جامعة بيرزيت
BIRZEIT UNIVERSITY

# Materials for Design

DSGN3240

Lecture 2

## HISTORICAL OVERVIEW

## MATERIALS CLASSIFICATIONS

Christine Hadid

Fall 2022

# The objective of Materials Science Study

Design issues are always related to material selection.
Understanding the behavior of materials, particularly structure-property correlation, will help selecting suitable materials for a particular application.

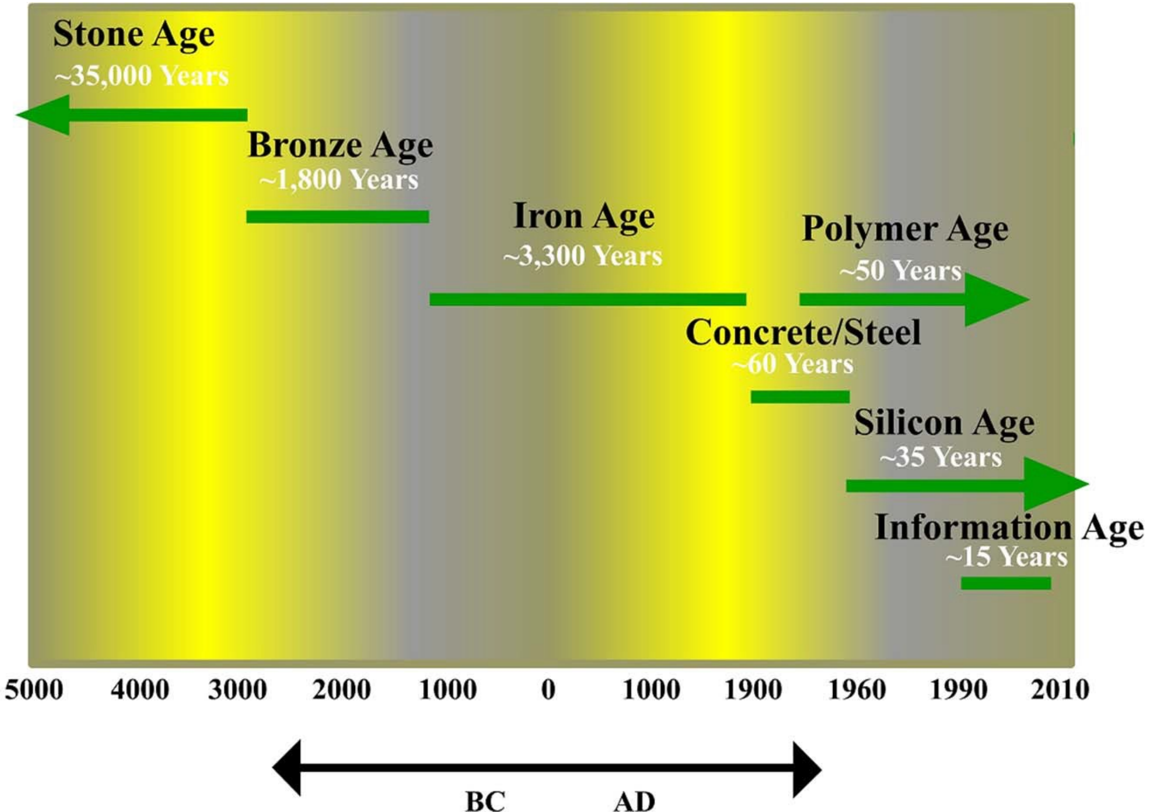
The objective of studying materials science is to develop this understanding .

# Historical Overview

- The discovery, extraction, manufacturing, installation, maintenance, and reuse of materials are important to understand within a chronological and geographical context.
- Reflecting upon the history of various material processes can inspire designers to consider materials in innovative ways or to create new ones.
- Knowing when and where a specific material or fabrication technology was first used can foster connections among materials, fabrication, users, and place.
- This can provide a better understanding of social and cultural connotations inherent in the use of specific materials.

