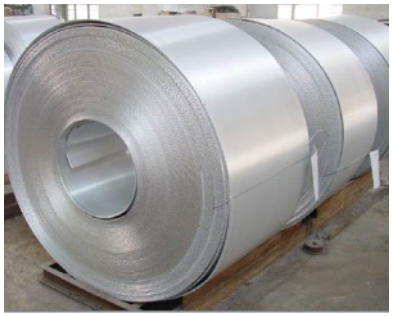
Engineering Material

man-made

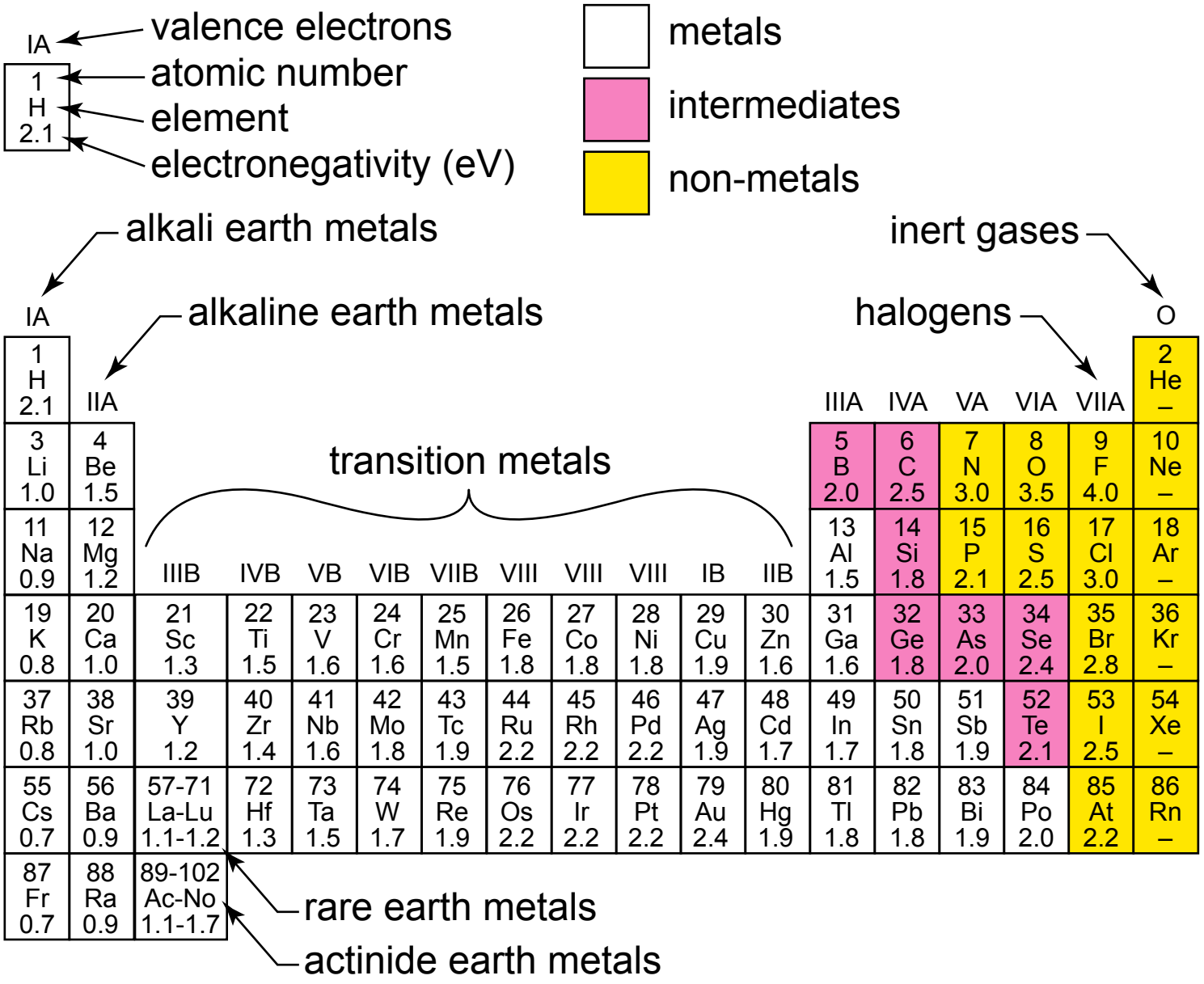
- metals
- plastics
- ceramics
- semiconductors
- composites



Biological Material

nature-made, e.g.

