Science Olympiad

Exploring the World of Science

North Carolina Science Olympiad

Materials Science

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Wisconsin Science Olympiad

Materials Science

Metals, Ceramics, Polymers and Composites
Processing and Performance

Materials Science Resources

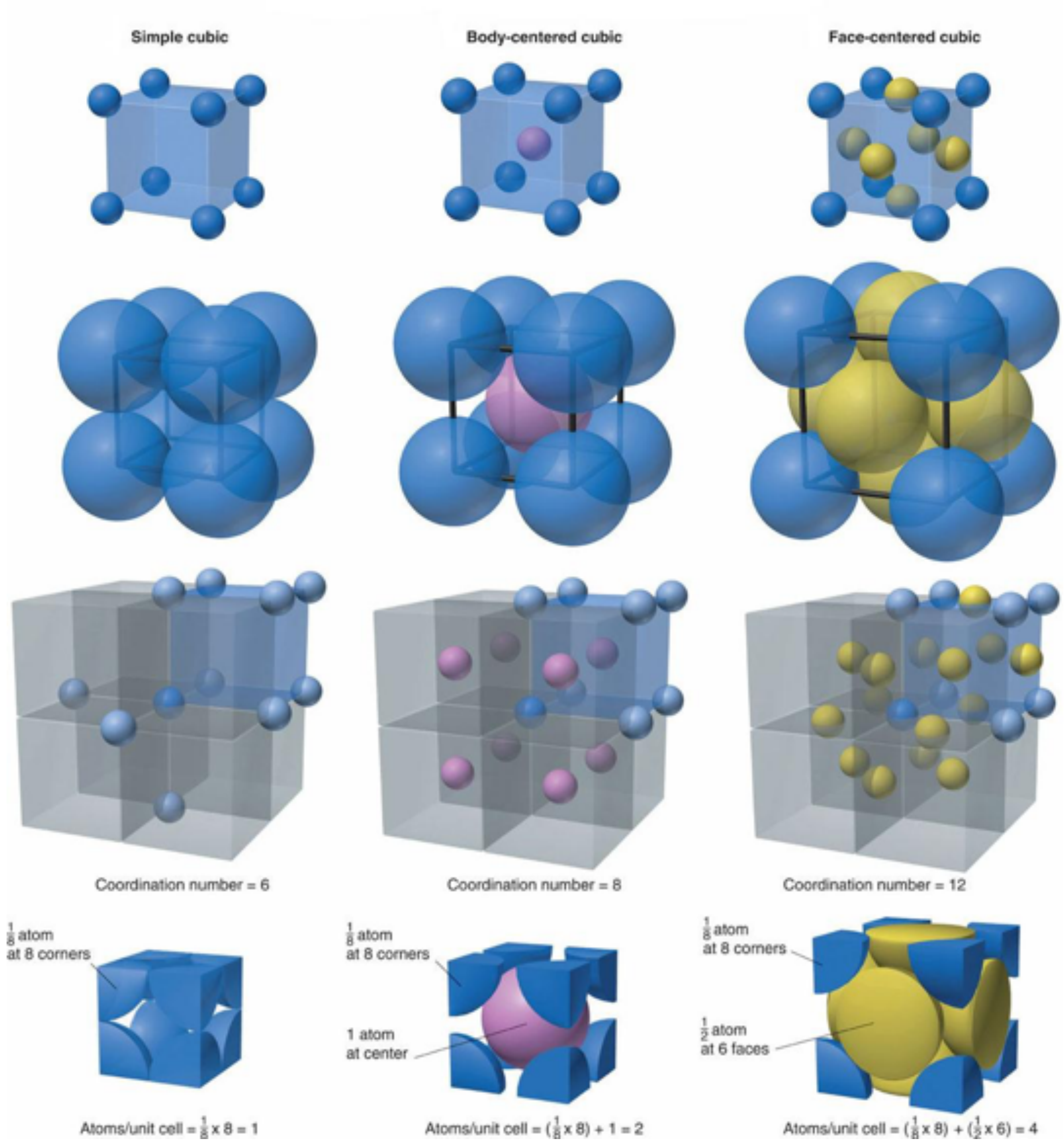
https://www.nde-ed.org/EducationResources/CommunityCollege/Materials/cc_mat_index.htm

http://textbooks.elsevier.com/manualsprotectedtextbooks/9780750663809/Static/index.htm

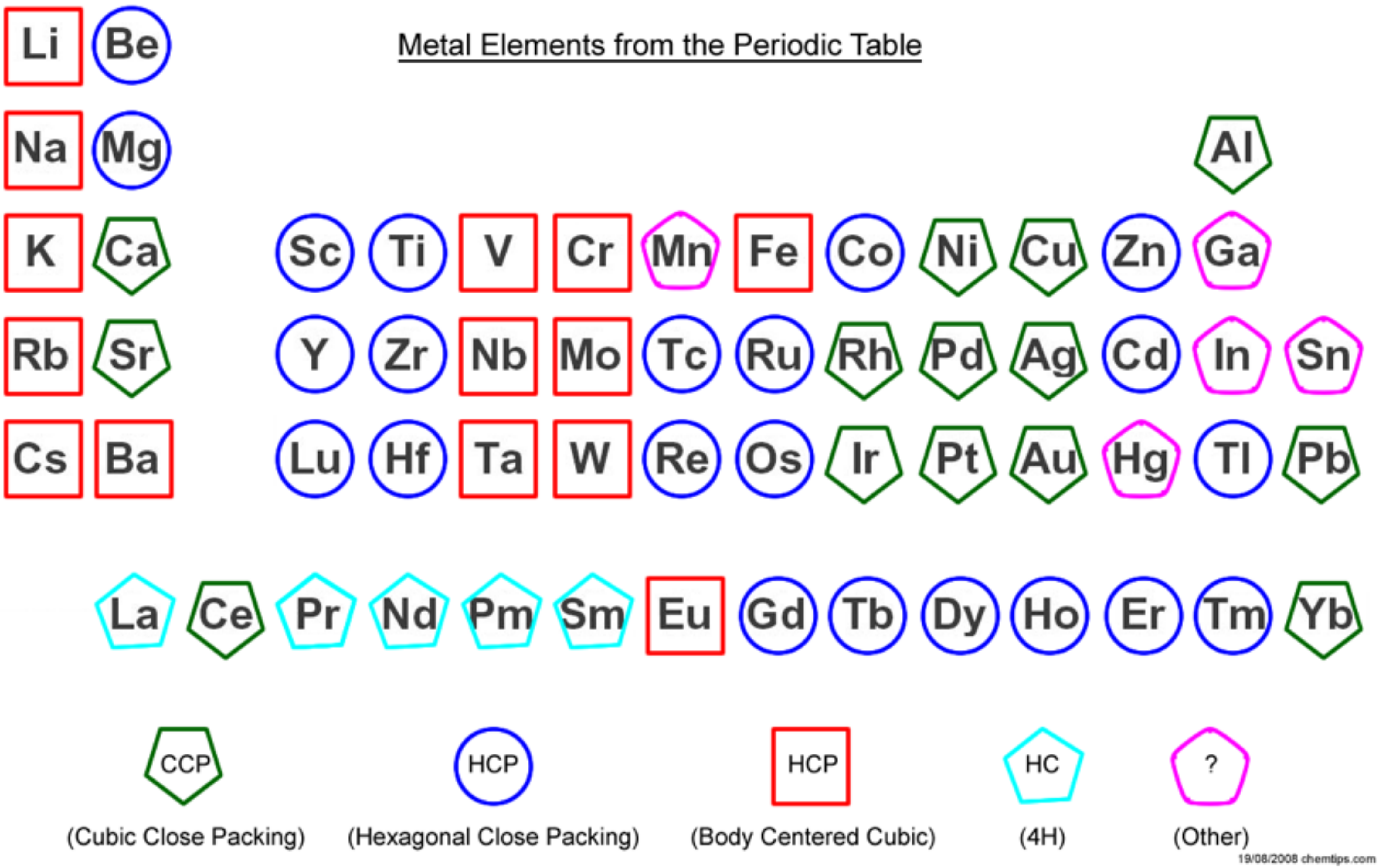
http://classroom.materials.ac.uk/index.php

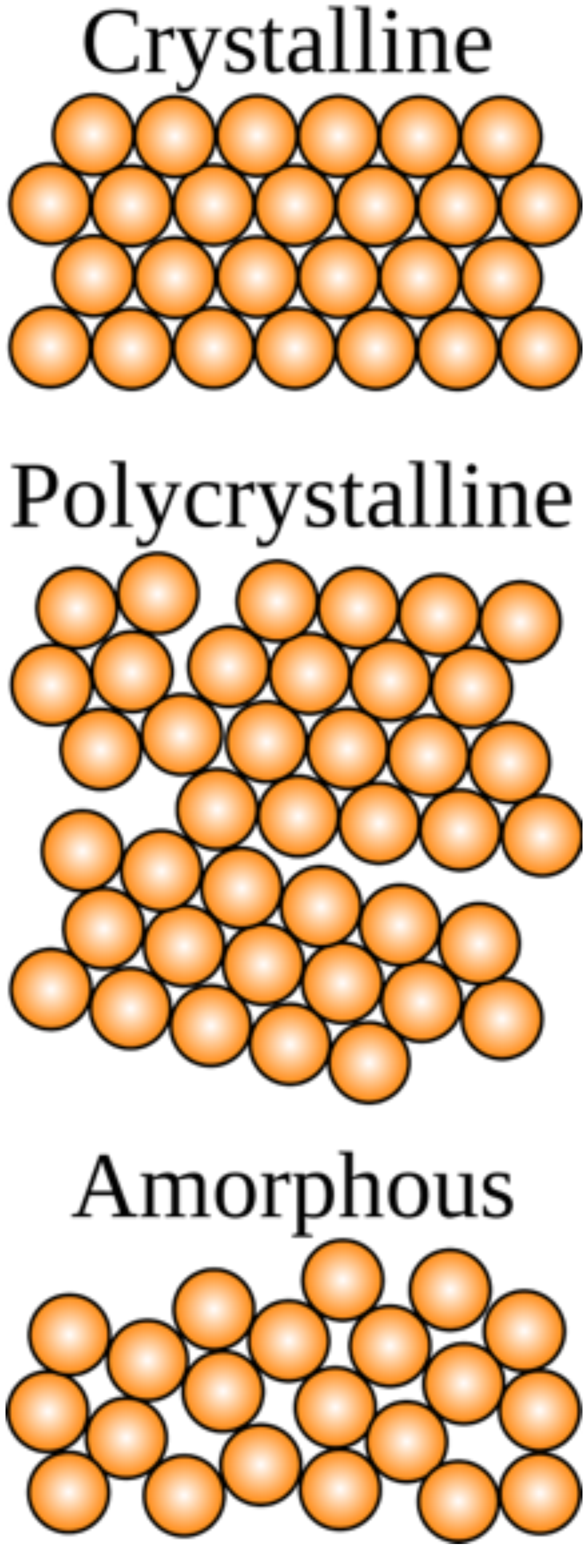
3. **THE COMPETITION**:
   a. The competition will focus on: evaluating the mechanical performance of materials and the intermolecular forces of materials.
   b. The event will consist of an activity or activities with supporting questions.
   c. Students will interpret data by preparing data tables and constructing graphs of the data.
   d. All measurements must be recorded with correct significant figures and units. All calculations must also include correct significant figures and units.
4. **LABS**: Material Performance & Atomic/Molecular Structure Topics are limited to:
   a. **General properties of material classes (metals, ceramics, polymers, composites)**: i. **Physical characteristics** (density, strength, thermal properties, etc.), ii. **Manufacturing techniques and natural occurrences**, iii. **Chemical composition** (elements, bonds, etc.)
   b. **Material characterization techniques**: i. **Visual** (optical and electron microscopy), ii. **Physical tests**: Stiffness of material (Young's Modulus), Breaking strength of a material (Yield Strength), Surface Area/Volume ratio, Permanent deformation of material under constant load (Creep Rate), Resistance to flow (Viscosity). For State and National tournaments: Resistance to fracture (Fracture toughness), Resistance to repetitive strain (Fatigue Limit), Stiffness under shear load (Shear Modulus), Transverse, inherent strain (Poisson's Ratio), Bulk Modulus. iii. **Material selection for specific applications** (choosing the best material for an application based off of a list of materials and their properties)
   c. **Intermolecular Forces and Surface Chemistry**: i. **Chemical tests**: Surface Chemistry, surface tension, contact angle. ii. **Crystal Structures**; Ionic, Covalent, Crystalline, Semi-Crystalline, Amorphous, Common atomic packing (FCC, BCC, HCP, Simple Cubic), Atomic packing factor (Geometry only)

