

The NSLS Infrared Microscopes: Photographing Chemistry with Invisible Colors

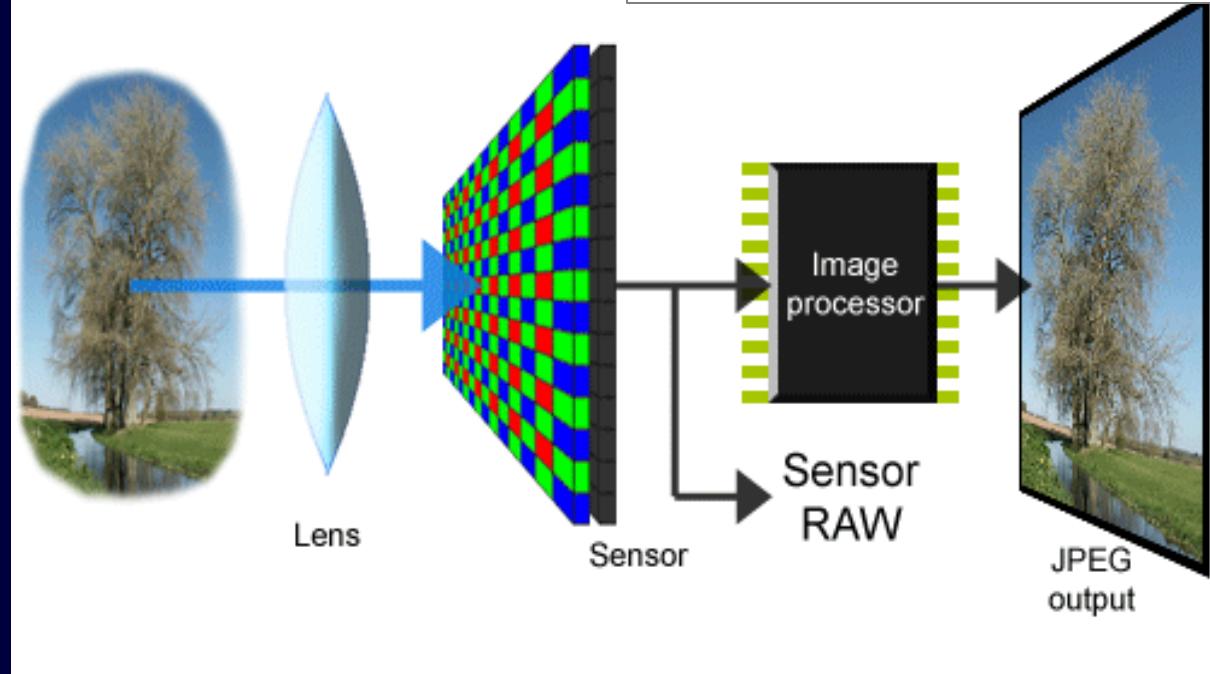
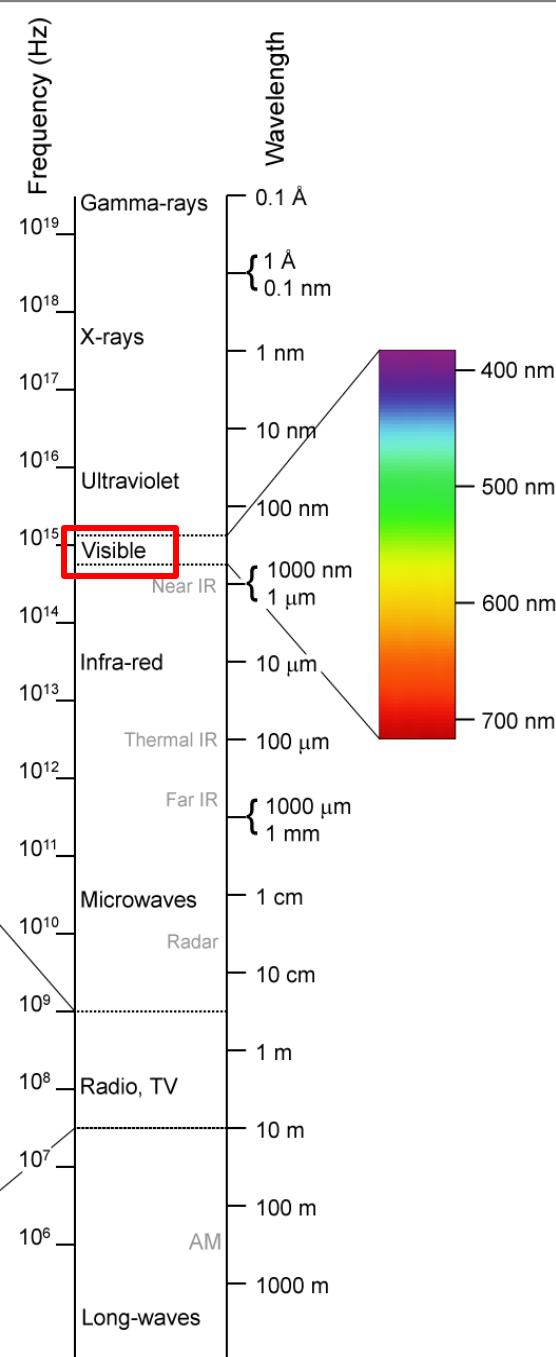
Lisa M. Miller

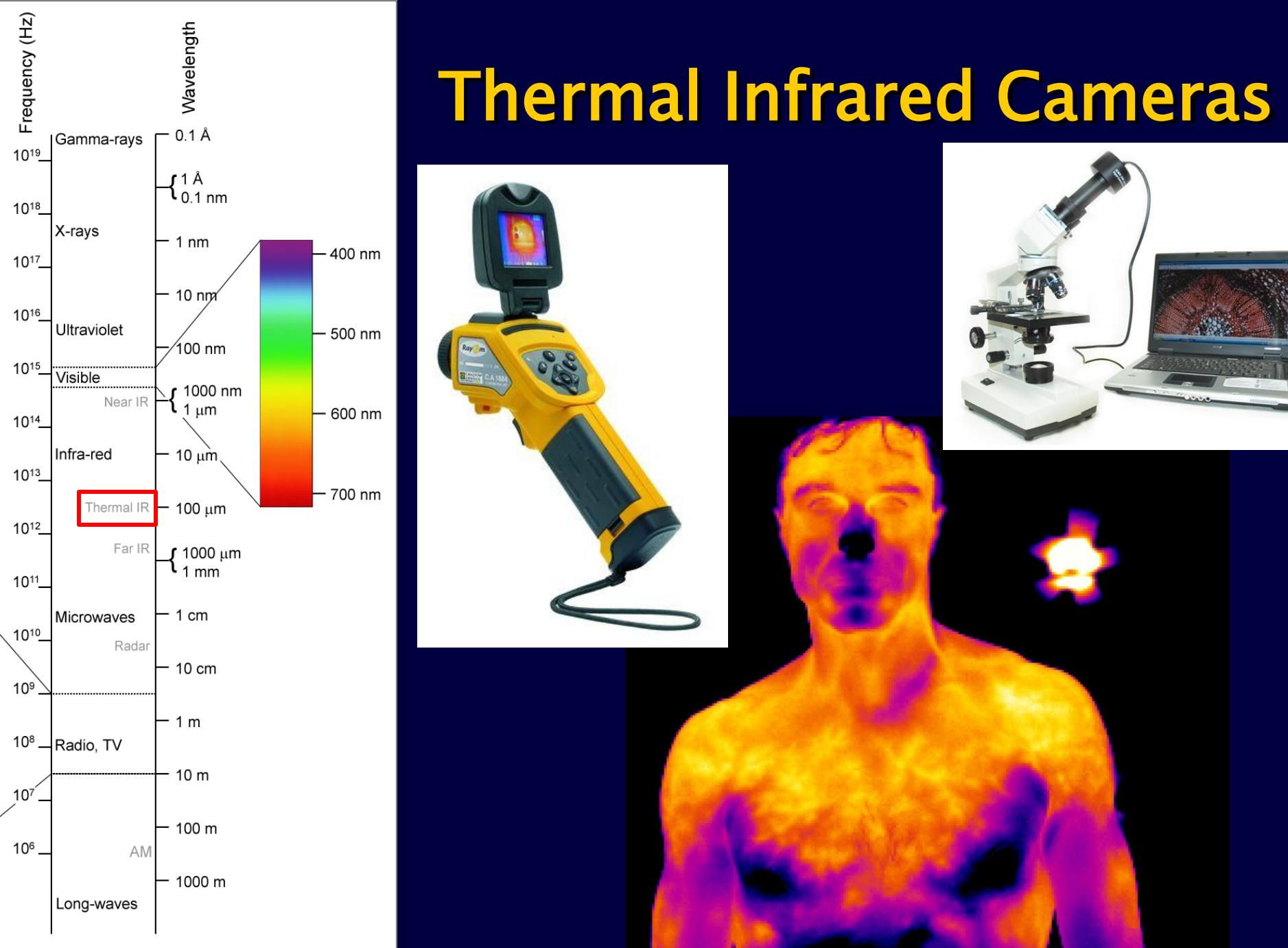
National Synchrotron Light Source
Brookhaven National Laboratory