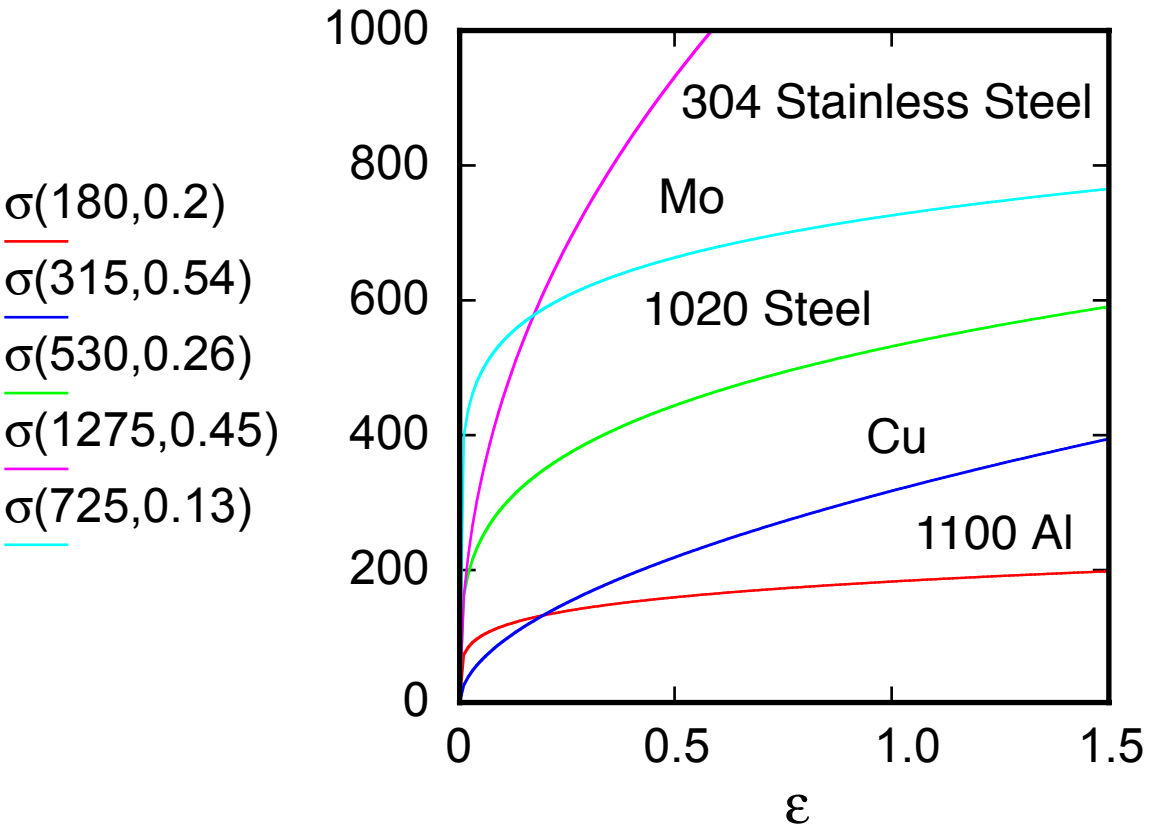
- bone
- skin
- seashell
- wood
- rubber



Adapted from: L. Pauling, *The Nature of the Chemical Bond*, 3rd edition, Cornell University, 1960.

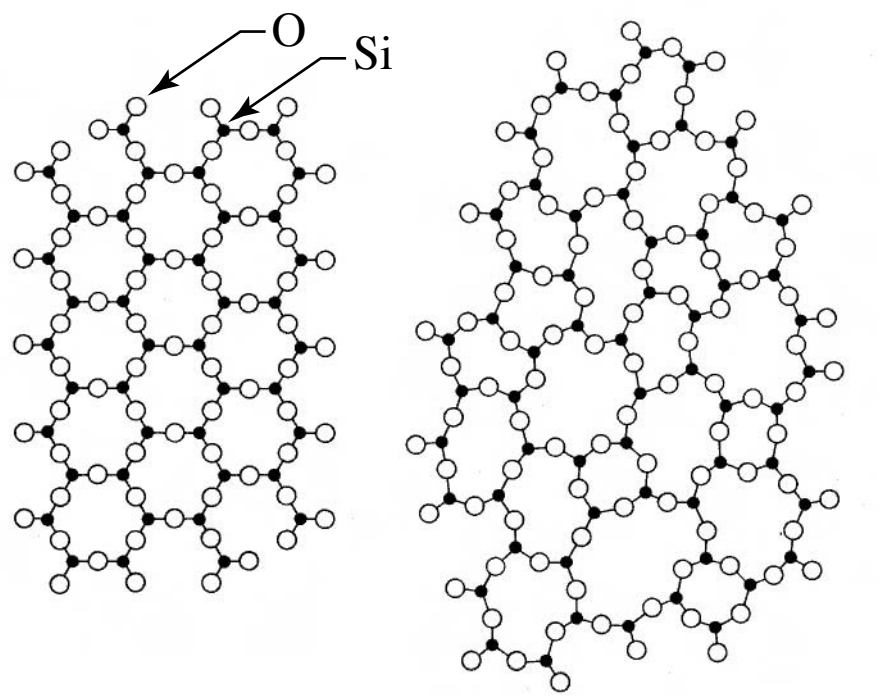
Power Law for Stress/Strain Data

$\sigma(K,n) = K \cdot \varepsilon^n$ $\varepsilon = 0, 0.01 \ldots 1.5$ $K = 180$ $n = 2$



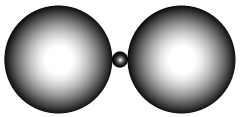
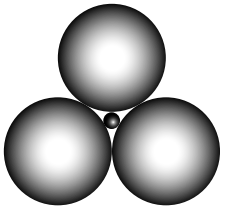
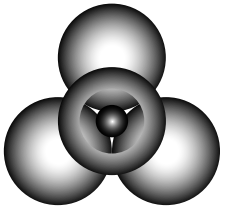
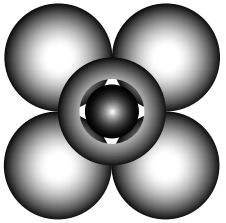
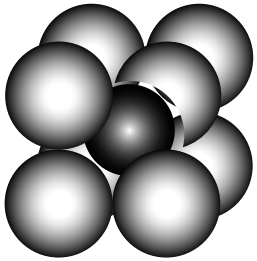
Crystalline vs. Non-Crystalline (SiO_2)

crystalline SiO_2 non-crystalline SiO_2



Adapted from: W.D. Kingery, H.K. Bowen and D.R. Uhlmann, *Introduction to Ceramics*, 2nd edition, John Wiley and Sons, Inc., New York, 1976.

