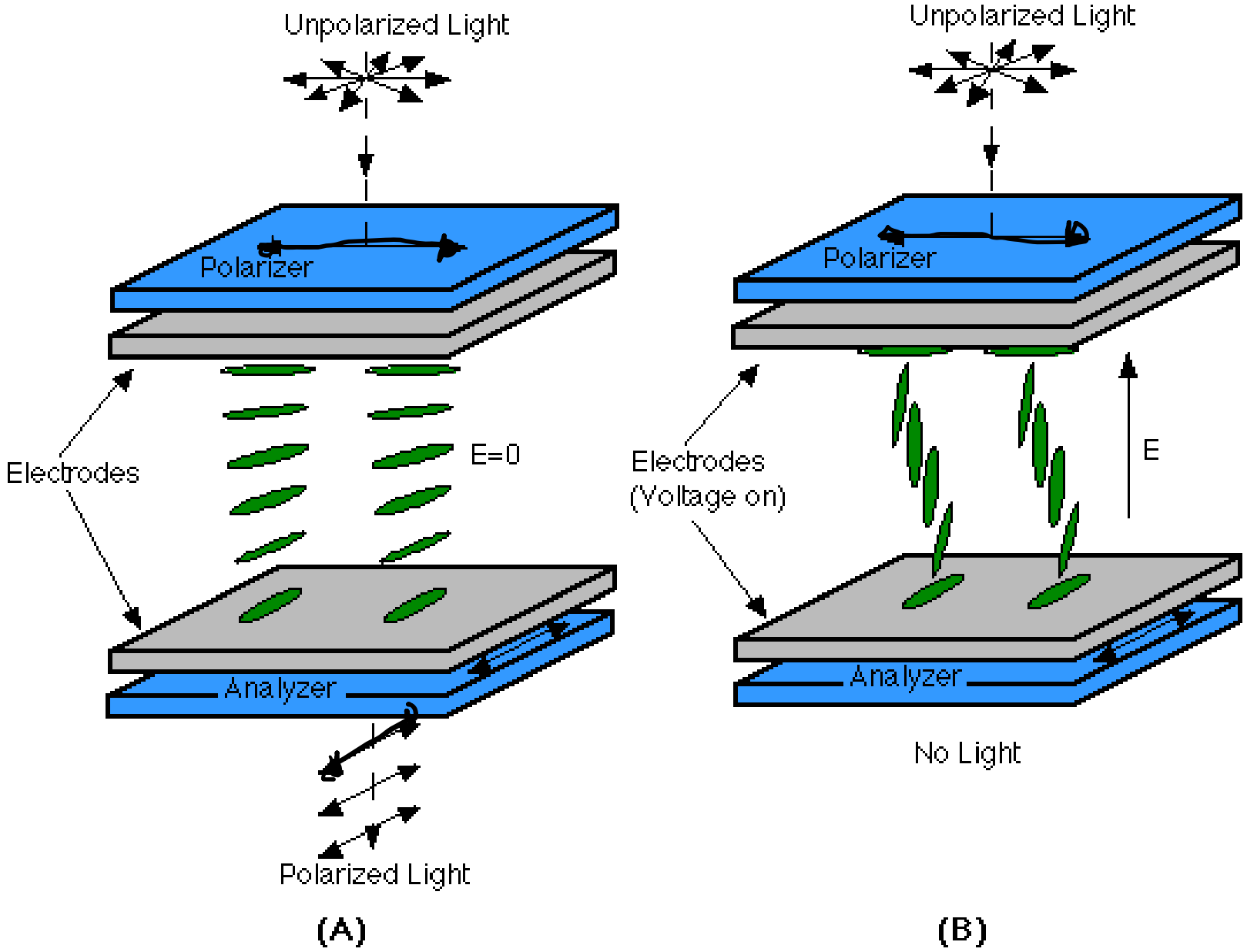


https://www.google.com/search?q=liquid+crystal+structure&rlz=1C1GCEU_pt-BRBR821BR822&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjEw7HZ0_LrAhVOHLkGHQ8-C8wQ_AUoAXoECBcQAw&biw=1920&bih=969#imgrc=LKPwvhPAStGEDM



https://electrosome.com/lcd-display-fundamentals/


Un-polarized
white Light
Polarizing Filters
Substrate Glass
TFT
ITO-Layer
Alignment Layer
Liquid Crystal
Alignment Layer
Color Filter
ITO-Layer
Substrate Glass
Polarizing Filters
© Merck KGaA, Darmstadt, Germany, 2004


Unpolarized Light
Polarizer
Electrodes
E=0
Analyzer
Polarized Light
(A)
Unpolarized Light
Polarizer
Electrodes
(Voltage on)
E
Analyzer
No Light
(B)

INTERAÇÃO ENTRE NP E A LUZ

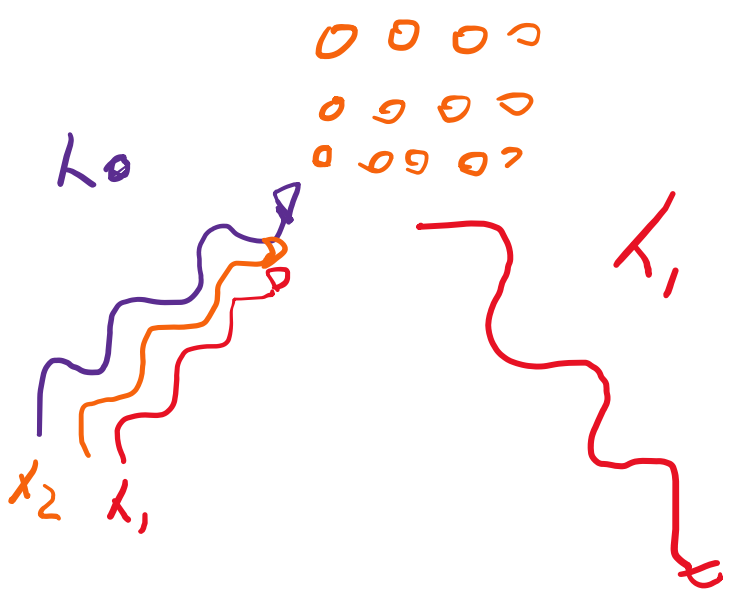
OS MATERIAIS NANO ESTRUTURADOS POSSUEM A CAPACIDADE DE MODIFICAR A ENERGIA, FASE, POLARIZAÇÃO E A DIREÇÃO DA LUZ

