Clays: Colloidal Properties in Nanodomain

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Why clay?

- The ever-growing application of clays in nanotechnology rests on fundamental principles of colloid chemistry
- They make soils as nature's great electrostatic chemical reactor
- The unit cell dimensions of clay minerals are in nanometer scale in all three axes (x, y, and z)

Differences with other colloidal material

- Anisotropic and often irregular particle shape
- broad particle size distribution
- different types of charges within the unit cells
- heterogeneity of layer charges
- pronounced CEC
- disarticulation and flexibility of layers
- different modes of aggregation

advantages of clays

- their ordered arrangements,
- their large adsorption capacity,
- their shielding against sunlight (ultraviolate radiation),
- their ability to concentrate organic chemicals, and
- their ability to serve as polymerization templates.

Industrial uses of clay

- Petroleum refinery
- Cement
- Soaps, detergents, shampoos, lipsticks
- Pesticide carrier
- Ceramics, pottery and sculpture
- Fertilizer conditioner
- Environmental clean up operations
- Pharmaceuticals and catalyst

Nanomaterials

- either newly-created through nanotechnology, or that exist in nature
- Example:
  - clays, zeolites, imogolite, Fe & Mn oxides
- Potential:
  - to manipulate structures or other particles at the nanoscale and to control and catalyze chemical reactions

nanomaterial

Applications:

- provide transparency, or increased strength with decreased weight
- Smart fabrics
- Controlled Environment Agriculture

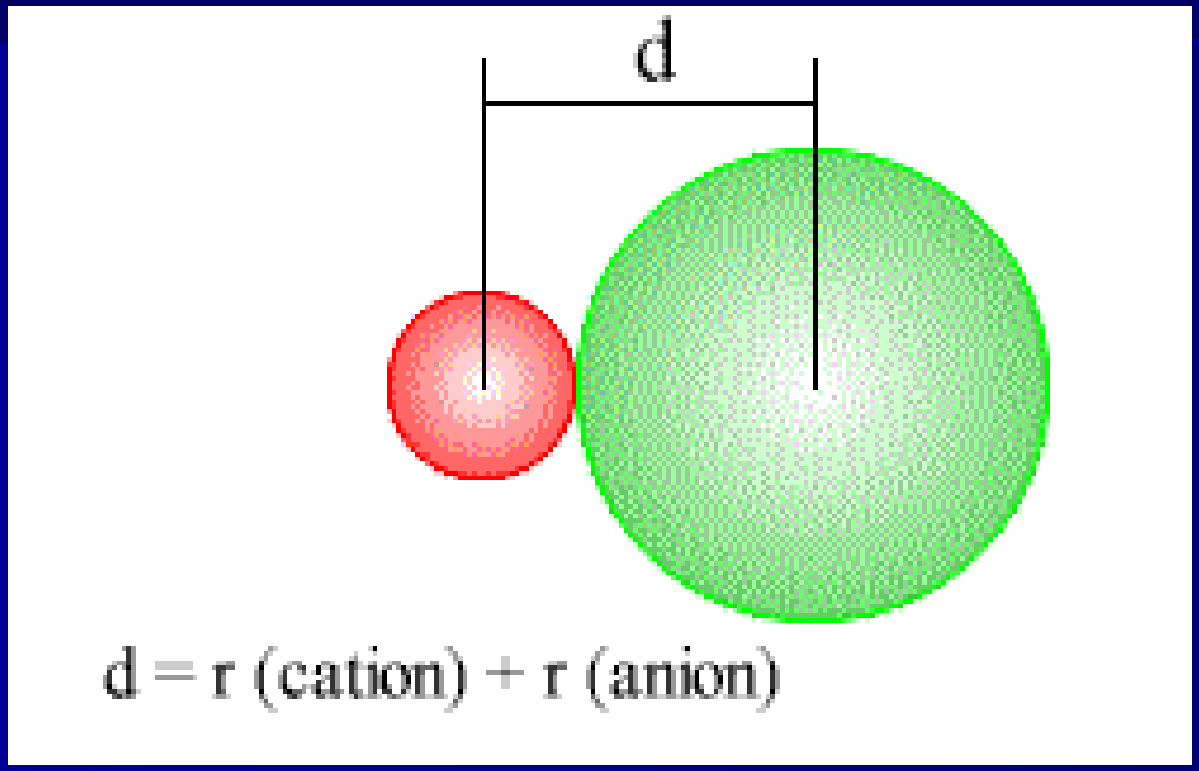
Some successful ventures of nanotechnology involving clay

