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SYNTHESIS OF NANOPARTICLES

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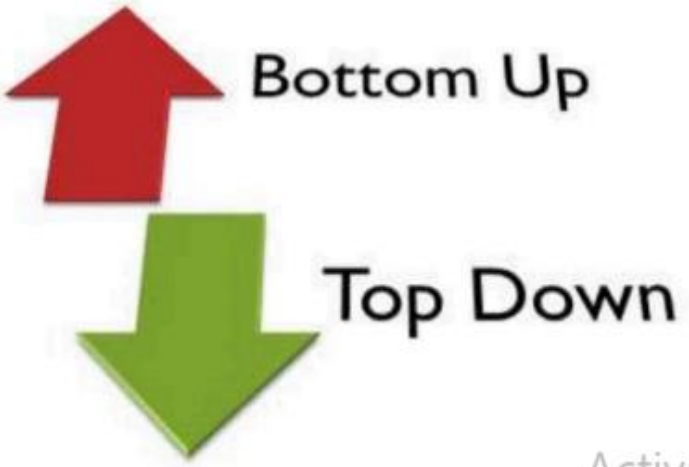
Sarah Raheem

SYNTHESIS OF NANOMATERIALS

* 2 approaches
  - bottom up approach
  - top down approach



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BOTTOM UP APPROACH

* These seek to arrange smaller components into more complex assemblies
* Use chemical or physical forces operating at the nanoscale to assemble basic units into larger structures
* examples :

1. Indiun gallium arsenide(InGaAs) quantum dots can be formed by growing thin layers of InGaAs on GaAs
2. Formation of carbon nanotubes

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TOP DOWN APPROACH

* These seek to create smaller devices by using larger ones to direct their assembly
* The most common top-down approach to fabrication involves lithographic patterning techniques using short wavelength optical sources

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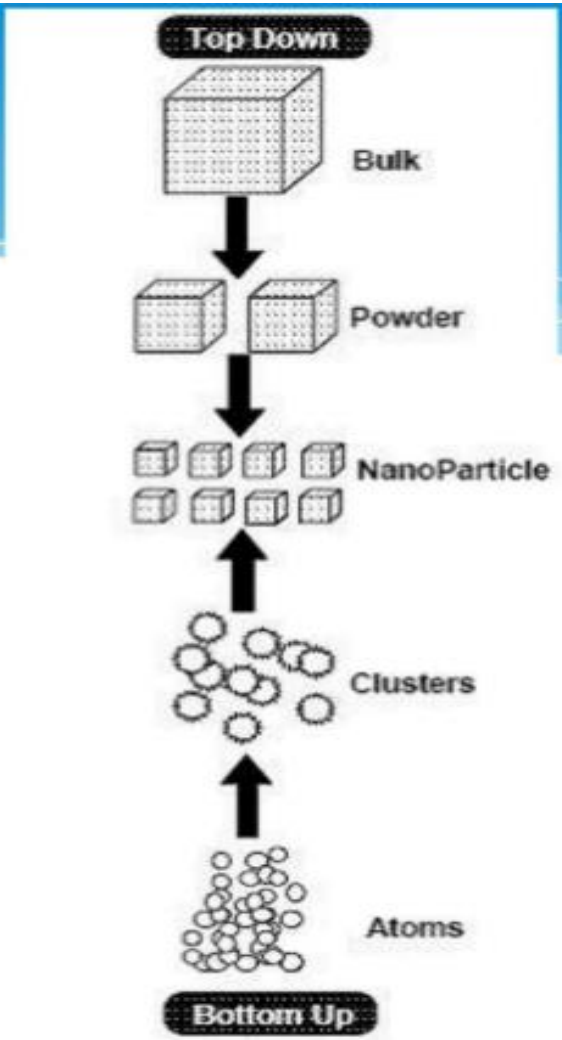

Top Down
Bulk
Powder
NanoParticle
Clusters
Atoms
Bottom Up

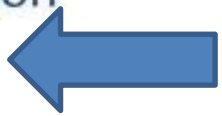
METHODS

3 methods of synthesis

- Physical
- Chemical
- Biological

PHYSICAL METHODS OF SYNTHESIS

* 2 methods
- Mechanical
1. High energy ball milling
2. Melt mixing
- Vapour
1. Physical vapour deposition
2. Laser ablation
3. Sputter deposition
4. Electric arc deposition
5. Ion implantation