MATERIAIS NANO ESTRUTURADOS, EXEMPLO

i) CRISTAIS - REDE DE GUAMNA

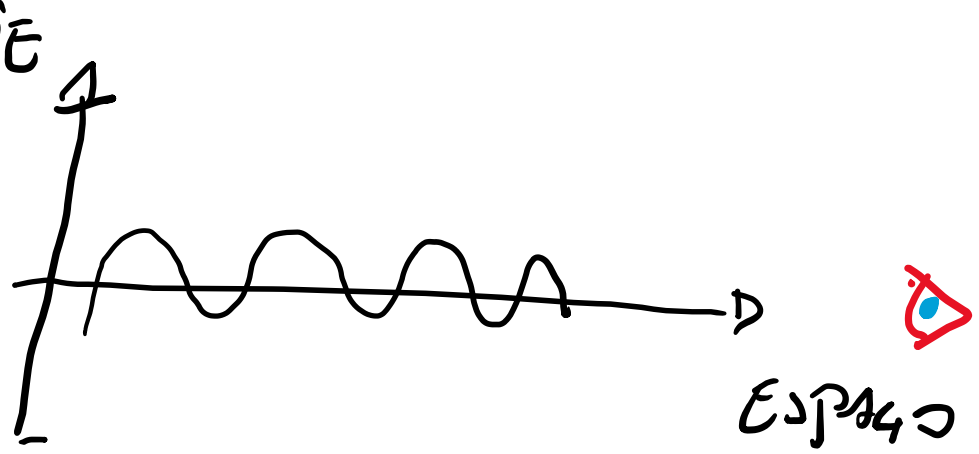
ii) CRISTAIS LÍQUIDOS

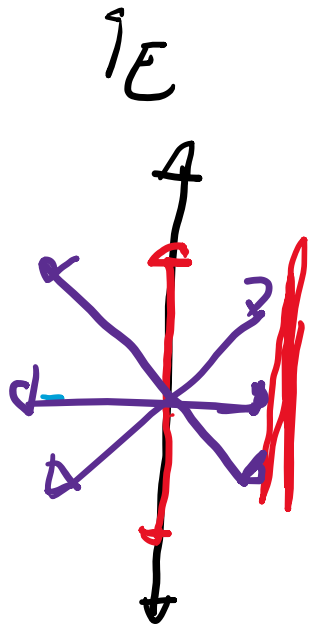
iii) ASAS DAS BORBOLETAS / INSETOS

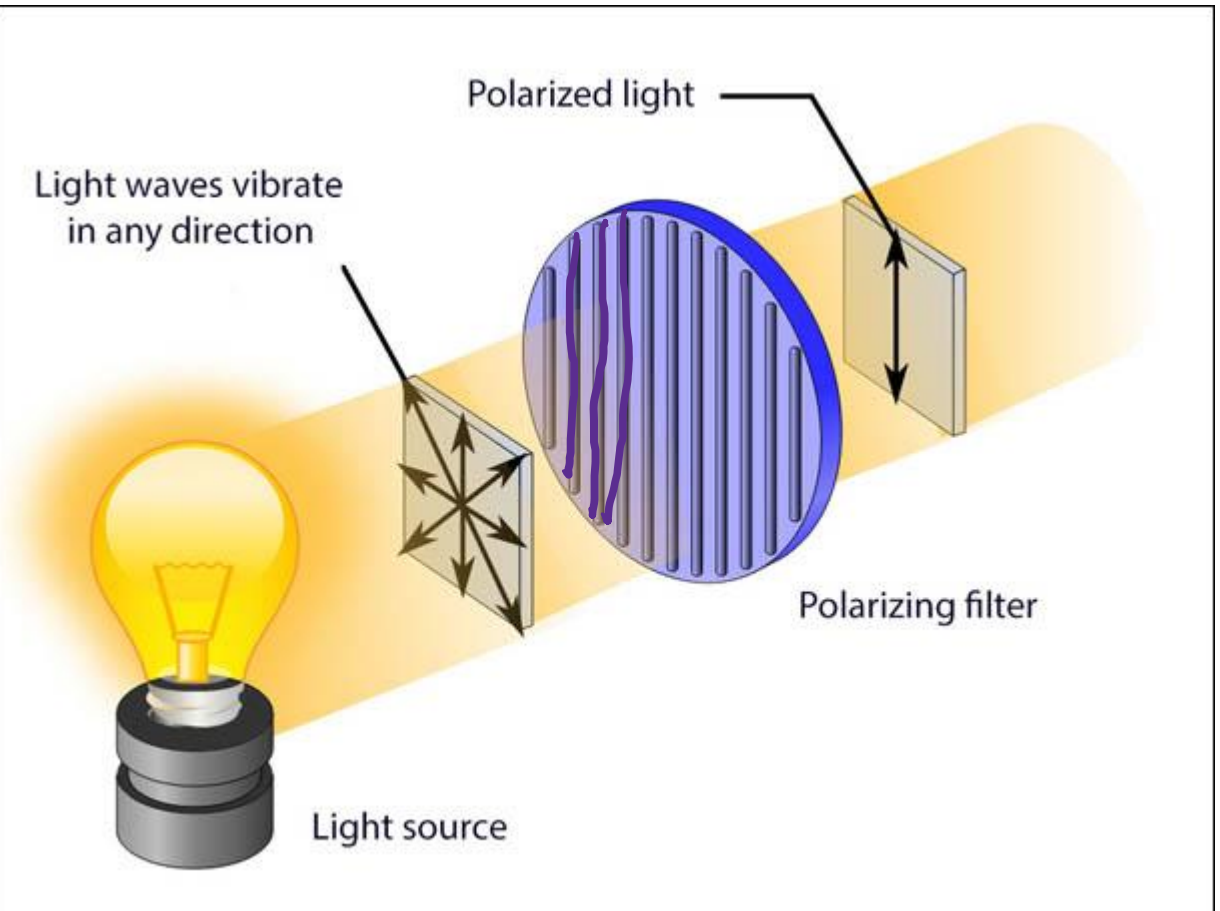


MANIPULAÇÕES DE

- ENERGIA
- DIREÇÃO
- POLARIZAÇÃO







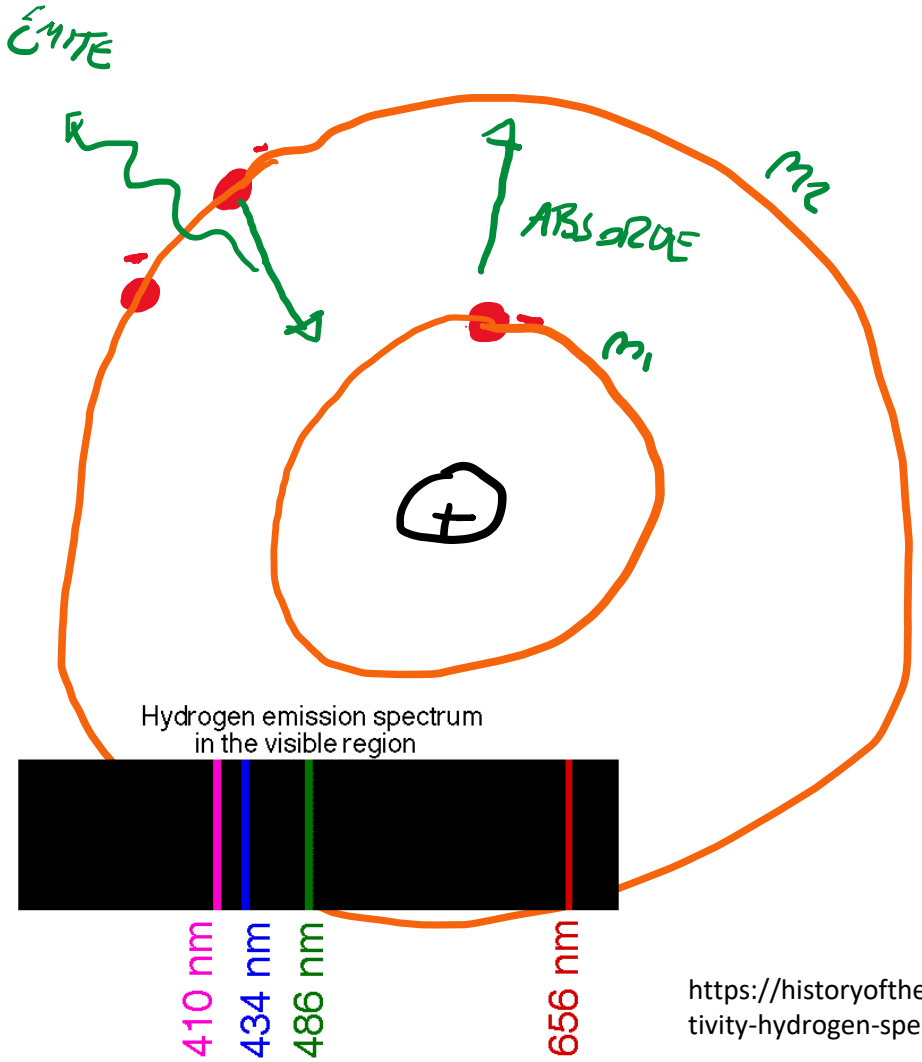
https://www.electricalelibrary.com/2017/08/22/display-de-cristal-liquido/

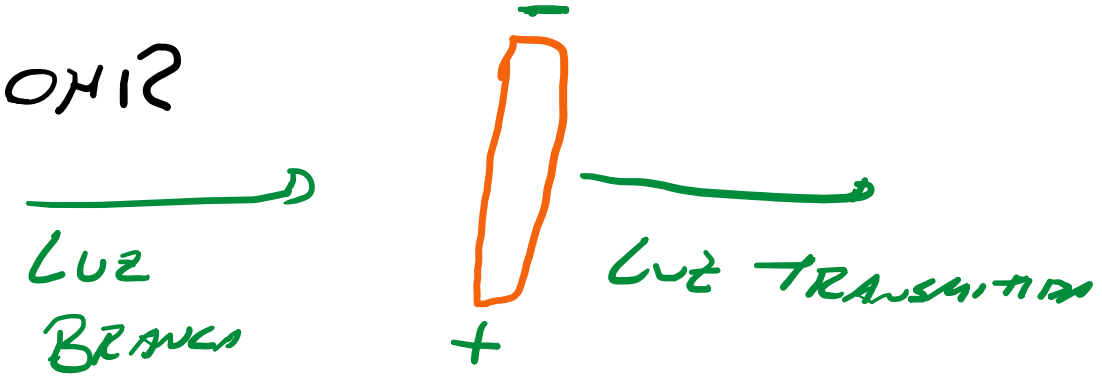
TRANSIÇÕES ELETRÔNICAS

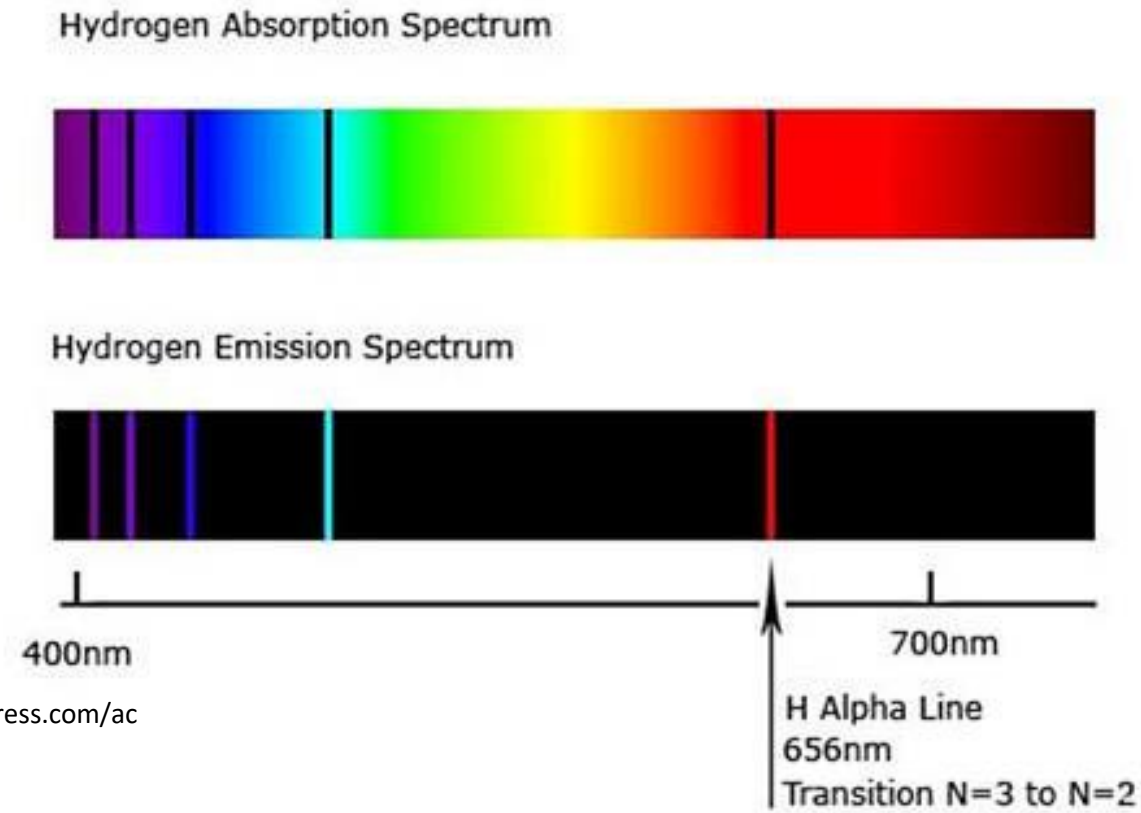
EXEMPLO: FOTOMETRIA DE CHAMA, É USADA NA DETERMINAÇÃO DE SÓDIO E POTÁSSIO

https://mundoeducacao.uol.com.br/quimica/quimica-dos-fogos-artificio.htm

Modelo Atômico de Bohr



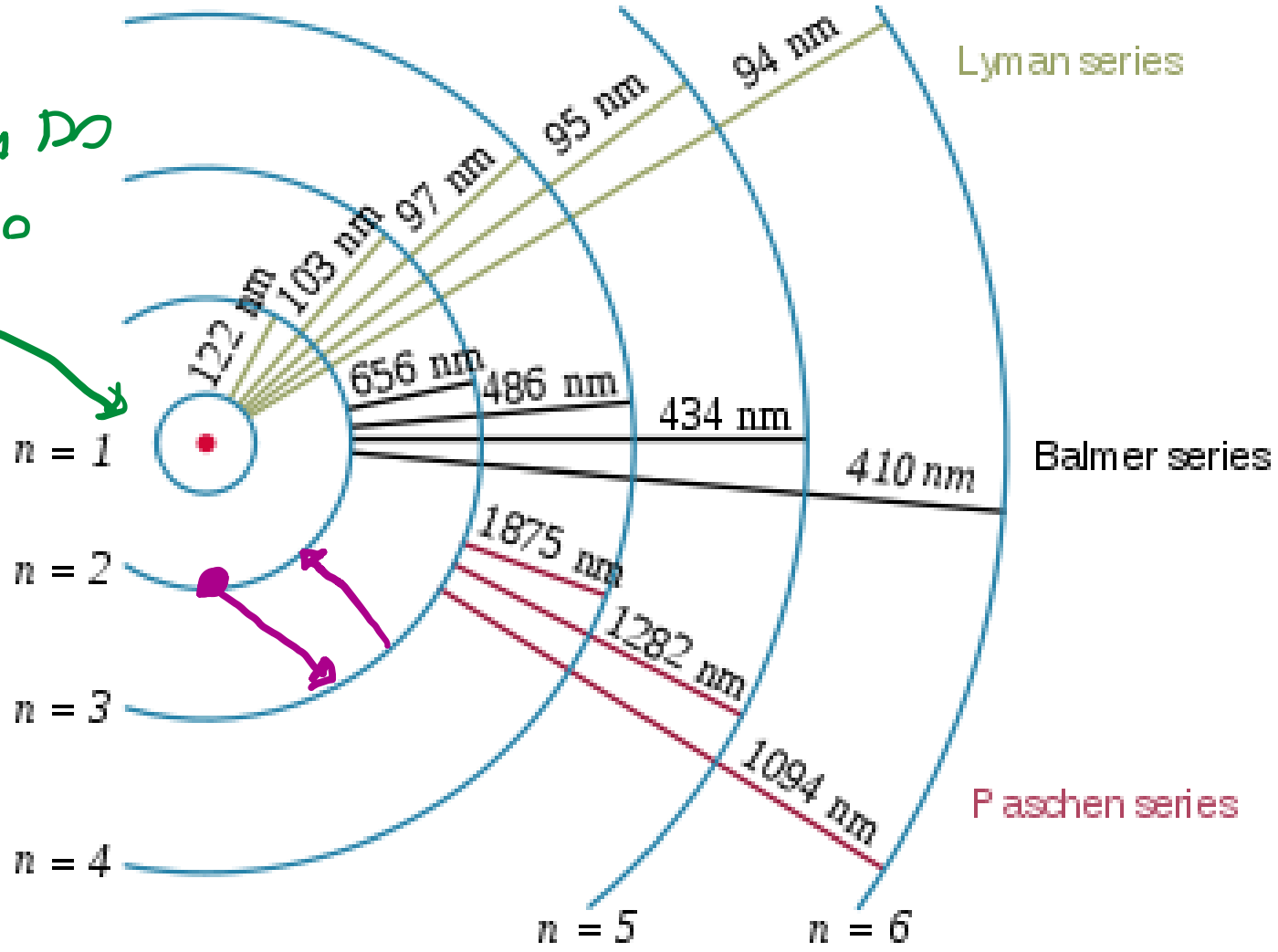




https://historyoftheatomictheory.wordpress.com/activity-hydrogen-spectrum/

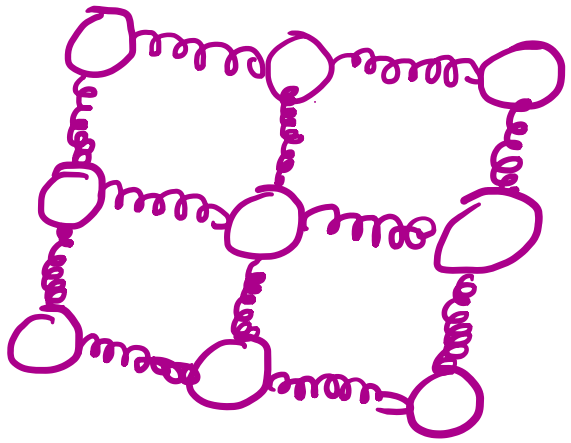
https://www.khanacademy.org/science/class-11-chemistry-india/xfbb6cb8fc2bd00c8:in-in-structure-of-atom/xfbb6cb8fc2bd00c8:in-in-bohr-s-model-of-hydrogen-atom/a/absorptionemission-lines

