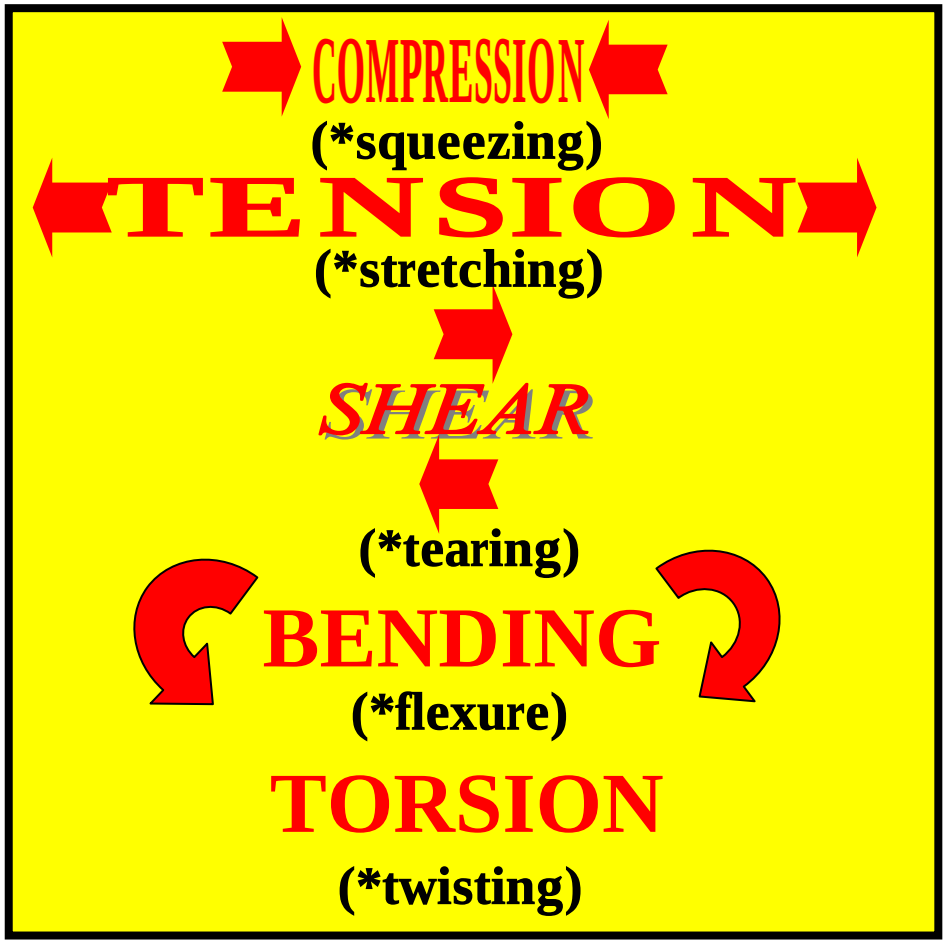
LECTURE #1 :
3.11 MECHANICS OF MATERIALS F02

INSTRUCTOR : Professor Christine Ortiz
OFFICE : 13-4022 **PHONE** : 452-3084
WWW : http://web.mit.edu/cortiz/www