## Materials: The Milestones of Progress

- Development and advancement of Human societies- closely related with materials
- Civilizations have been named based on the level of their materials development – Stone age, Bronze age etc.

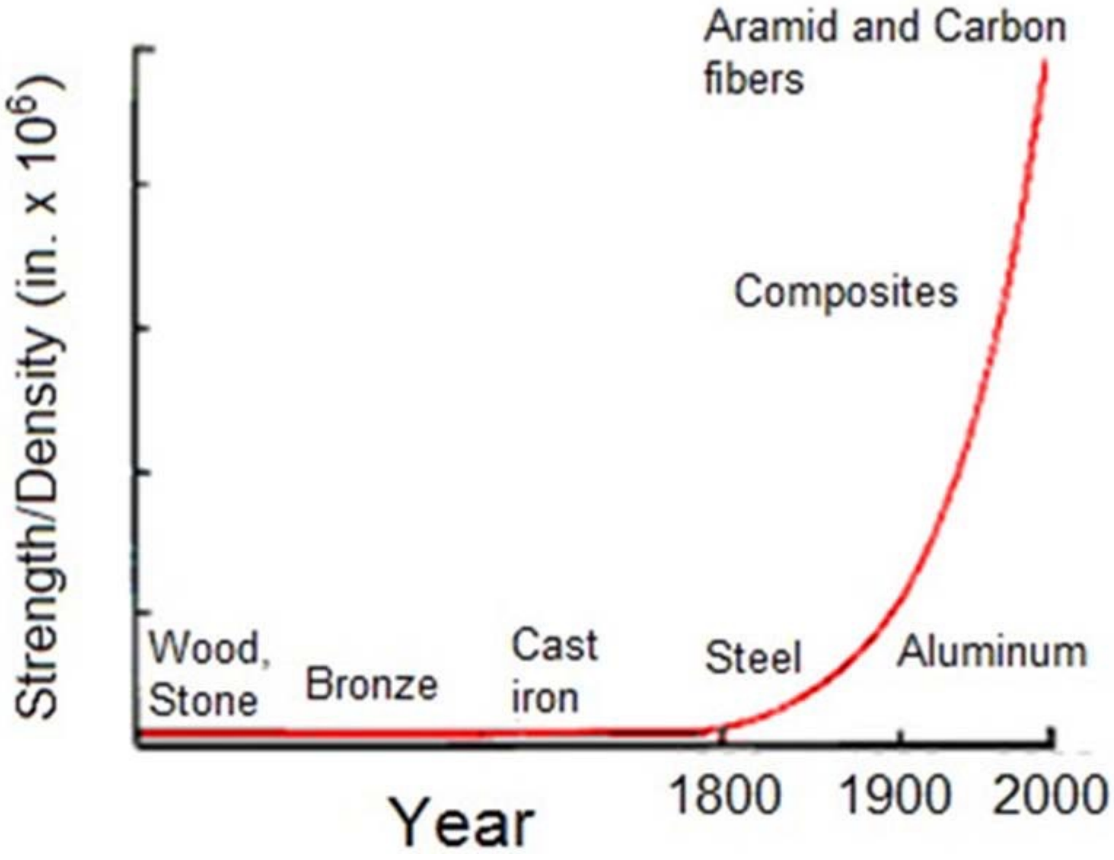


# Quest for newer materials:

## The driving force for the progress- stone age to IT age

Quest for more advanced materials to meet the growing needs as the civilization progressed.

A look at the history of materials chronologically clearly reveals this



# Stone age

300,000 BC

Stone age – People living in caves and hunting with stone-made weapons

200,000 BC

Discovery of fire – Said to be the most significant discovery in human civilization. However, till the time the fire was controlled to contain and utilize the heat, it was not significant.

Containing the fire – Was not possible without materials. Started with clay (a ceramic material) pots and now we have all kinds of means to control and contain fire.