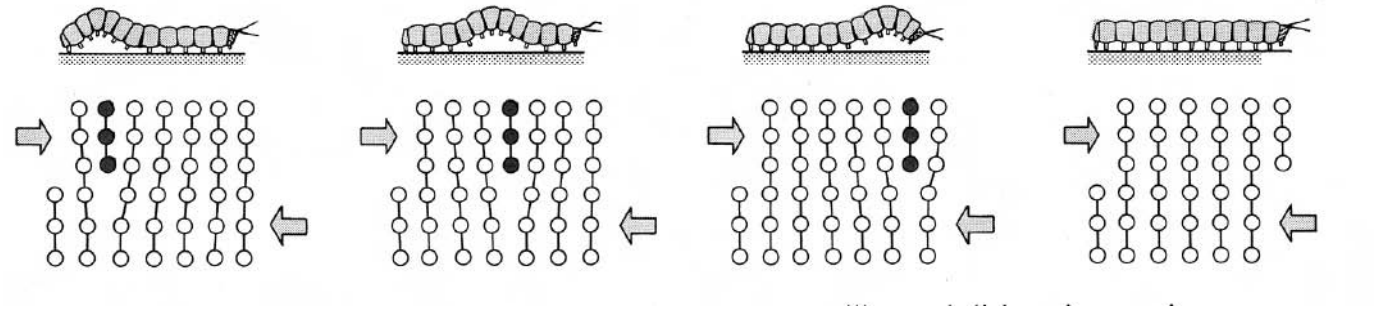
Critical cation/anion radius ratios for various coordination numbers

coordination number	cation/anion radius ratio	coordination geometry
2	< 0.155	
3	0.155-0.225	
4	0.225-0.414	
6	0.414-0.732	
8	0.732-1.0	

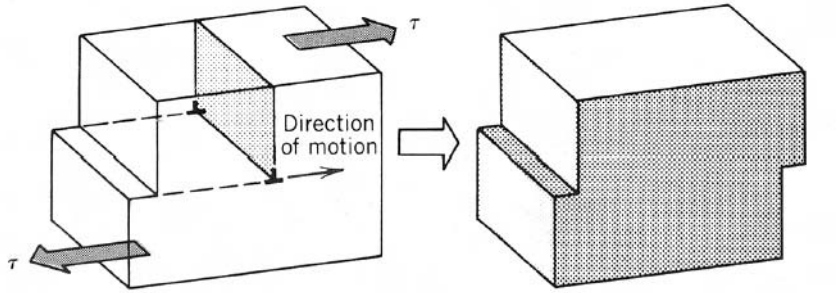
Adapted from: W.D. Kingery, H.K. Bowen and D.R. Uhlmann, *Introduction to Ceramics*, 2nd edition, John Wiley and Sons, Inc., New York, 1976.

Dislocations

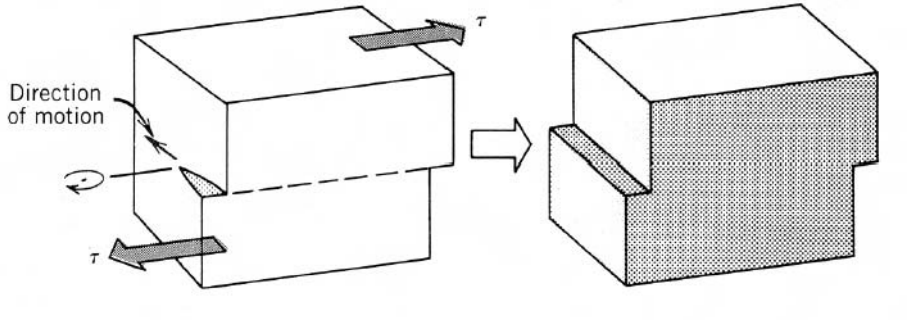
motion analogy:



edge:

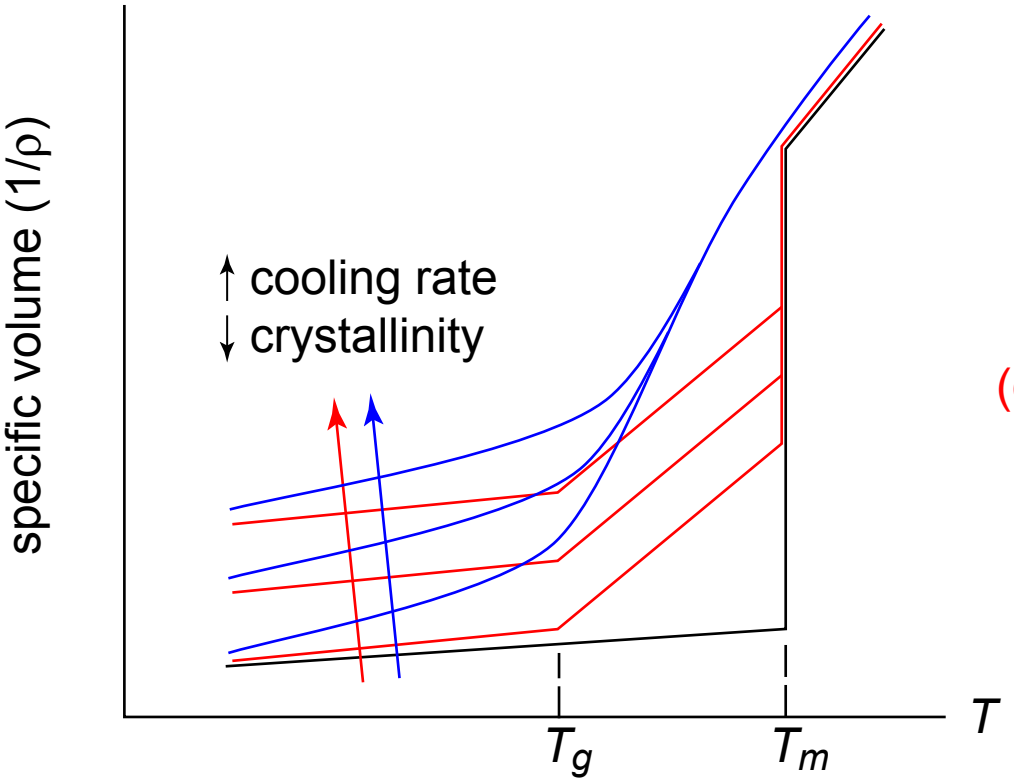


screw:



W.D. Callister, Jr., *Materials Science and Engineering*, 2nd Ed., John Wiley and Sons, New York, 1991.

Molecular Structure: Crystallinity

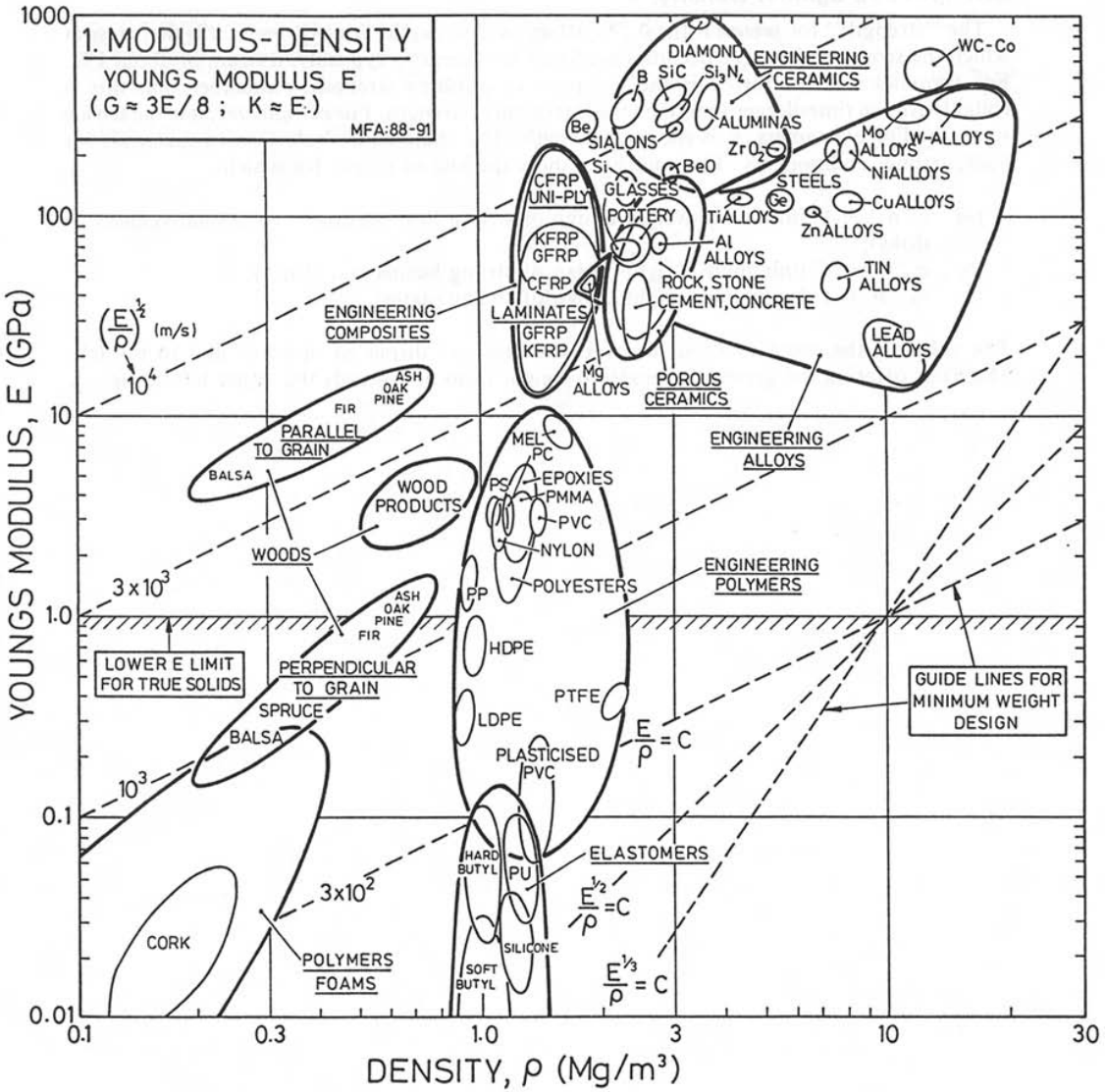


noncrystalline
(e.g., polystyrene
or silicate glass)

semicrystalline
(e.g., polyethylene)