- **COURSE OVERVIEW**
- **INTRODUCTION TO MECHANICS OF MATERIALS**

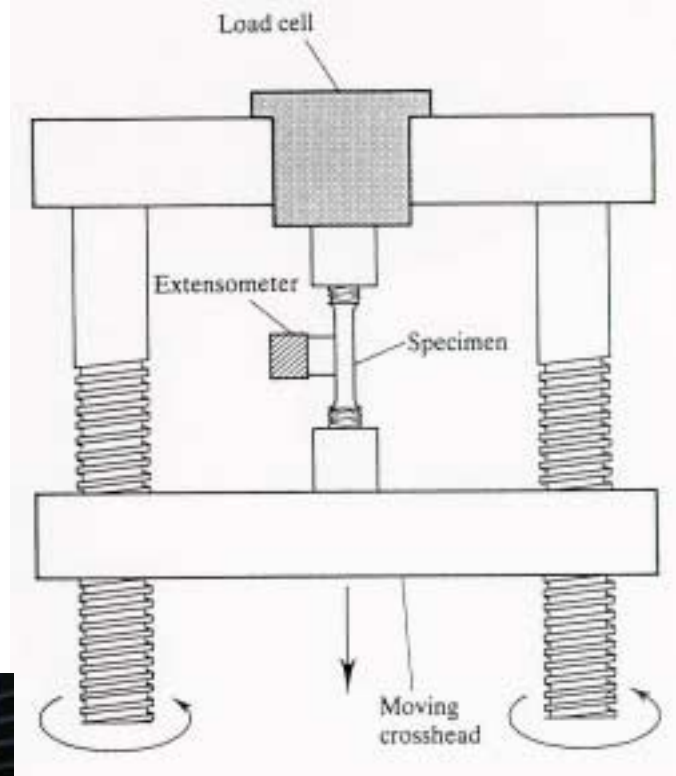
Mechanical Properties of Materials



Why Study Mechanics of Materials?