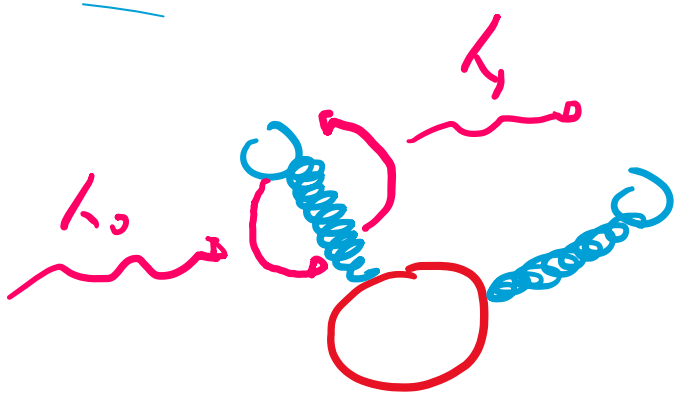
CARGA DO NÚCLEO

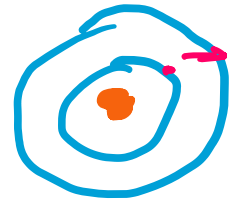


https://en.wikipedia.org/wiki/Hydrogen_spectral_series

SAL OU ÓXIDO



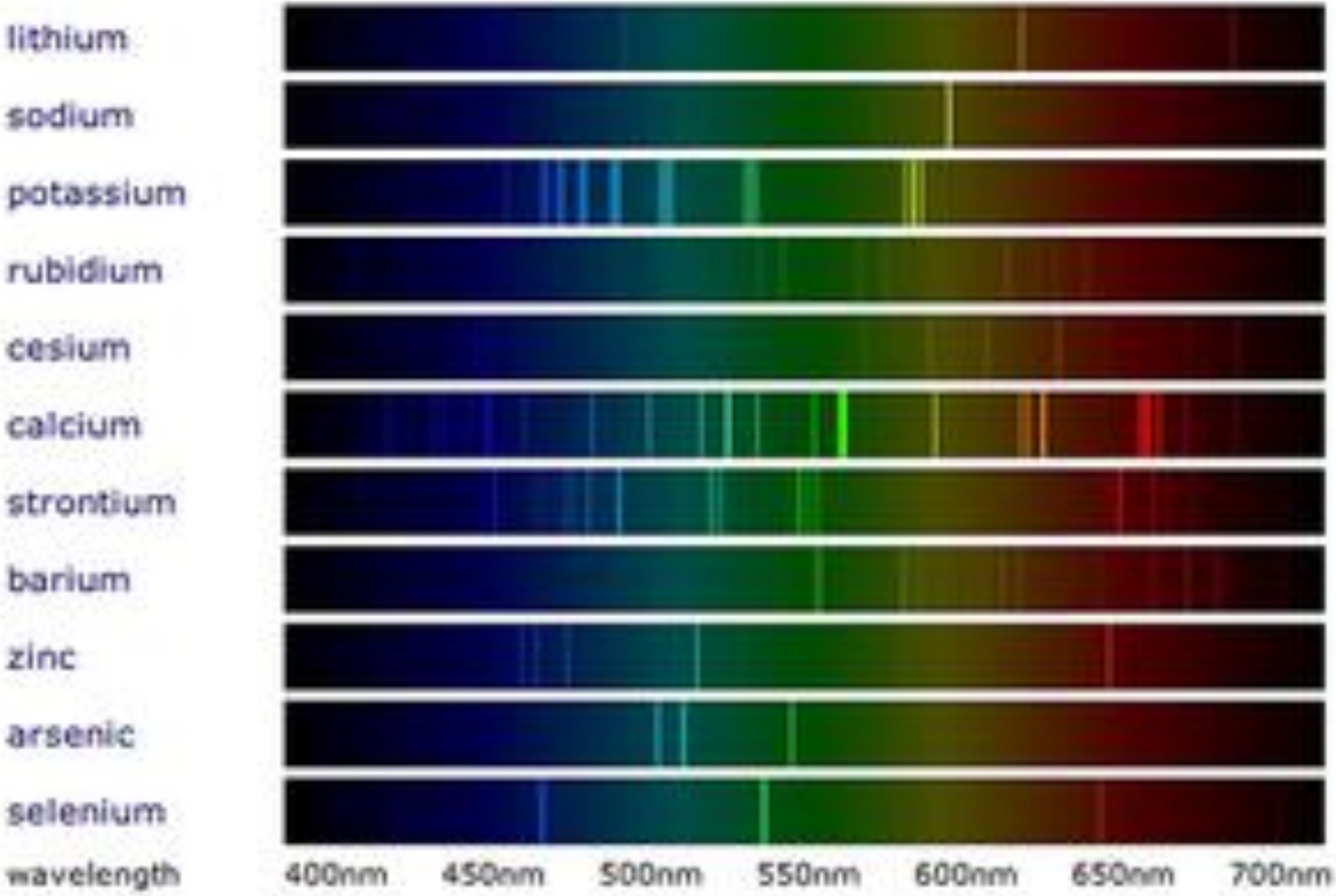




→ OS ÁTOMOS VÃO SE COMBINAR FORMANDO MOLÉCULAS

SAIS

ÓXIDOS



potassium

Calcium

https://keystagewiki.com/index.php/Flame_Emission_Spectroscopy

http://alanieflametest.blogspot.com/2013/11/flame-test-experiment.html

Azul de Metileno
SOLUTION

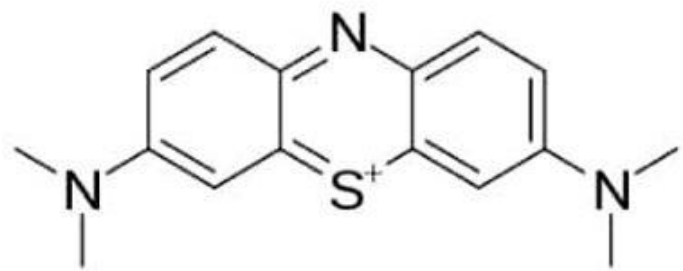
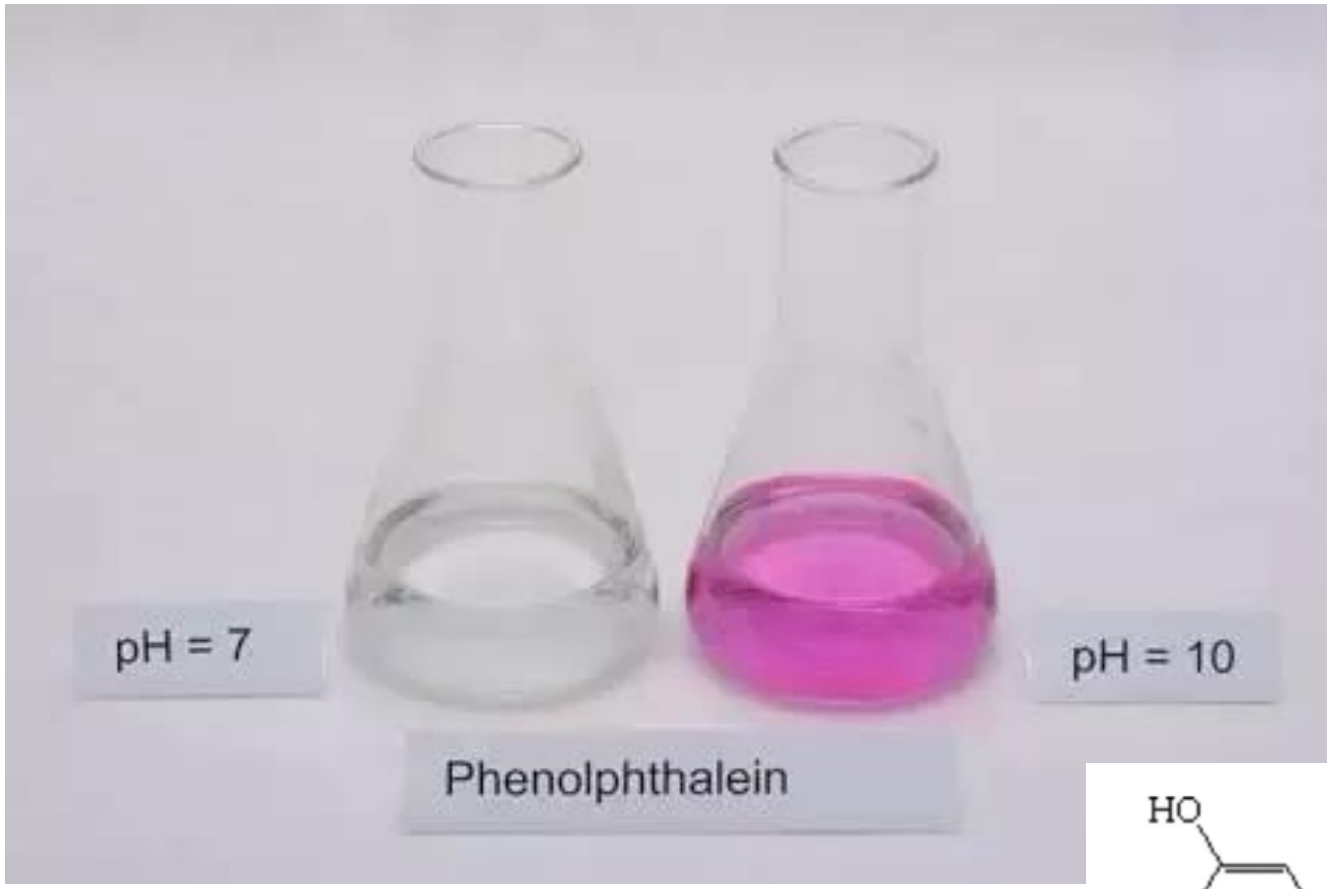


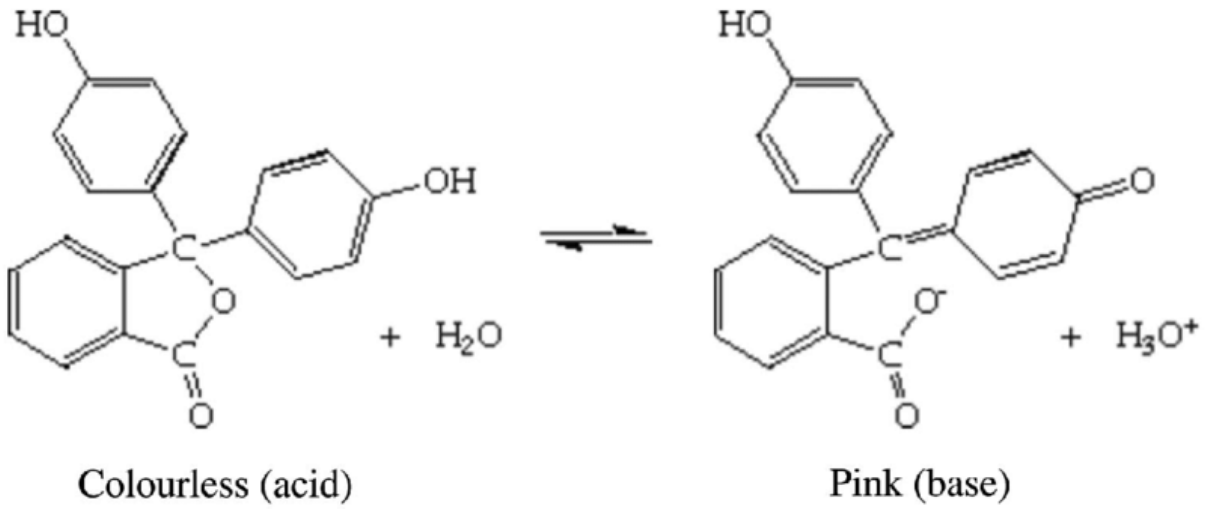
*Imagem Ilustrativa

https://www.natuel.com.br/azul-de-metileno-pa-beneficios-comprar



https://www.quora.com/What-are-the-colours-of-Phenolphthalein-in-acidic-and-basic-solution

A MUDANÇA DE COR É PROVOCADA POR UMA MUDANÇA DE ESTRUTURA



NOTAS

i) ÁTOMOS ABSORVEM E EMITEM LUZ. OS COMPRIMENTOS DE ONDA ENVOLVIDOS NAS TRANSIÇÕES DEPENDEM DO NÚMERO ATÔMICO

ii) MOLÉCULAS ABSORVEM E EMITEM LUZ. OS COMPRIMENTOS DE ONDA DEPENDEM DOS ÁTOMOS E DE COMO ELES ESTÃO ORGANIZADOS

iii) SÓLIDOS/PARTÍCULAS PODEM ABSORVER E EMITIR LUZ. OS COMPRIMENTOS DE ONDA DEPENDEM DOS ÁTOMOS, MOLÉCULAS E DA FORMA COMO ELES ESTÃO ORGANIZADOS