غير مطلوب

HIGH ENERGY BALL MILLING

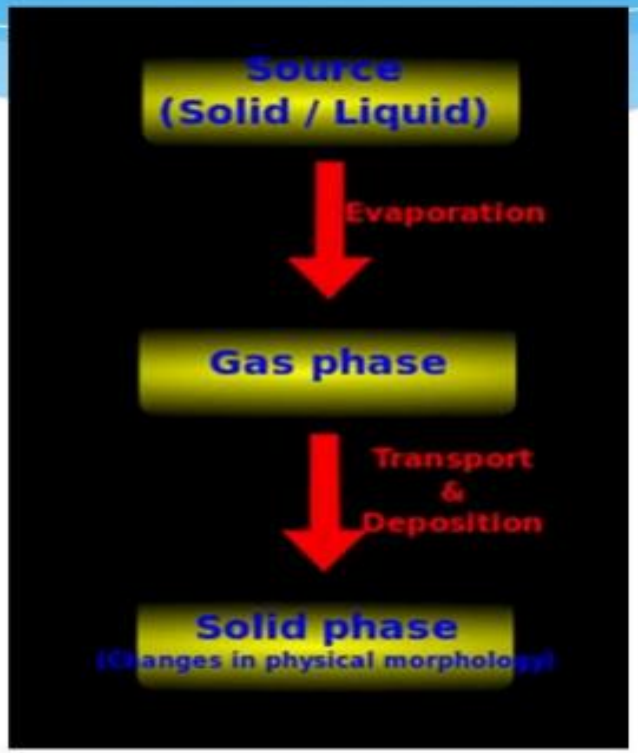
* Simplest method of making nanoparticle in the form of powder
* Various types of mills
  - Planetary
  - Vibratory
  - Rod
  - Tumbler

Evaporation based method physical vapour deposition

EVAPORATION BASED METHOD PHYSICAL VAPOUR DEPOSITION

* Material of interest as source of evaporation
* An inert or reactive gas
* A cold finger(water or liquid N_2 cooled)
* Scraper

All processes are carried out in a vacuum chamber so that the desired purity of end product can be obtained



CHEMICAL METHODS OF SYNTHESIS

COLLOIDS AND COLLOIDS IN SOLUTION

* Nanoparticles synthesized by chemical methods form "colloids"
* Two or more phases (solid, liquid or gas) of same or different materials co-exist with the dimensions of at least one of the phases less than a micrometre
* May be particles, plates or fibres
* Nanomaterials are a subclass of colloids, in which the dimensions of colloids is in the nanometre range

Colloids

Colloid-- A mixture of two phases of matter

emulsions	*aerosols*
smoke	*fog*
foams	*gels*
milk	*clouds*

Gel & Foam

Clouds

Milk

ADVANTAGES

* Simple techniques
* Inexpensive instrumentation
* Low temperature (<350°C) synthesis
* Doping of foreign atoms (ions) is possible during synthesis
* Large quantities of material can be obtained
* Variety of sizes and shapes are possible
* Self assembly or patterning is possible

SYNTHESIS OF METAL NANOPARTICLES BY COLLOIDAL ROUTE

* Reduction of some metal salt or acid
* Highly stable gold particles can be obtained by reducing chloroauric acid ($HAuCl_4$)with tri sodium citrate($Na_3C_6H_5O_7$)

$$HAuCl_4 + Na_3C_6H_5O_7 \longrightarrow Au^{+} + C_6H_5O_7^{-} + HCl + 3\ NaCl$$

* Metal gold nanoparticles exhibit intense red, magenta etc., colours depending upon the particle size

