12.007 Geobiology
Spring 2009

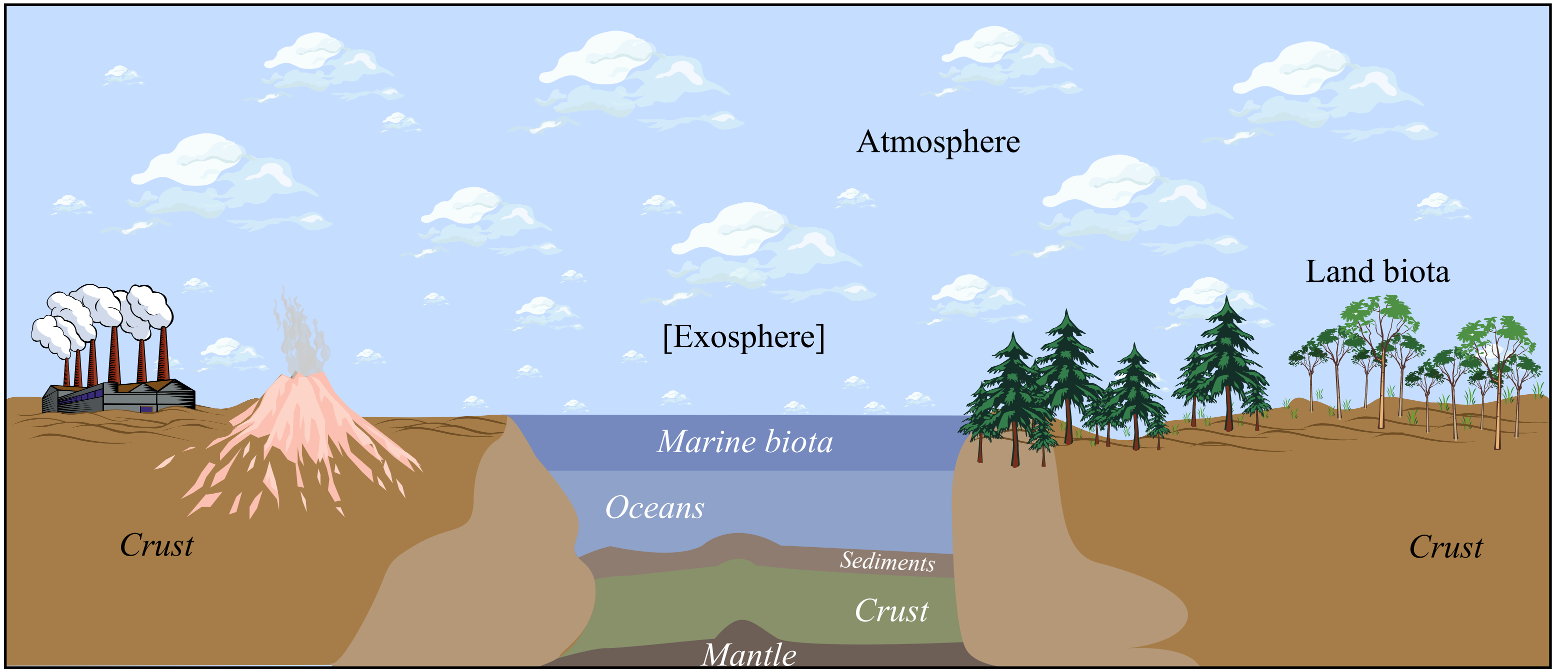


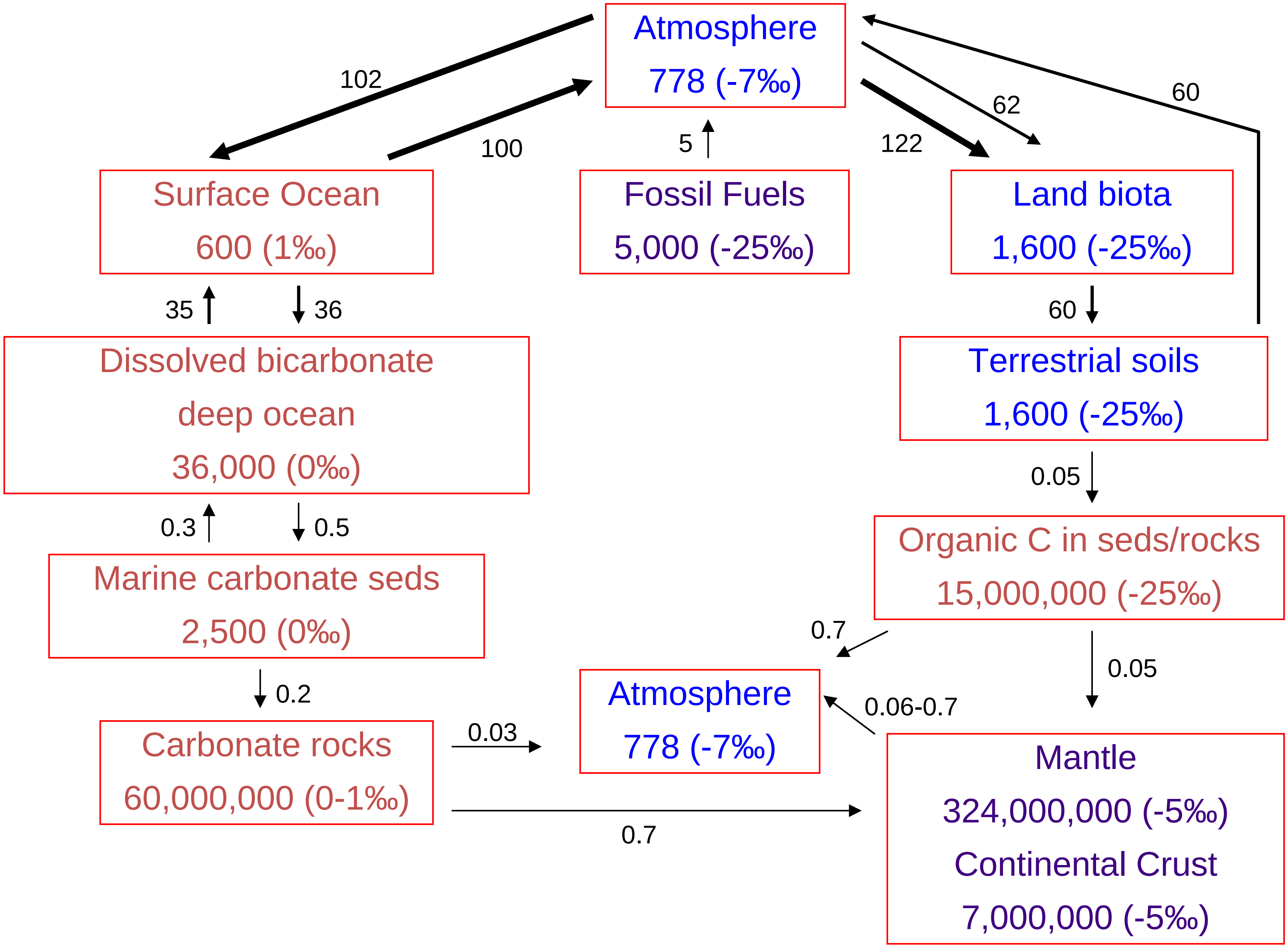
Figure by MIT OpenCourseWare.

Reservoirs in Giga tons of carbon
Atmosphere = 770
Oceans
Total inorganic C in surface = 600; deep = 36,000
Total organic C in Oceans = 1,000

Lithosphere
Sedimentary carbonates = >60,000,000
Kerogens = 15,000,000

Living biomass = 1,600
Dead biomass = 1,000-3,000
Aquatic biosphere = 1-2
Fossil fuels = 5,000
Coal = 3,150
Gas = 140
Other (peat) = 250