# Introduction of metals

5500 BC First metals to be discovered – Copper and Gold

5000 BC Material processing - Annealing and Shaping.
Throwing copper into camp fire and hammering in early days

4000 BC Melting and casting of metals. Melting of Gold to give it different shapes

3500 BC Reduction of copper from its ore – Nile Valley
The dawn of metallurgy.
Perhaps discovered by chance much before by early potters

# Discovery of Alloy - Metal Combinations

**3000 BC** The discovery of alloy – combination of metals

Mixing of Tin with Copper – Bronze
Copper ore invariably contains some Tin – Mixing of different ores having different Tin content produced the first Bronzes.

# Iron and Steel – Building blocks of human civilization

**1450 BC** Iron wheels – discovery of iron making. Revolution in warfare and cultivation

**1500 AD** Invention of Blast furnace – Production of pig iron from ores

**1855 AD** Sir Henry Bessemer (1813-1898)
Bessemer steel making patent

**20th Century** Many other steel making processes – LD, Electric Arc, VAR for making high quality steels

# Early 20th Century – The golden era

1886 AD

Hall process- Electrochemical process for extraction of Aluminium from Alumina ($Al_2O_3$)

1890 - 1910 AD

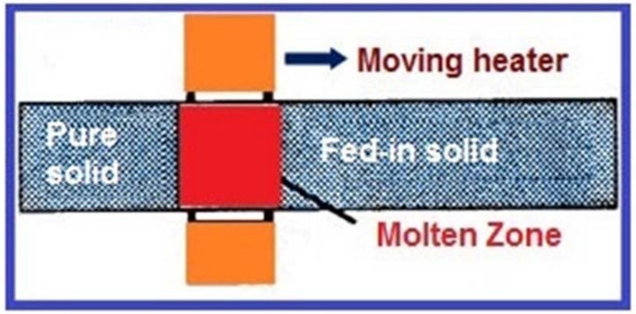
Revolution in Transportation – Discovery of automobiles and Aero plane

1939

Process for making Nylon – Introduction of plastics

# The Electronic revolution

1940's

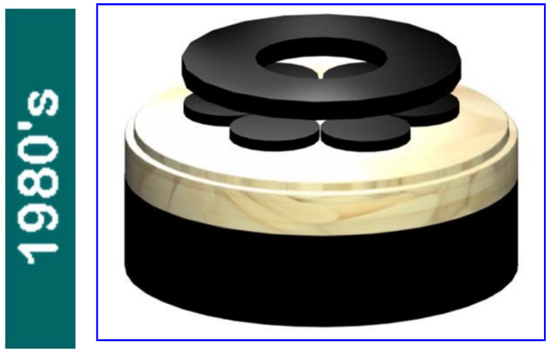



Zone refining – A metallurgical process to produce ultra pure Silicone

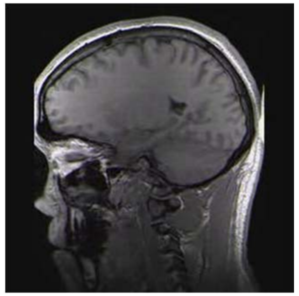
1960's

Ultra pure Silicone through zone refining – Si chip, the heart of electronics. Smaller and smaller Si wafers - Miniaturization

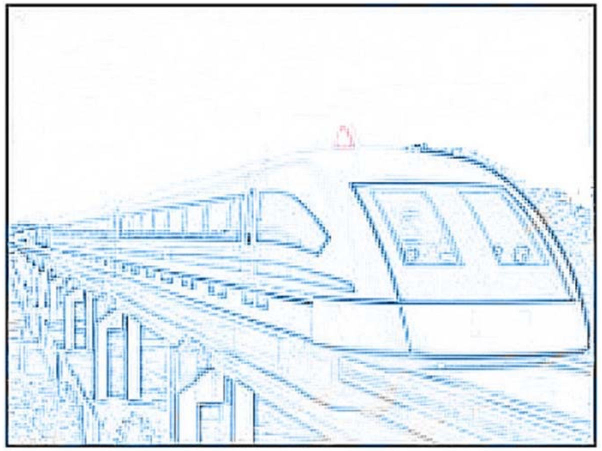
# Superconductors




High temperature ceramic superconductors



MRI Machine, Brain Scan – Advancement in Medical science



Magnetic Levitation: Maglev train :– 300 – 500 kmph

# Classification of Materials

- It is the systematic arrangement or division of materials into groups on the basis of some common characteristics.