Metals Begin with Crystal Arrangements

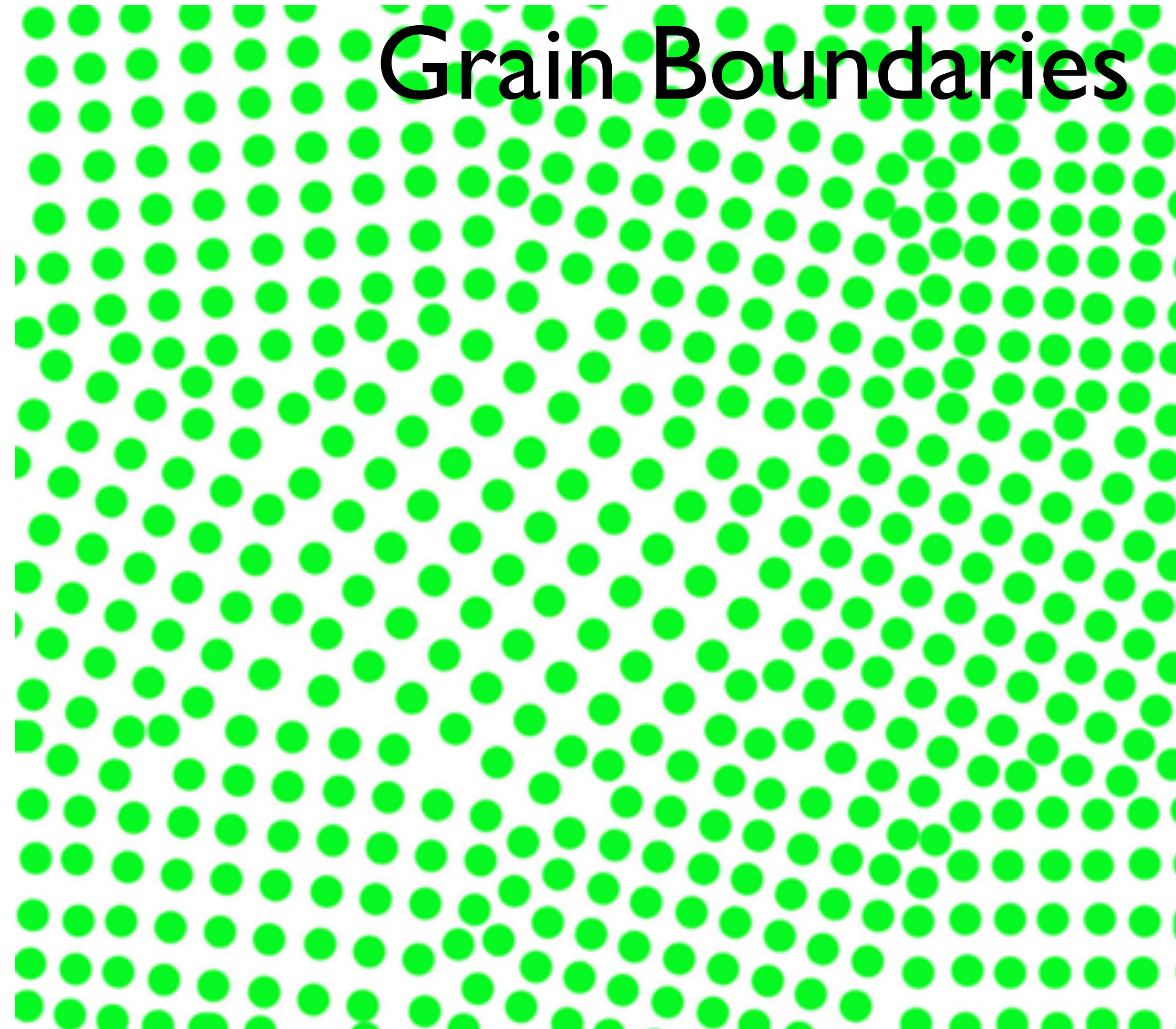


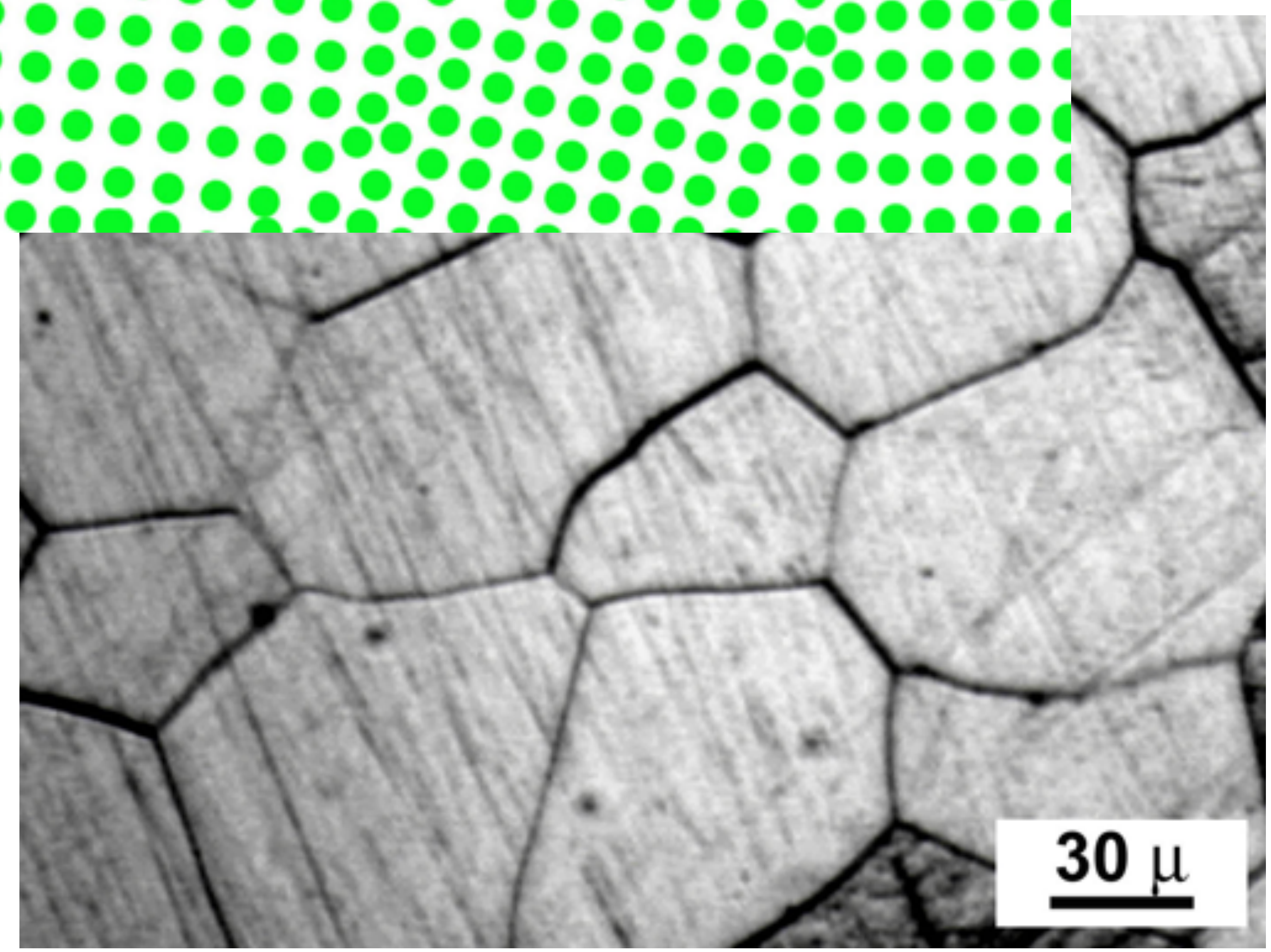
Metal Crystals




Crystalline
Polycrystalline
Amorphous

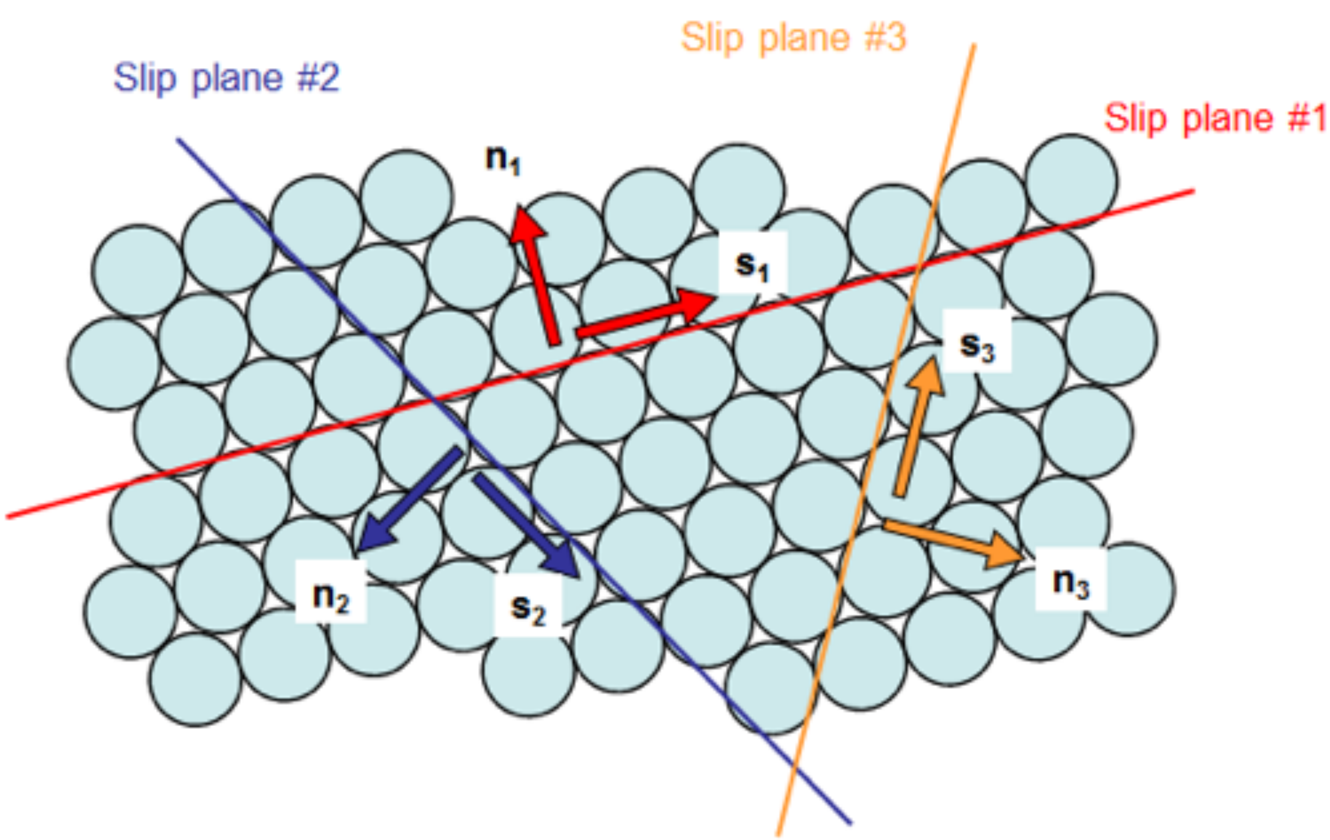
the “norm”