Departments of Chemistry and Biomedical Engineering
Stony Brook University

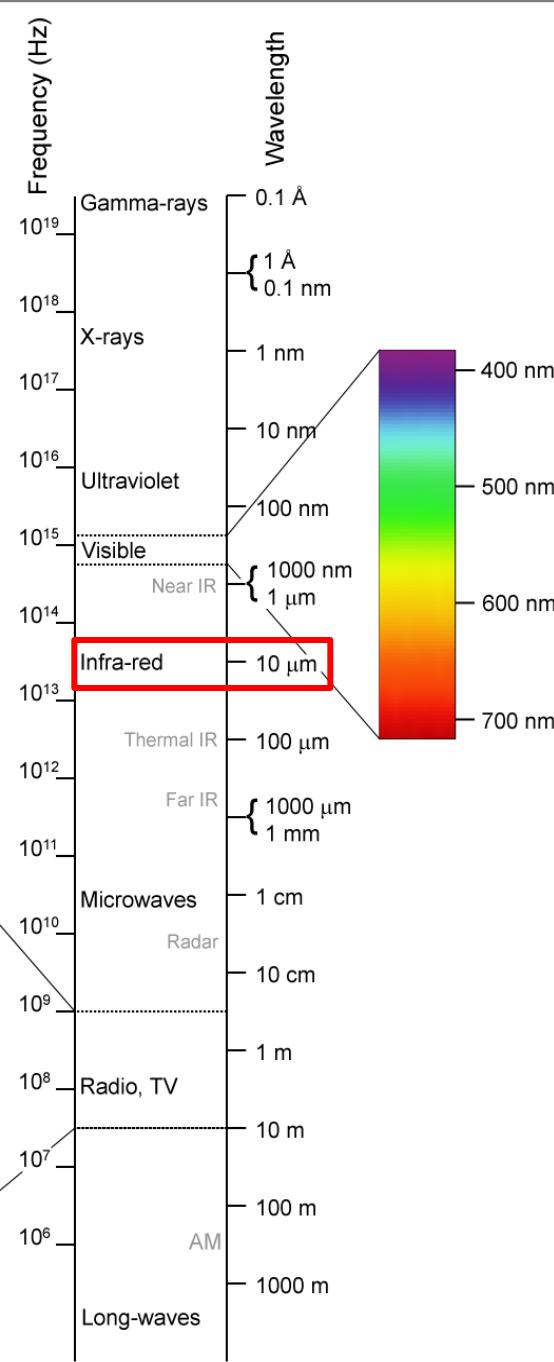
lmiller@bnl.gov
(631) 344-2091

Digital Cameras

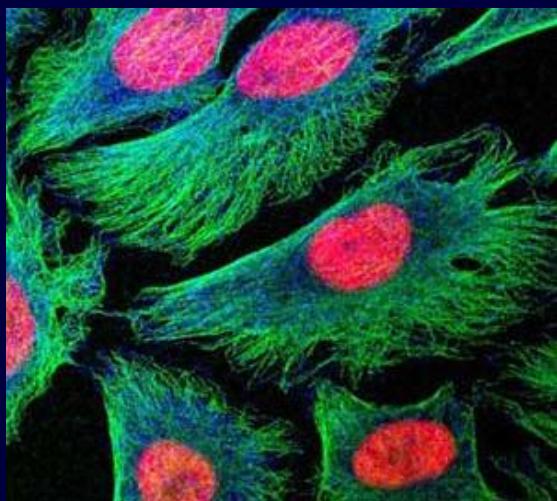




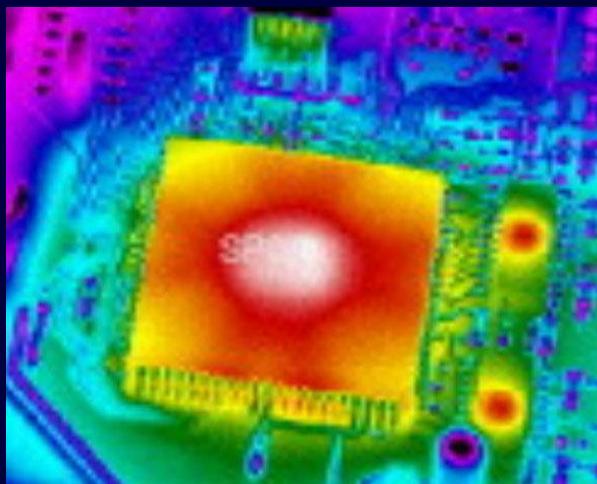
Mid-Infrared “Cameras”



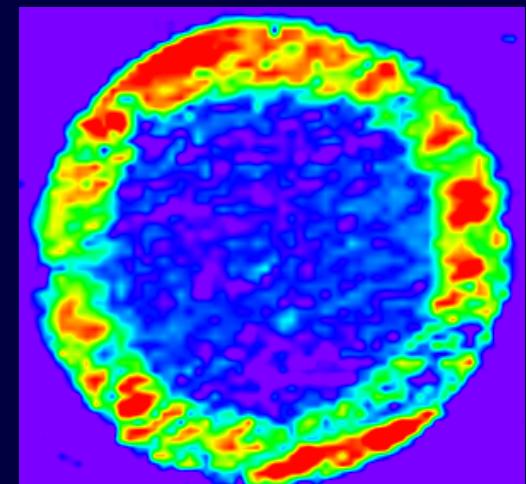
What Do We “See”?



visible light image

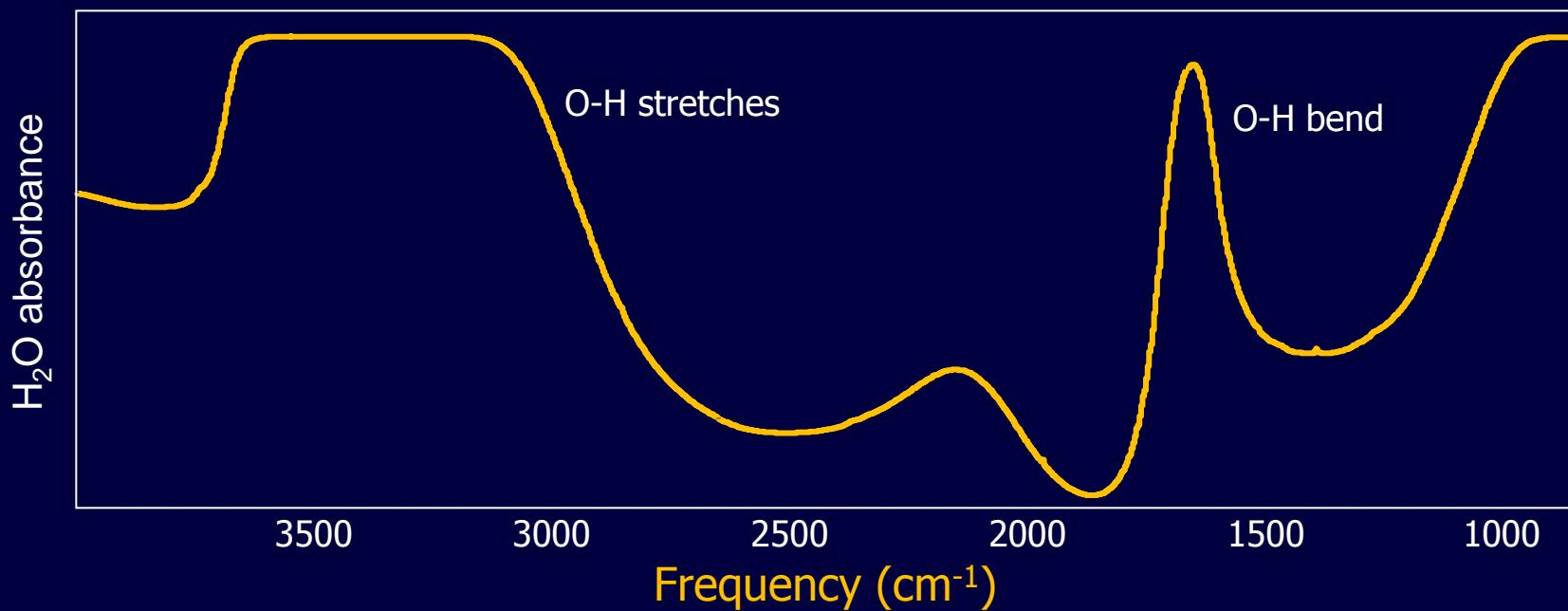
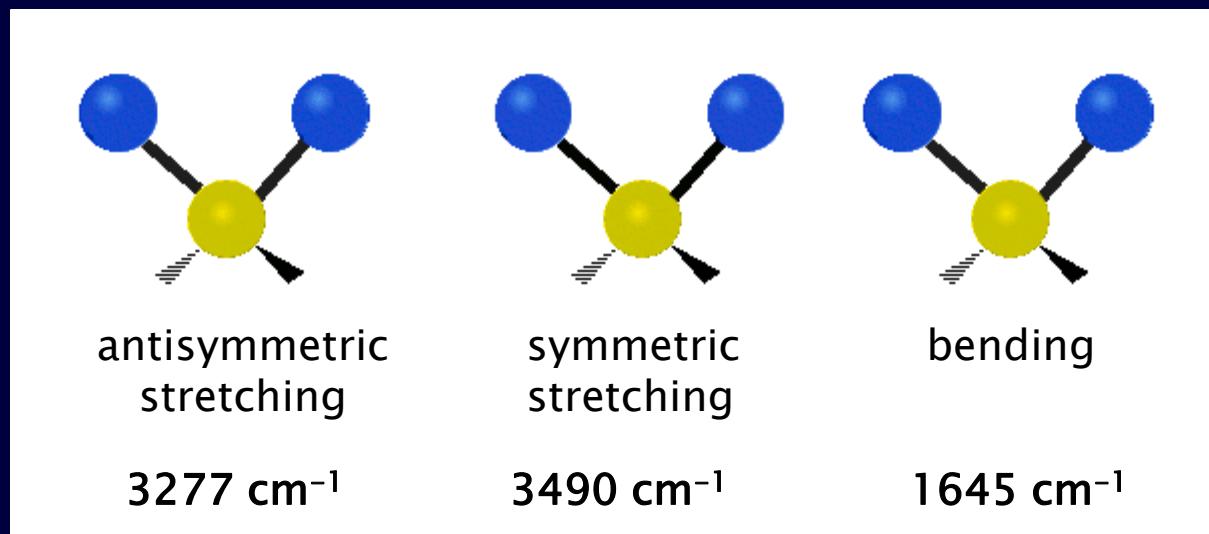