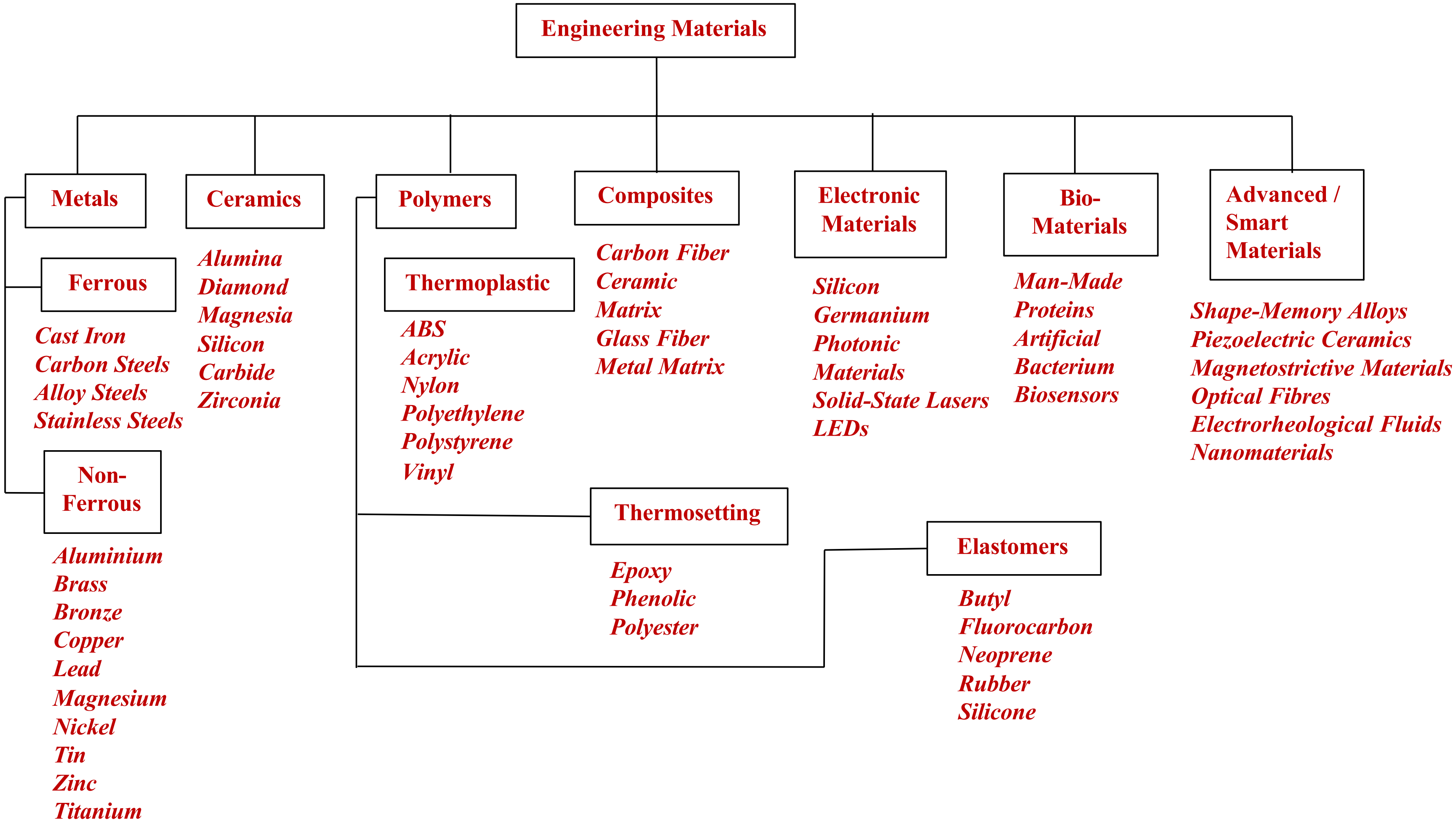
*1.According to General Properties*

*2.According to Nature of Materials*

*3.According to Applications*

# Classification of Engineering Materials

## According to Nature of Materials



# Classification of Materials

## METALS

Metallic materials are normally combinations of metallic elements (such as iron, aluminium, copper, titanium, gold, and nickel), and often also non- metallic elements (for example, carbon, nitrogen, and oxygen) in relatively small amounts. They have large numbers of nonlocalized electrons; that is, these electrons are not bound to particular atoms. Atoms in metals and their alloys are arranged in a very orderly manner.

Many properties of metals are directly attributable to these electrons.

- Good conductors of electricity and heat
- Opaque.
- Polished metal surface has a lustrous appearance.
- Metals are quite strong, yet deformable.

## Ceramics

Ceramics are compounds between metallic and nonmetallic elements; they are most frequently oxides, nitrides, and carbides.
Examples: aluminum oxide (or alumina, $Al_2O_3$), silicon dioxide (or silica, $SiO_2$), silicon carbide (SiC), silicon nitride ($Si_3N_4$), clay minerals (i.e., porcelain), cement, and glass.

- Insulator to electricity and heat
- More resistant to high temperatures and harsh environments than metals and polymers.
- Hard but very brittle.
- Optical characteristics – can be transparent, translucent, or opaque