Carbon Cycle Fluxes and $\delta^{13}C$ Values



Ca^{+2} and Mg^{+2}

Inputs and Outputs of Ca, Mg and SO_4 to/from the Ocean

Calcium sulfate weathering input

$CaSO_4 \rightarrow Ca^{++} + SO_4^{-}$

Pyrite weathering input

$4FeS_2 + 15O_2 + 8H_2O \rightarrow 2Fe_2O_3 + 8H_2SO_4$

Silicate and Carbonate weathering input

$2H_2CO_3 + H_2O + CaSiO_3 \rightarrow Ca^{++} + 2HCO_3^{-} + H_4SiO_4$

$H_2CO_3 + CaCO_3 \rightarrow Ca^{++} + 2HCO_3^{-}$

$2H_2CO_3 + H_2O + MgSiO_3 \rightarrow Mg^{++} + 2HCO_3^{-} + H_4SiO_4$

$2H_2CO_3 + CaMg(CO_3)_2 \rightarrow Ca^{++} + Mg^{++} + 4HCO_3^{-}$

$H_2SO_4 + 2CaCO_3 \rightarrow 2Ca^{++} + SO_4^{--} + 2HCO_3^{-}$

$H_2SO_4 + CaSiO_3 + H_2O \rightarrow Ca^{++} + SO_4^{--} + H_4SiO_4$

$2H_2SO_4 + 2CaMg(CO_3)_2 \rightarrow 2Ca^{++} + 2Mg^{++} + 2SO_4^{--} + 4HCO_3^{-}$

$H_2SO_4 + MgSiO_3 + H_2O \rightarrow Mg^{++} + SO_4^{--} + H_4SiO_4$

Basalt-seawater reaction and dolomitization (output of Mg and input of Ca)

Mg^{++} + Ca-basalt $\rightarrow Ca^{++}$ + Mg-basalt

$Mg^{++} + 2CaCO_3 \rightarrow Ca^{++} + CaMg(CO_3)_2$

Outputs of Ca, Mg and SO_4 from the ocean

$Ca^{++} + 2HCO_3^{-} \rightarrow CO_2 + H_2O + CaCO_3$

$Ca^{++} + SO_4^{--} \rightarrow CaSO_4$

$2Fe_2O_3 + 8Ca^{++} + 8SO_4^{--} + 8CO_2 \rightarrow 4FeS_2 + 15O_2 + 8CaCO_3$

$2Fe_2O_3 + 4Ca^{++} + 4Mg^{++} + 8SO_4^{--} + 8CO_2 \rightarrow 4FeS_2 + 15O_2 + 4CaMg(CO_3)_2$

Figure by MIT OpenCourseWare.