thermal image



chemical image

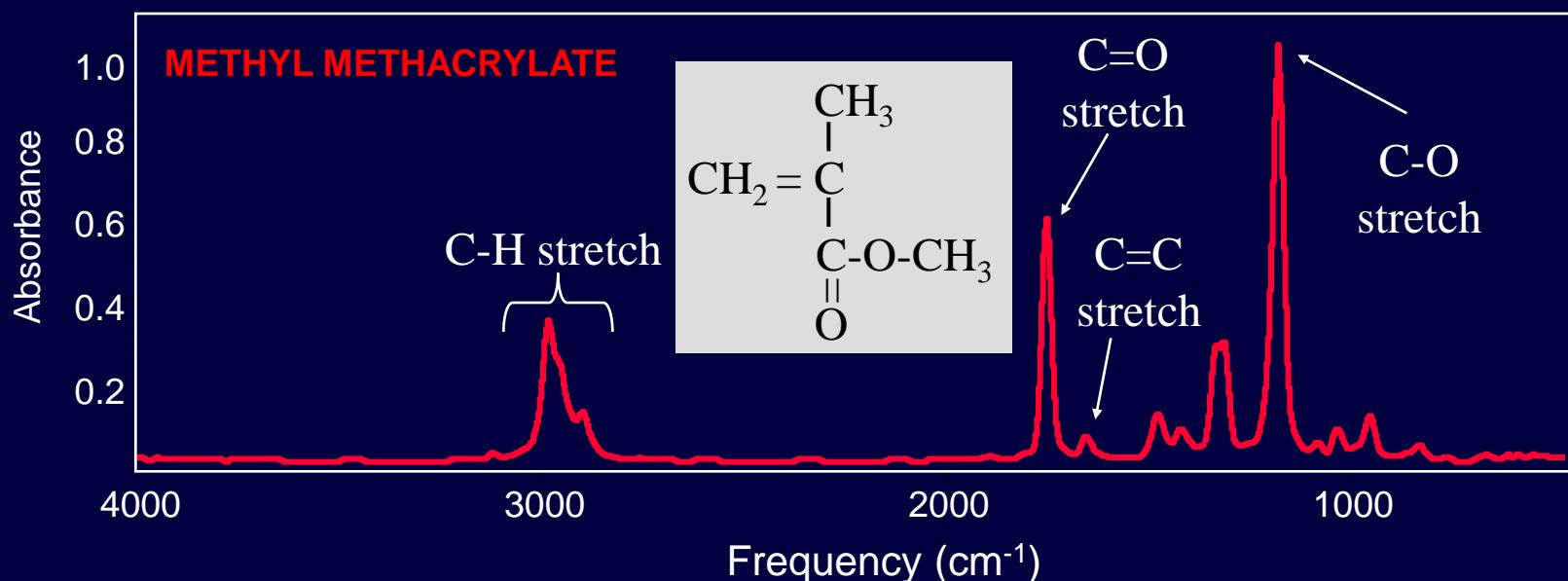
Vibrating Molecules Absorb Infrared Light



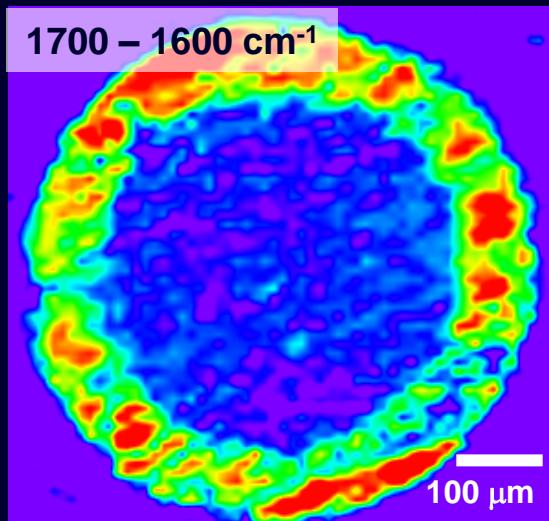
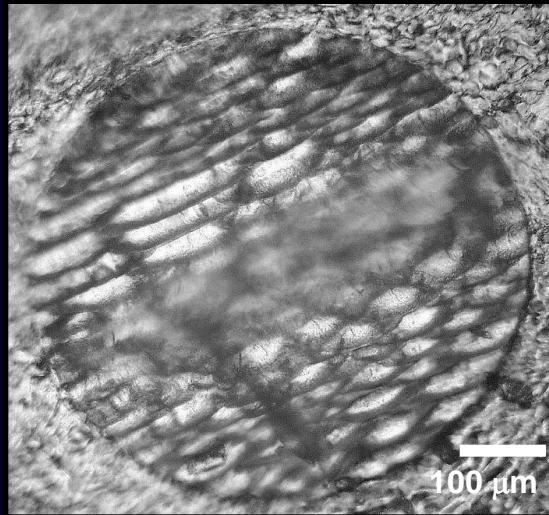
Infrared Microscopy = Molecular Fingerprint

-C-O	1050-1150 cm ⁻¹
-C=O	1640-1750 cm ⁻¹
-C-Cl	600-800 cm ⁻¹
-C-Br	500-600 cm ⁻¹

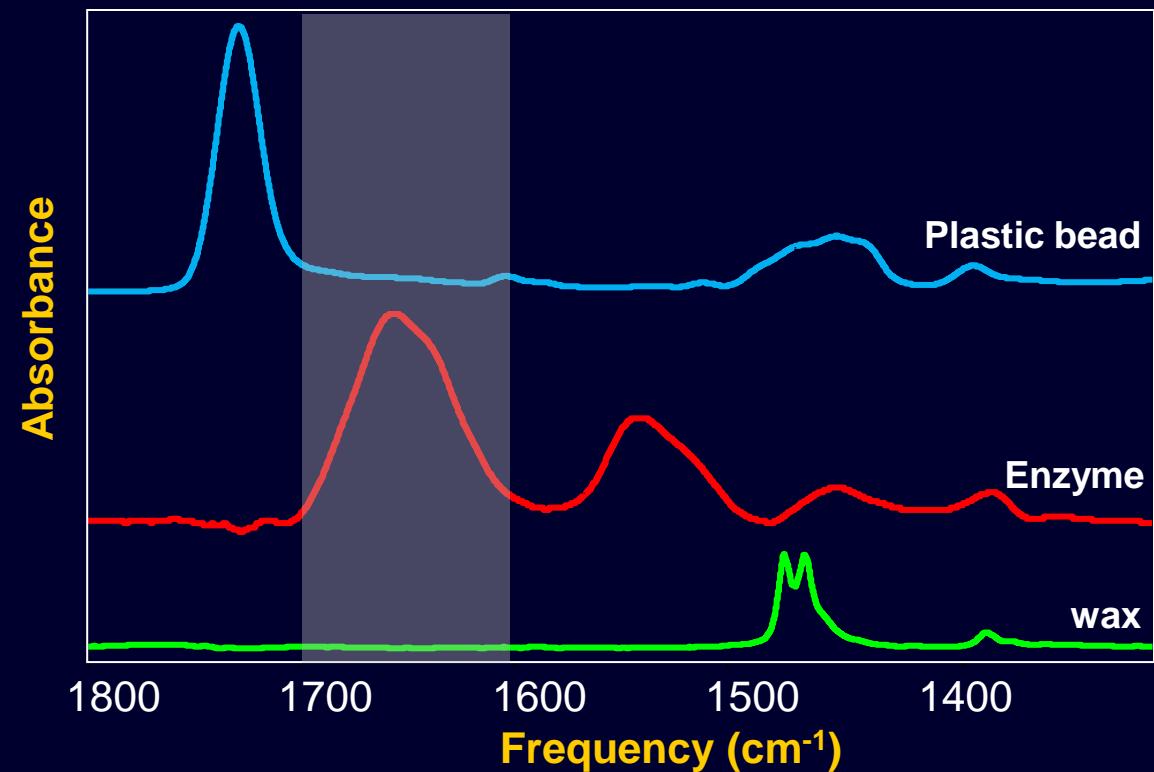
atom type, size, and
bond strength
influence vibrational
frequencies



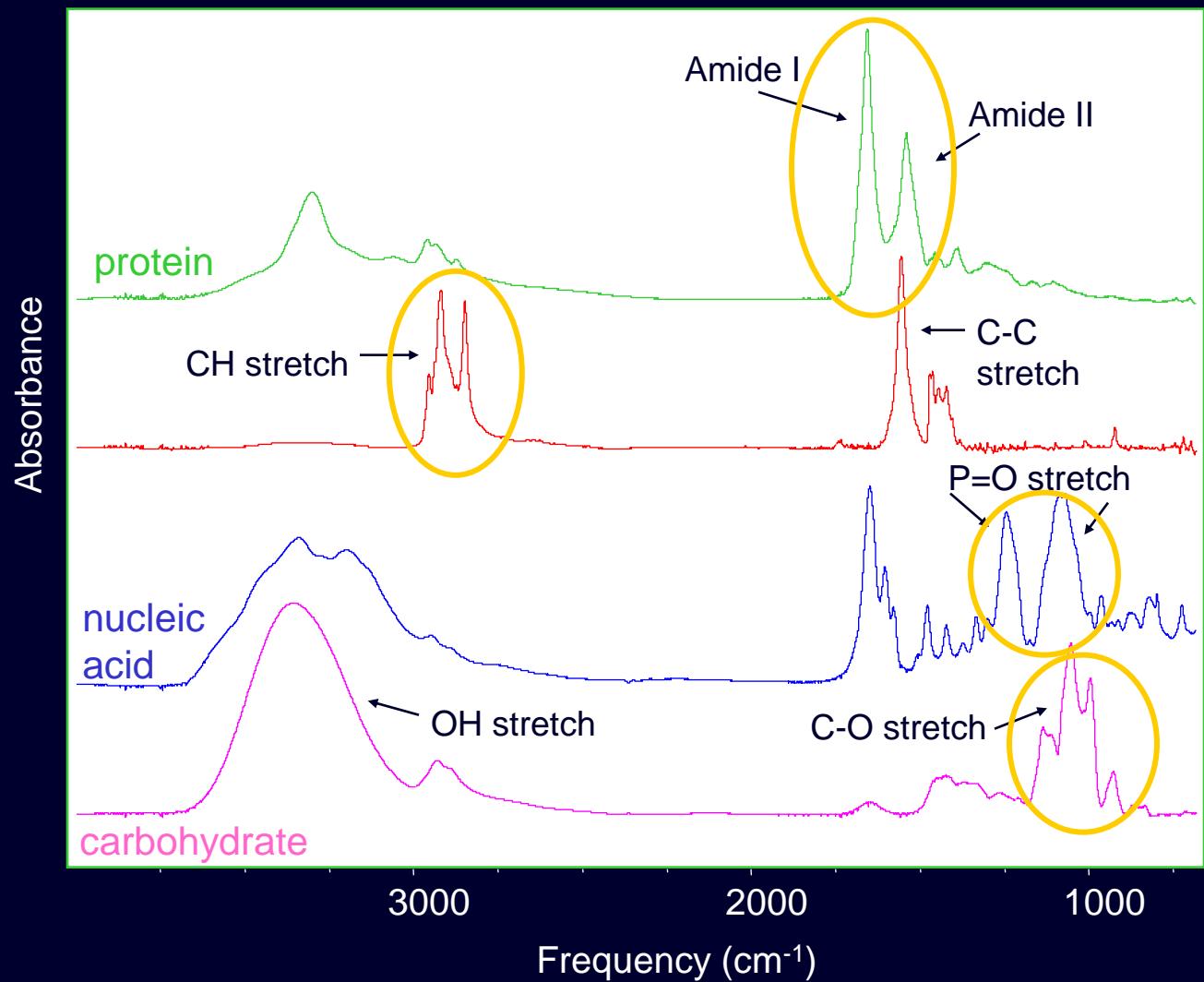
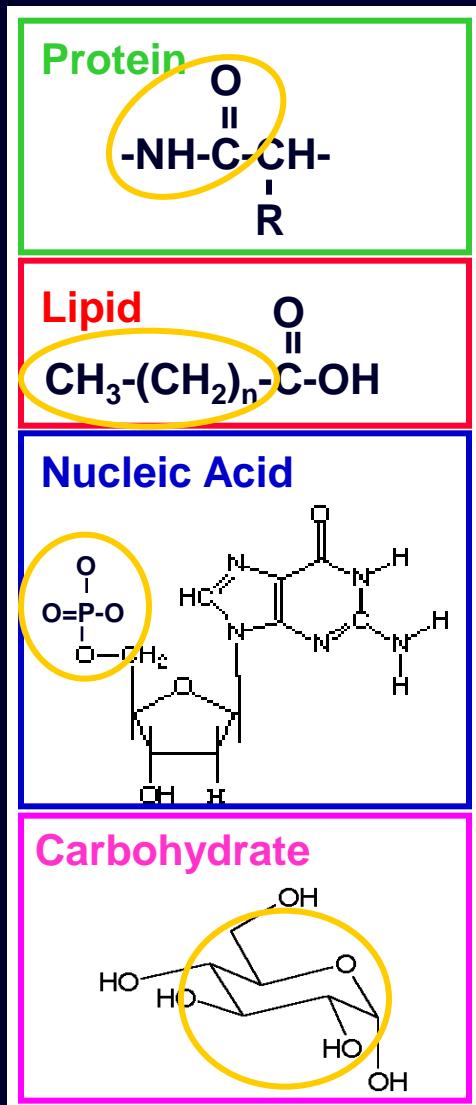
Mid-Infrared Imaging