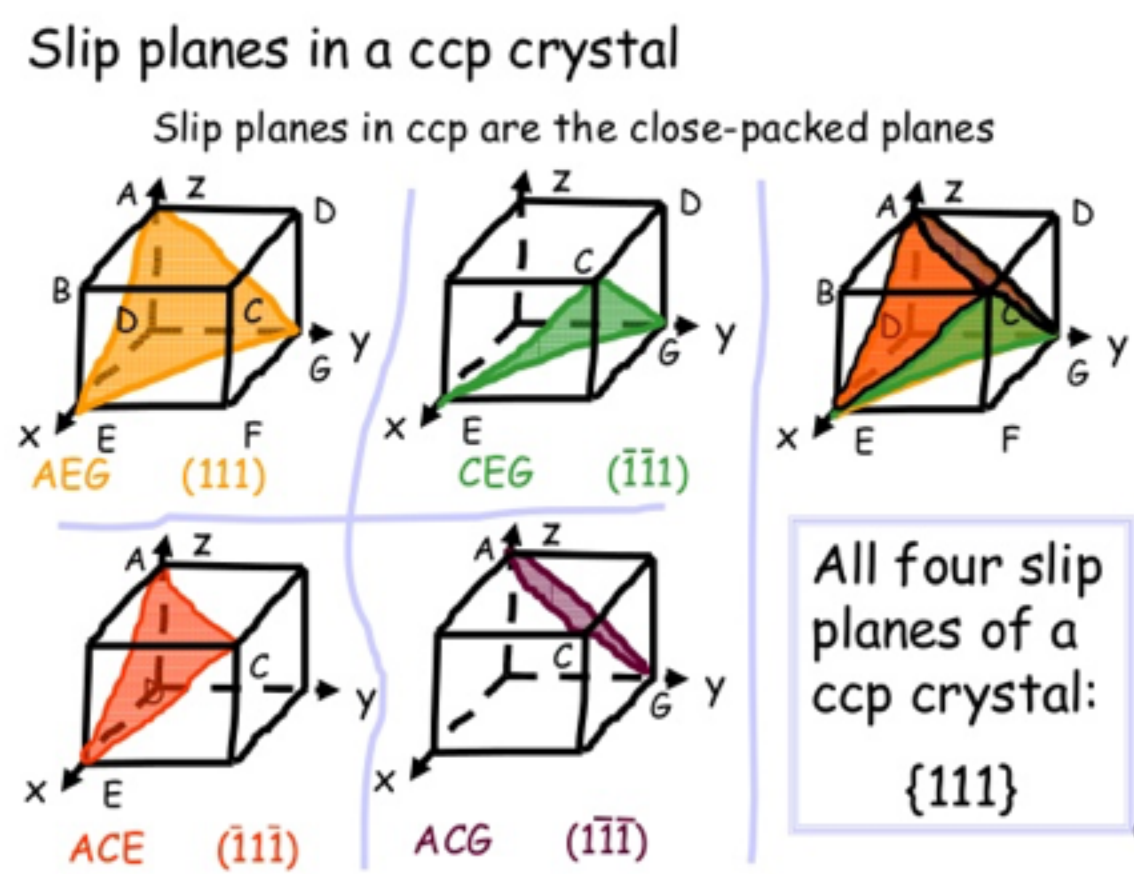

Grain Boundaries

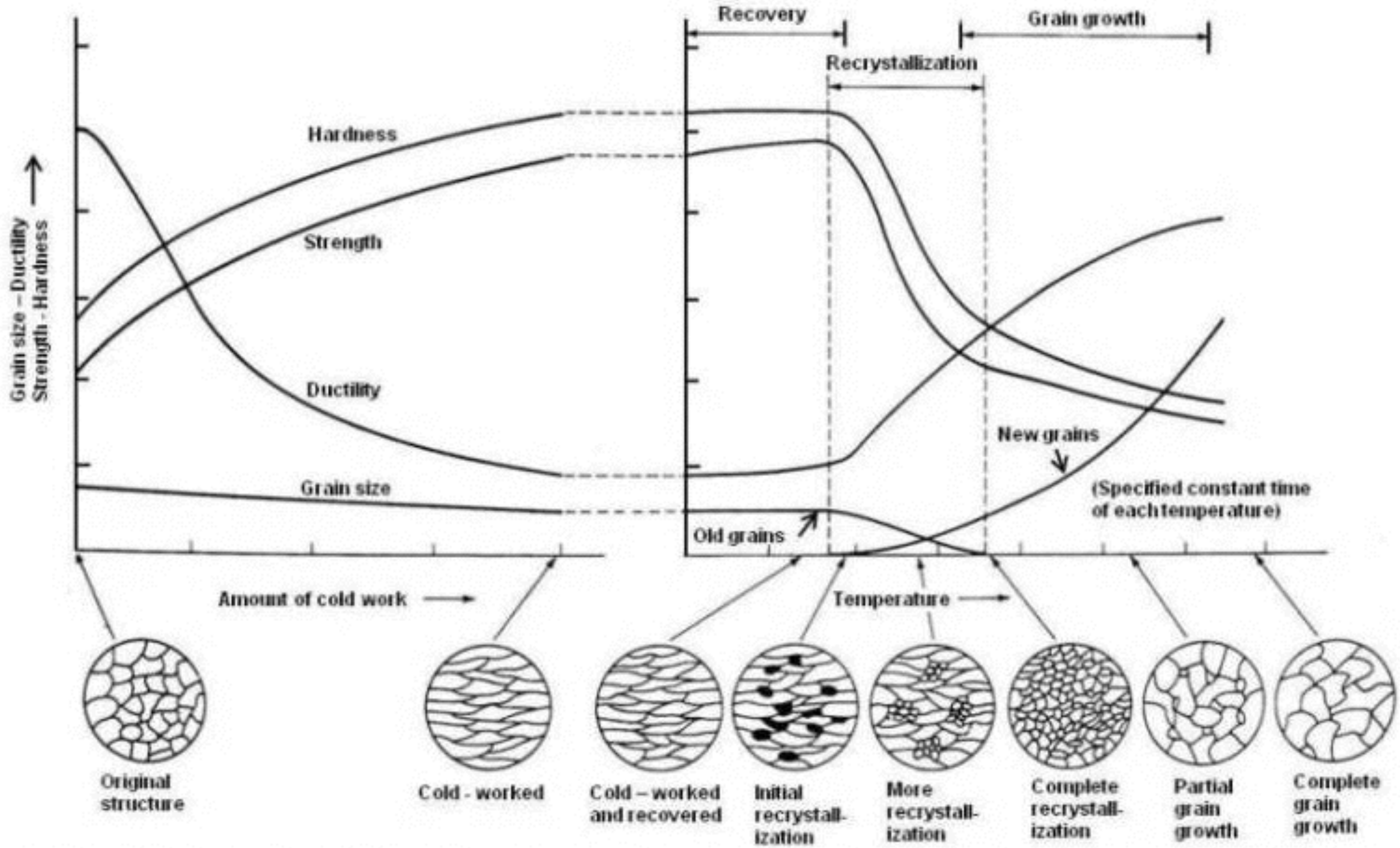

30 μ

Metal Performance

Metals slip alongs planes to enable ductility, when planes are disrupted, then ductility is decreased.