Product	Application	Institution*
Nanocides	**pesticides encapsulated in nanoparticles for controlled release**	BASF
	nanoemulsions for greater efficiency	Syngenta
Bucky ball fertilizer	**ammonia from buckyballs**	Kyoto Univ, Japan
Nanoparticles	**Adhesion-specific nanoparticles for removal of *Campylobacter jejuni* from poultry**	Clemson Univ.
Food packaging	**airtight plastic packaging with silicate nanoparticles**	Bayer
Use of agri-cultural waste	**nanofibres from cotton waste for improved strength of clothing**	Cornell univ
Nano-sensors	**contamination of packaged food**	Nestle, Kraft
	pathogen detection	Cornell Univ
Precision agriculture	**nanosensors linked to GPS for real-time monitoring of soil conditions and crop growth**	USDA
Live stock and fisheries	**nano-veterinary medicine (nanoparticles, buckyballs, dendrimers, nanocapsules for drug delivery, nanovaccines; smart herds, cleaning fish ponds (Nanocheck); feed (iron nanoparticles)**	Cornell Univ, Nanovic,

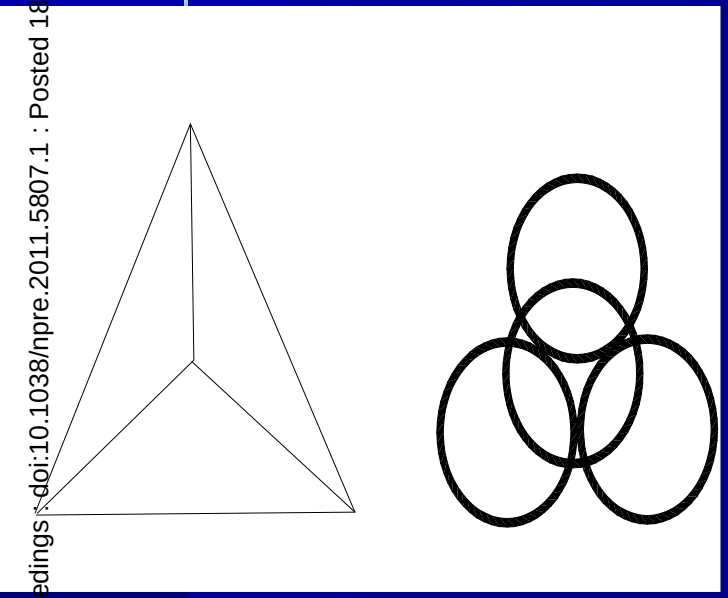
Possible innovations

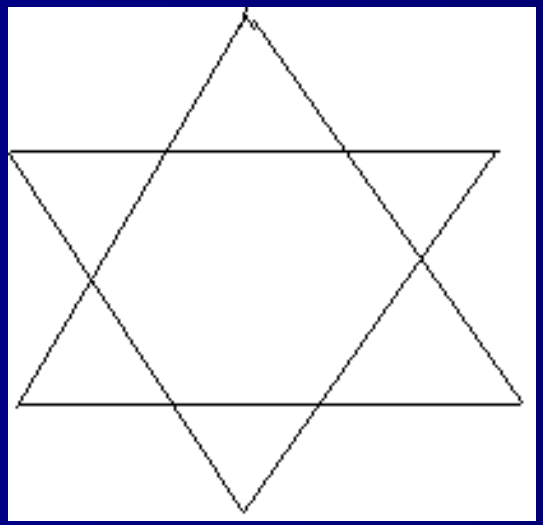
- nano-enhanced products (e.g. nanofertilizers and nanopesticides)
- nano-based smart delivery system (use of halloysite)
- Nanoporous materials (e.g. hydrogels and zeolites)
- nanoporous membranes
- Nanosorbents
- Nanocrystals of magnetite (< 12 nm)
- Nanosensors
- nanoscale precision farming