Bahama banks

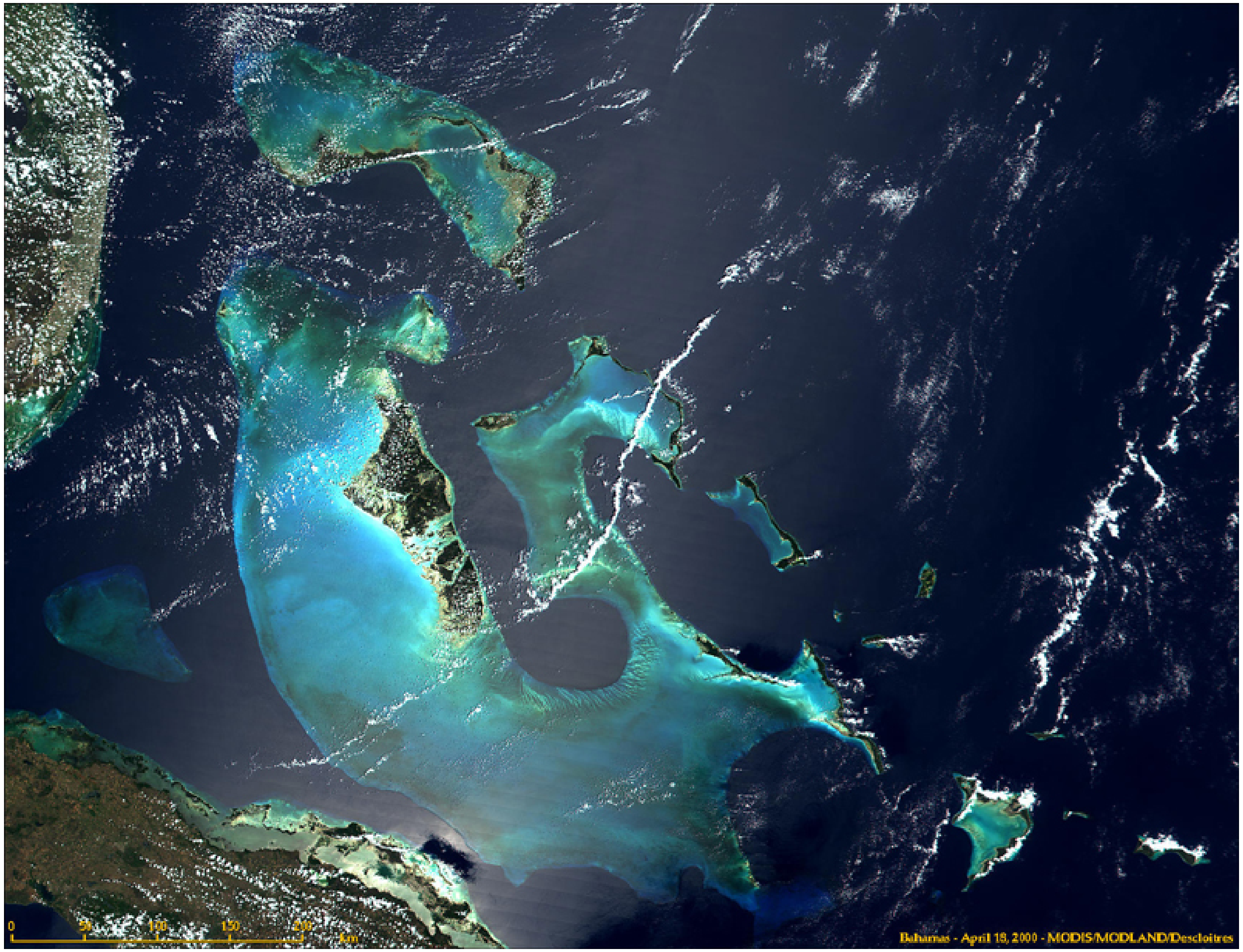


Image courtesy of NASA.

Dasyclad algae

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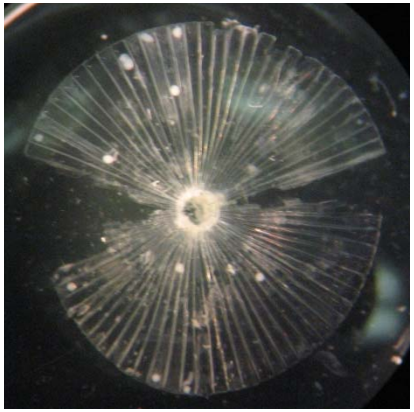
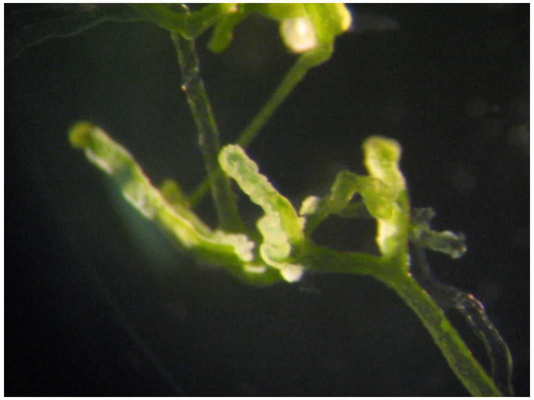
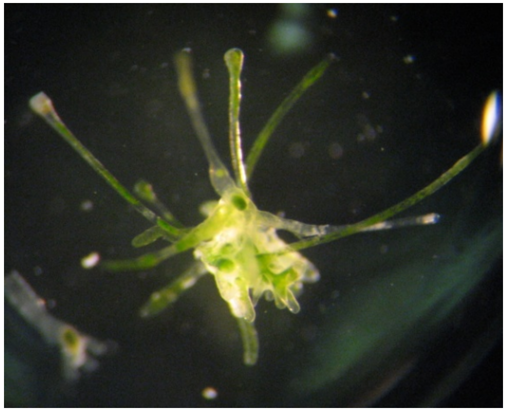
Please see:
http://coexploration.org/bbsr/coral/assets/images/acetabularia.jpg

Whiting events

Image courtesy of NASA.