Uniaxial Mechanical Testing

*(*http://www.me.udel.edu/~tierney/mechanics.html#+/- 45o Tension)*

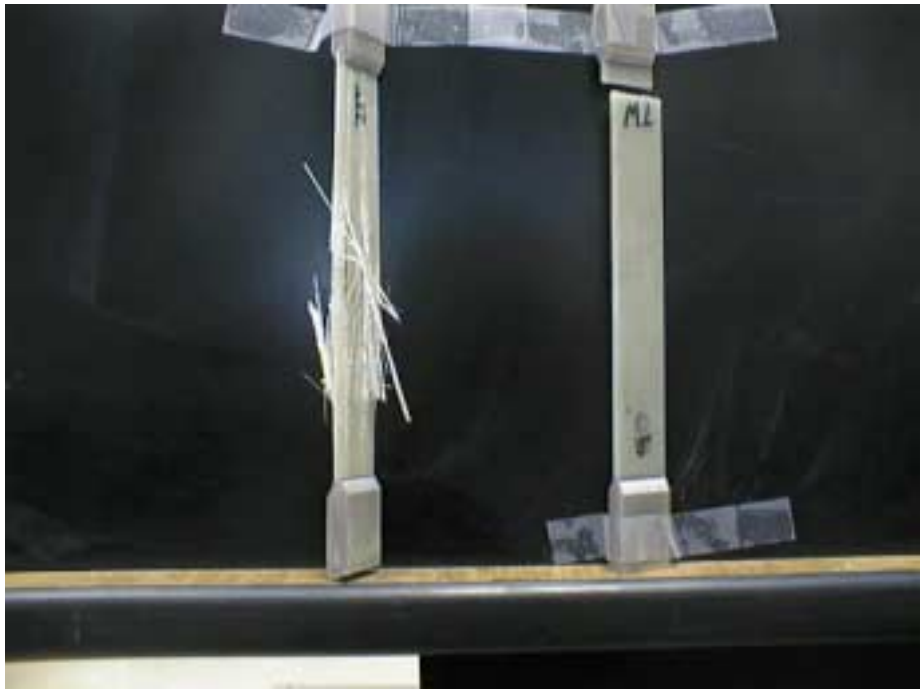


TENSION

COMPRESSION

Uniaxial Tensile Testing

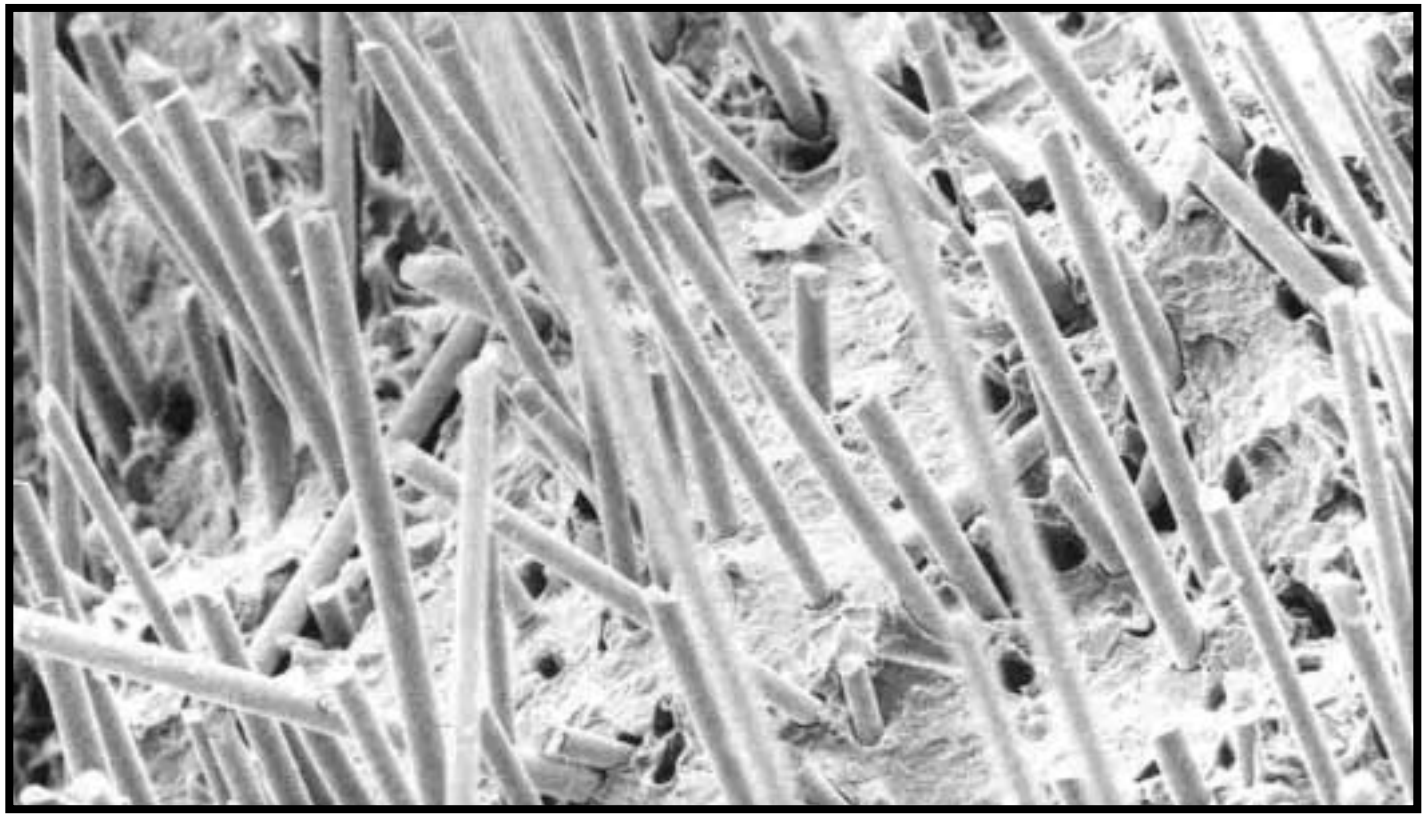
*(*http://www.me.udel.edu/~tierney/mechanics.html#+/- 45o Tension)*



samples are made from the same exact material ???

Composite Fracture Surface

http://www.fpchem.com/fap_5a-en_fig.html#fig2a



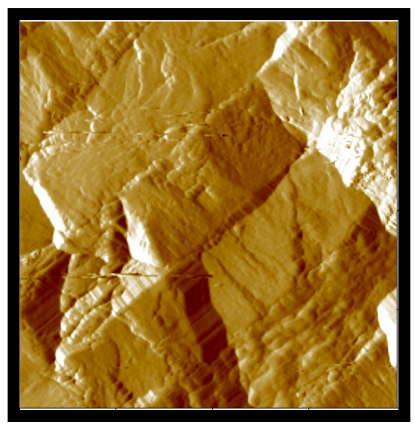
Short-glass-fiber-reinforced homo-polypropylene. **Conventional fiber sizing composition.** SEM micrograph of the (tensile) fracture surface (average fiber diameter = 13 microns).