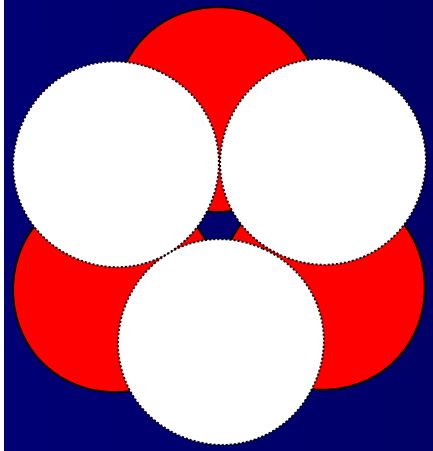
Soil mineral structures



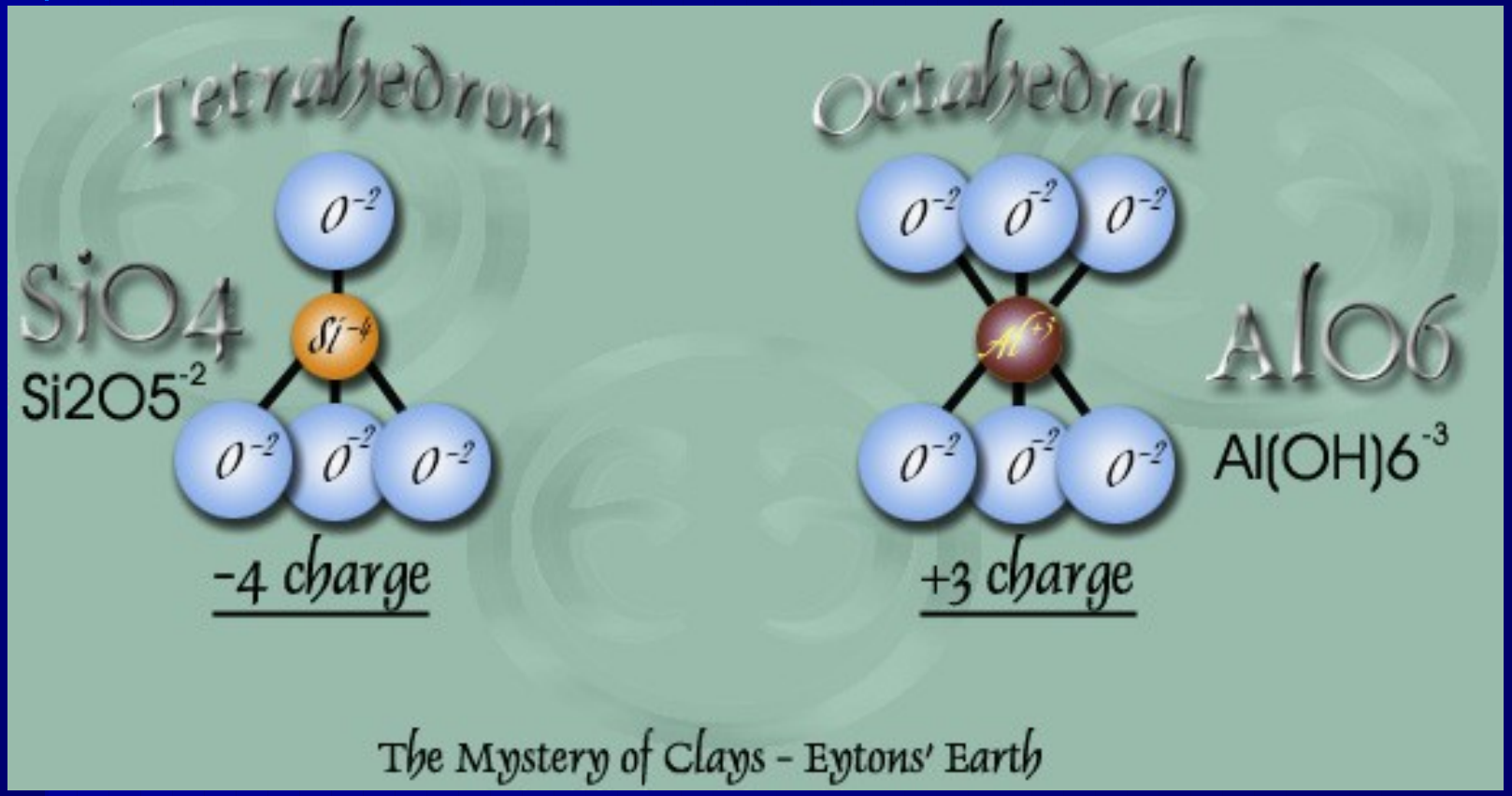
Si-tetrahedron and Al-octahedron structure