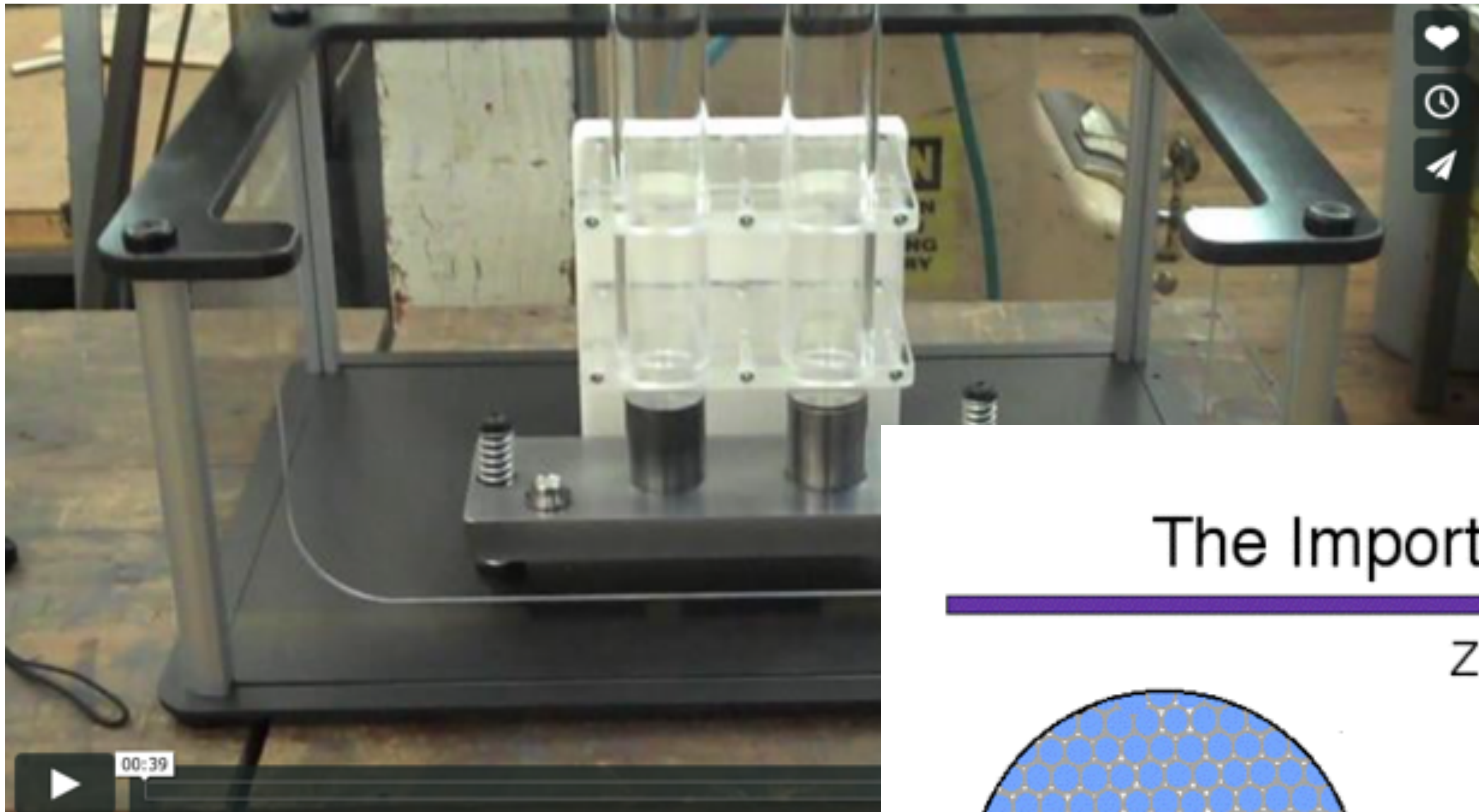


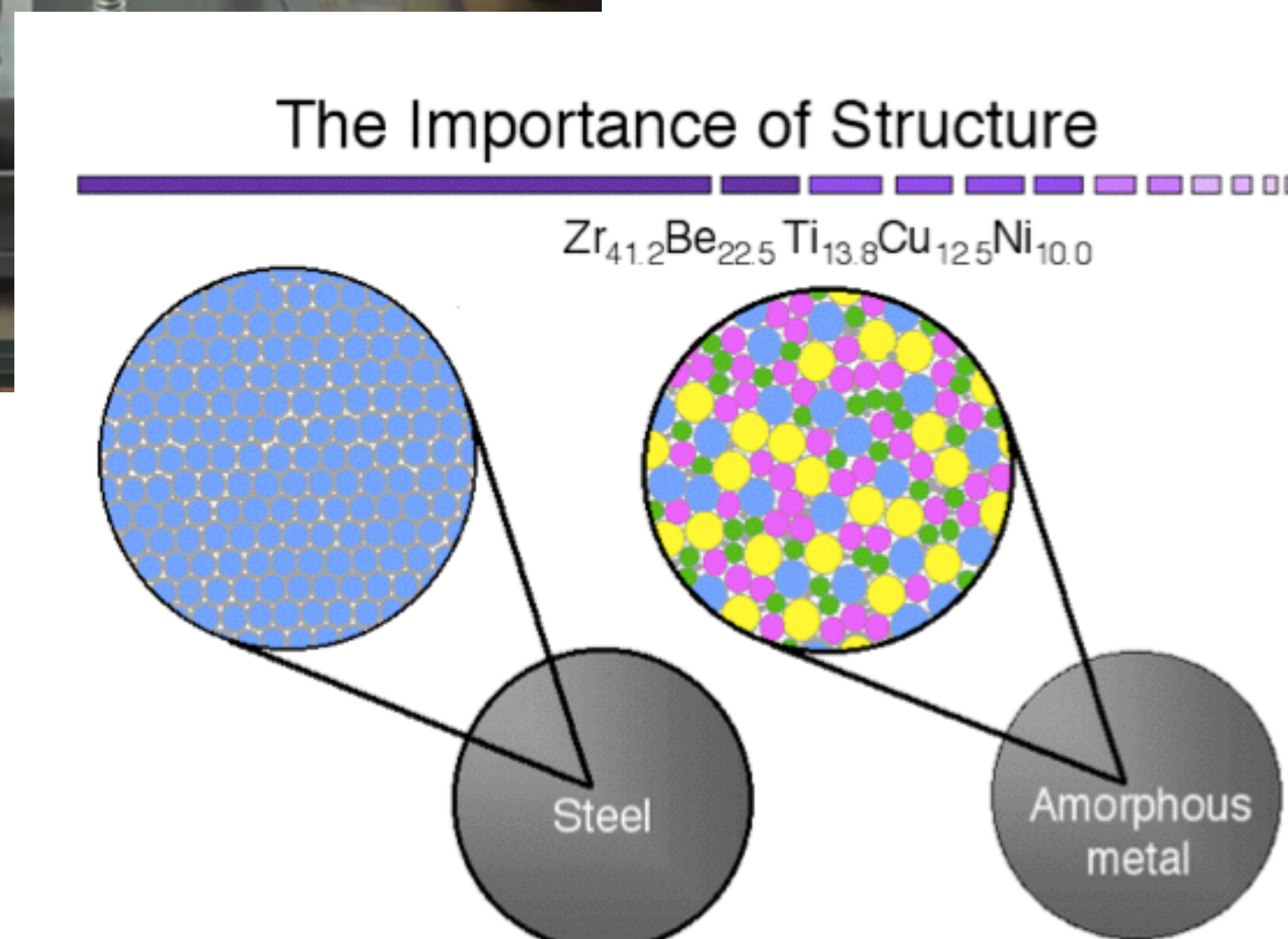


Schematic Representation of the Cold-worked and Anneal Cycle showing the effects on Properties and Microstructure

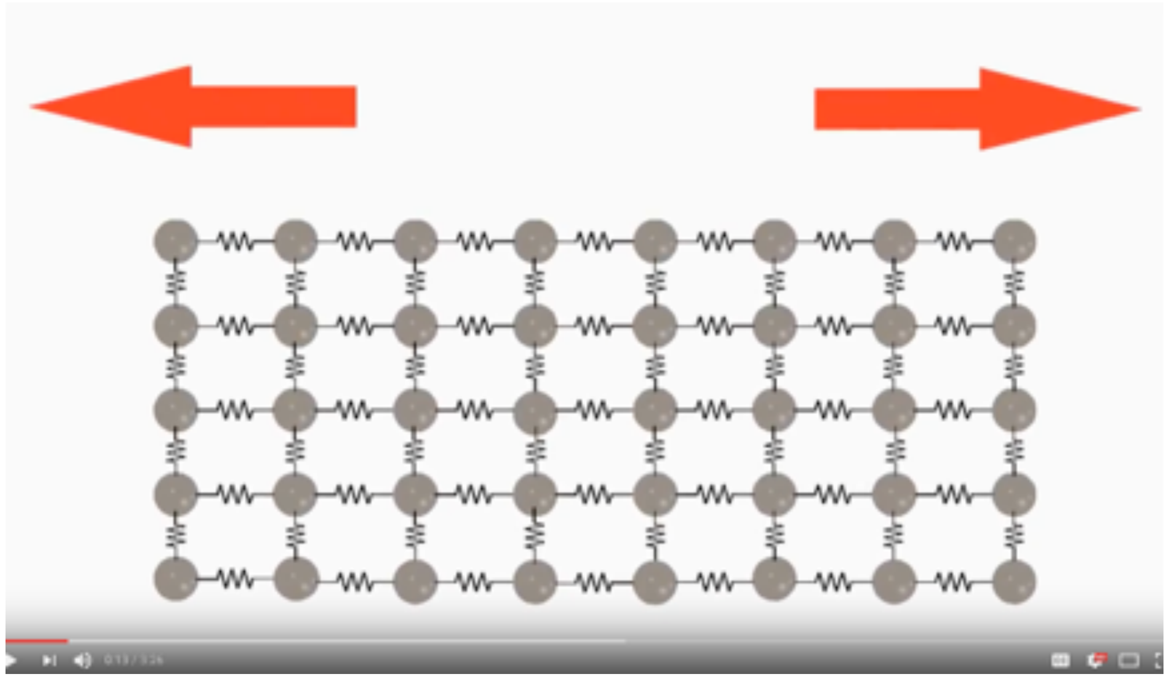
crystalline poly-crystalline and amorphous crystalline

Amorphous Metal Bounce





https://vimeo.com/18940108



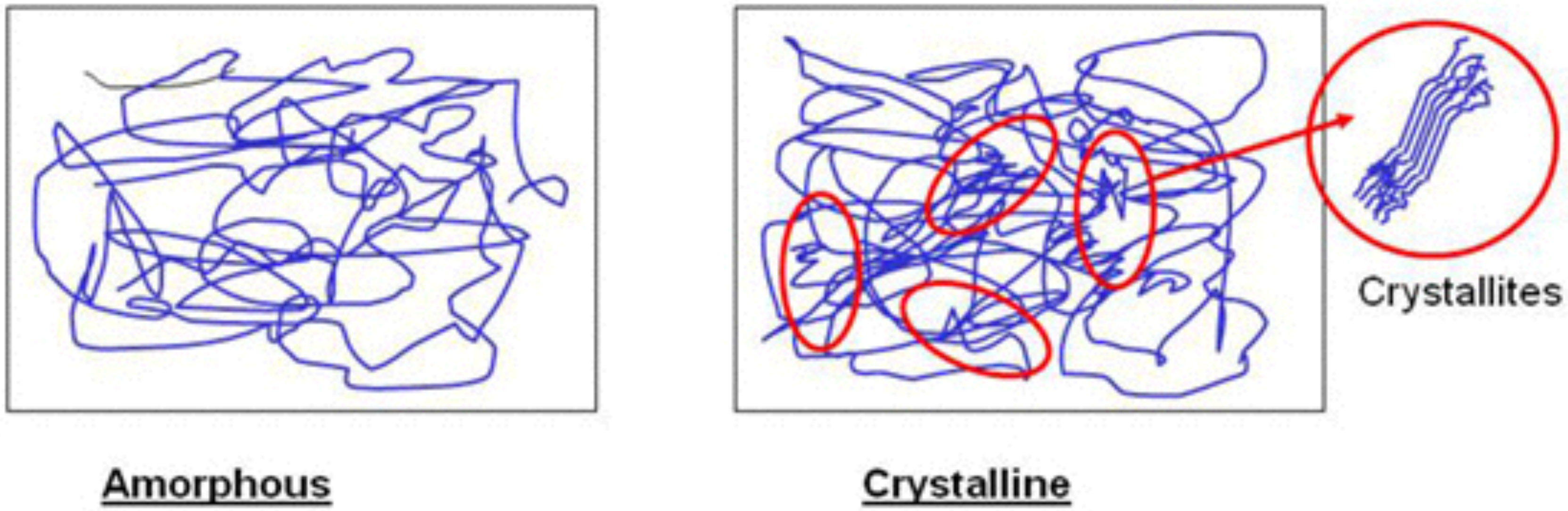
https://youtu.be/n7LXYyohmgg

Stress-Strain Modern

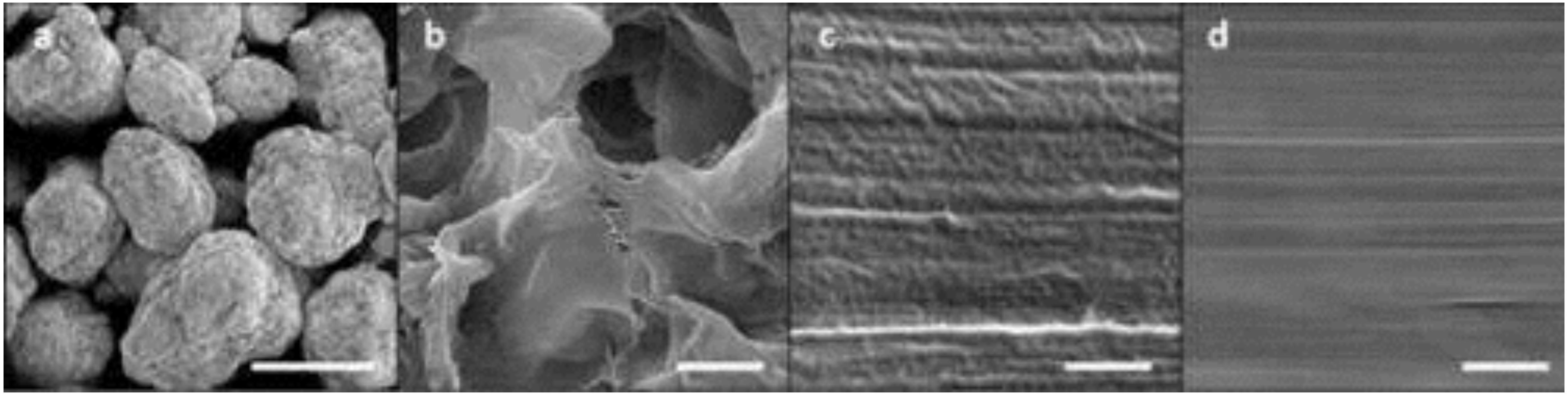
Processing Classic!