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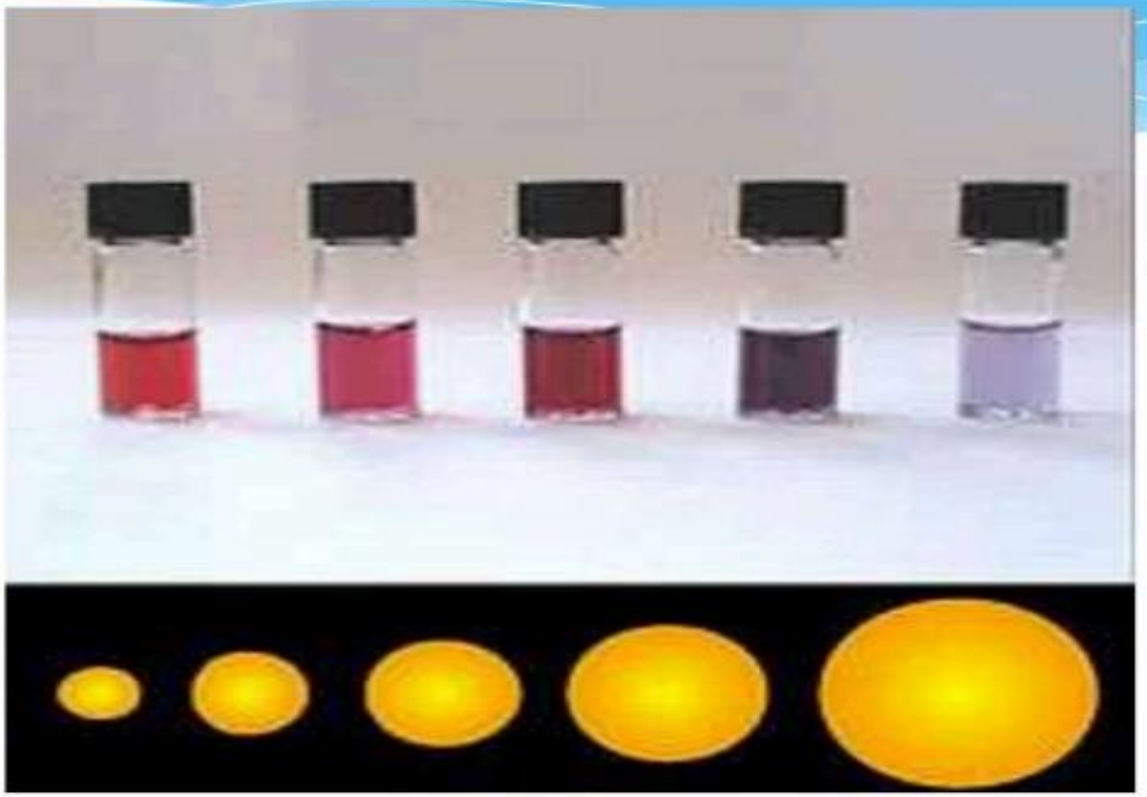

BIOLOGICAL METHODS

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* *Green synthesis*
* 3 types:

1. Use of microorganisms like fungi, yeats(eukaryotes) or bacteria, actinomycetes(prokaryotes)
2. Use of plant extracts or enzymes
3. Use of templates like DNA, membranes, viruses and diatoms

SYNTHESIS USING MICROORGANISMS

* Microorganisms are capable of interacting with metals coming in contact with hem through their cells and form nanoparticles.
* The cell- metal interactions are quite complex
* Certain microorganisms are capable of separating metal ions.

SYNTHESIS USING PLANT EXTRACTS

* Leaves of geranium plant (*Pelargonium graveolens*) have been used to synthesize gold nanoparticles
* Plant associated fungus- produce compounds such as taxol and gibberellins
* Exchange of intergenic genetics between fungus and plant.
* Nanoparticles produced by fungus and leaves have different shapes and sizes.

finely crushed leaves
(Erlenmeyer flask)

↓

boiled in water (1 min)