Microstructure of *Trochus Niloticus* *(Gastropod Mollusk)*

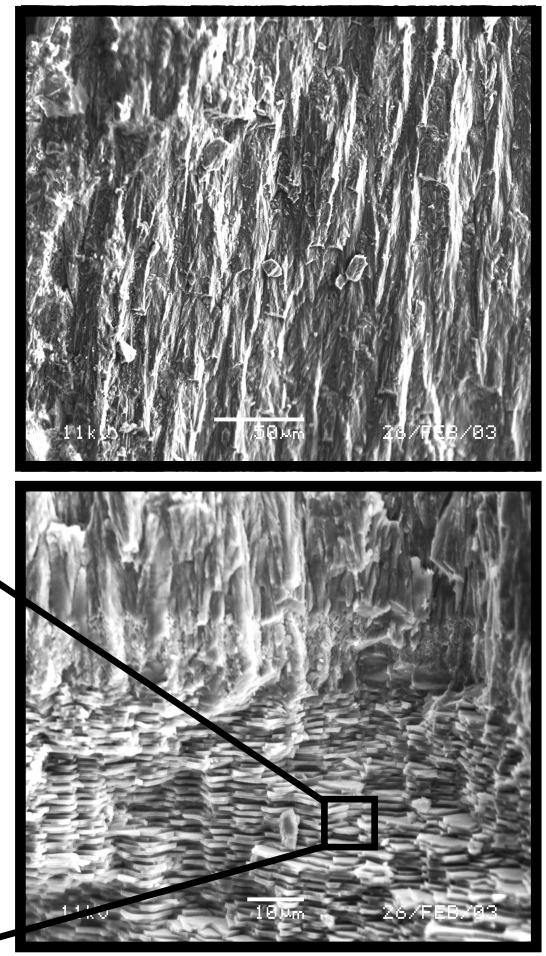
5 different types of microscopic layers observable:

- *Outermost:* periostracum, a thin organic layer composed mainly of sclerotized protein
- Prismatic (aragonite+calcite)
- **Laminar columnar, nacreous (aragonite)**
- Laminar foliated (argonite+calcite)
- *Innermost* : irregular crossed-lamellar (calcite)

Trochus Niloticus



AFM Image (4 µm)



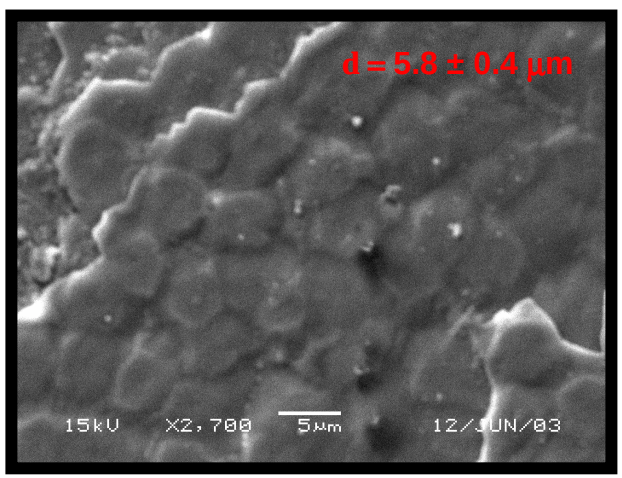
SEM images

prismatic layer

columnar nacreous layer

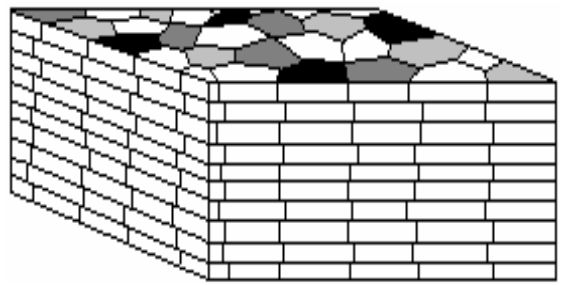
Microstructure of *Trochus Niloticus* *(Gastropod Mollusk)*