https://www.youtube.com/watch?v=uG35D_euM-0

Polymer long-chain "spaghetti" control through synthesis or processing



Example of Polymer Processing on Morphology

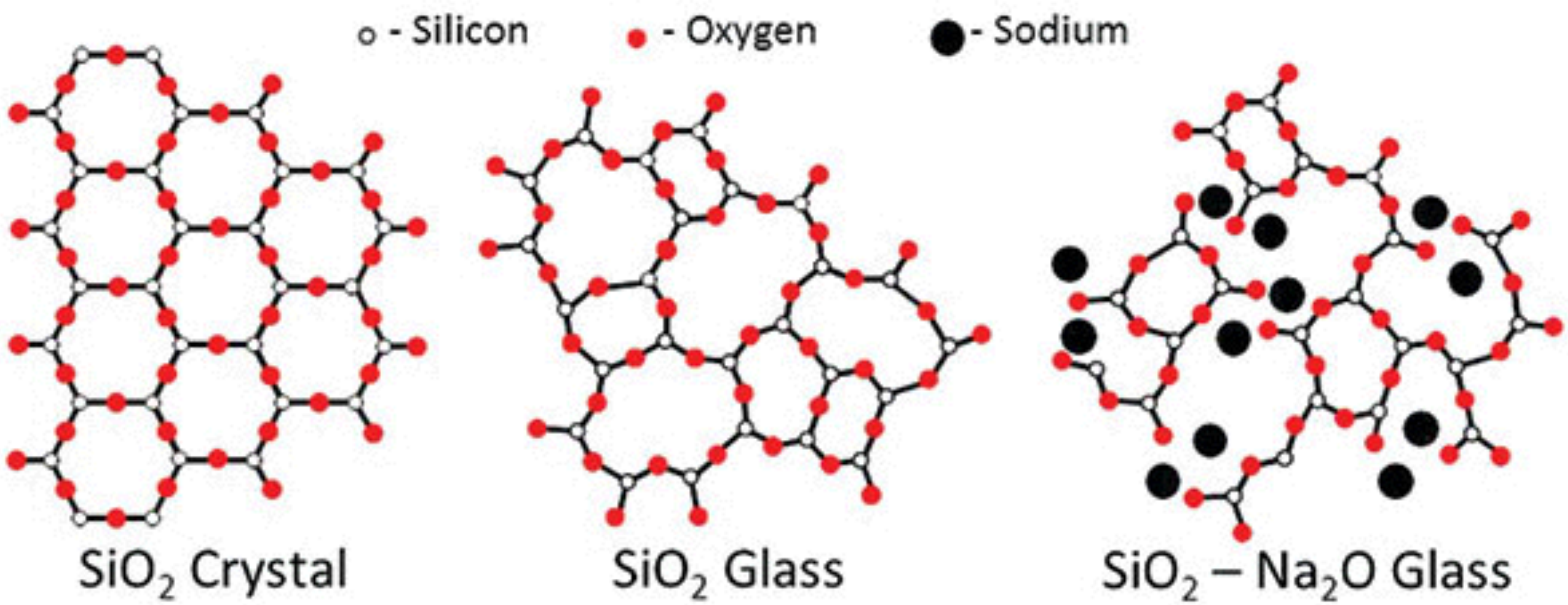


This sequence of scanning electron microscopy (SEM) images demonstrates drastic changes in polyethylene surface morphology resulting from the fabrication process. The initial polymer particulate material resembled tightly wound balls of string (a). Comparing this to the extruded sample (b), however, polymer disentanglement as a result of the high shear rate Couette-based extrusion process is evident. SEM images of 50× (c) and 100× (d) drawn films. As shown, film structure is uniform fibrous with minimal defects. Scale bar represents 100 microns (a), and 2 microns (b-d).

Read more at: http://phys.org/news/2014-10-fabrication-highly-aligned-polymer-method.html#jCp

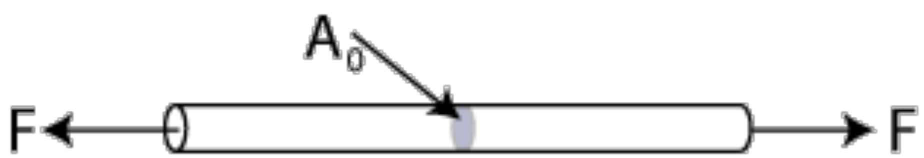
Ceramics-think in term of covalent networks

no shifting or bending of bonds, just breakage = Brittle



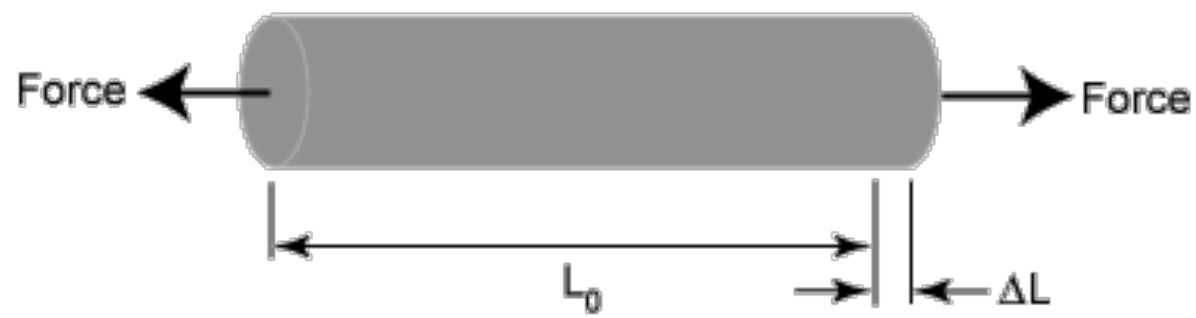
Clays are layers of ceramics with water in between

STRESS



$$\text{Stress, } \sigma = \frac{\text{Force}}{\text{Cross-Sectional Area}} = \frac{F}{A_0}$$

STRAIN



$$\text{Strain} = \frac{\text{Elongation}}{\text{Original Length}} = \frac{\Delta L}{L_0}$$

Process [edit]

The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the *engineering strain*, ε, using the following equation:[4]

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$$

where ΔL is the change in gauge length, L_0 is the initial gauge length, and L is the final length. The force measurement is used to calculate the *engineering stress*, σ, using the following equation:[4]

$$\sigma = \frac{F_n}{A}$$

where F is the tensile force and A is the nominal cross-section of the specimen. The machine does these calculations as the force increases, so that the data points can be graphed into a *stress–strain curve*.[4]

Example from NSO Exam

(20 points) STRESS-STRAIN CURVE ACTIVITY: A cylindrical specimen of aluminum having a diameter of 12.8 mm and a length of 50.800 mm is pulled in tension. Use the load-elongation characteristics tabulated below to plot a stress-strain curve and complete problems a through d.