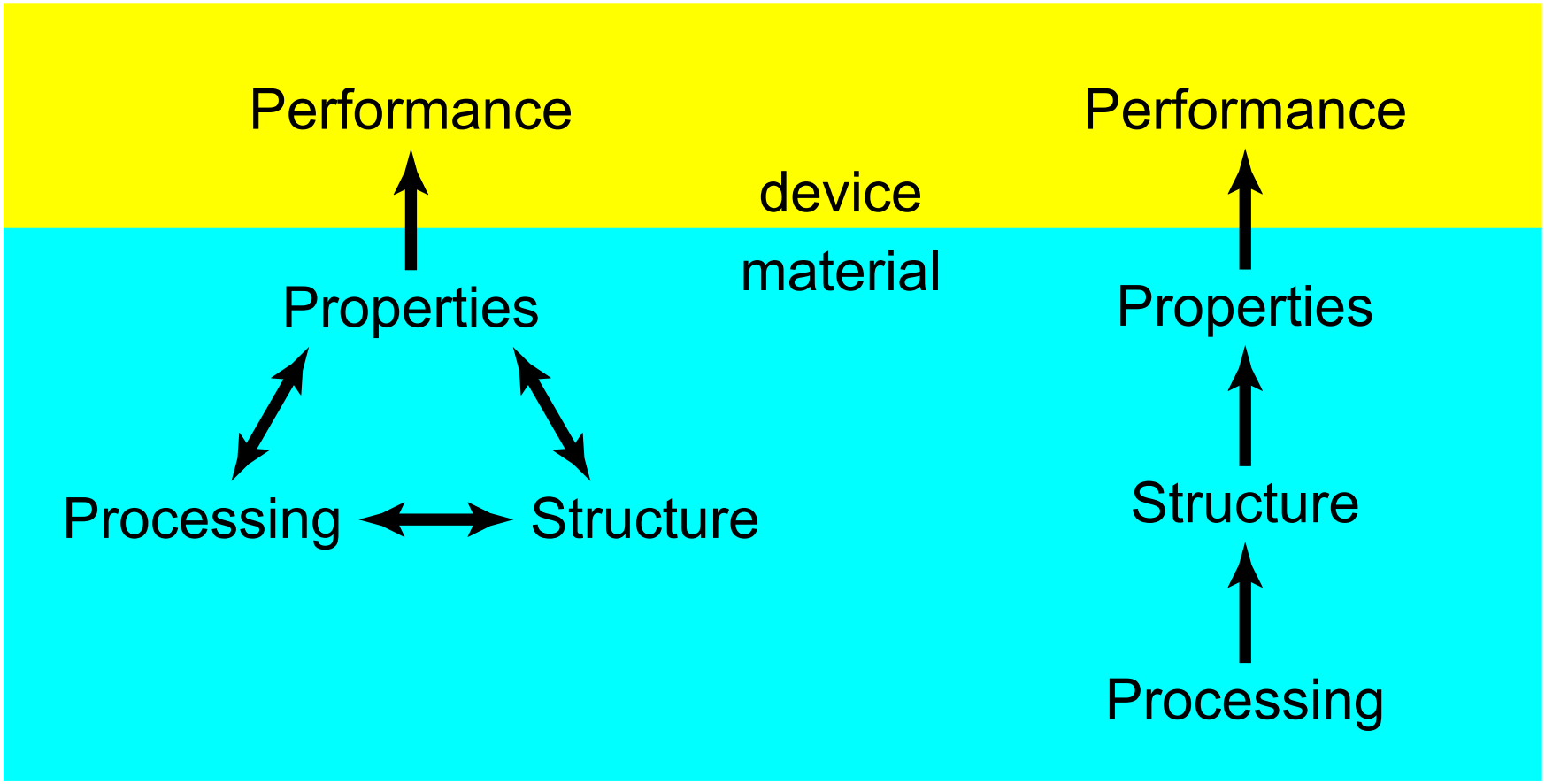
crystalline
(e.g., metals)