Scleractinian corals

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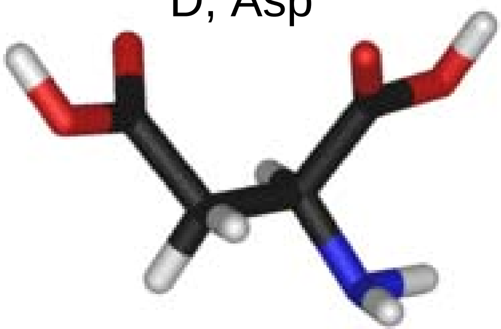
Please see:
http://www.aims.gov.au/monmap/aesthetics/aes19103Sf1.html

Deep water corals

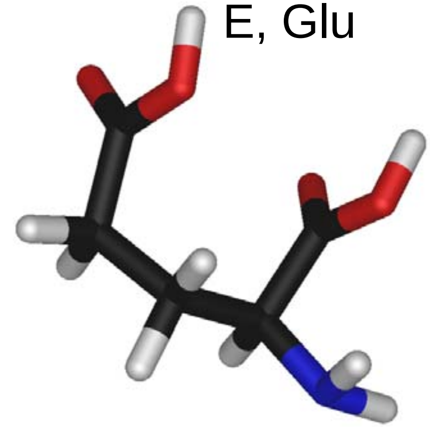
Image courtesy of NOAA.