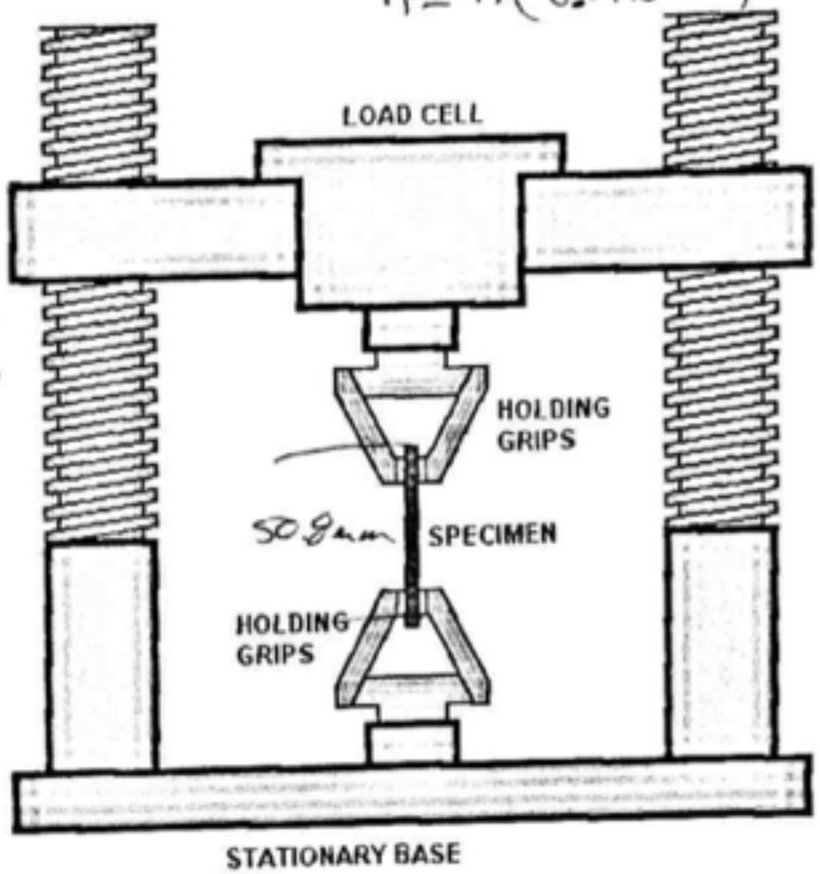
12.8mm

$r = 6.4\,mm$

$r = 6.4 \times 10^{-3}\,m$

$A = \pi(6.4 \times 10^{-3}\,m)^2$

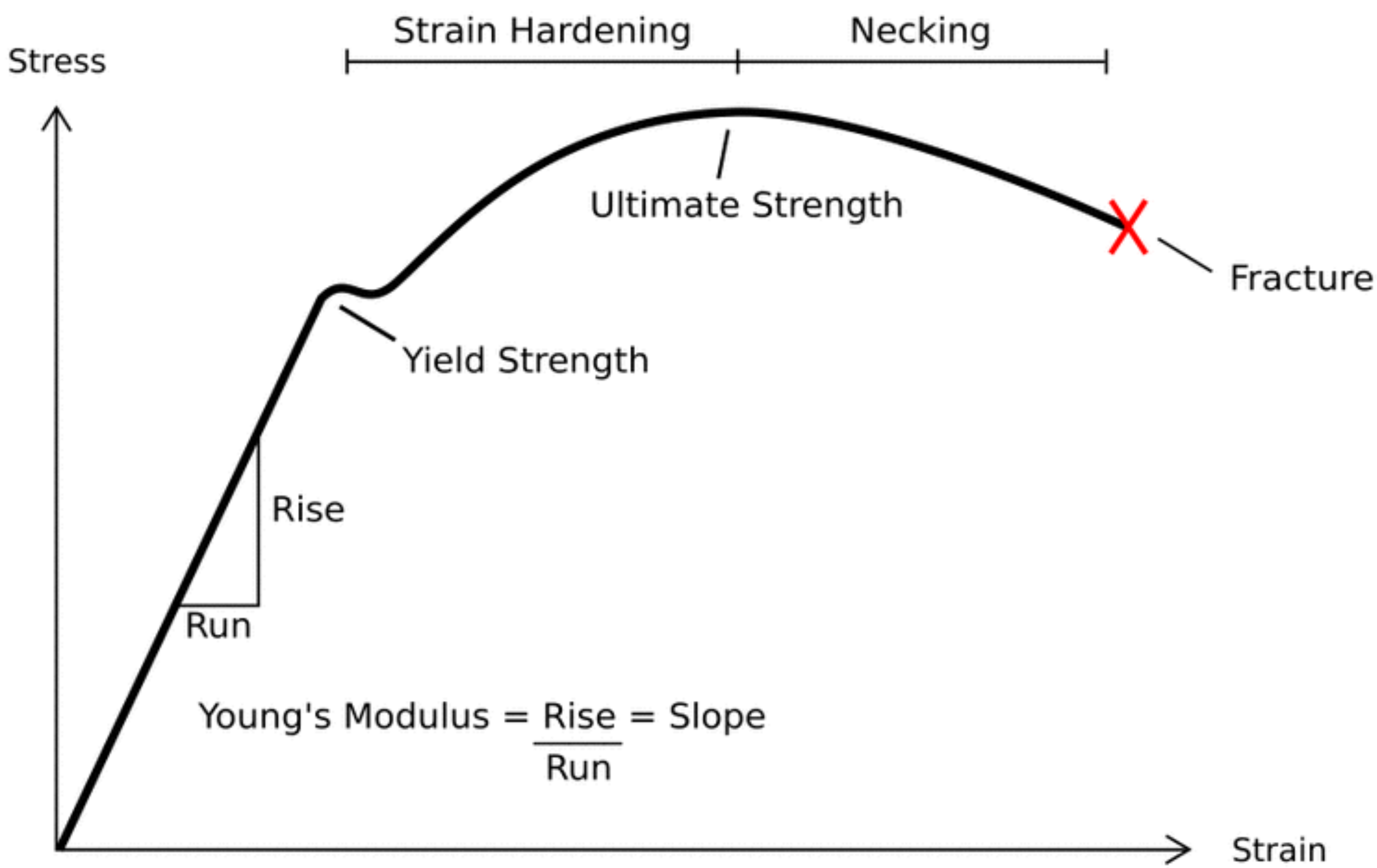
Load (N)	mPa	Length (mm)	mm	
0		50.800		
7,330	56.82 ~~14.26~~	50.851	0.051	0.001
15,100	116.9 ~~29.37~~	50.902	0.102	0.002
23,100	175.9 ~~44.94~~	50.952	0.152	0.003
30,400	235 ~~59.14~~	51.003	0.203	0.004
34,400	266 ~~66.93~~	51.054	0.254	0.005
38,400	297 ~~74.70~~	51.308	0.508	0.01
41,300	320 ~~80.35~~	51.816	1.016	0.02
44,800	347 ~~87.16~~	52.832	2.032	0.04
46,200	358 ~~89.88~~	53.848	3.048	0.06
47,300	366 ~~92.02~~	54.864	4.064	0.08
47,500	368 ~~92.41~~	55.880	5.08	0.1
46,100	357 ~~89.69~~	56.896	6.096	0.12
44,800	347 ~~87.16~~	57.658	6.858	0.135
42,600	330 ~~82.88~~	58.420	7.62	0.15



$F = ma$

$\frac{F}{A} = \frac{kg\,m}{s^2\,m^2} = \frac{kg}{m\,s^2}$

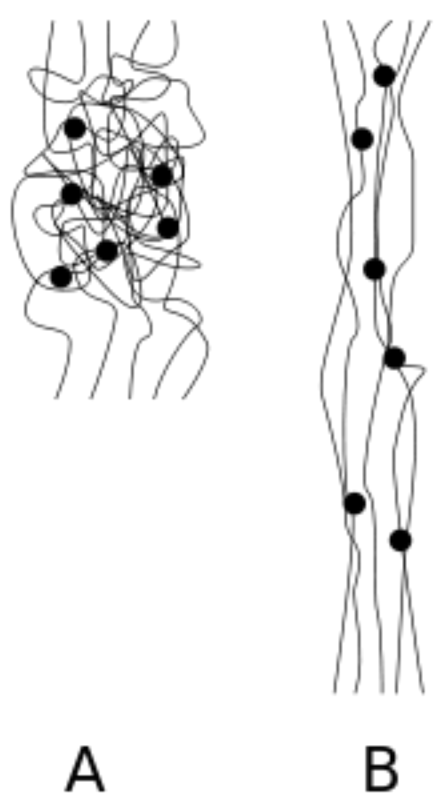
http://classroom.materials.ac.uk/index.php paper (notebook), brown paper towel, bag, parafilm, aluminum foil