# POLYMERS

Polymers include the familiar plastic and rubber materials. Many of them are organic compounds that are chemically based on carbon, hydrogen, and other nonmetallic elements (O, N, and Si). Inorganic polymers also exist such as silicon rubber.; furthermore, they have very large molecular structures.

- Have low densities and may be extremely flexible.
- Thermal & electrical insulators
- Optically translucent or transparent

# COMPOSITES

A composite consist of two (or more) individual materials formed from
metals, ceramics, and/or polymers.
A number of composite materials have been engineered that consist of more than one material type.
A composite is designed to display a combination strength and flexibility.
The design goal of a composite is to achieve a combination of properties that is not displayed by any single material, and also to incorporate the best characteristics of each of the component materials.
Fiberglass is a familiar example, in which glass fibers are embedded within a polymeric material.

- stiff, strong (from the glass) flexible, and ductile (from polymer)

# Advanced Materials

Materials that are utilized in high-technology:

**Typically traditional materials whose properties have been enhanced, newly developed, high-performance materials**.

Include all material types (e.g., metals, ceramics, polymers).

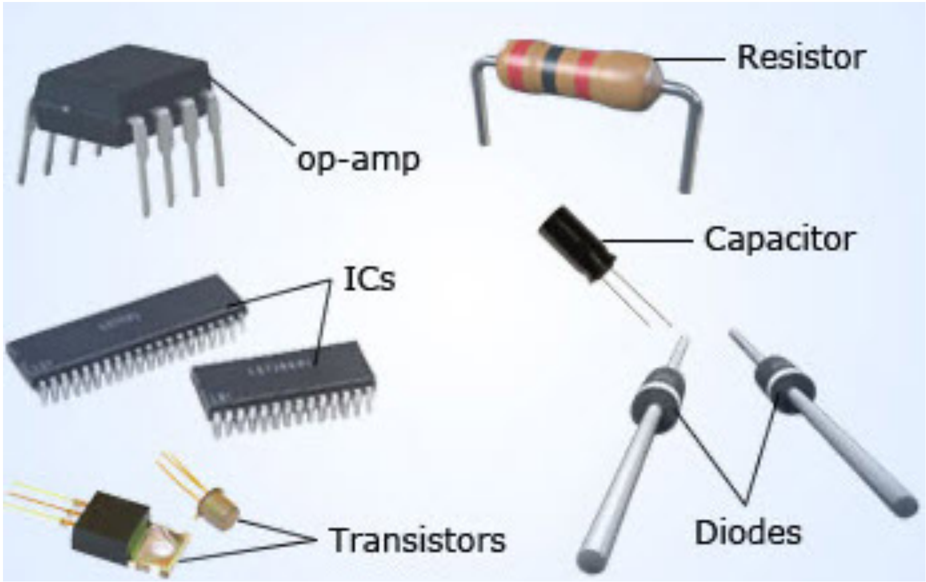
Generally expensive.