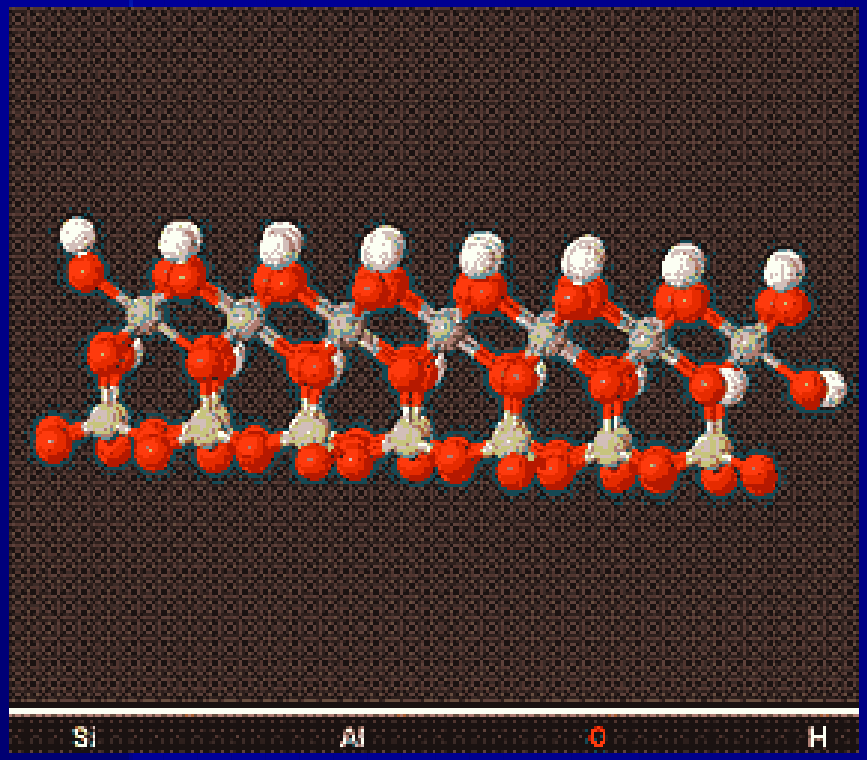


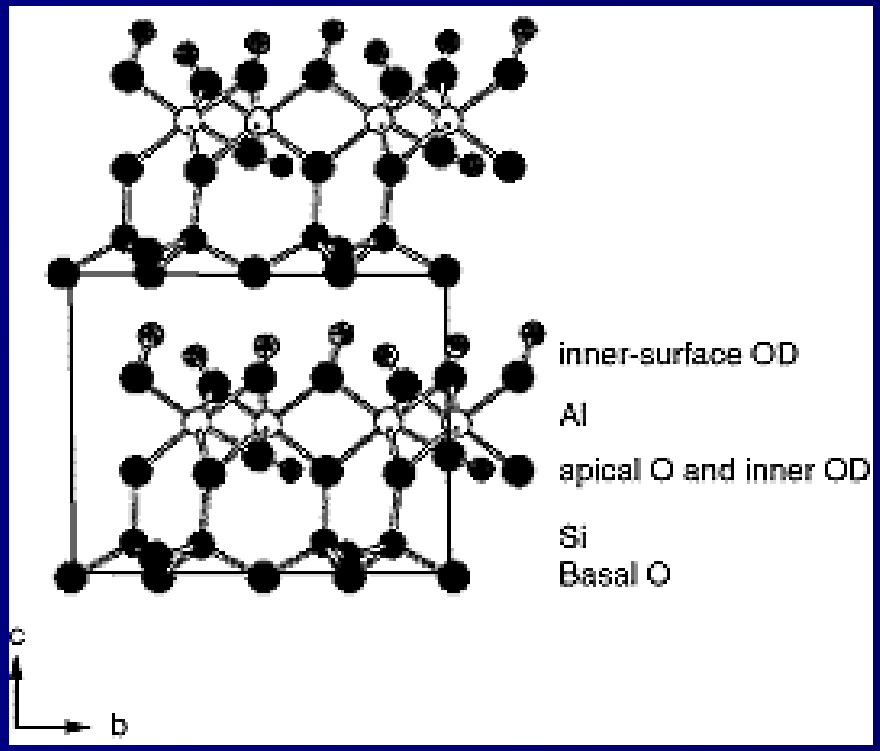


Si tetrahedra and Al