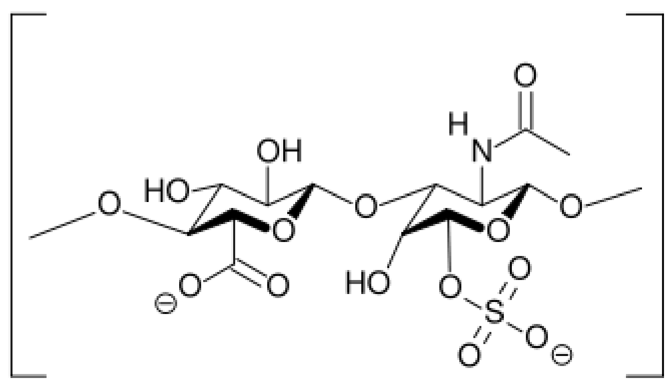
Acidic macromolecules

D, Asp



E, Glu





Nacre – aragonite

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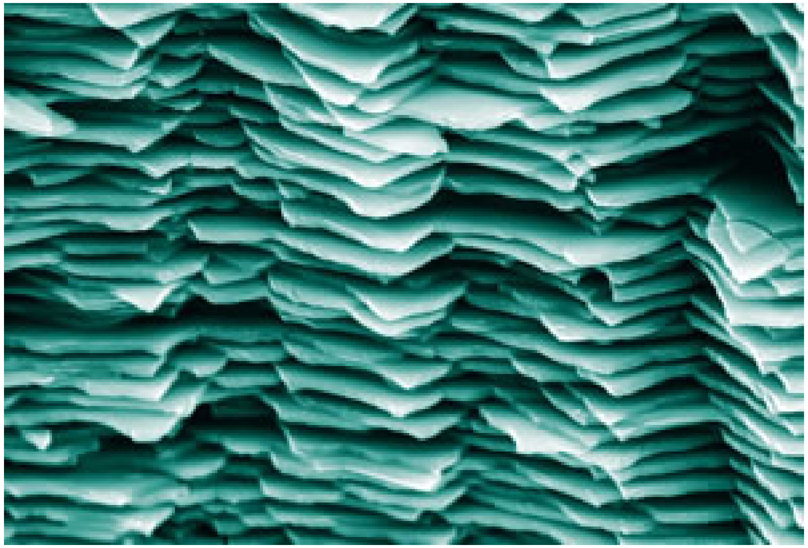
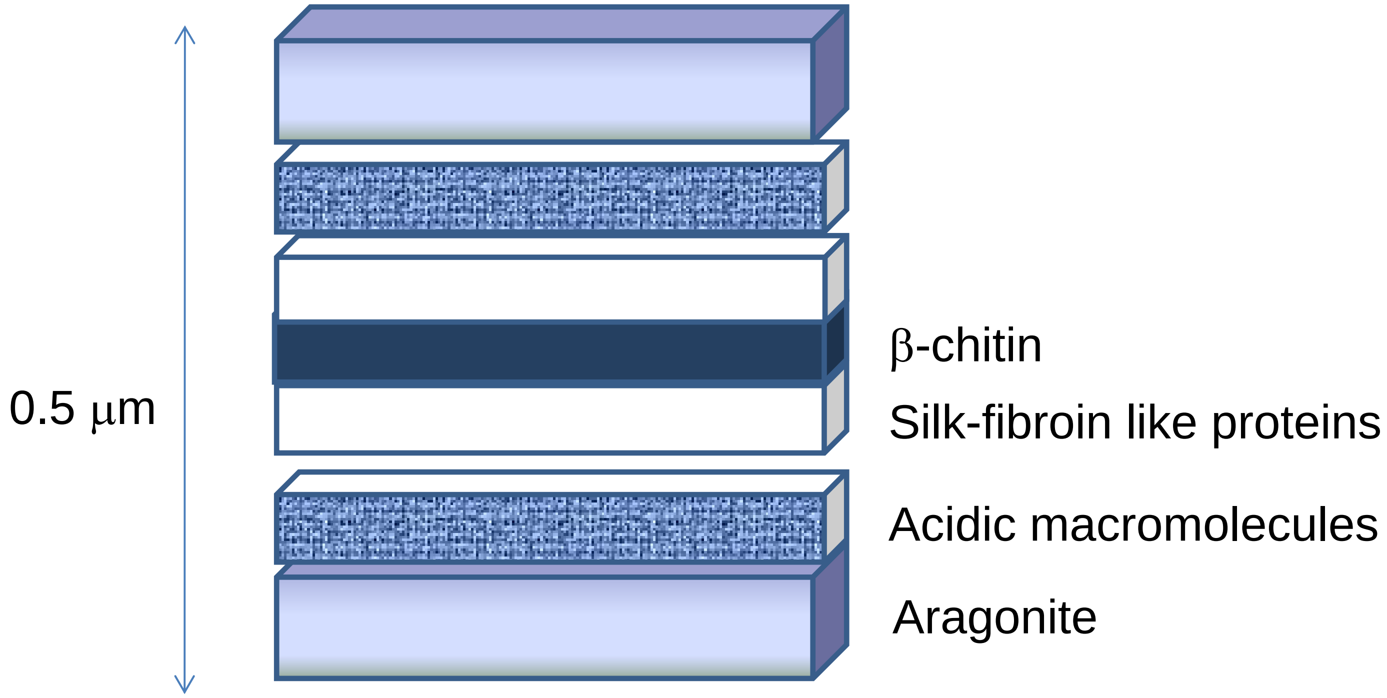
Please see the image on page: http://blogs.zdnet.com/emergingtech/?p=621



http://www.lbl.gov/Science-Articles/Archive/MSD-artificial-bone.html

Nacre – cross section



Avian egg shells

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Please see the image on page:
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Silicatein – protein that condenses silicate

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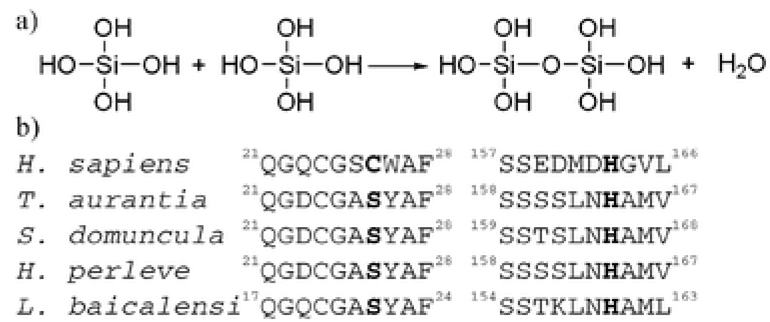

Image courtesy of pubmed.gov.

Please see: Jennifer N. Cha *et al* "Silicatein filaments and subunits from a marine sponge direct the polymerization of silica and silicones in vitro" *PNAS* January 19, 1999 vol. 96 no. 2 361-365.