plastic bead soaked in enzyme,
embedded in wax, and cut to thin section



Chemical Features of Biological Components

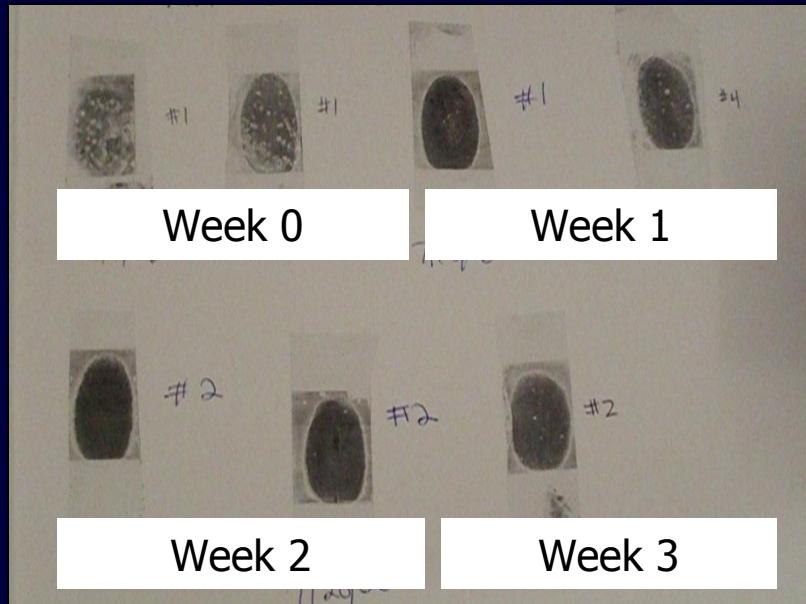


Examples

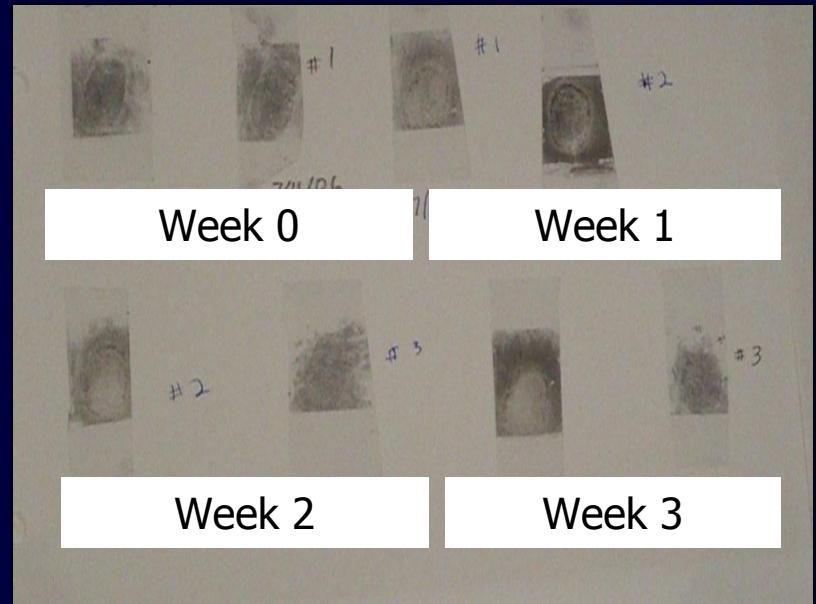
- Fingerprints
- Hair
- Plants
- Soil
- Bones, Fossils
- Biological Cells