octahedra in clay minerals

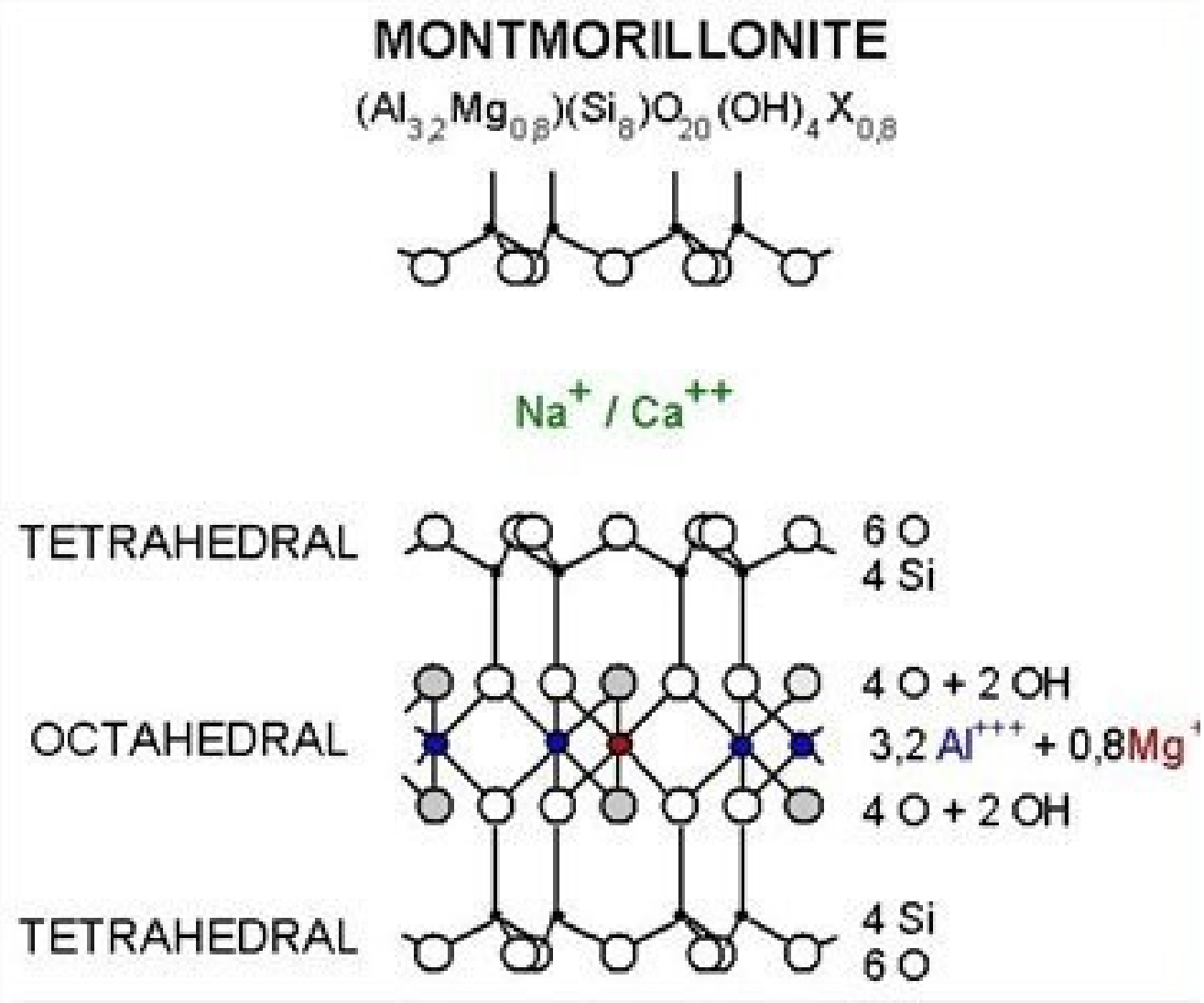


Structure of kaolinite (China clay)