SEM : side view
ceramic microlaminate columnar structure



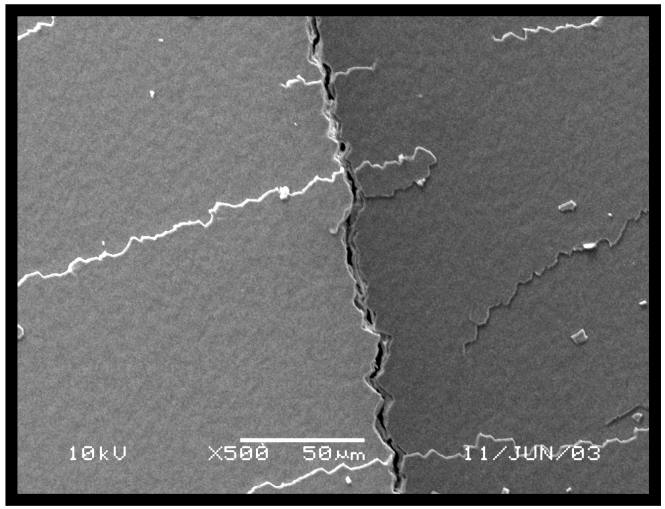
SEM : top view
rounded polygonal ceramic plates

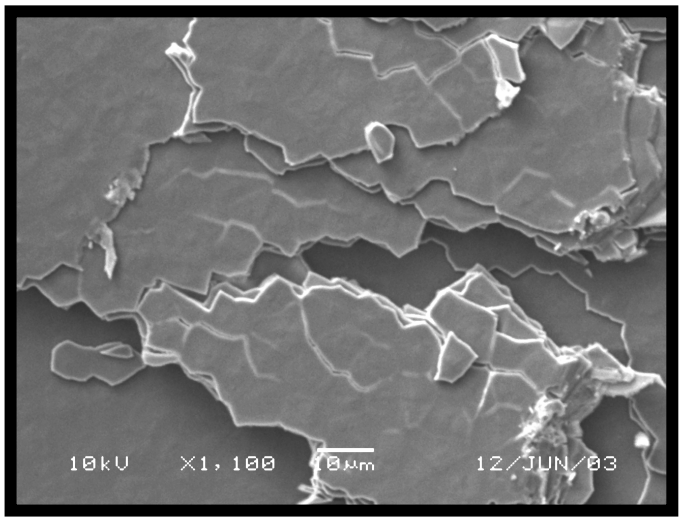
Nacreous (mother of pearl) columnar microstructure