Children's vs. Adults' Fingerprints

Fathers

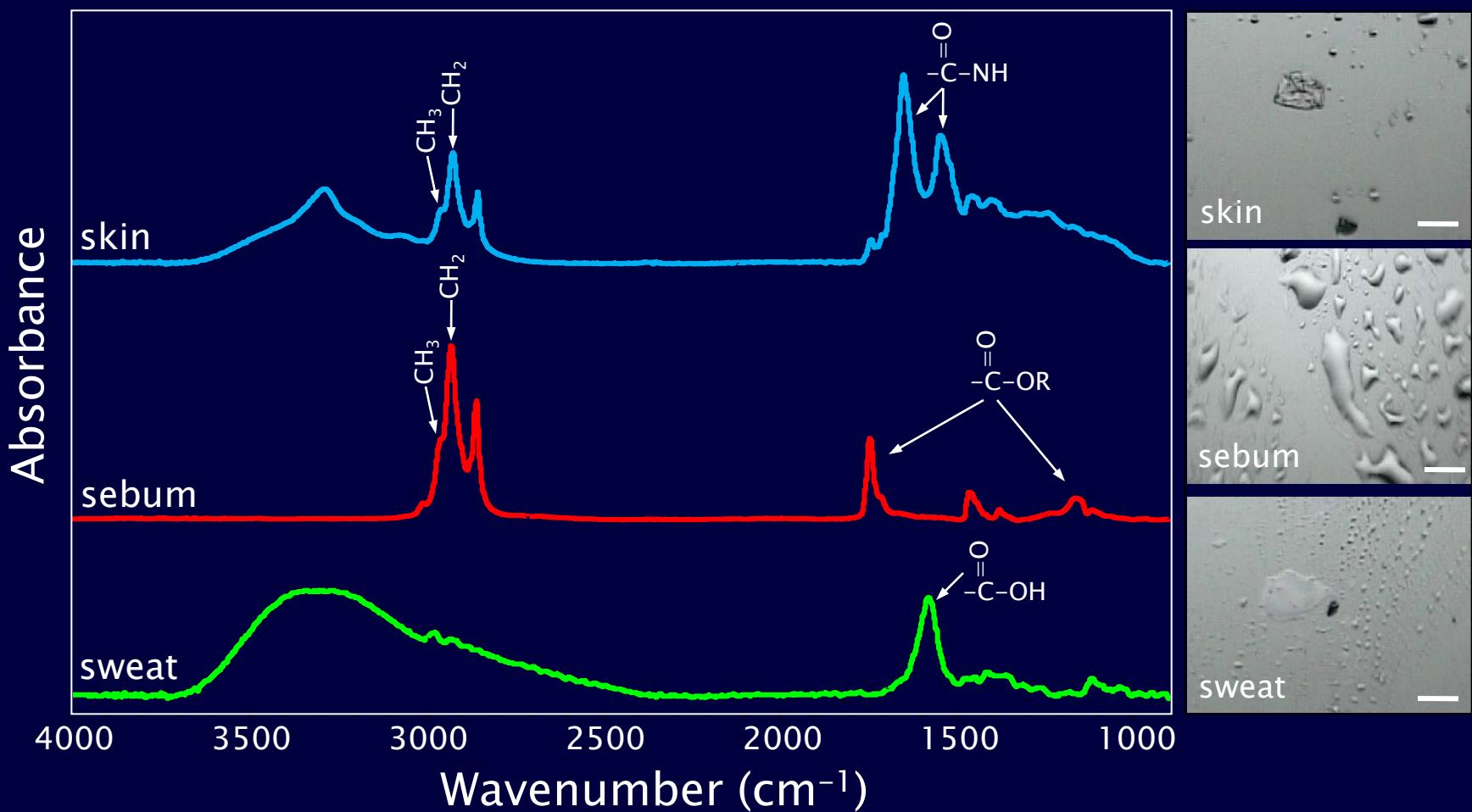


Sons

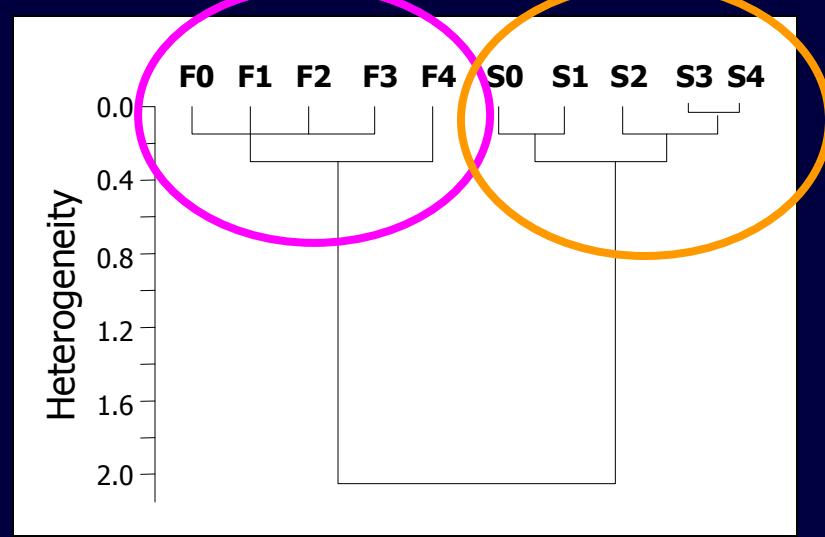
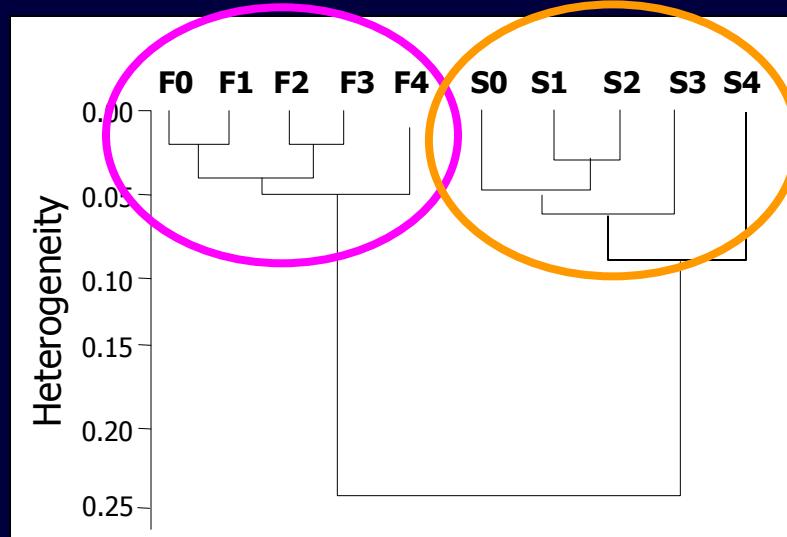
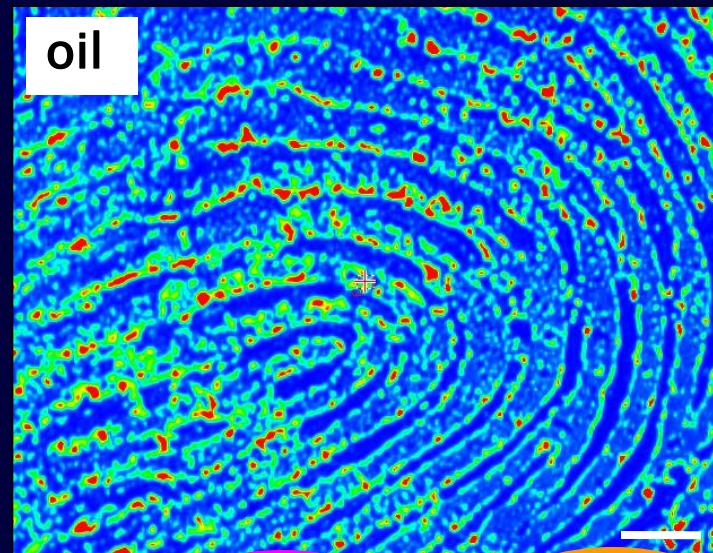
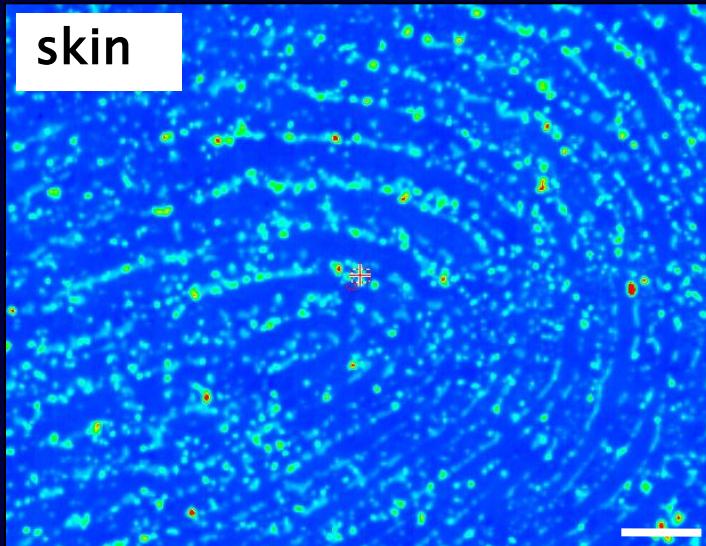


Why do children's fingerprints disappear faster than adults?

Children's vs. Adults' Fingerprints



FTIR Microscopy of Fingerprints



Fathers' prints cluster separately from the sons' prints

Examples

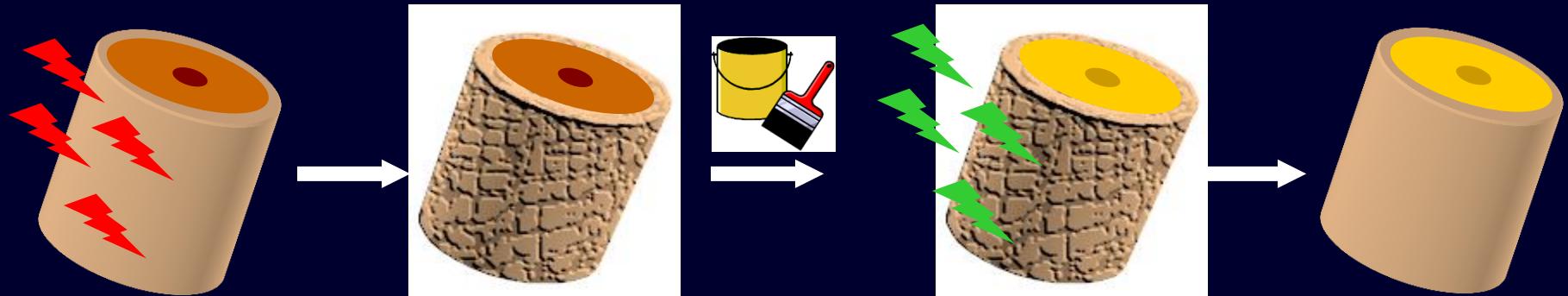
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Chemical Imaging of Hair