Examples include: materials that are used for lasers, integrated circuits, magnetic information storage, fibre optics, etc.

## SEMICONDUCTORS

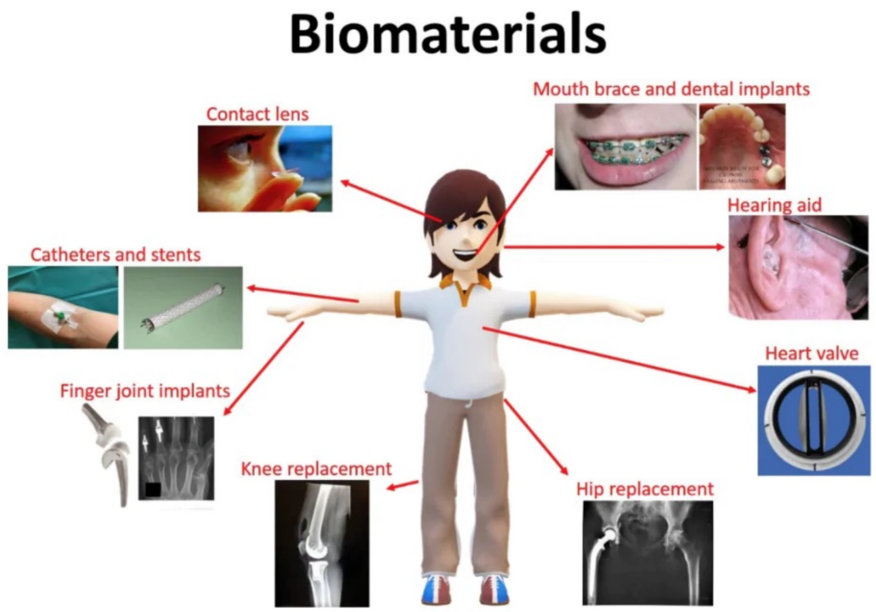
Semiconductors have electrical properties that are intermediate between the electrical conductors (metals and metal alloys) and insulators (ceramics and polymers).
The electrical characteristics of these materials are extremely sensitive to the presence of minute concentrations of impurity atoms and temperature.

**Examples: gallium arsenide, germanium.**




## BIOMATERIALS

Employed as components implanted into the human body for replacement of diseased or damaged body parts.
Biocompatible - must not cause adverse biological reactions. Can be metals, ceramics, polymers, composites, or semiconductors.