iv) EM NANOMATERIAIS EXISTE UMA DA DEPENDÊNCIA DA COMPOSIÇÃO ESTRUTURA E TAMANHO

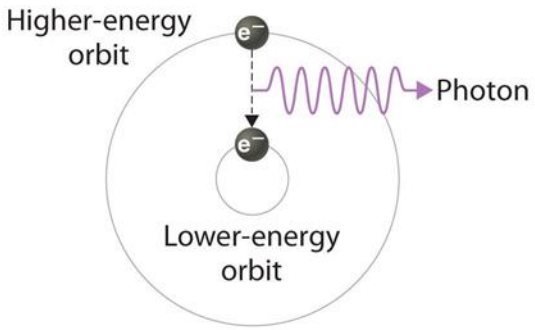
ÁTOMOS → ORBITAIS ATÔMICOS

MOLÉCULAS → ORBITAIS MOLECULARES

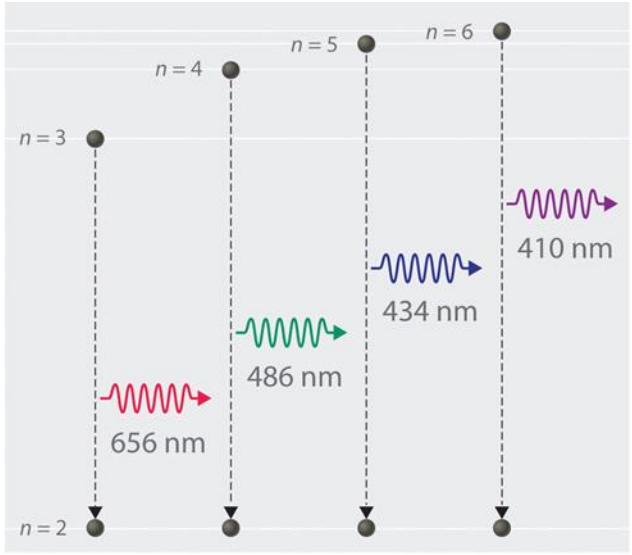
SÓLIDOS → ESTRUTURA DE BANDAS

↳ REGIÕES ONDE O ELÉTRON PODE SER ENCONTRADO

ATOMO

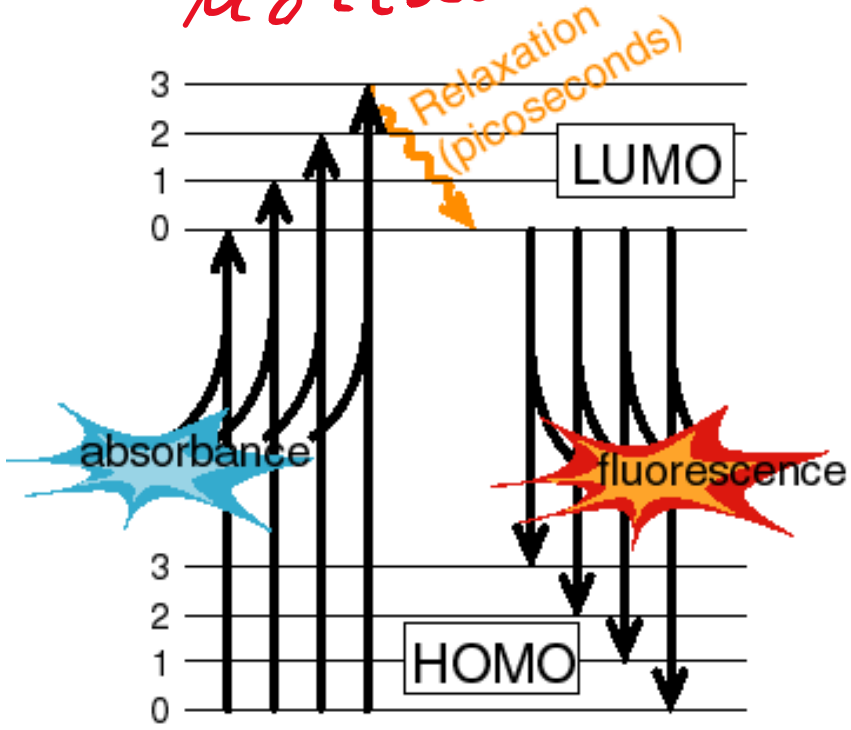


(a) Electronic emission transition



(b) Balmer series transitions

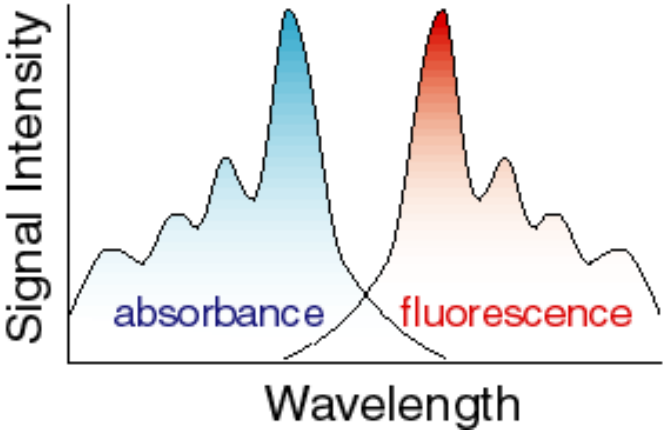
MOLECOLA



https://chem.libretexts.org/Courses/University_of_Missouri/MU%3A__1330H_(Keller)/06._Electronic_Structure_of_Atoms/6.3%3A_Line_Spectra_and_the_Bohr_Model

HOMO = HIGHEST OCCUPIED MOLECULAR ORBITAL

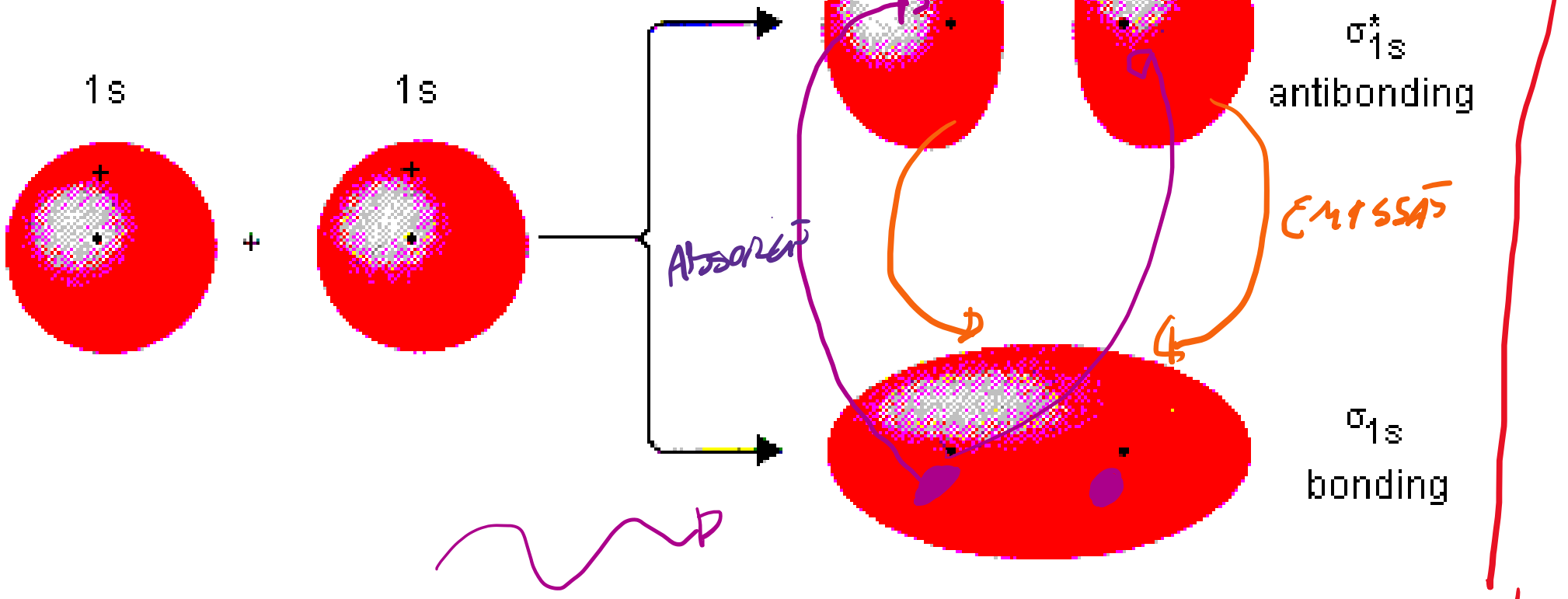
LUMO = LOWEST UNOCCUPIED MOLECULAR ORBITAL



http://www.public.asu.edu/~laserweb/woodbury/classes/chm467/bioanalytical/spectroscopy/absflr.html

ORBITAIS MOLECULARES

ORBITAIS ATÔMICOS

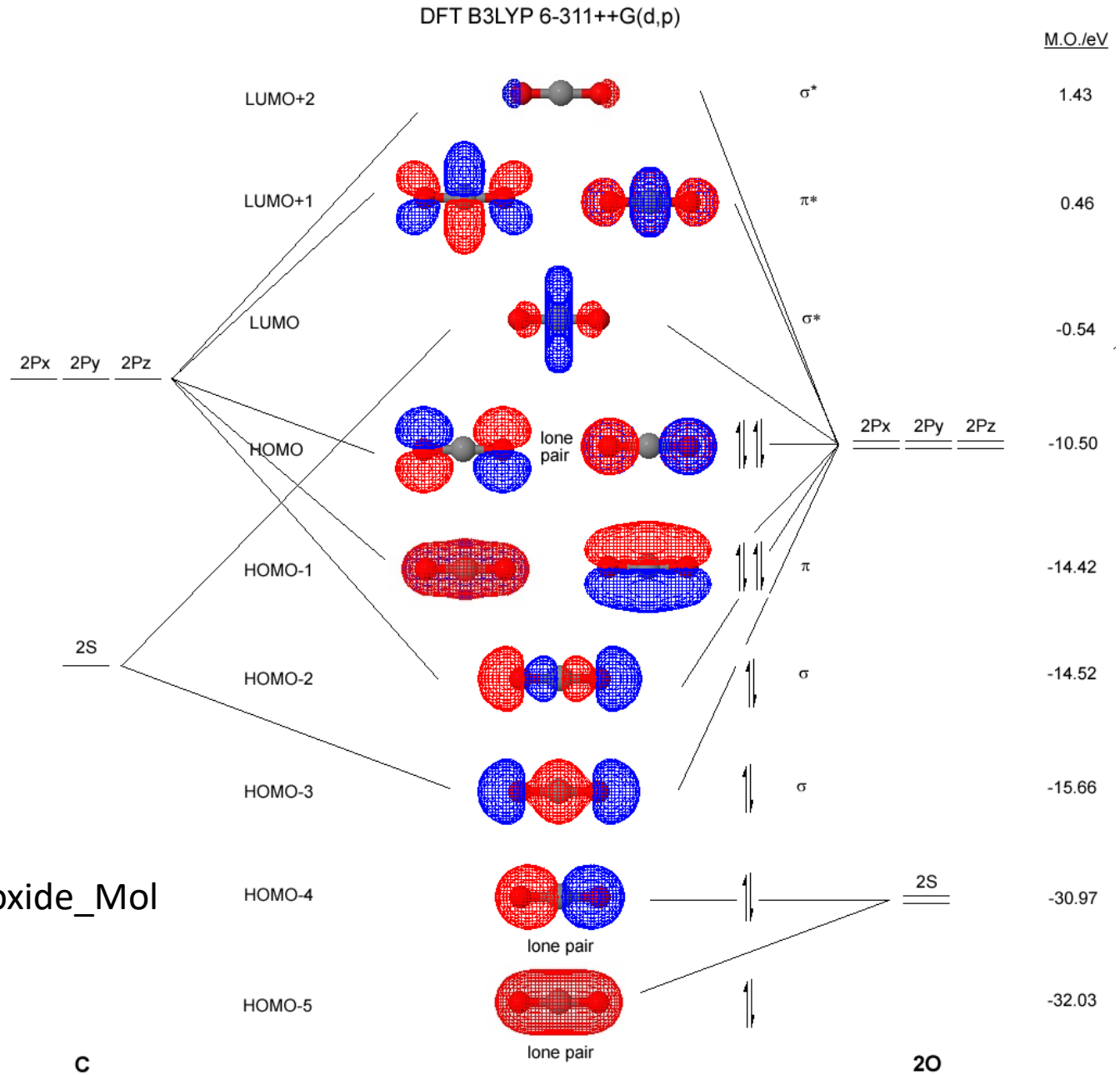


H_2

H — H

https://medium.com/@megamberlim/molecular-orbital-diagrams-simplified-c07fbb88f4a2