Materials Selection in Design

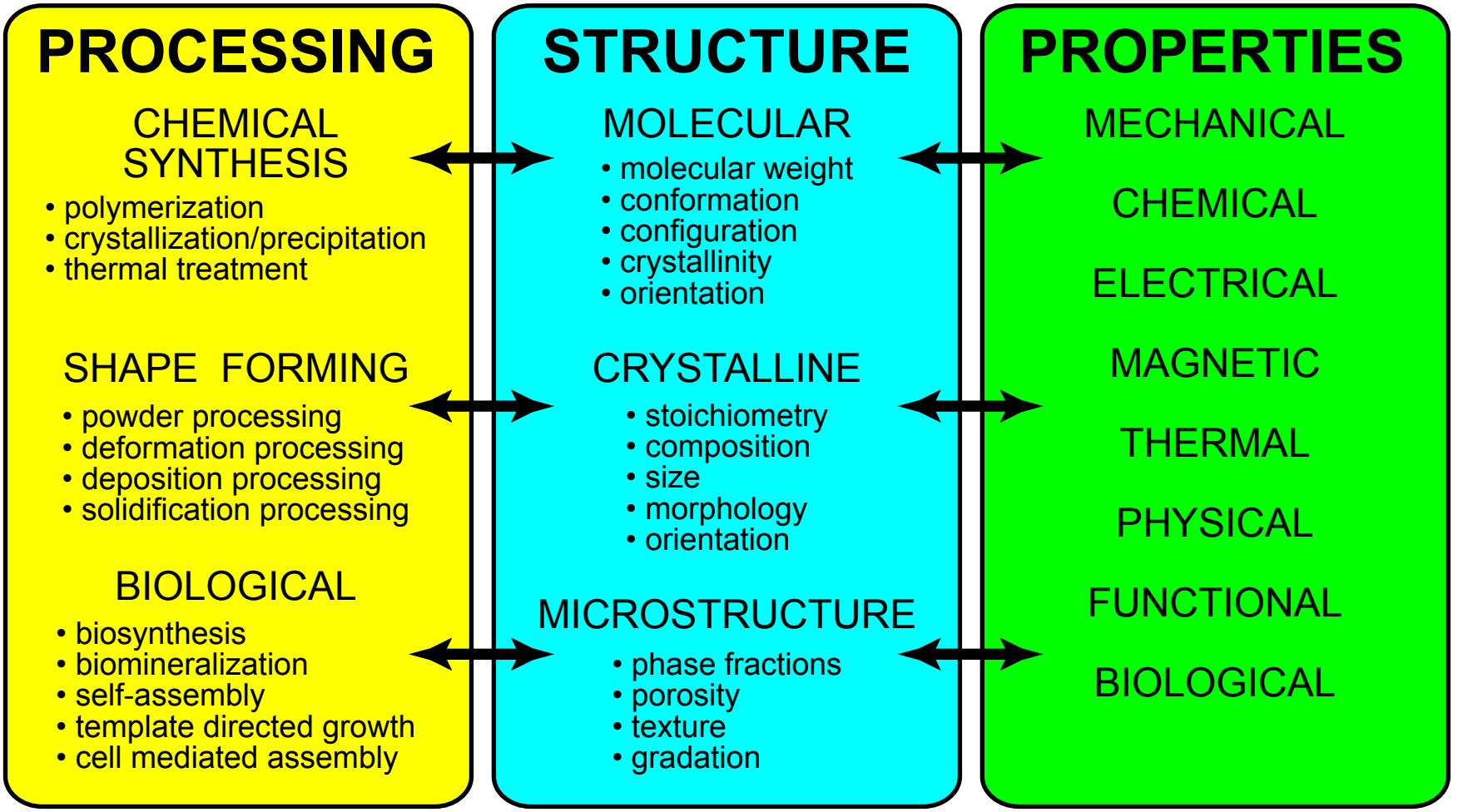


M.F. Ashby, *Materials Selection in Mechanical Design*, 1st edition, Pergamon Press, New York, 1992.