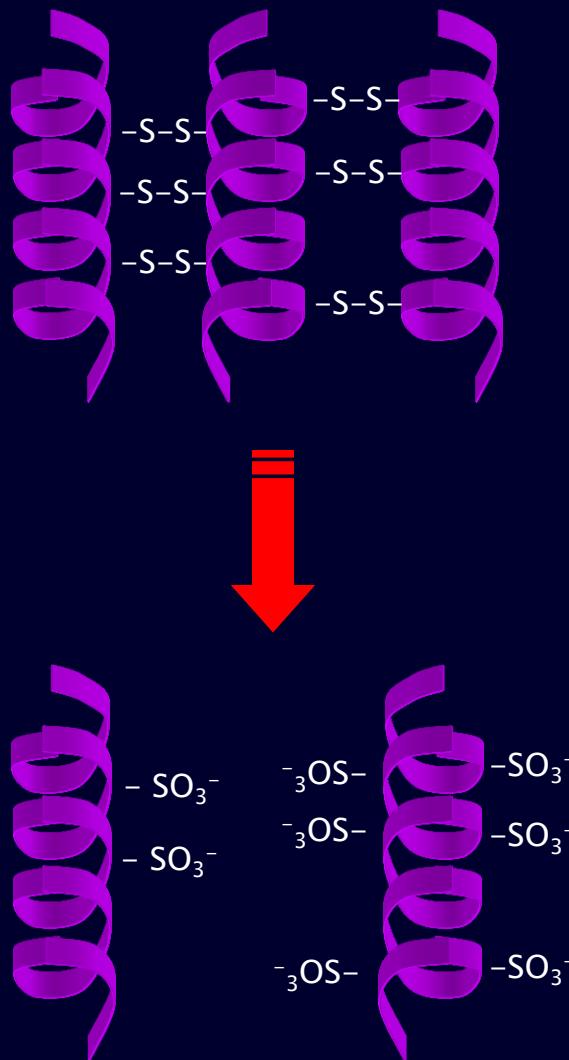


Jean Louis Bantignes and Paul Dumas, *LURE*

Chemical treatments of hair: Bleaching, Coloring

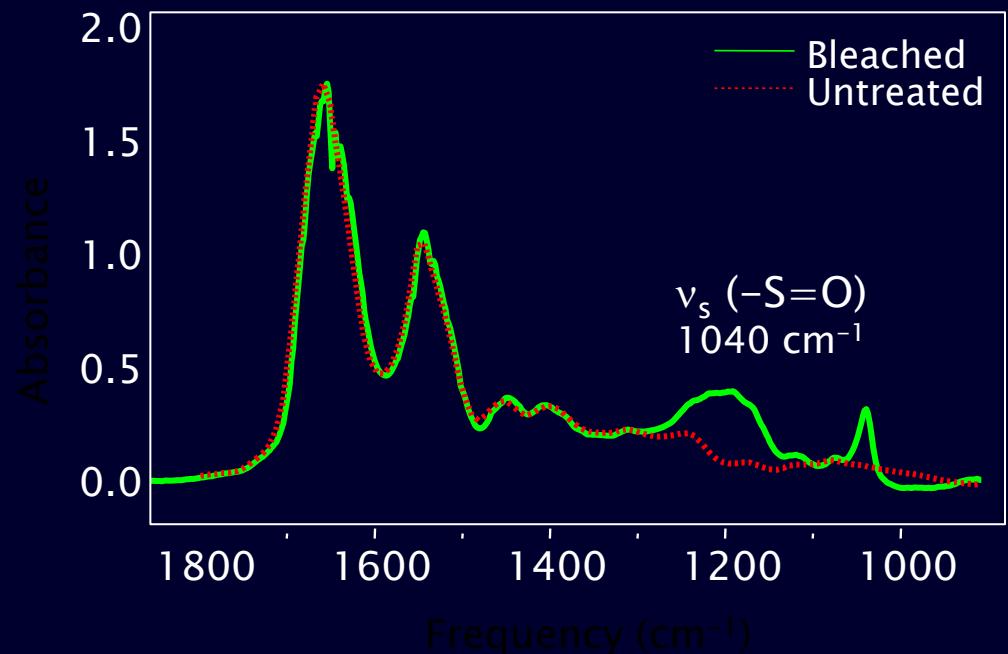


Bleaching Causes Keratin Oxidation

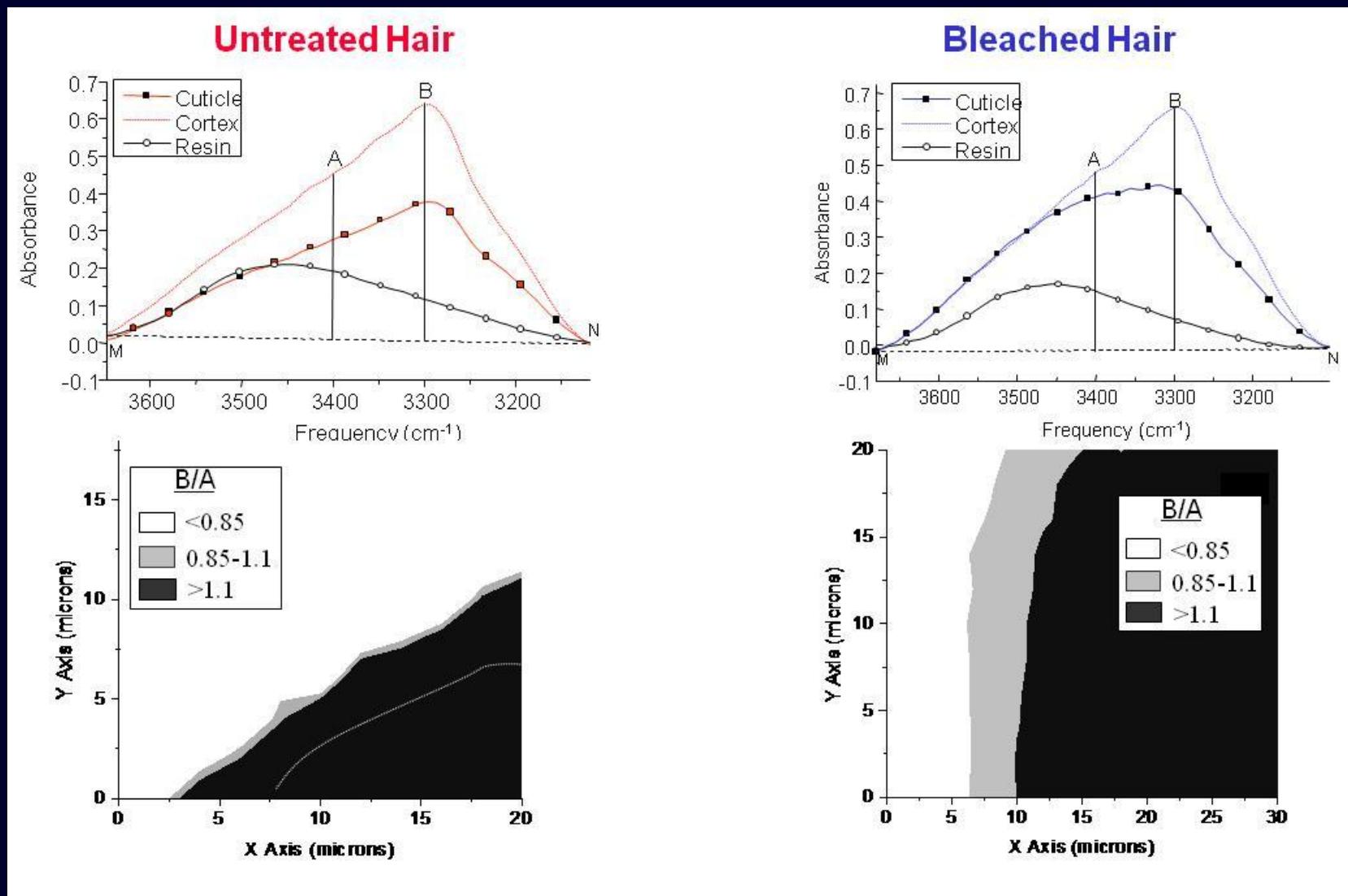


- keratin helices are cross-linked with disulfide bonds
- bleaching disrupts cross-linking as cysteine is oxidized

Cortex before and after bleaching



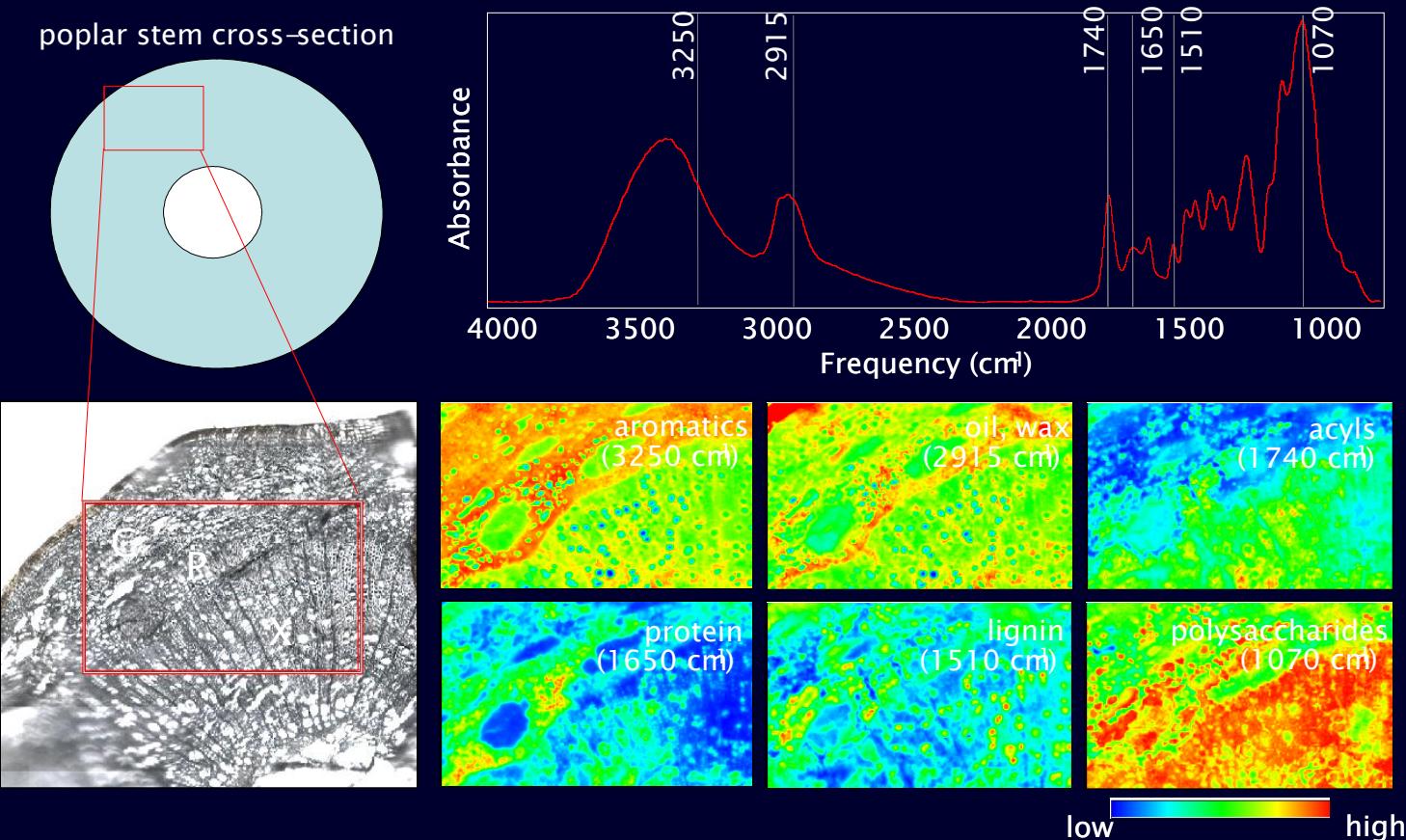
Bleaching Causes Hydration of the Cuticle



Examples

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IR Imaging of Plant Composition



- In order to convert cellulose to ethanol, degradation of plant cell walls is necessary
- To make efficient biofuels, cell wall degradation needs to be improved
- Understanding plant composition can improve biofuel efficiency

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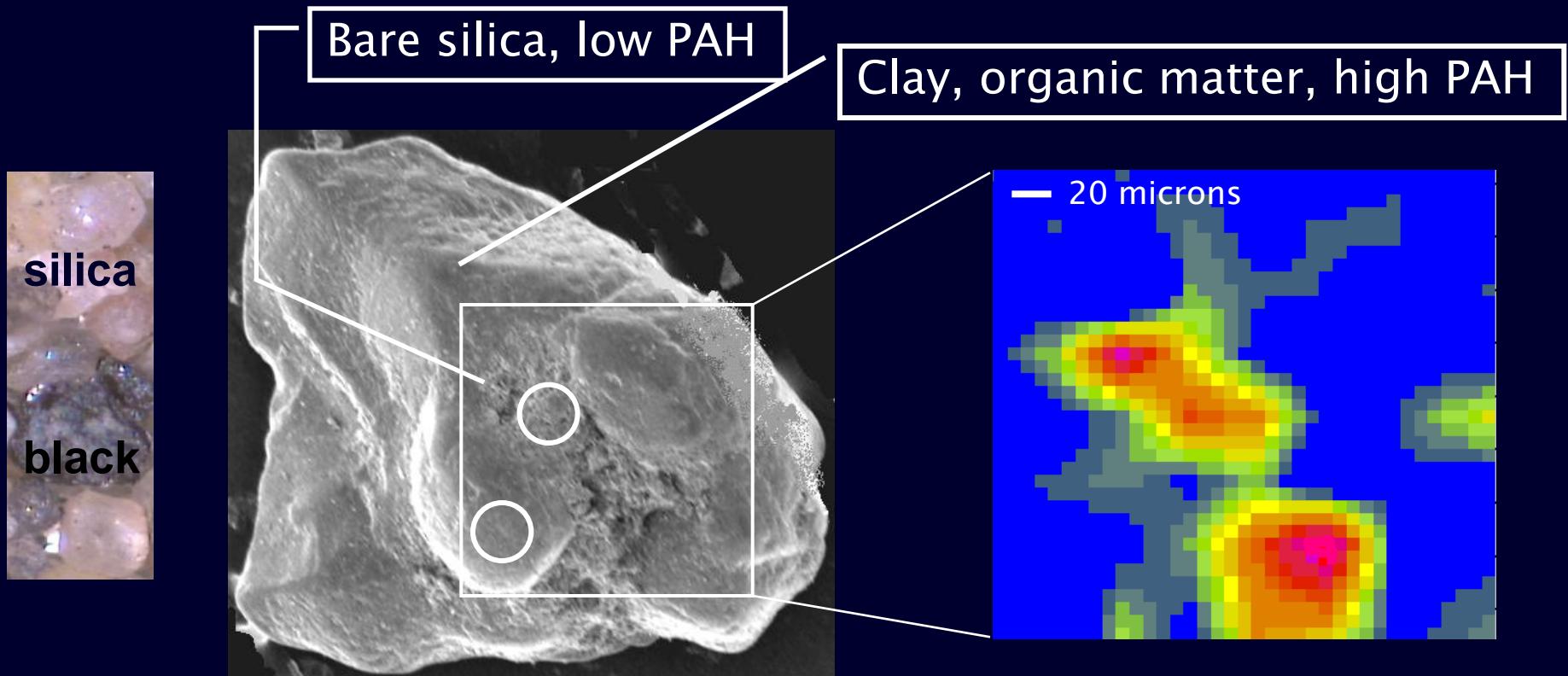
Polycyclic Aromatic Hydrocarbons (PAHs) in Sediments