CO_2 $O=C=O$



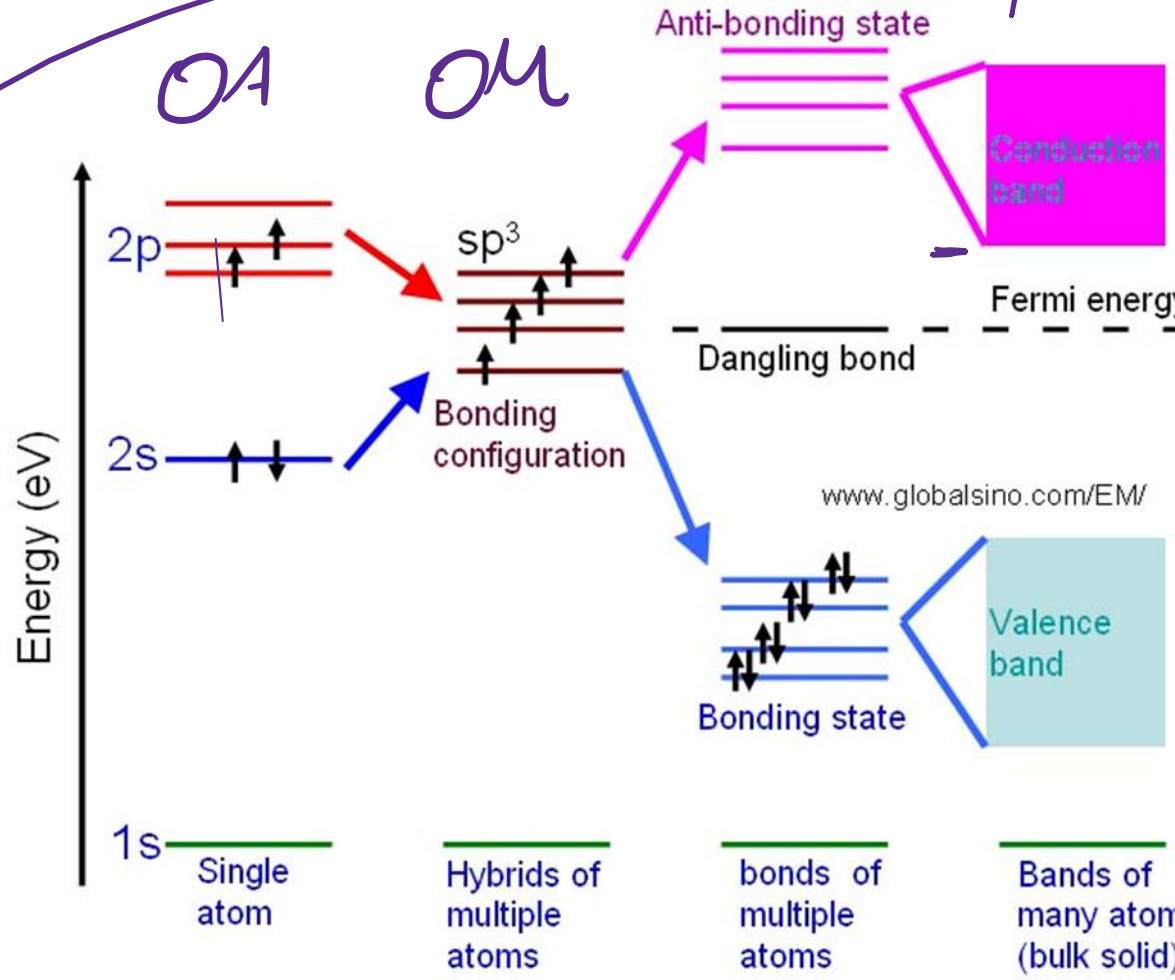
https://commons.wikimedia.org/wiki/File:Carbon_Dioxide_Molecular_Orbitals.png

PARTÍCULA/SÓLIDO

100 nm - QUANTOS ÁTOMOS APROXIMADAMENTE

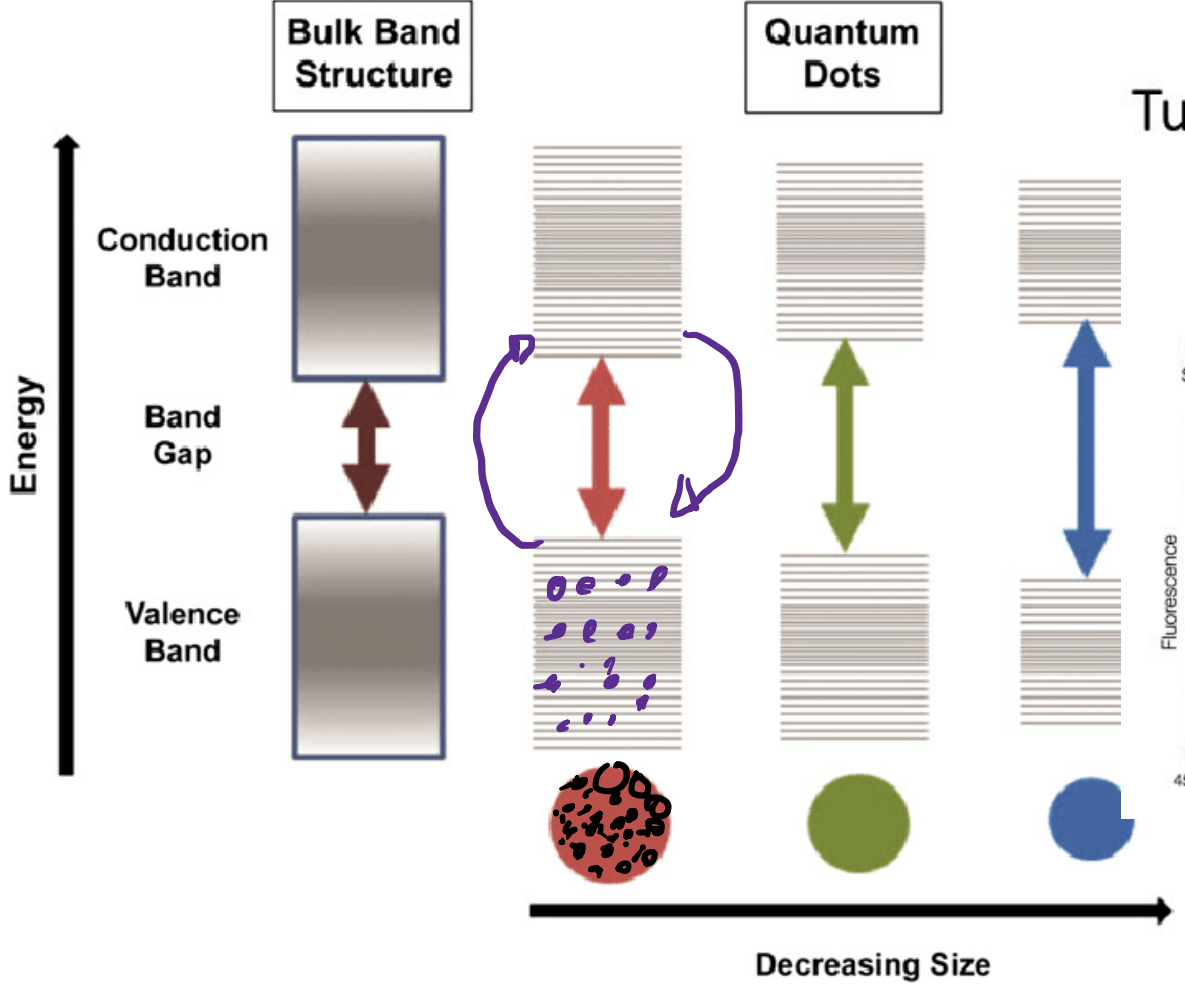
SÓLIDOS SEMICONDUTORES

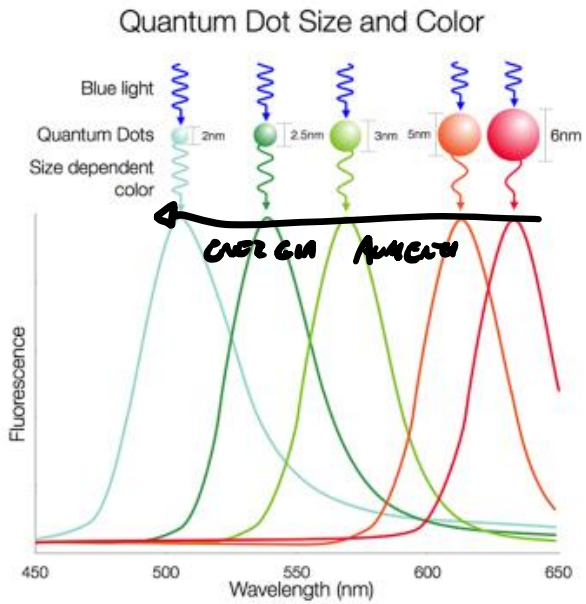
OA OM OM



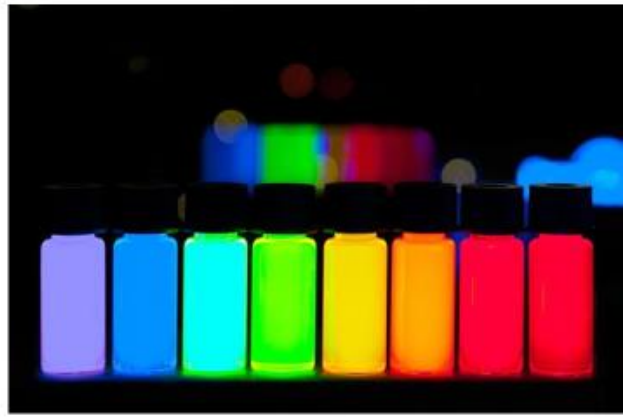
http://www.globalsino.com/EM/page2633.html

Tuning Light emission- Quantum dots





As dispersões coloidais estão sendo irradiadas com Luz UV



https://www.radiantvisionsystems.com/blog/quantum-dots-nanotechnology-meets-displays

https://ceramics.onlinelibrary.wiley.com/doi/epdf/10.1111/jace.12943

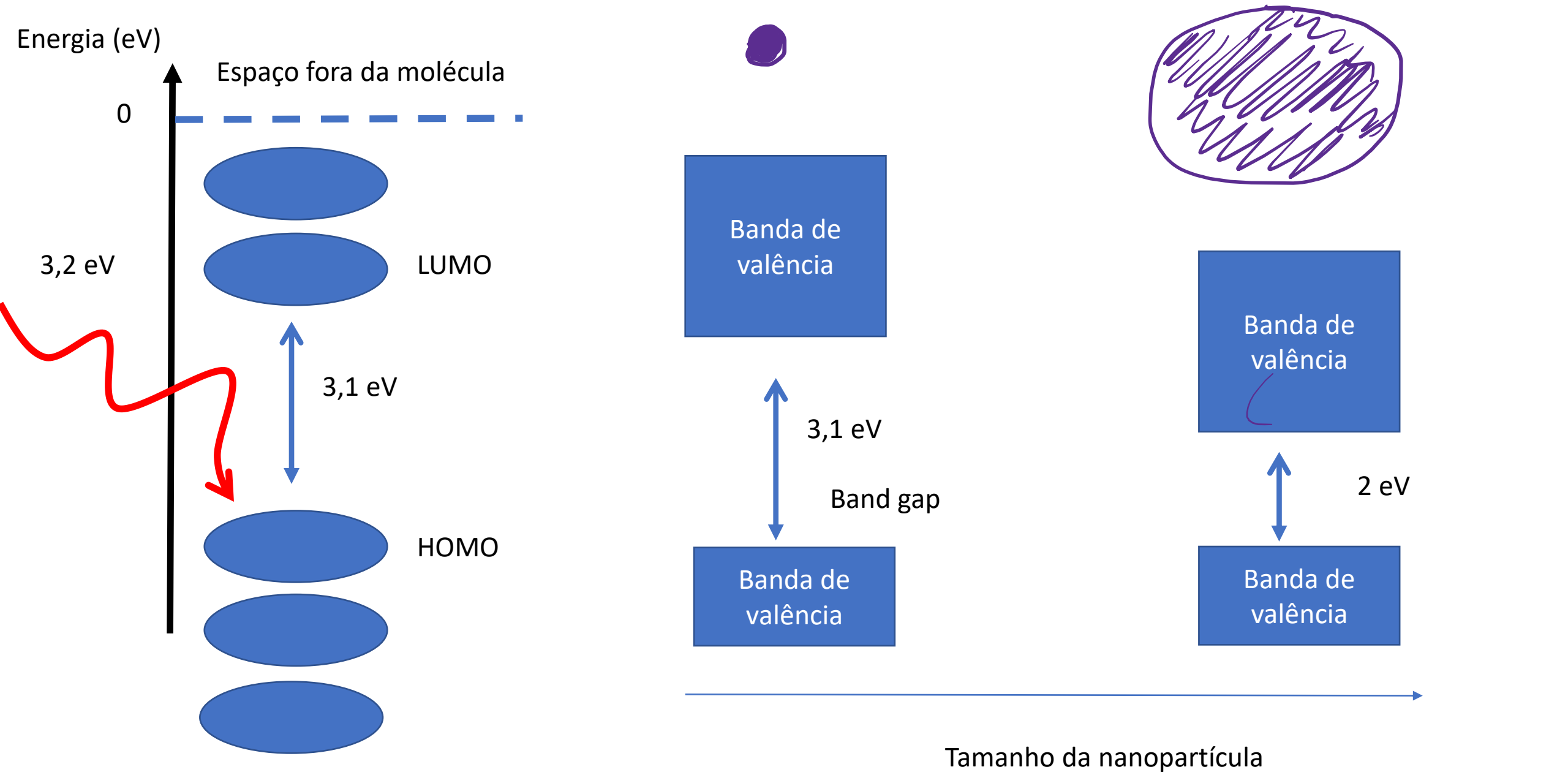
https://www.radiantvisionsystems.com/blog/quantum-dots-nanotechnology-meets-displays

ENERGIA DAS BANDAS DE VALÊNCIA E CONDUÇÃO DEPENDEM:

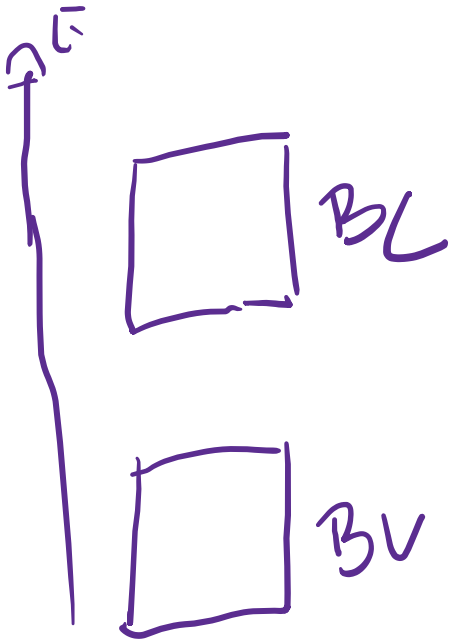
i) COMPOSIÇÃO QUÍMICA

ii) FORMA DAS PARTÍCULAS

iii) TAMANHO


Energia (eV)
Espaço fora da molécula
0
3,2 eV
LUMO
3,1 eV
HOMO
Banda de valência
3,1 eV
Band gap
Banda de valência
Banda de valência
2 eV
Banda de valência
Tamanho da nanopartícula