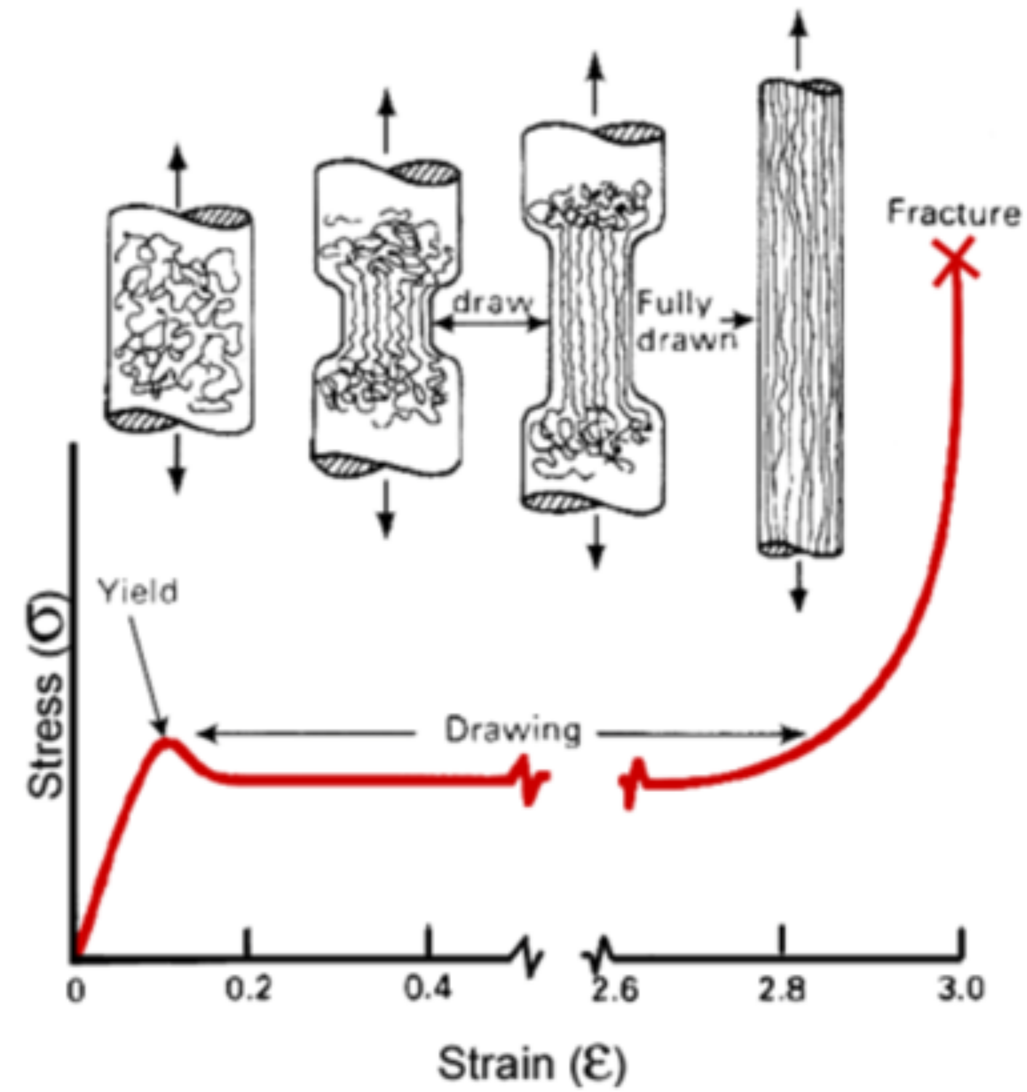


https://www.teachengineering.org/lessons/view/cub_mechanics_lesson07

Stress-Strain Curve

common for many plastics

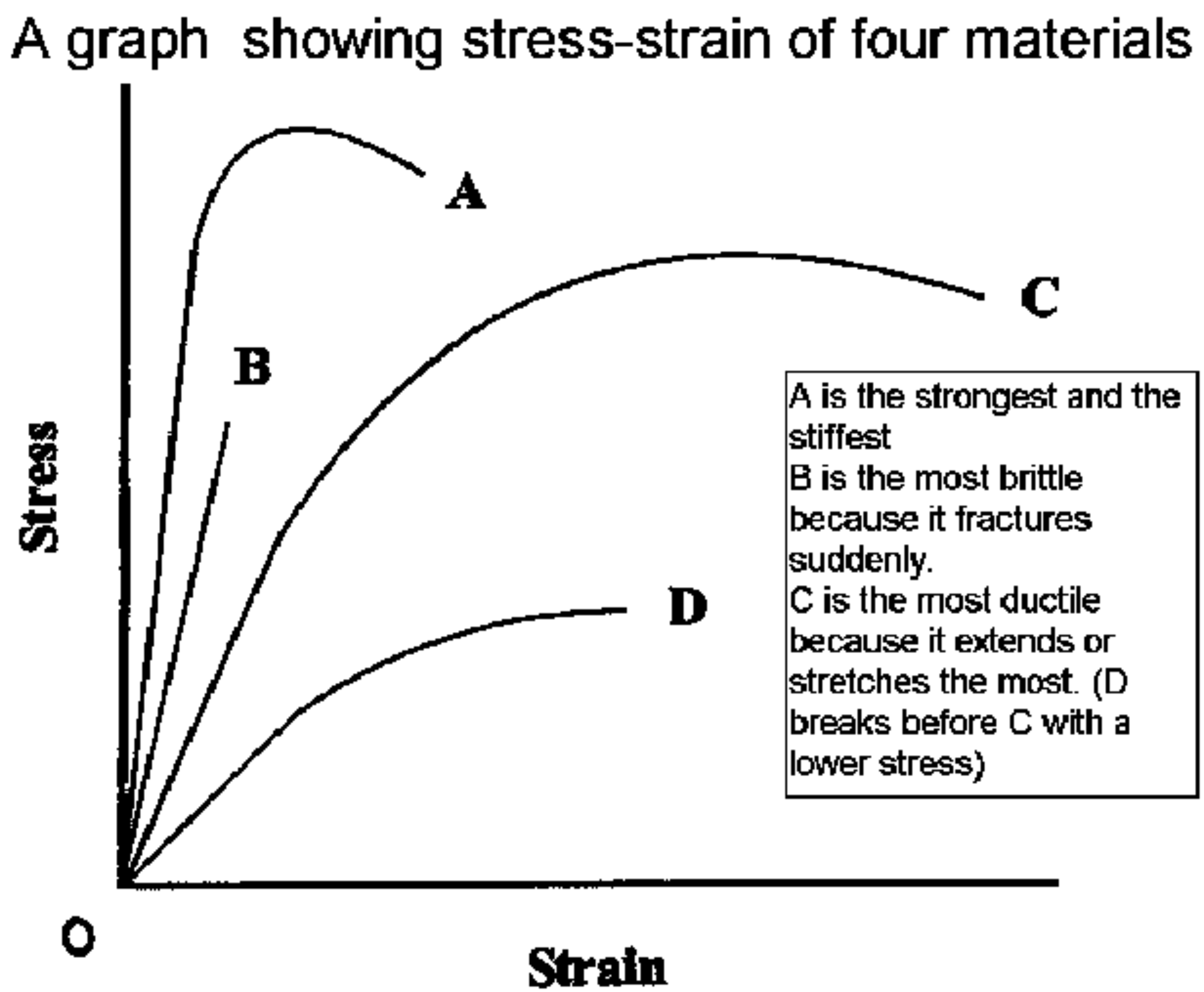




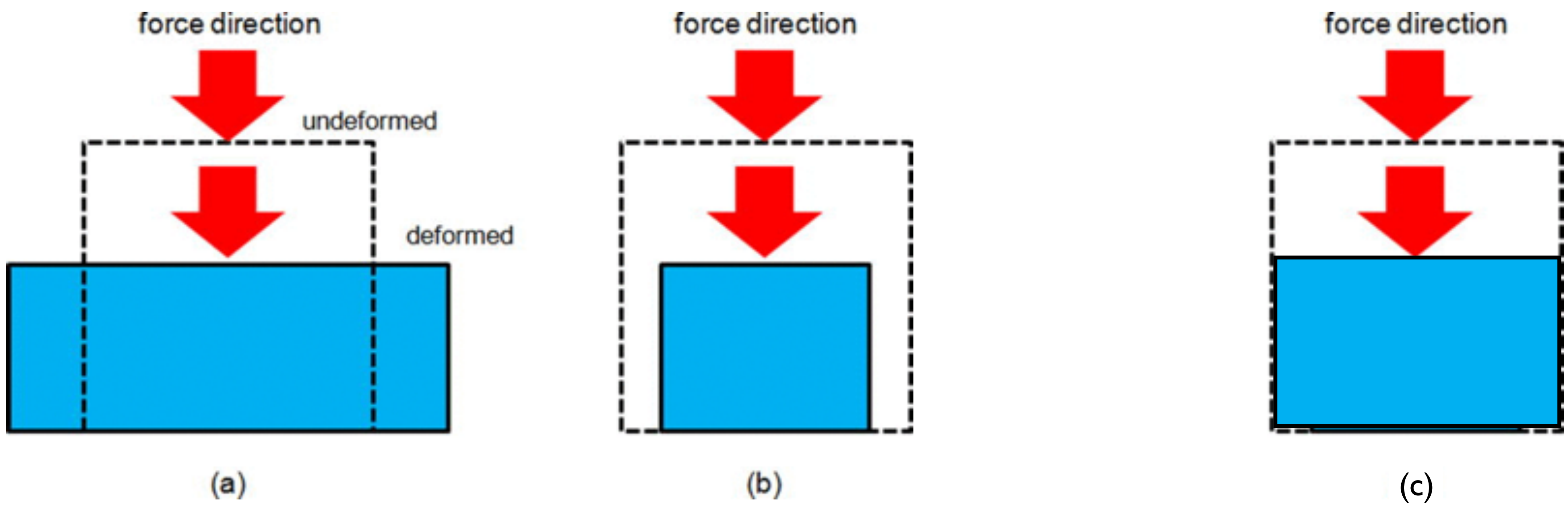
Stretching out polymer chains

Breaking polymer chains

Stress-Strain Curve



Poisson Deformation



Positive Ratio   Negative Ratio   "ZERO" Ratio

Poisson Ratio = strain with load/strain at right angle

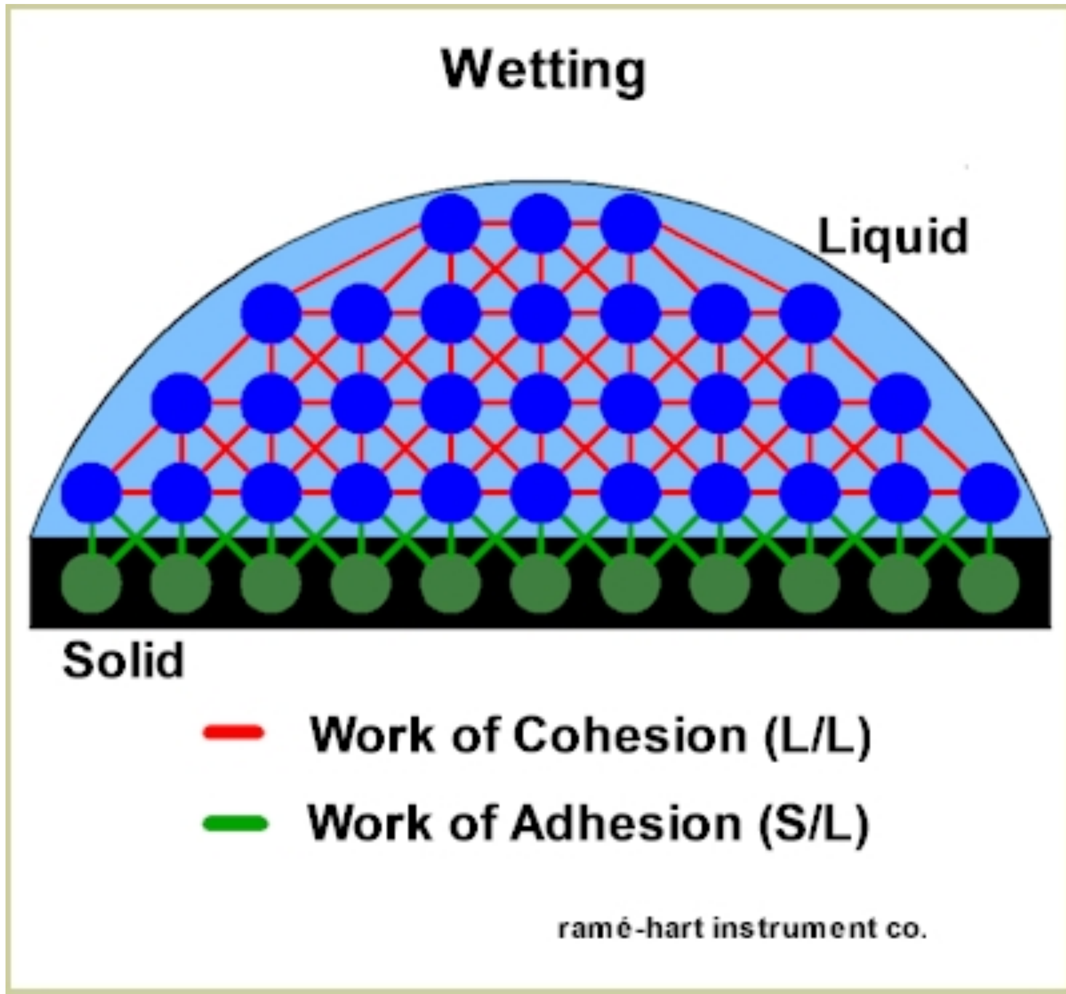
bread, marshmallows

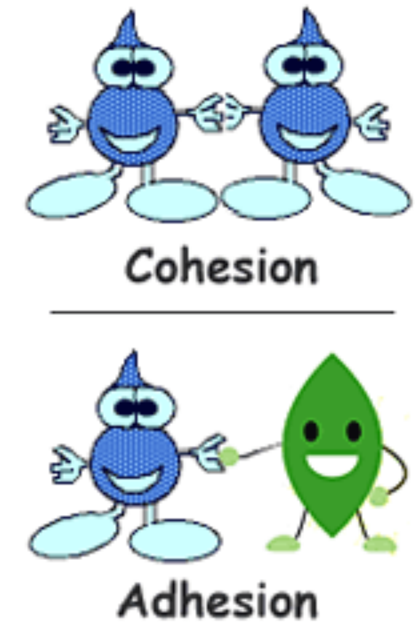
bulge if rubber

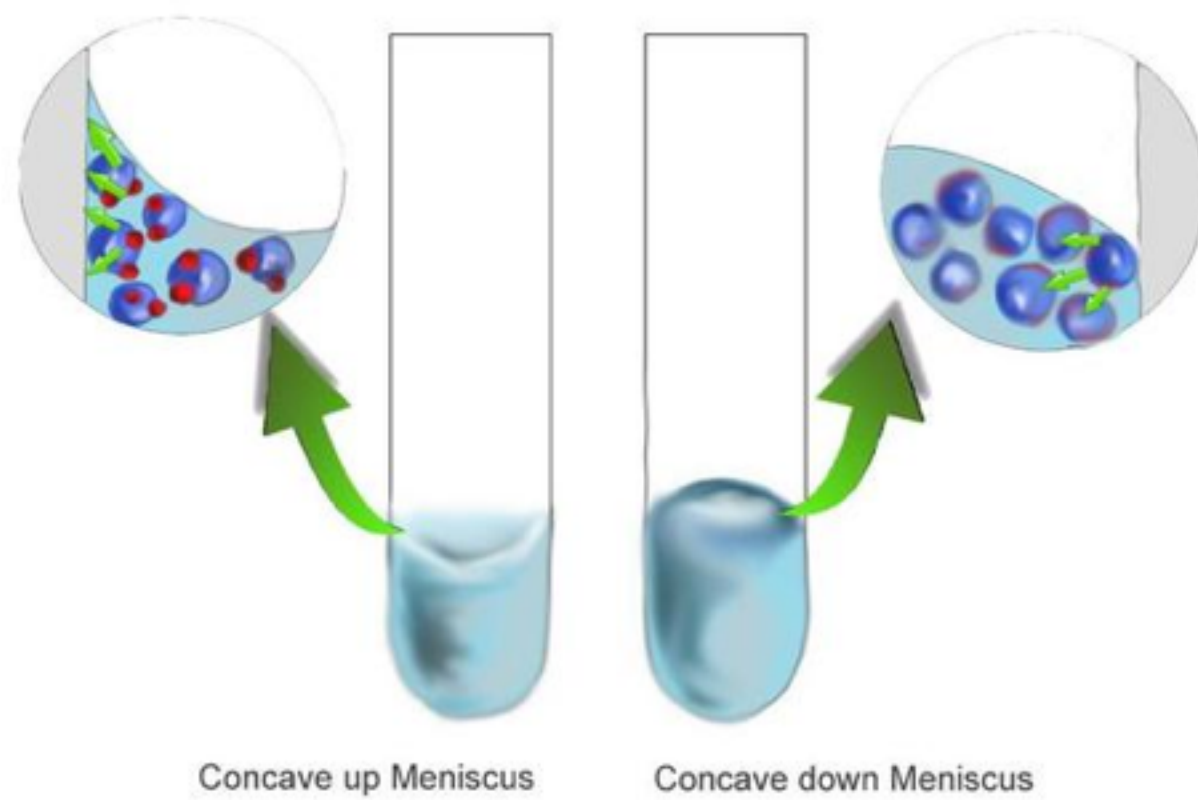
Poisson's ratio values for different materials [edit]

Material	Poisson's ratio
rubber	0.4999 [8]
gold	0.42–0.44
saturated clay	0.40–0.49
magnesium	0.252-0.289
titanium	0.265-0.34
copper	0.33
aluminium-alloy	0.32
clay	0.30–0.45
stainless steel	0.30–0.31
steel	0.27–0.30
cast iron	0.21–0.26
sand	0.20–0.45
concrete	0.1-0.2
glass	0.18–0.3
foam	0.10–0.50
cork	0.0