U. Ghosh and R.G. Luthy, *Carnegie Mellon University*



How to stabilize PAHs in dredged soil?

Association of PAHs with Silica Particles

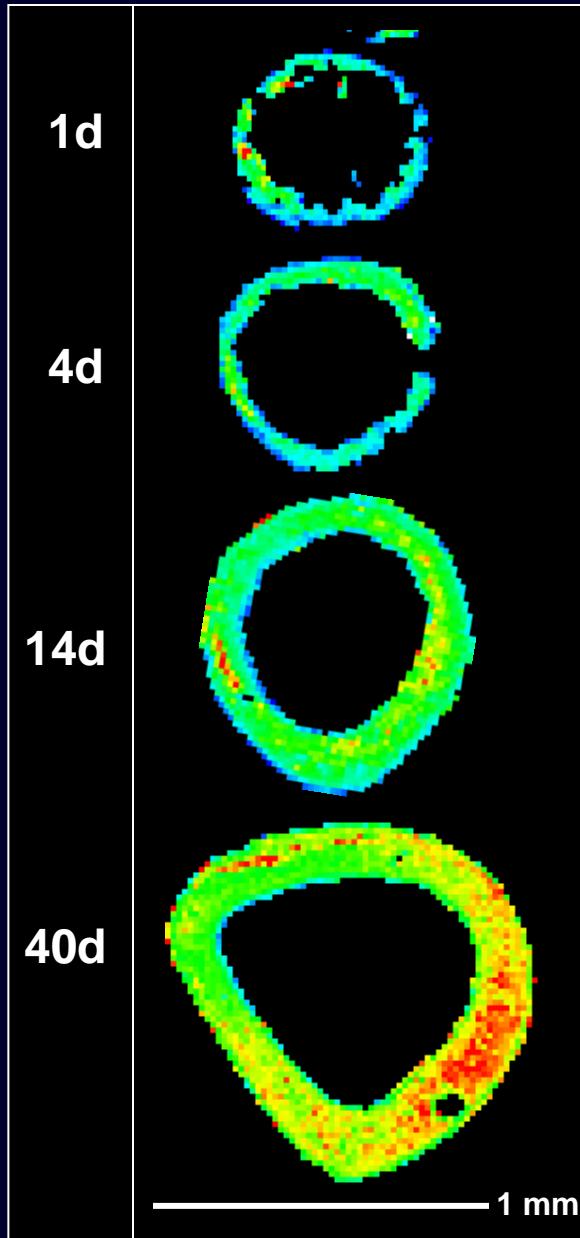


PAHs present on silica particles were found associated with organic carbon locations. These regions containing PAHs are colonized by bacteria during biodegradation studies.

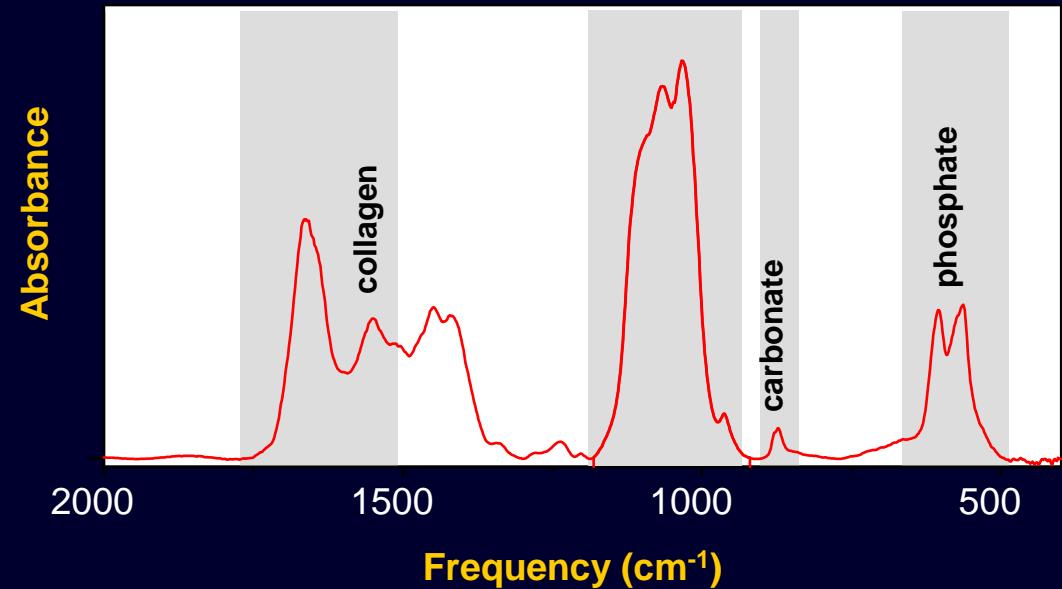
Examples

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Bone Composition in Osteoporosis



Alvin Acerbo, Lisa Miller, *BNL*
Stefan Judex, *Stony Brook University*



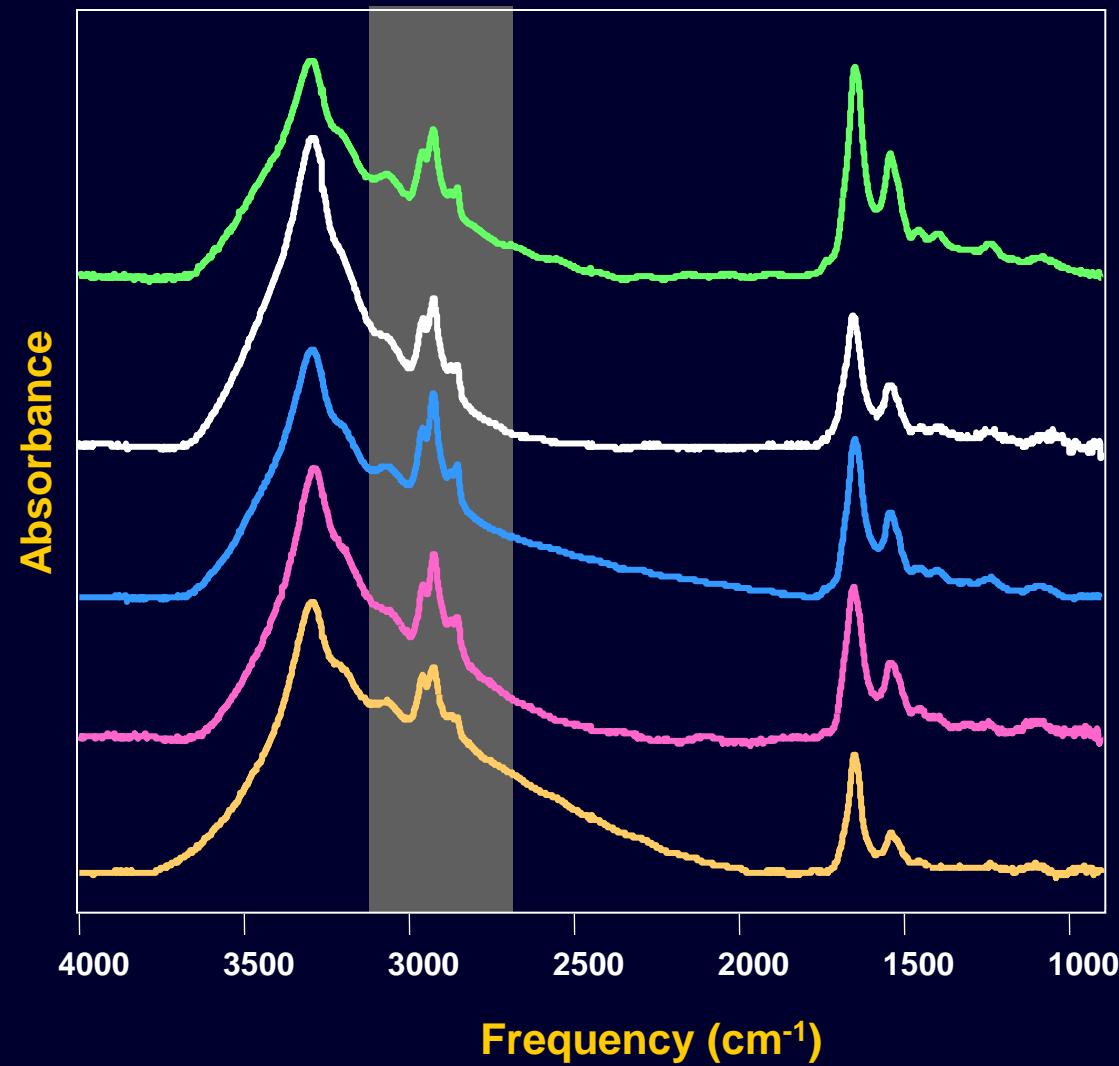
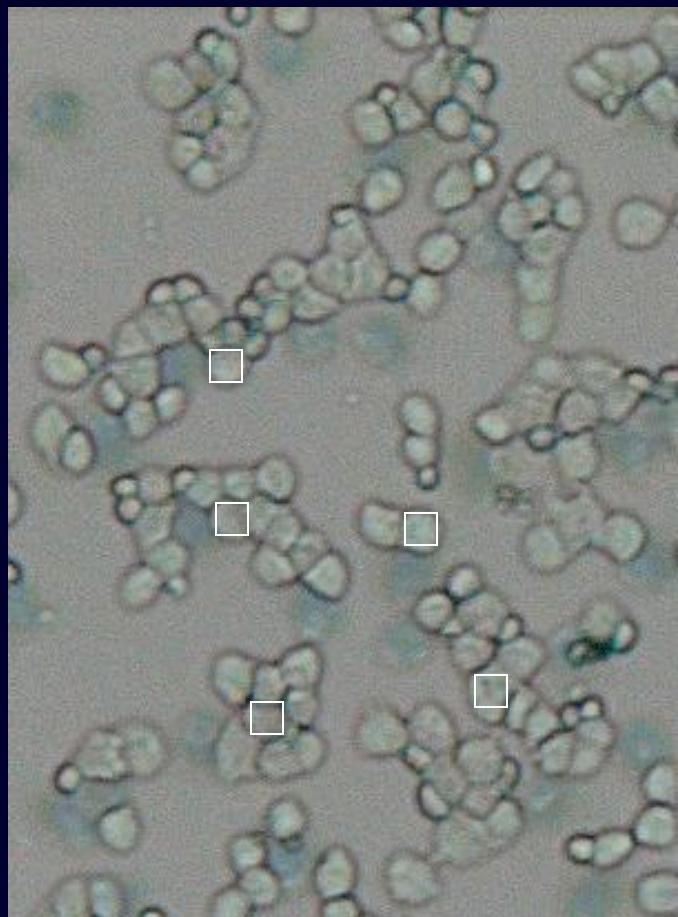
- Bone is composed of protein (collagen) and mineral (hydroxyapatite)
- Bone mineralization increases with age.
- Bone quantity is decreased in osteoporosis, but is the mineralization affected?