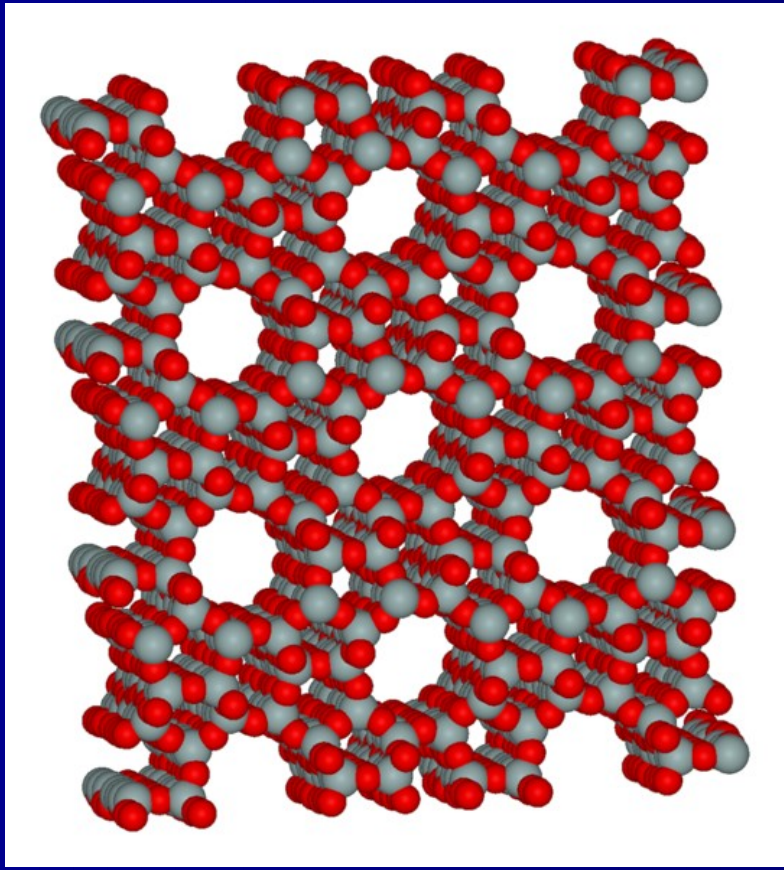




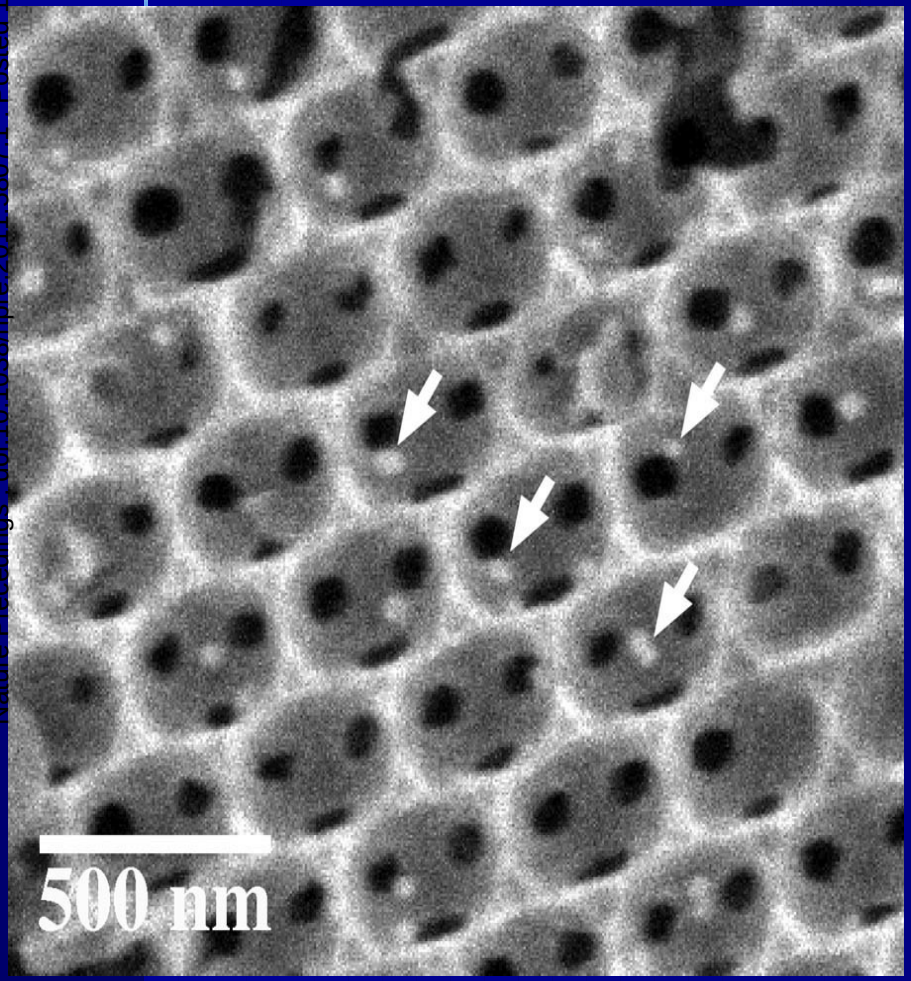
Structure of

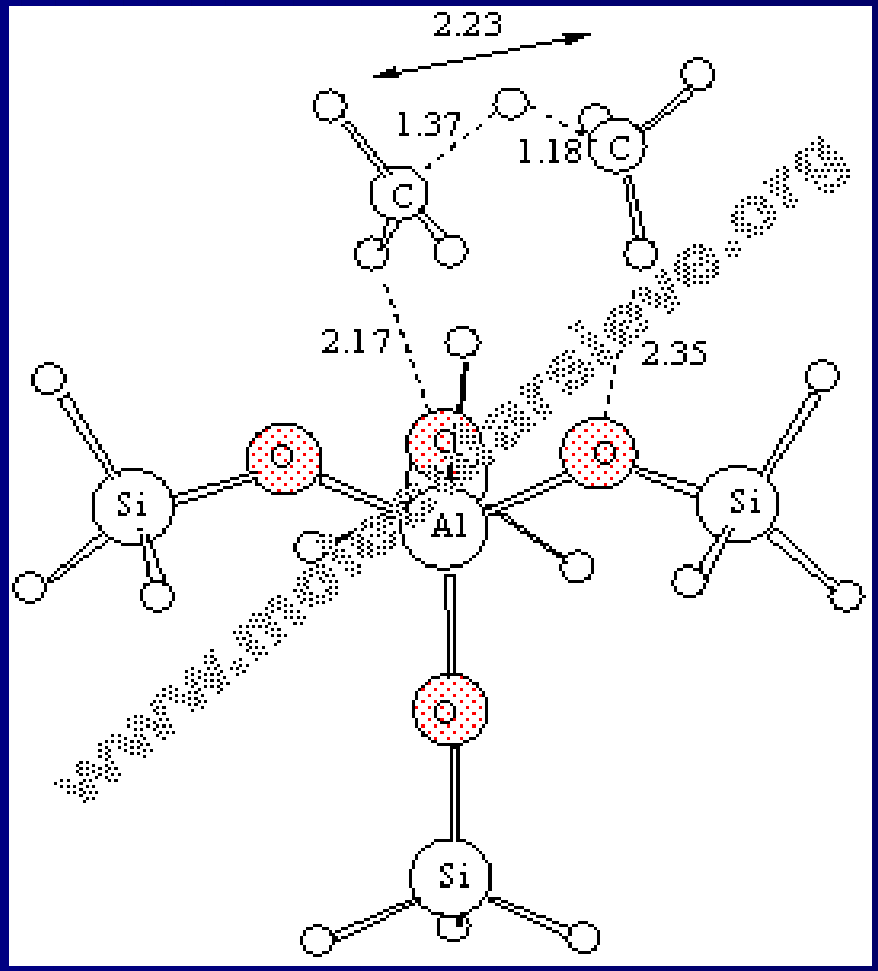


Tectosilicates: Zeolite

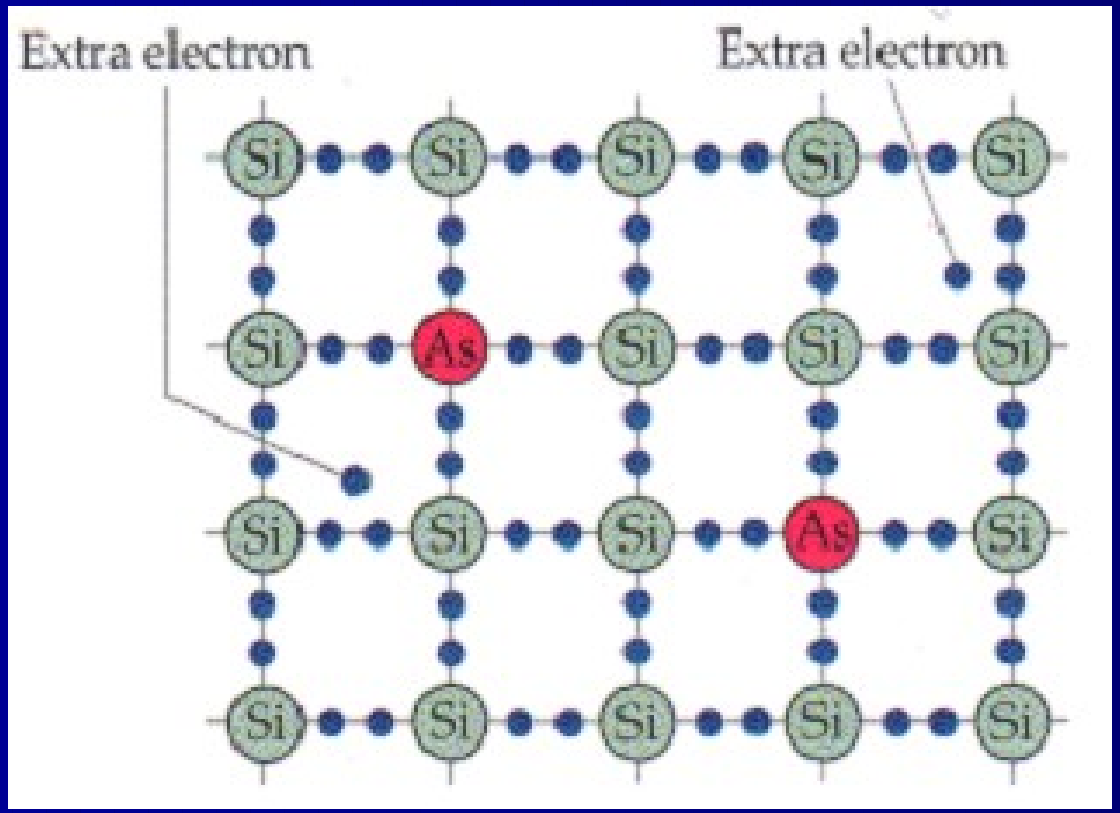


TEM of a zeolite





Birth of semicondctivity



Promises of nanotechnology

- greatest technological breakthrough in history, doing for our control of matter what computers did for our control of information.
- Though limits to growth will remain, we will be able to harvest solar power a trillion times greater than all the power now put to human use.

Defining nanotechnology

- is a new interdisciplinary venture-field that converge science, engineering, and agriculture and food systems into one –

  Dr. APJ Abdul-Kalam

- understanding and control of matter at dimensions of roughly 1-100 nm, where unique physical properties make novel applications possible (EPA, 2007).

What will nano materials do to the environment?

- Our expanding ability to synthesize nanoparticles for use in electronics, biomedical, ceramics, pharmaceutical, cosmetic, energy, environmental, catalytic, material etc. has alarmed concern for these particles role

Year	Amount of Engineered material used
2004	2000 tons
2011-2020	58000 tons (expected)

Zeophonics

- System founded on the concept of interconnected nature of all life-forms and life-support-forms
- Relies on recycling and operation of system-components
- The system provides a framework where impetus and response are almost equal.

- This is the only means of survival in the extraterrestrial planets, space stations, and in the Antarctica

Nanotechnology in agriculture is
like a game of Quiddich that
Harry Potter and other pupils played
in the School of Magic.
No matter what's the score, if
the seeker catches snitch,
his team wins.