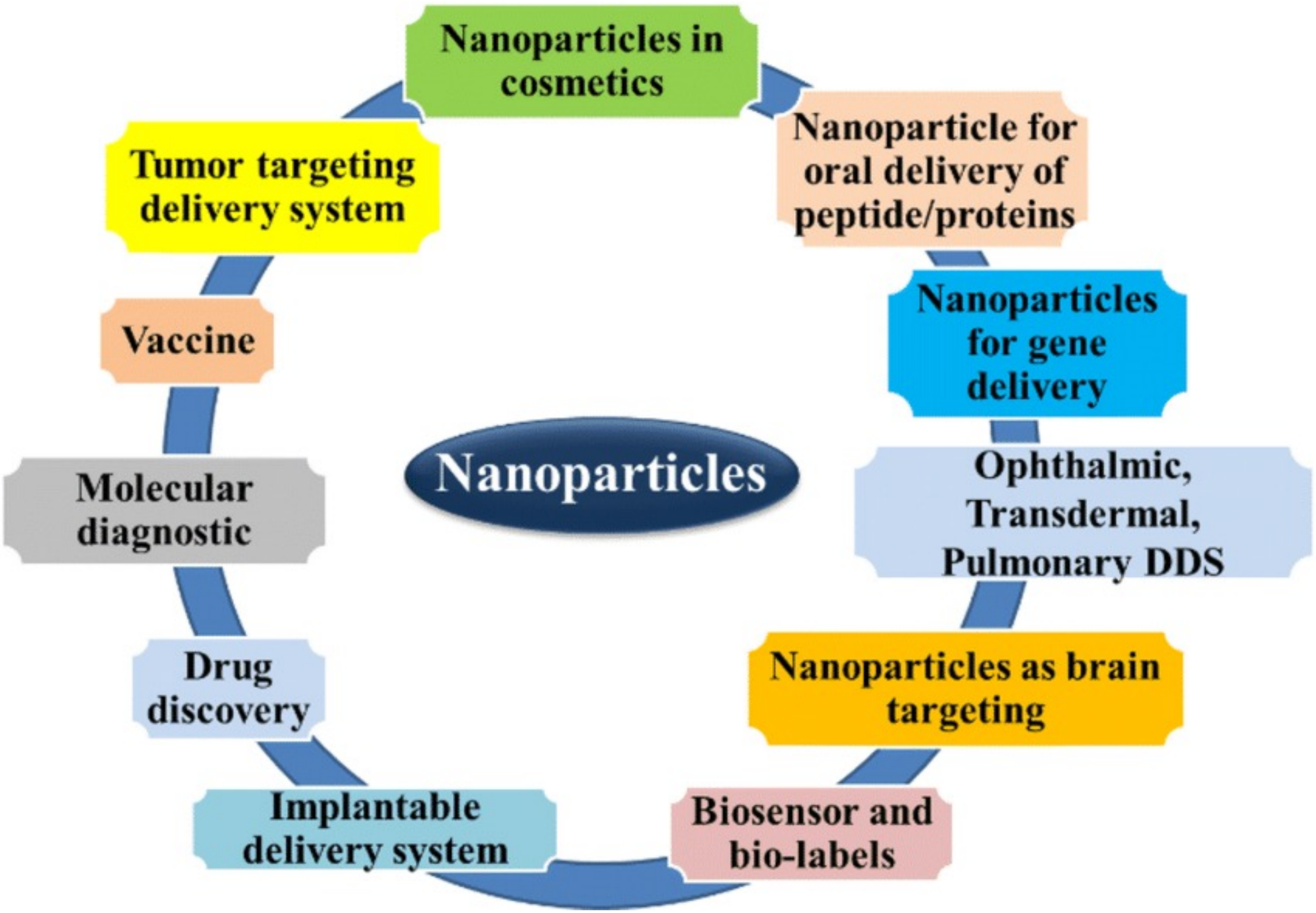


## Nano-engineered materials:

Nanomaterials typically have sizes of below 100 nm
(1 nm = 10-9m).

At these dimensions materials can acquire novel properties (i.e. optical, mechanical, thermal).

**Example: Bulk silver and silver nanoparticles.**



# SMART MATERIALS

also called intelligent or responsive materials, are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, moisture, electric or magnetic fields,
light, temperature, pH, or chemical compounds.
Smart materials are the basis of many applications, including sensors and actuators, or artificial muscles.
Smart materials technology enables us to adapt to environmental changes by activating its functions. Multifunctional materials, sort of smart materials, can be activated by electrical stimuli so as to produce its geometry change or property change. There are many multifunctional materials available by the advent of nanotechnology.