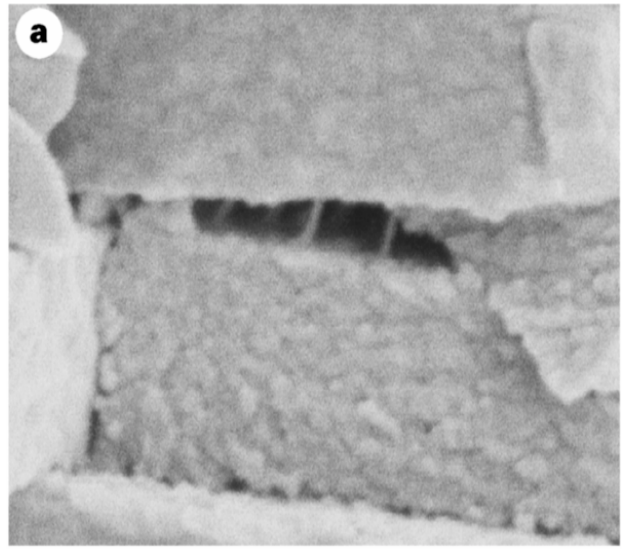


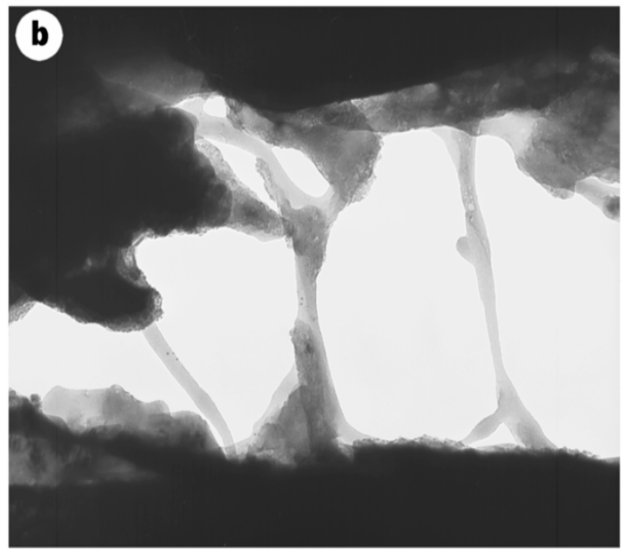
- ~95 wt% polygonal to rounded aragonite (a form of $CaCO_3$) single crystal tablets in parallel sheets *(Carter and Clark, 1985. Stucky, 1998)*
- Coinciding centers determine the nucleation site of the overlying tablet *(Mutzei, 1980)*
- Mineral is continuous through bulk via c-axis bridges *(Stucky, 1998)*
- Up to 5 wt% biomacromolecules, nm-thick layer between ceramic plates *(Wang, 2001)* also within plates *(Morse, 1996)*

Microscopic Fracture Mechanisms of *T. Niloticus* Nacre in Uniaxial Compression









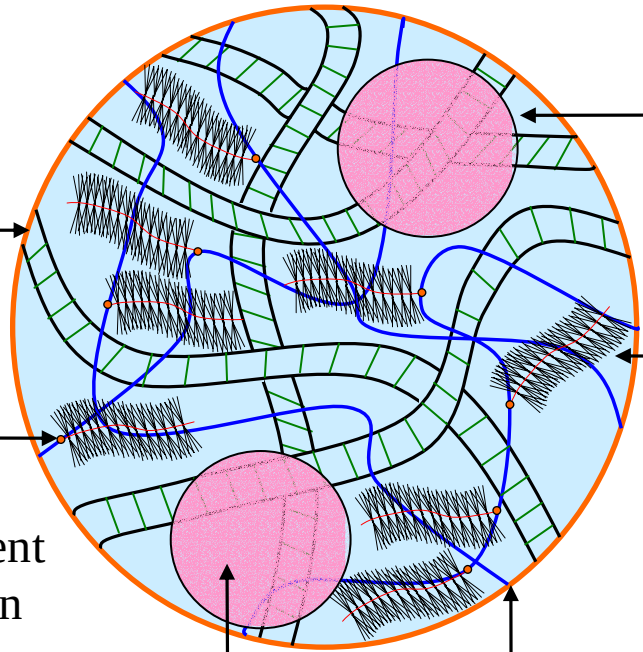
Structural Hierarchy and Function of the Components of Articular Cartilage

Structural Hierarchy and Function of the Components of Articular Cartilage

- **highly specialized, organized, and dense connective tissue in higher vertebrates**
  - found in the weight-bearing surfaces of movable articular joints
  - high strength, resiliency, toughness, shock absorption, lubrication, wear

collagen fibrils :
fiber-reinforcement responsible for shear and tensile strength, shape-retaining properties ~55-60% dry weight

link protein :
glycoprotein that stabilizes the noncovalent attachment of aggrecan to HA



extracellular matrix :
dense, sponge-like composite network where water ~65-80% vol.

aggrecan :
large, soluble, molecule responsible for compressive strength ~35% dry weight

chondrocyte cell :
produces and maintains cartilage ECM <5% vol.

hyaluronic acid :
central GAG filament which serves as the backbone for assembly of supramolecular aggregates of proteoglycans