Materials Engineering Paradigm

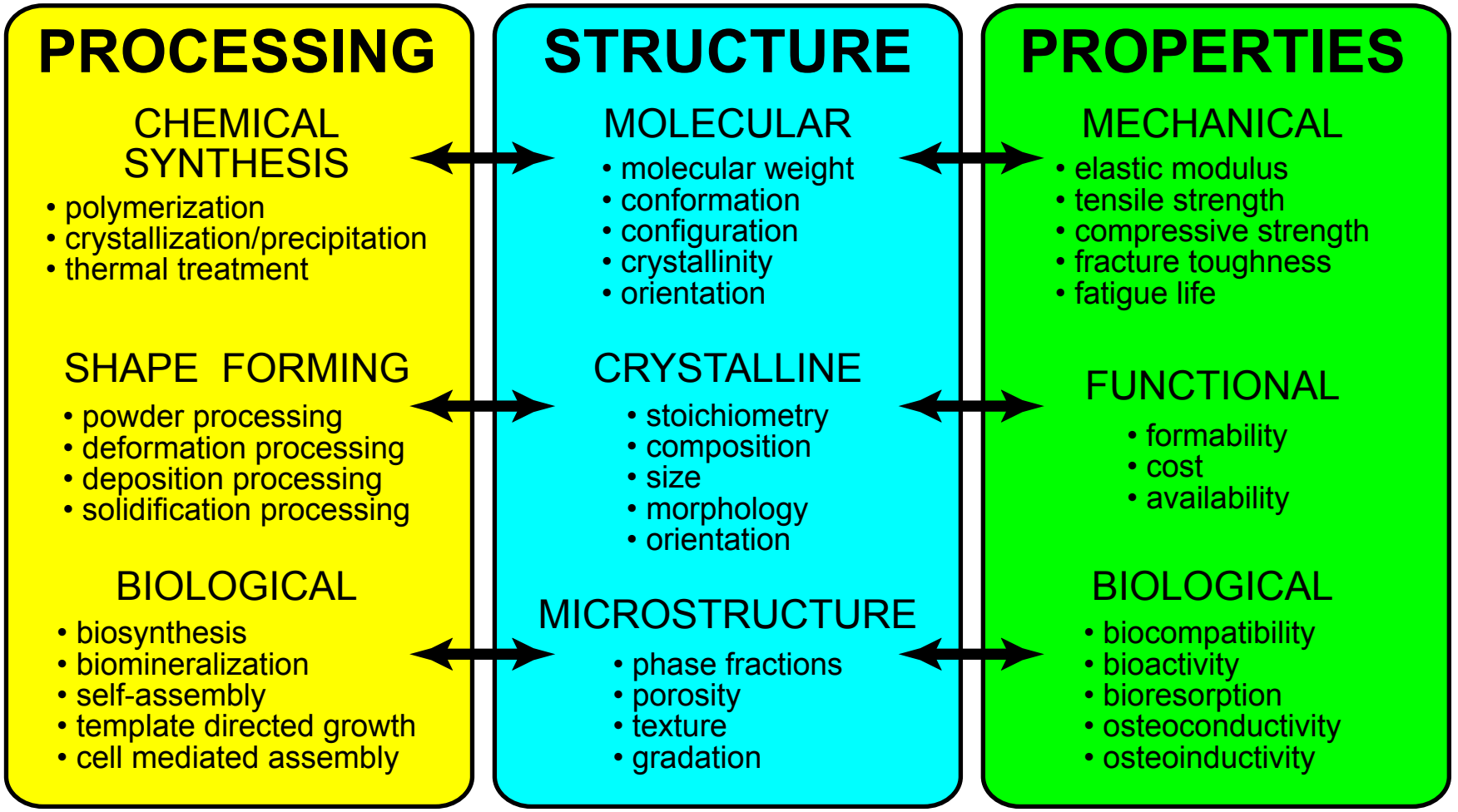


Materials Engineering Paradigm

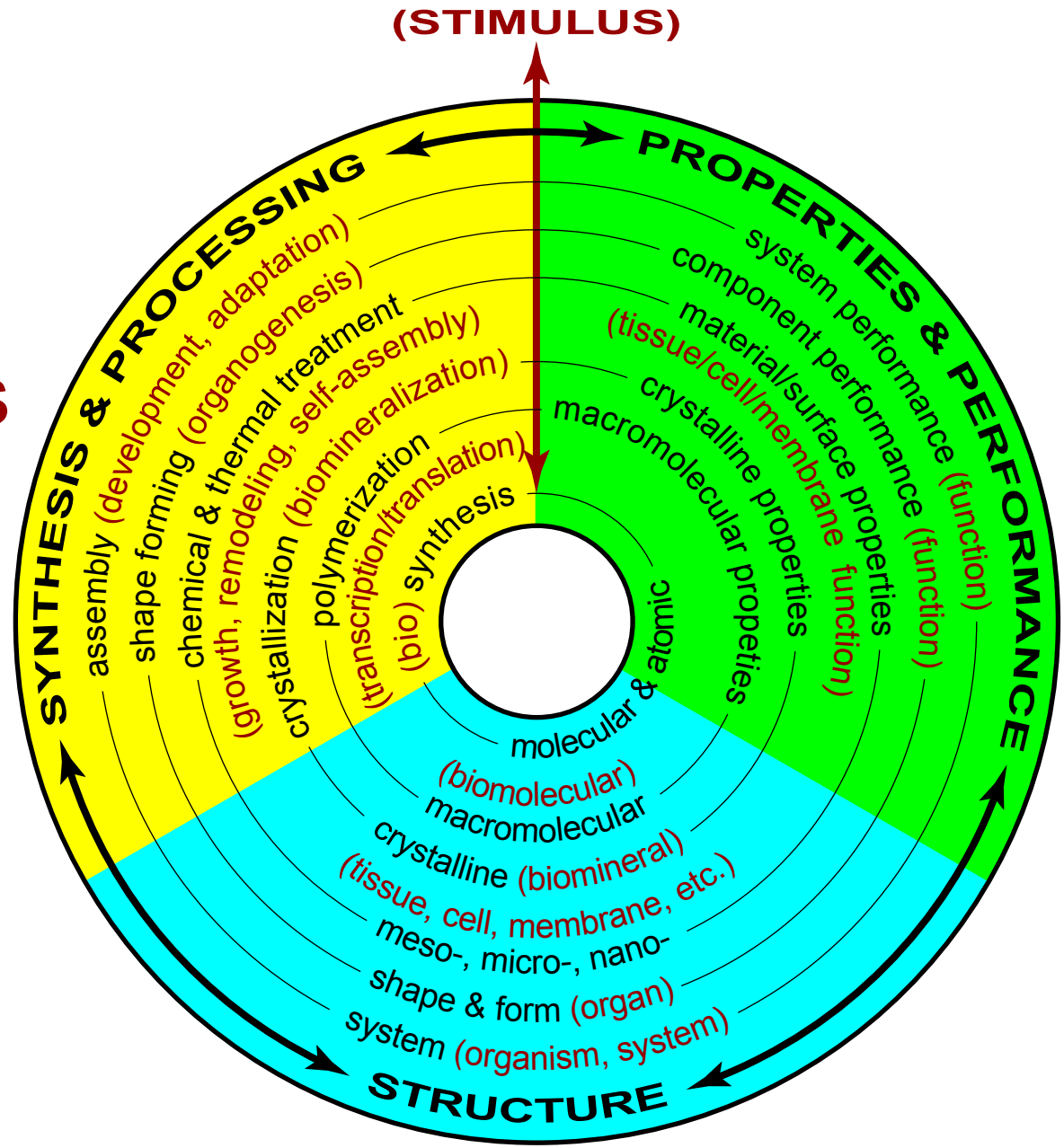


Materials Engineering Paradigm

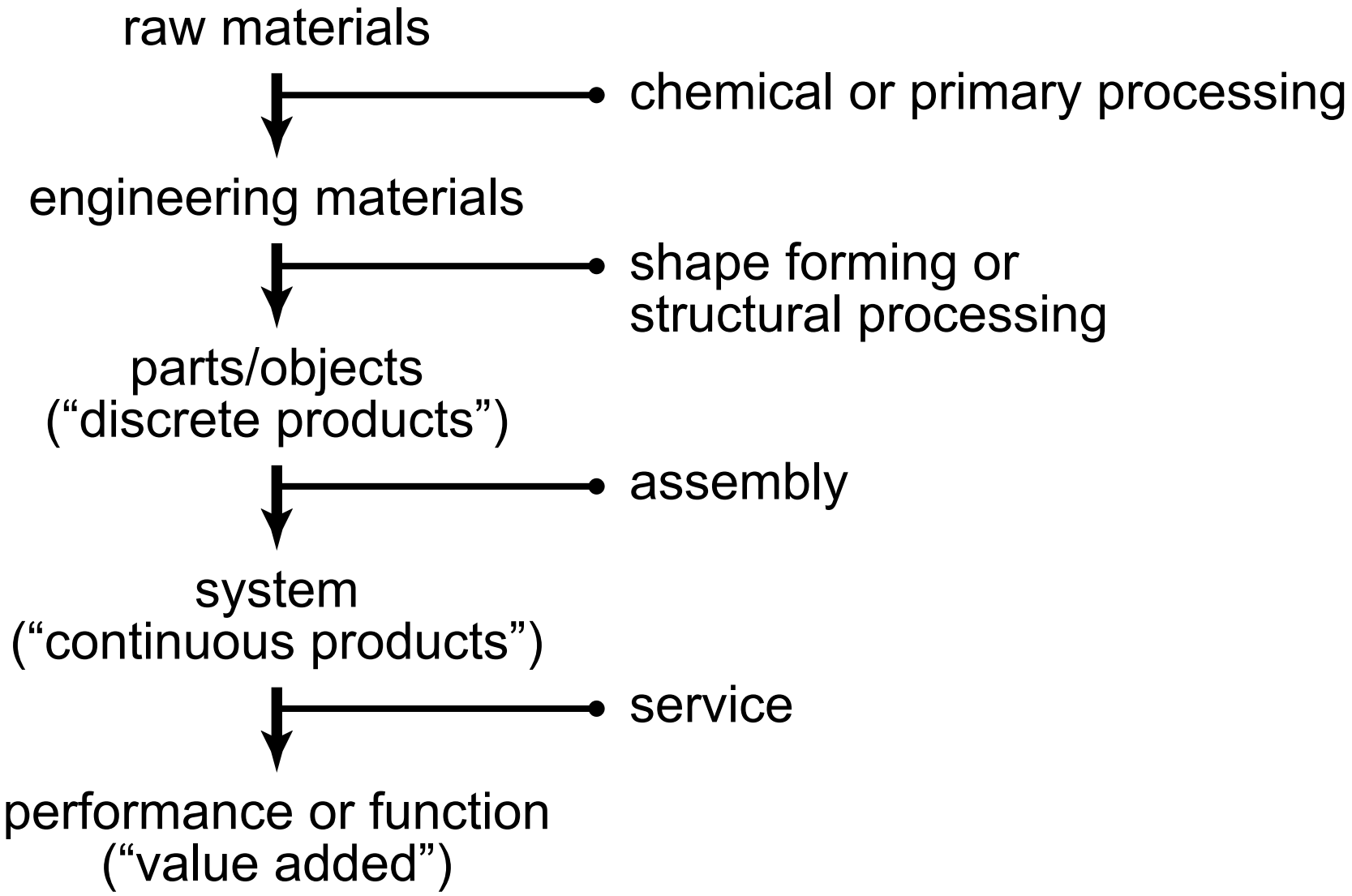
e.g., for a synthetic bone substitute



Modified Materials Engineering Paradigm (with Parallels to Biology)



Materials Processing



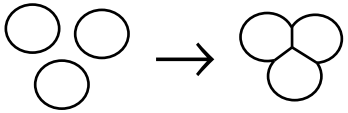
Chemical or Primary Processing

1) taken as is
   e.g., clay, sand, wood, some ceramics, Cu (not any more!)...

2) refined/extracted
   e.g., Cu, steel, most metals, rubber...

3) synthesized
   e.g., most polymers and ceramics...

Shape Forming or Structural Processing

Process	Shapes	Tolerances	Cost	Throughput
Solidification $(l \rightarrow s)$	complex, near-net	lower, rough surfaces	$f(T_m)$	batch, high
Deformation $(F \rightarrow \varepsilon)$	usually geometric	moderate	low	highest
Deposition $(g/l \rightarrow surface)$	planar, conformal	highest	highest, vacuum, gases	lowest
Powder 	complex, near-net	high, near-net	higher, $f(T_m,p)$	lower