↓

cooled and decanted

↓

added to $HAuCl_4$ aq. Solution

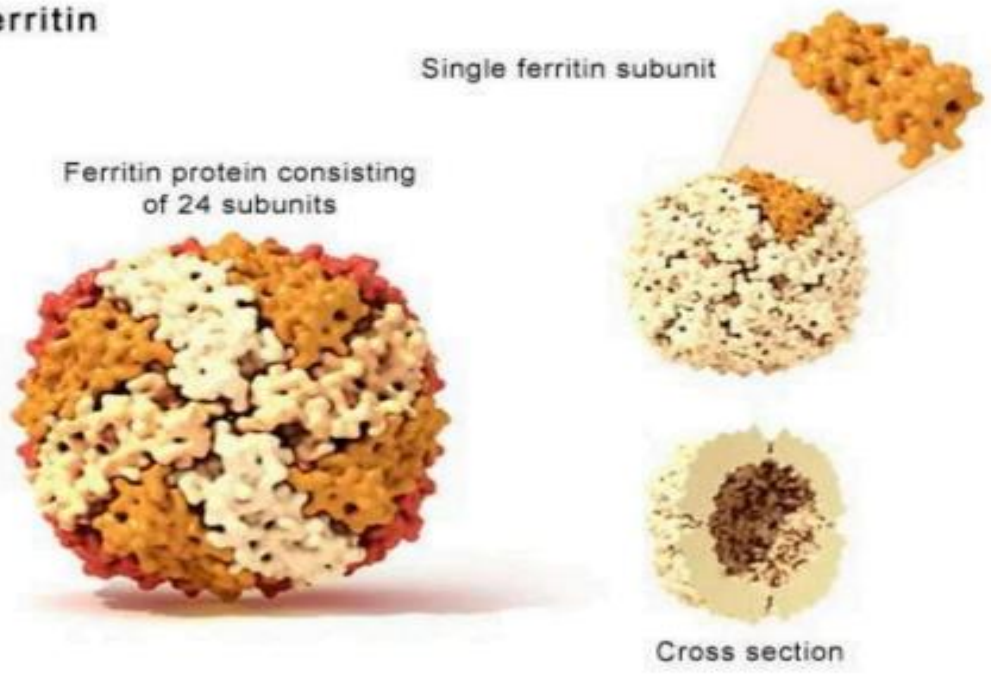
↓

gold nanoparticles within a minute

FERRITIN

* Ferritin is a colloidal protein of nanosize.
* Stored iron in metabolic process and is abundant in animals.
* Capable of forming 3 dimensional hierarchical structure.
* 24 peptide subunits – arranged in such a way that they create a central cavity of ~6 nm.
* Diameter of polypeptide shell is 12 nm.
* Ferritin can accommodate 4500 Fe atoms.

Ferritin



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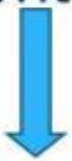
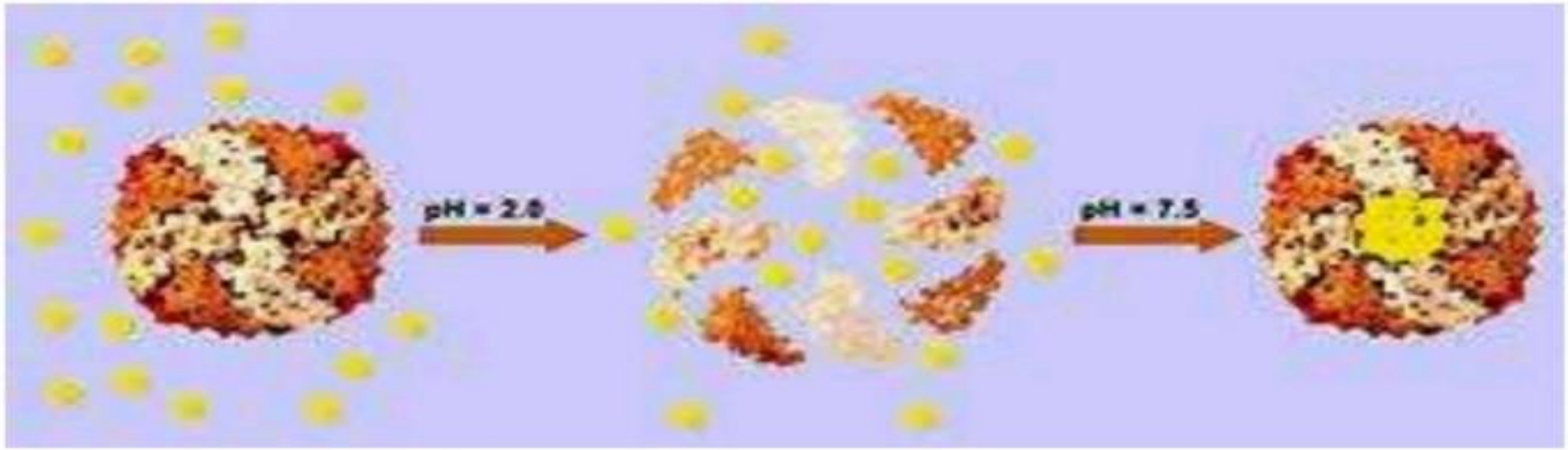
* Ferritin without inorganic matter in its cavity is called apoferritin and can be used to entrap desired nanomaterial inside the protein cage.

Remove iron from ferritin to form apoferritin



Introduce metal ions to form metal nanoparticles inside the cavity


pH = 2.8
pH = 7.5