Examples

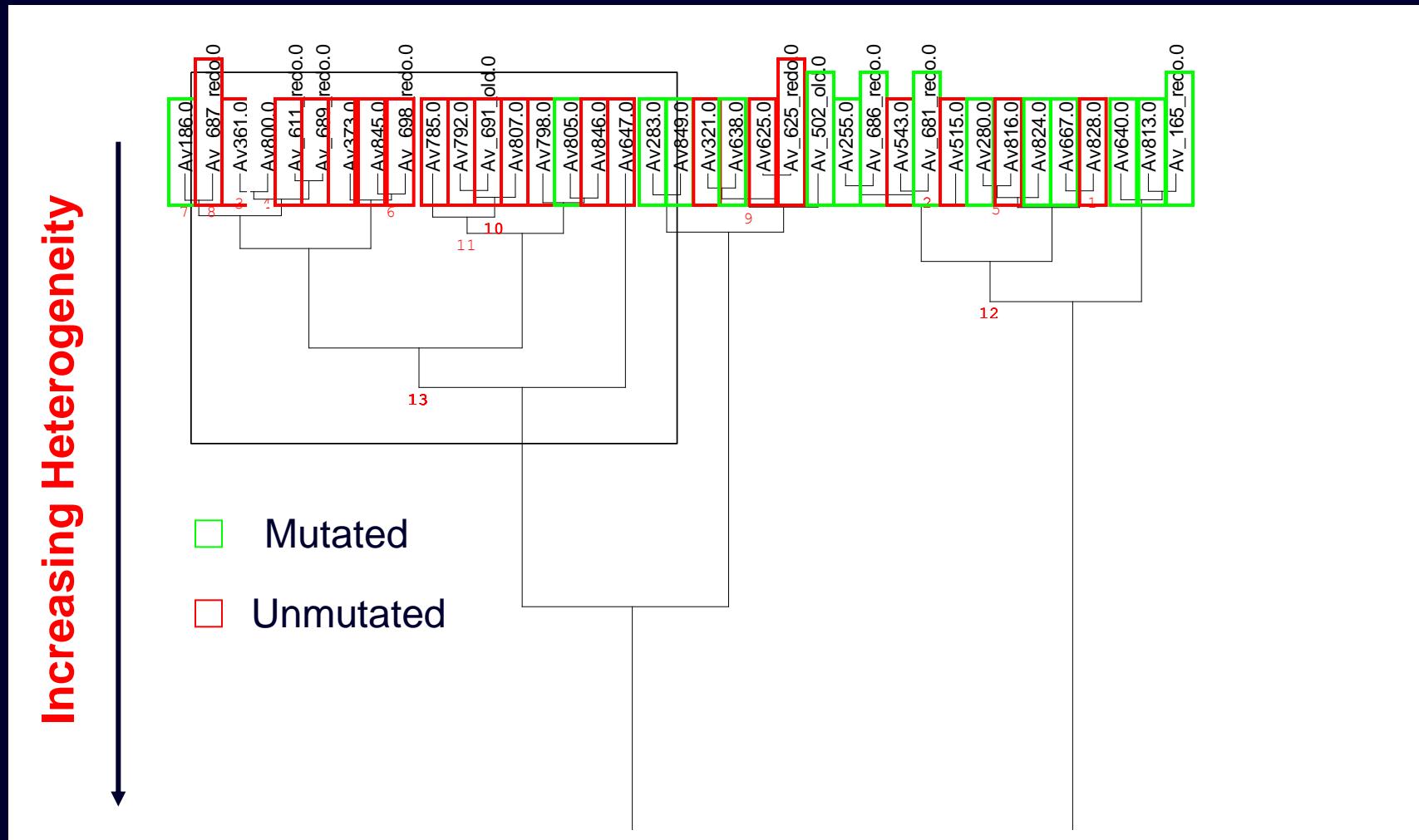
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Differentiation of Cell Types

Nick Chiorazzi, *North Shore - LIJ Hospital*

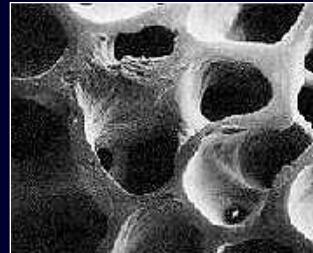


Cluster Analysis of Lipid Region

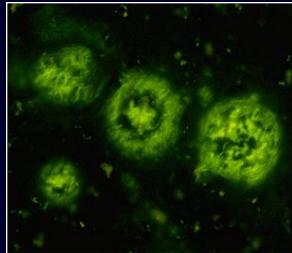


Infrared imaging of lipid region shows separate clusters for progressive vs. benign forms of disease

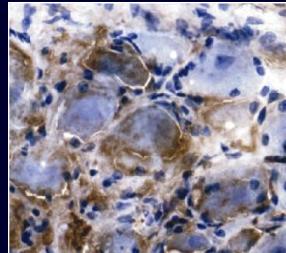
Other Examples



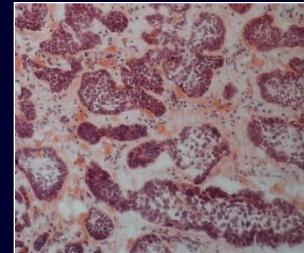
Bone disease



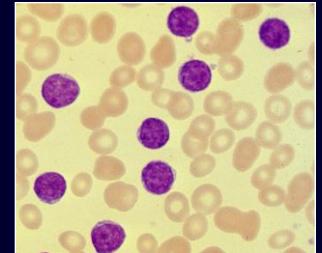
Alzheimer's disease



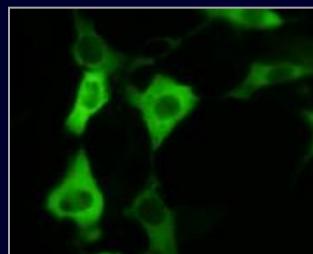
Prion diseases



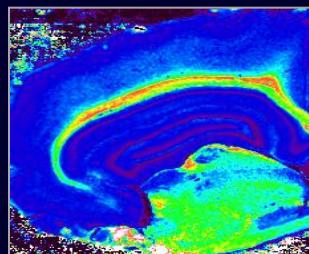
Cancer



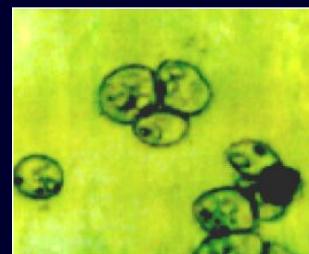
Leukemia



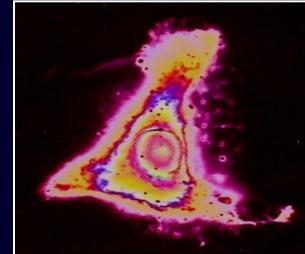
Lou Gehrig's disease



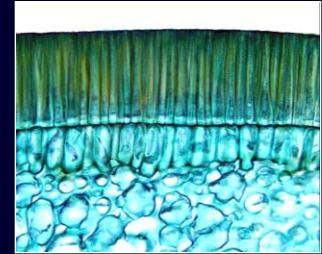
Radiation therapy



Apoptosis



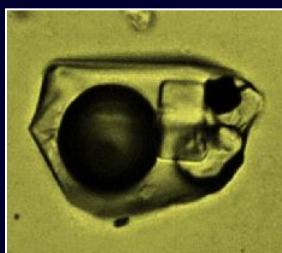
Melanoma



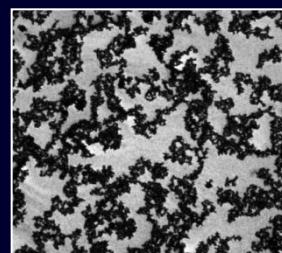
Biofuels



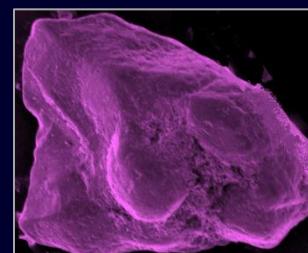
Biopolymerization



Fluid inclusions



Oil extraction



Remediation



Cosmetics