Silicatein is similar to cathepsin (protease)

Proposed mechanism for silicatein action

Fairhead et al. 2008

Cha et al. 1999

Silica in plants

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Please see:
Figure 2 on http://aob.oxfordjournals.org/cgi/content/full/100/7/1383.

Currie and Perry, 2007

Limpet teeth - goethite

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Please see:

http://www.bigelow.org/mitzi/mid_15.html

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Please see:

http://www.theseashore.org.uk/theseashore/LimpetsERS(ms).html

Bone growth

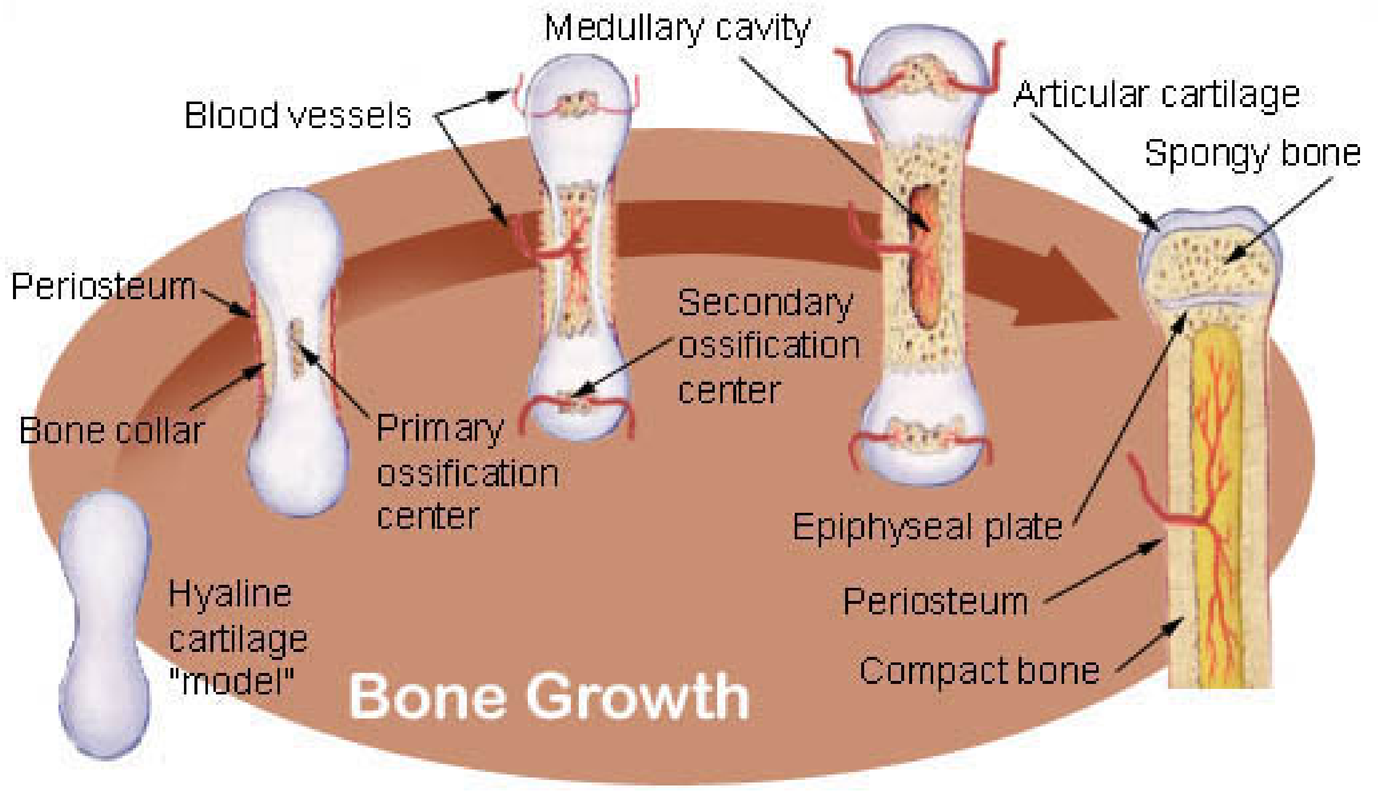

Image courtesy of National Cancer Institute.