→ MODELO DE PARTÍCULA NA CAIXA

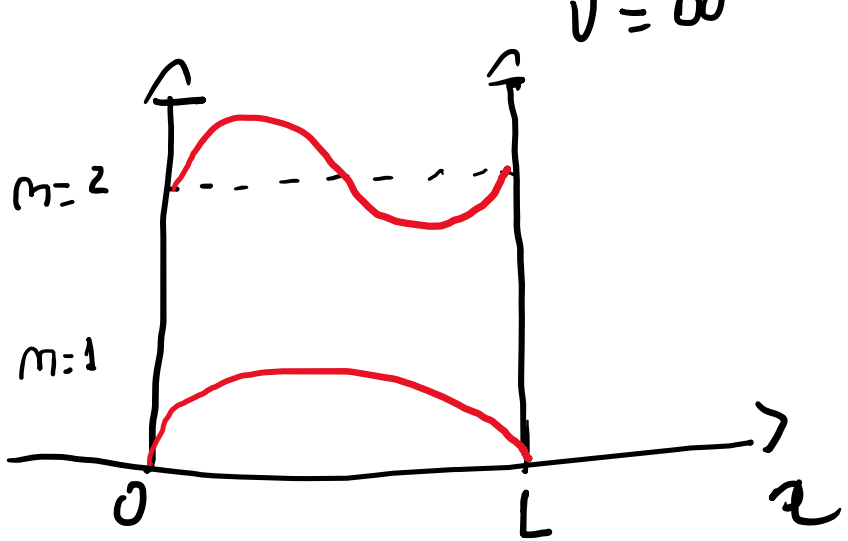


$$\hat{H}\,\psi = E\,\psi$$

- $\hat{H}$ → OPERADOR ENERGIA HAMILTONIANO
- ψ → FUNÇÃO DE ONDA
- E → ENERGIA

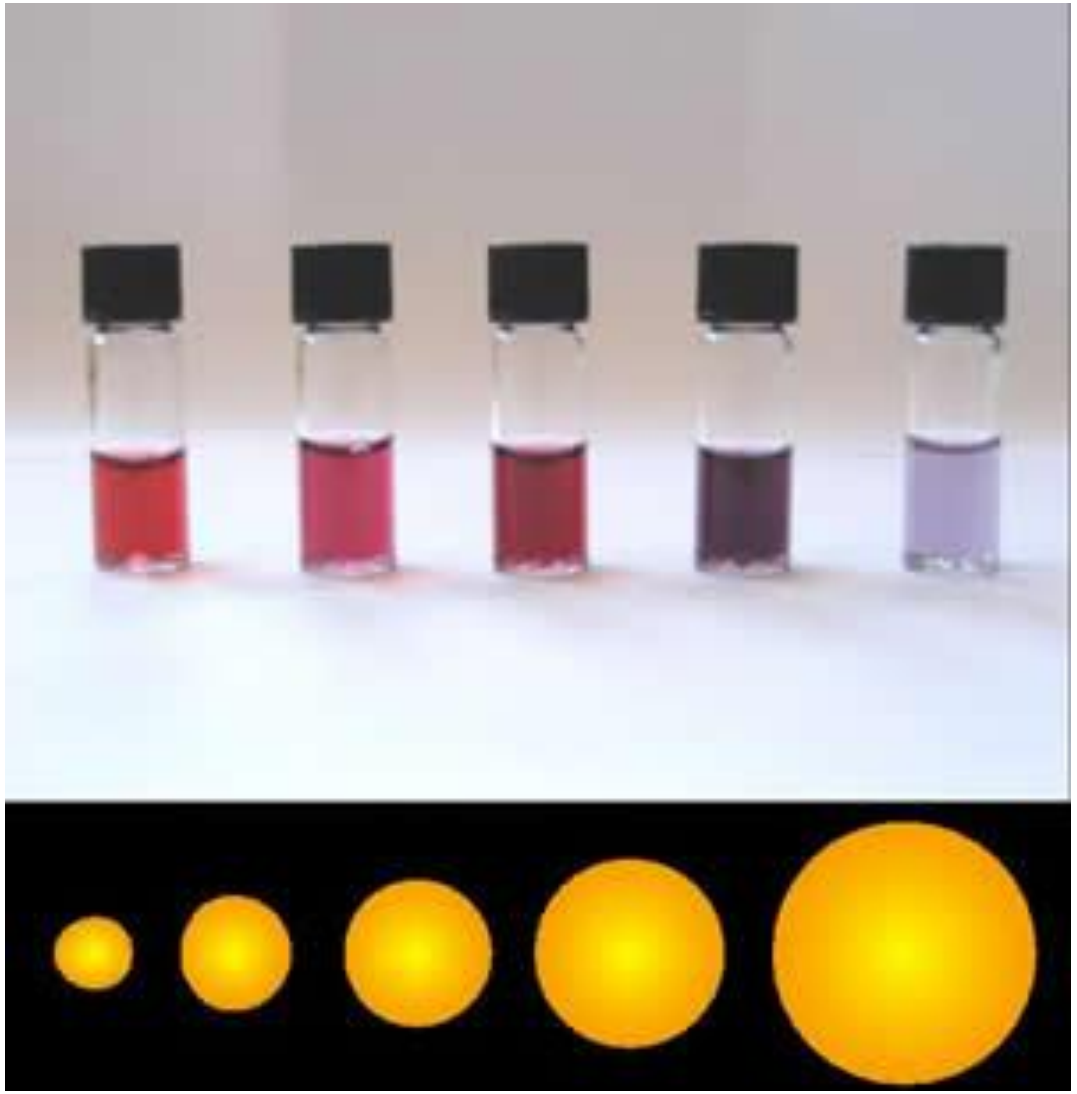
$$E = \frac{n^2 h^2}{8 m L^2}$$

- h → CONSTANTE DE PLANCK
- L → TAMANHO DA CAIXA
- m → MASSA DA PARTÍCULA

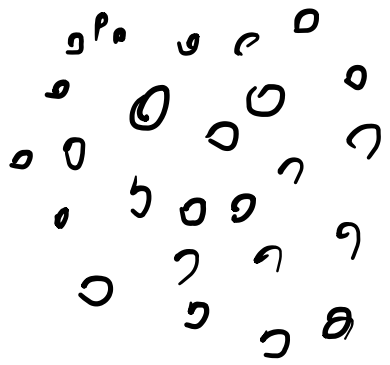


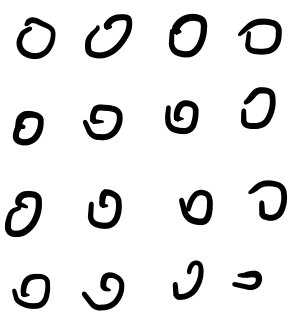
METAIS TAMBÉM APRESENTAM EMISSÃO DE POTÊNCIA DO TAMANHO

http://sustainable-nano.com/2019/11/12/gold-nanoparticles-color/



https://en.wikipedia.org/wiki/Colloidal_gold

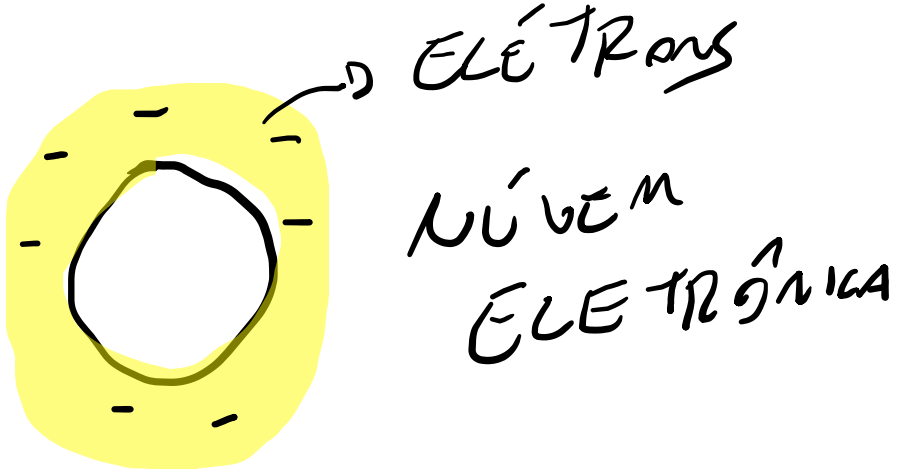


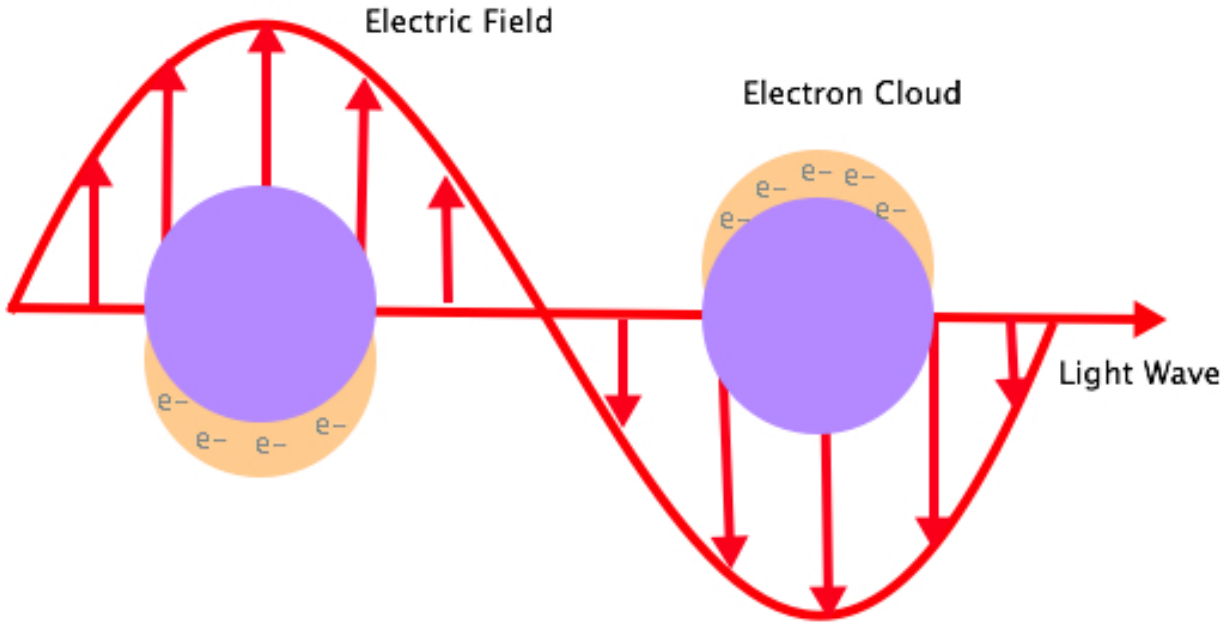


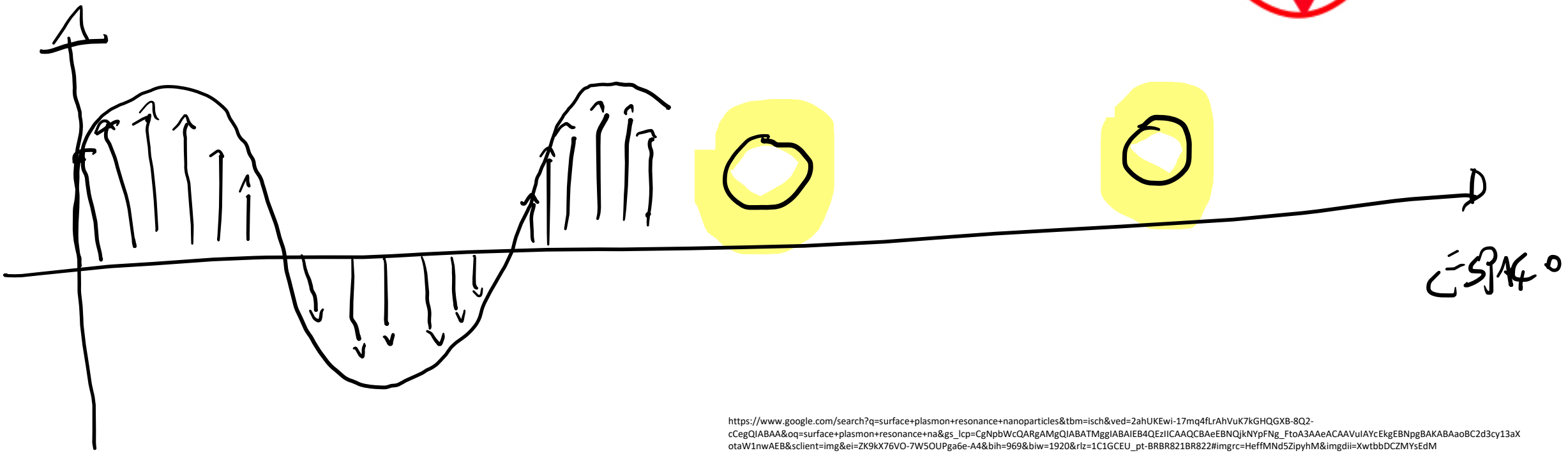
NP METAIS

→ NÃO PODEMOS USAR A ESTRUTURA DE BANDAS

→ NÃO PODEMOS USAR A ESTRUTURA, OU PERIODICIDADE, DO ARRANJO ESPACIAL







https://www.google.com/search?q=surface+plasmon+resonance+nanoparticles&tbm=isch&ved=2ahUKEwi-17mq4fLrAhVuK7kGHQGXB-8Q2-cCegQIABAA&oq=surface+plasmon+resonance+na&gs_lcp=CgNpbWcQARgAMgQIABATMggIABAIEB4QEzIICAAQCBAeEBNQjkNYpFNg_FtoA3AAeACAAVuIAYcEkgEBNpgBAKABAaoBC2d3cy13aXotaW1nwAEB&sclient=img&ei=ZK9kX76VO-7W5OUPga6e-A4&bih=969&biw=1920&rlz=1C1GCEU_pt-BRBR821BR822#imgrc=HeffMNd5ZipyhM&imgdii=XwtbbDCZMYsEdM