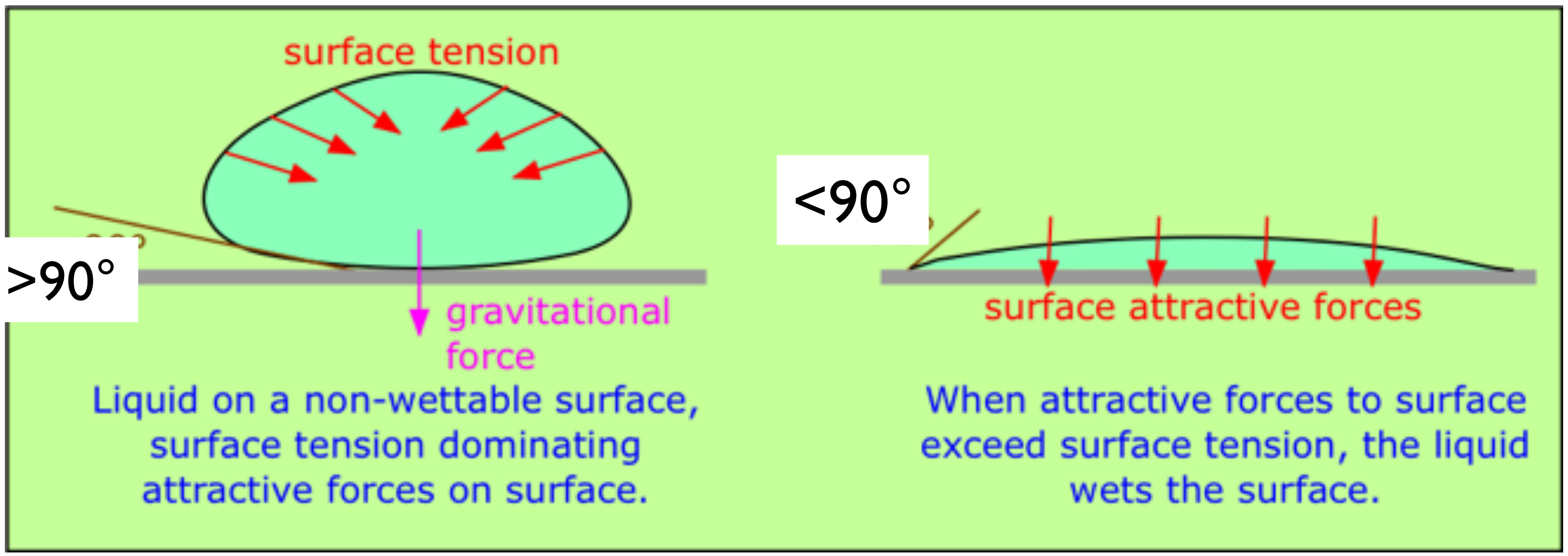
Intermolecular Forces

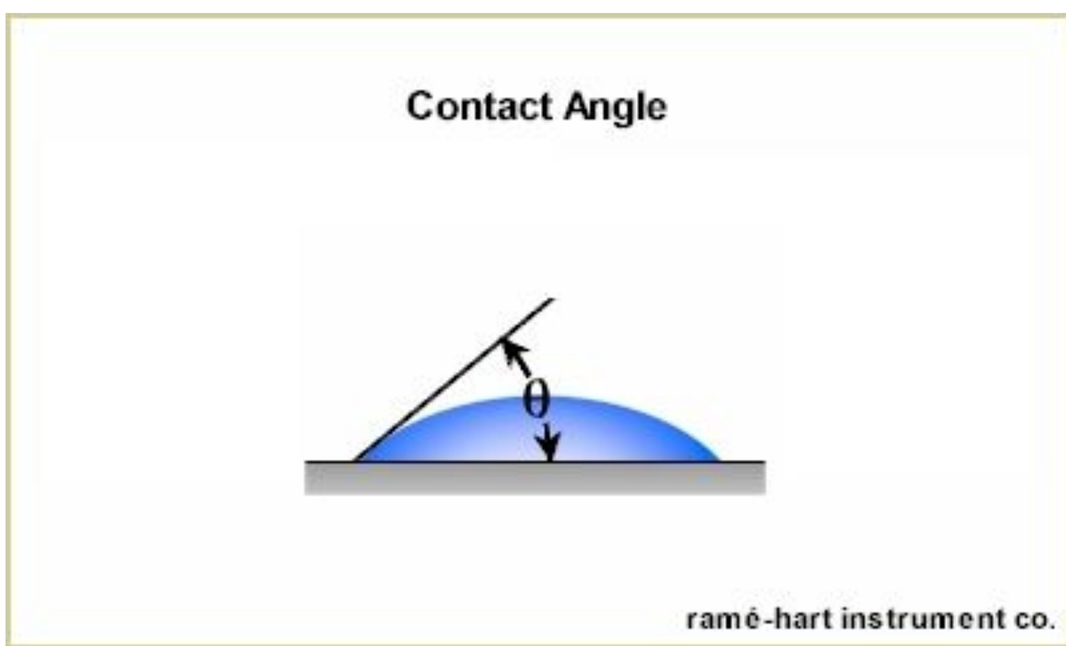


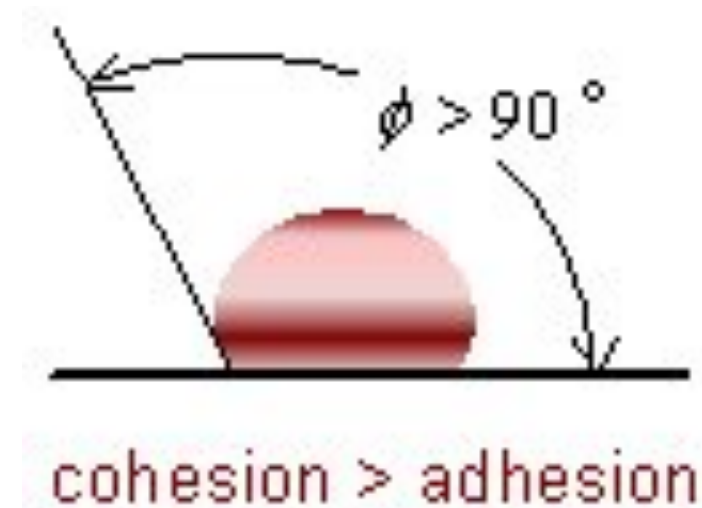




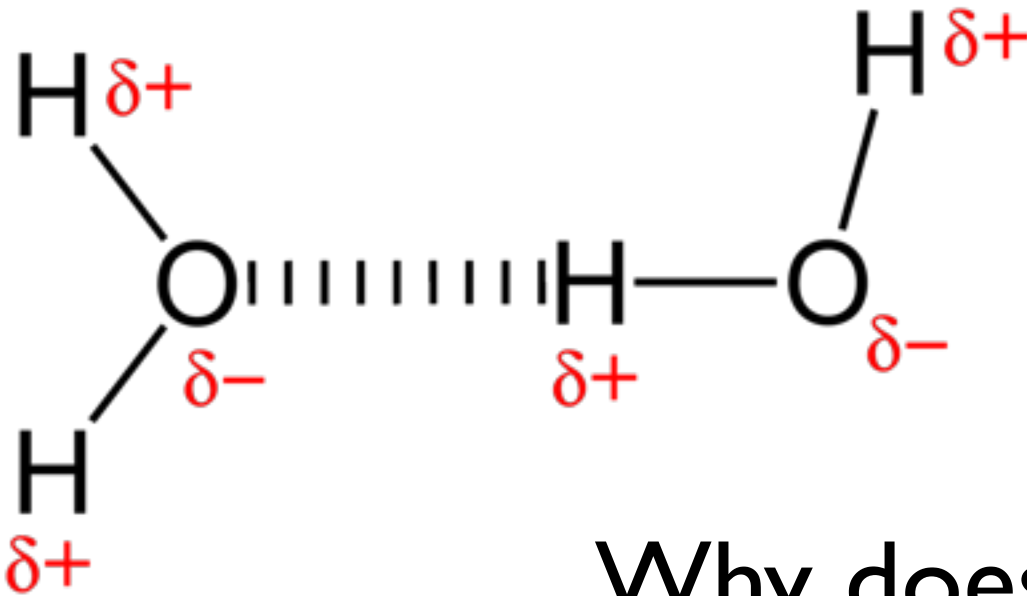
Contact Angle





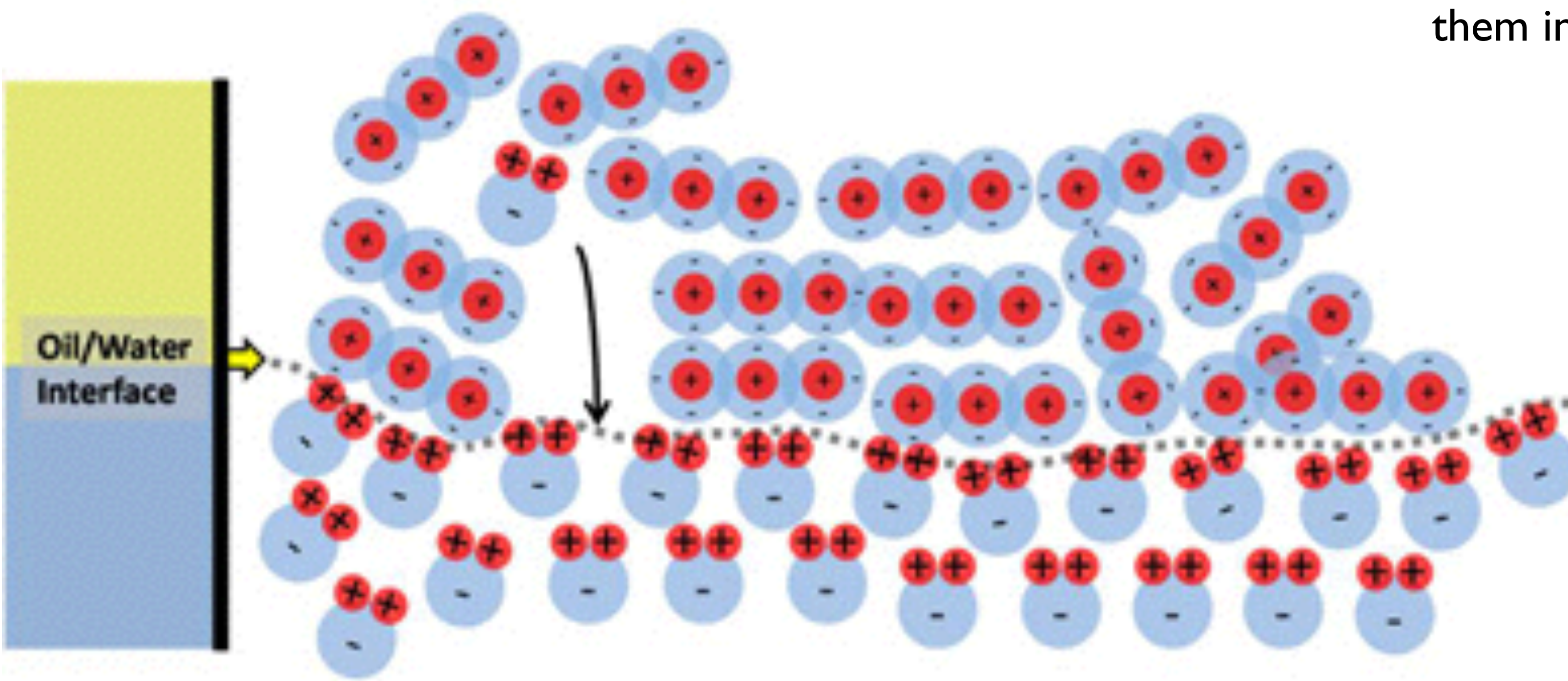


Hydrogen Bonding



Why does oil and water not mix?

Because water molecules are more attracted to water molecules, and the water molecules would have to organize around the oil molecule sth bring them into solution which would decrease the entropy of the system.



Does water repel oil?

Not really, oil is attracted to water, think in terms of oil slicks. So, the oil is attracted to the surface of water, but not easily taken up into the bulk water.

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Questions?

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