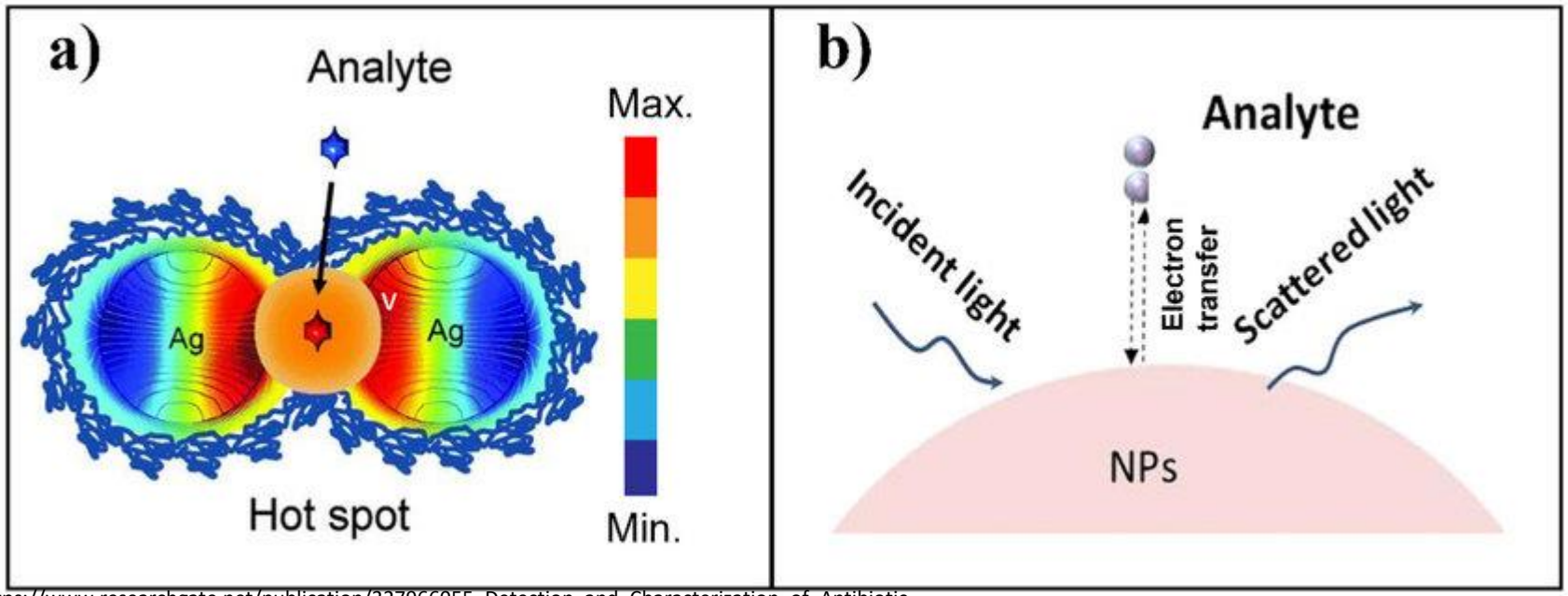
→ PLÁSMON = PARTÍCULA DE NUVEM

→ RESSONÂNCIA PLASMÔNICA

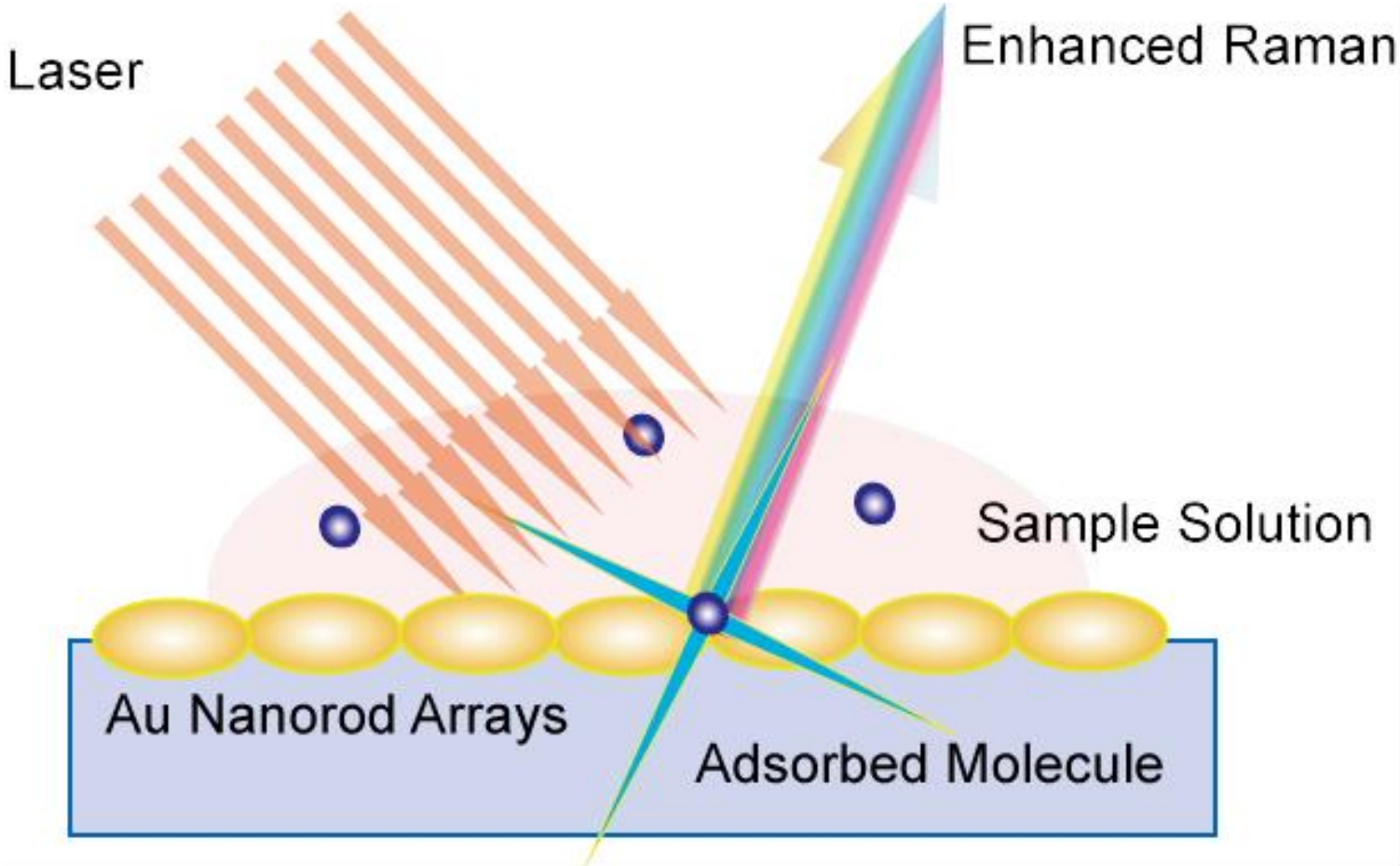
↳ AMPLIFICA CERTOS COMPRIMENTOS DE ONDA

→

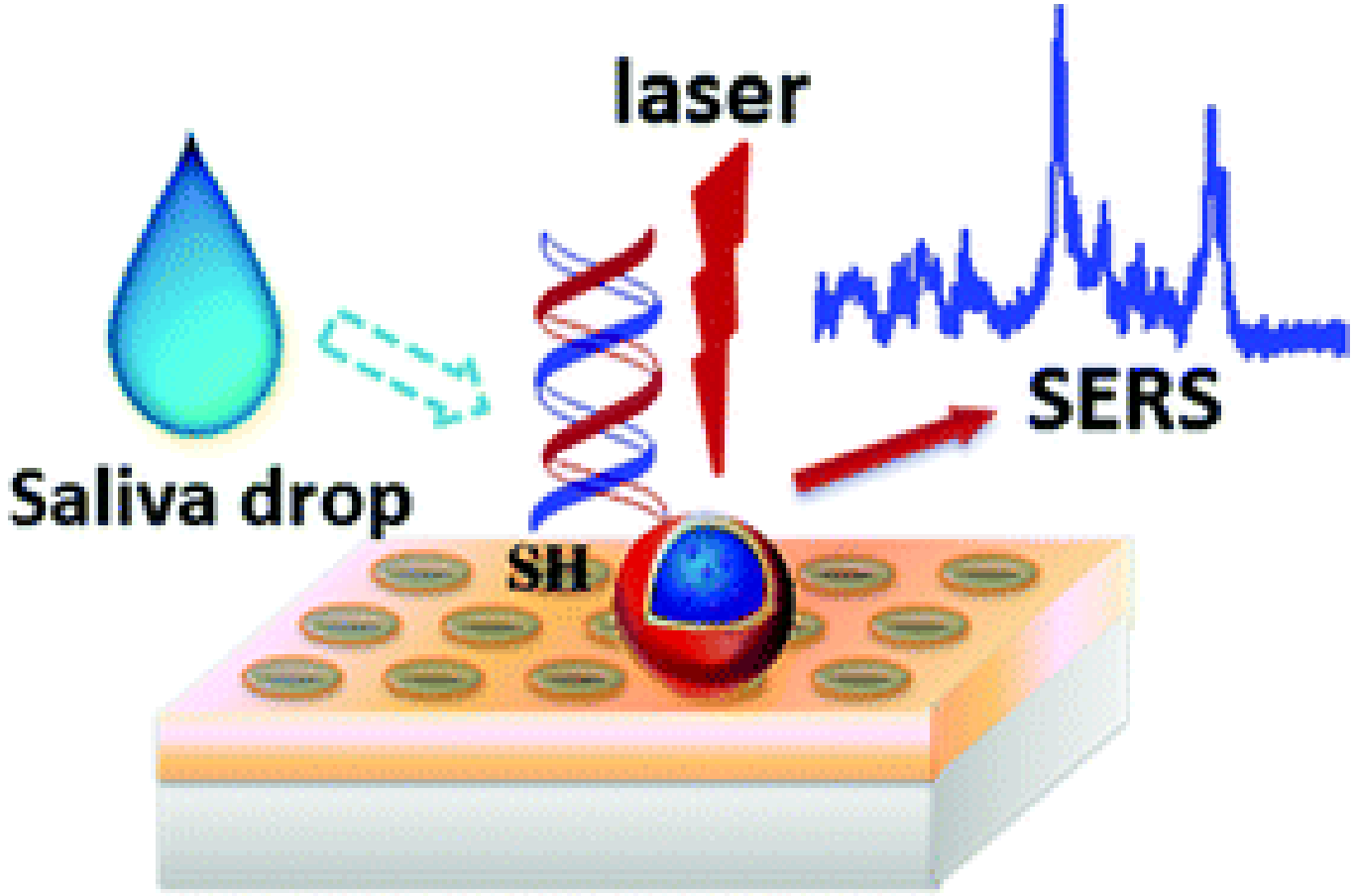
EXEMPLOS PRÁTICOS



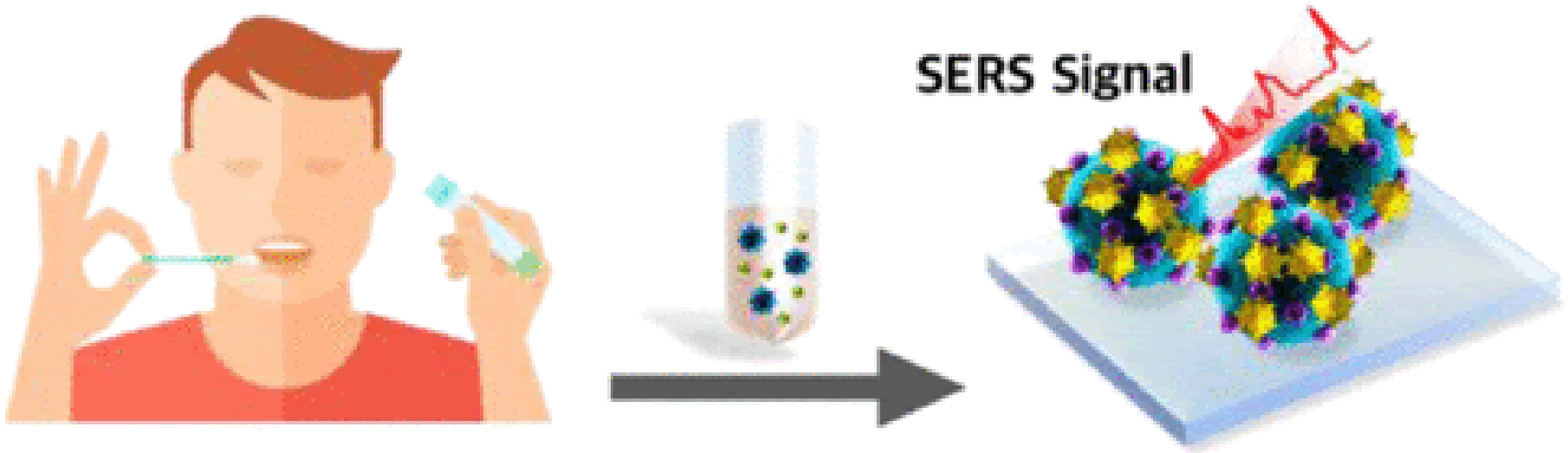
https://www.researchgate.net/publication/327966055_Detection_and_Characterization_of_Antibiotic-Resistant_Bacteria_Using_Surface-Enhanced_Raman_Spectroscopy/figures?lo=1&utm_source=google&utm_medium=organic



https://www.stjapan.de/accessories-1/raman-sers-substrates/



https://pubs.rsc.org/en/Content/Image/GA/C5NR02142A

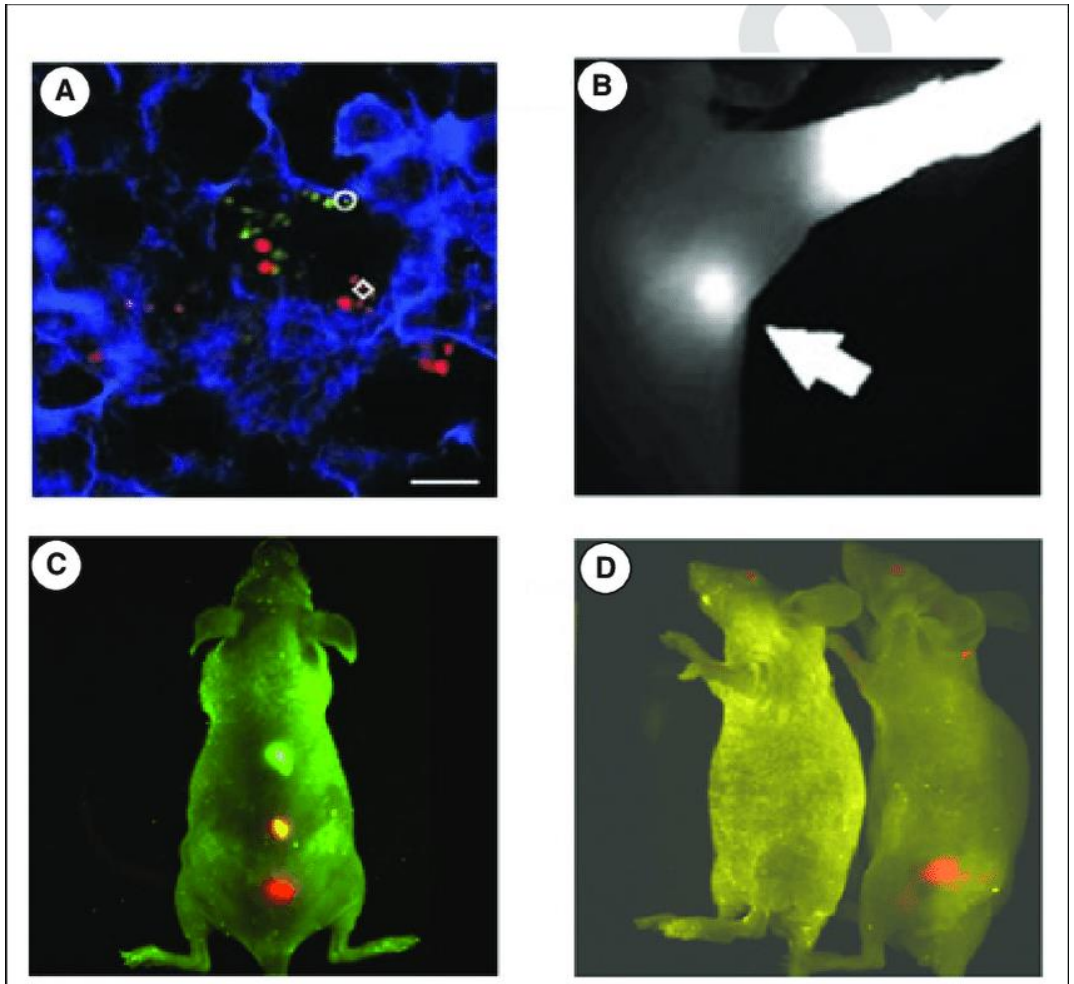


http://kangtaejoon.com/Publications.htm

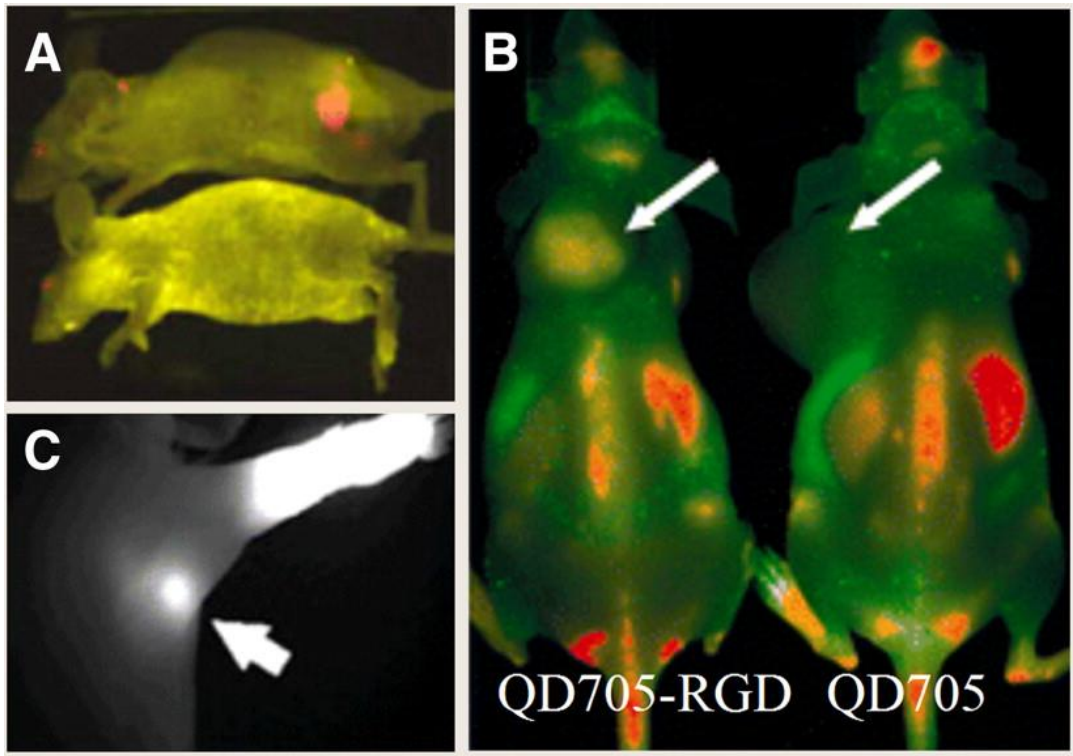
0.2217/17435889.1.2.xxx

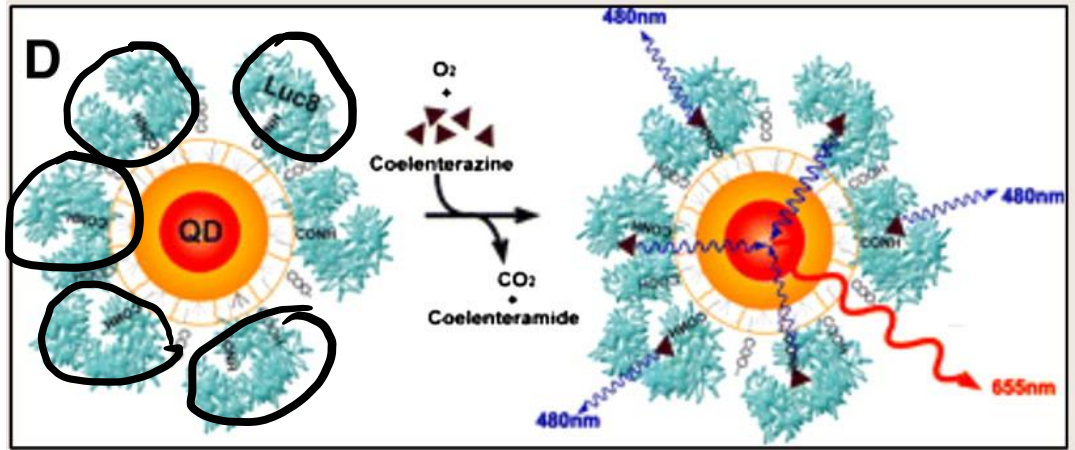
http://jnm.snmjournals.org/content/50/4/493/F1.expansion.html

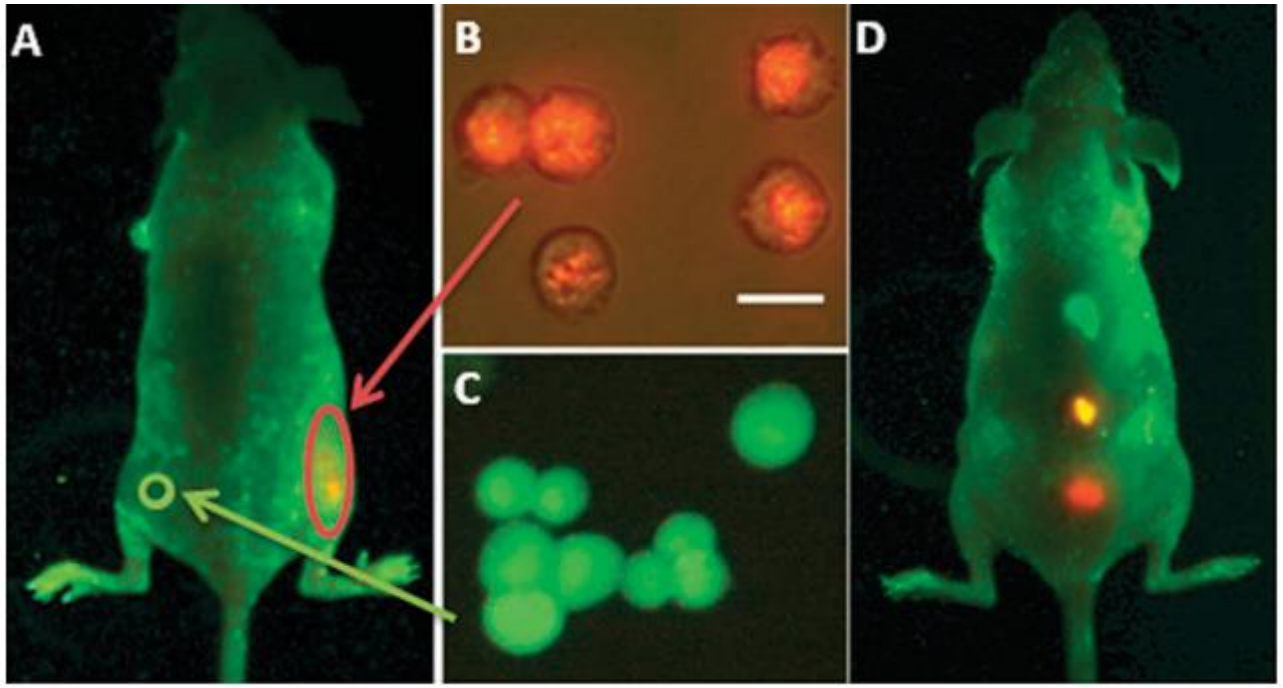
Light emission- Quantum dots



(A) *Ex vivo* tissue micrograph of quantum dot (QD)-labeled cancer cells trapped in a mouse lung. **(B)** Near infrared fluorescence image of water-soluble Type-II QDs taken up by sentinel lymph nodes [20]. **(C)** *In vivo* image of multicolor QD-encoded microbeads injected into a live mouse [37]. **(D)** Molecular targeting and *in vivo* imaging of a prostate tumor using a QD–antibody conjugate [37].







https://www.semanticscholar.org/paper/Designing-multifunctional-quantum-dots-for-and-drug-Zrazhevskiy-Sena/da84ada03aea37041846885a32864b201b7aa833/figure/16

EFEITO DO TAMANHO DAS NANOPARTÍCULAS SOBRE A CAPACIDADE / VELOCIDADE DE DISSOLUÇÃO