

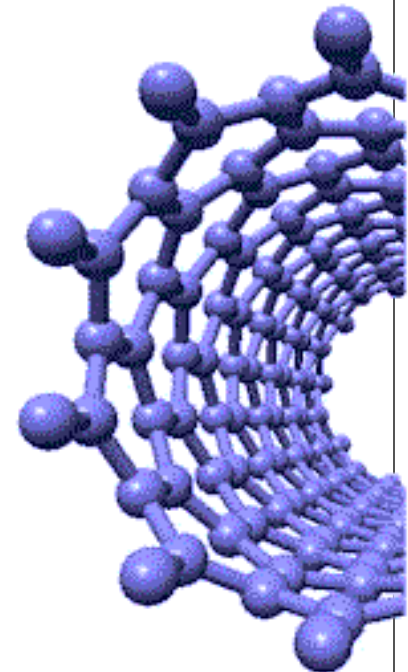


INVESTMENTS IN EDUCATION DEVELOPMENT

# Innovation and Development of Study Field Nanomaterials at the Technical University of Liberec

[nano.tul.cz](http://nano.tul.cz)

These materials have been developed within the ESF project: Innovation and development of study field Nanomaterials at the Technical University of Liberec



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**Technical University of Liberec**

# Definitions

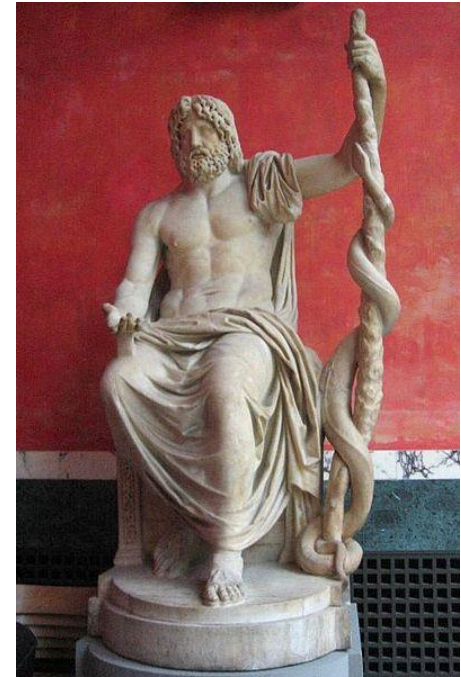
# Outlook

Since this course is entirely related to nanotechnology and medicine it is essential to provide any definitions and terms that will appear throughout its duration.



# Medicine

According to World Health Organization (WHO) traditional medicine is the sum total of the knowledge, skills, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness.



- *Statue of Asclepius, the Greek god of medicine, holding the symbolic Rod of Asclepius with its coiled serpent*

# Nanotechnology

**Nanotechnology** is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.

Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of light spectrum, and greater chemical reactivity than their larger-scale counterparts.



● *Physicist Richard Feynman, the father of nanotechnology.*

# Nanomaterial

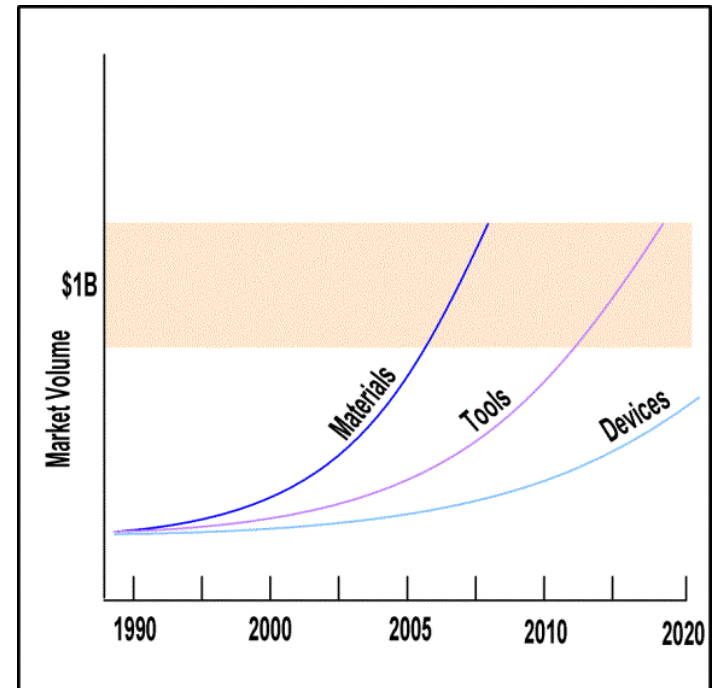
On 18 October 2011 the European Commission adopted the Recommendation on the definition of a nanomaterial. According to this Recommendation a "**Nanomaterial**" means:

*A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm.*

# Nanomaterial

In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50 % may be replaced by a threshold between 1 - 50 %.

By derogation from the above, fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials.



● *Projected nanotechnology growth*

# Molecule and biomolecule

A **molecule** is a group of two or more atoms linked together by sharing electrons in a chemical bond. Molecules are the fundamental components of chemical compounds and are the smallest part of a compound that can participate in a chemical reaction.

A **biomolecule** is any molecule that is produced by a living organism, including large macromolecules such as proteins, polysaccharides, lipids, and nucleic acids, as well as small molecules such as primary metabolites, secondary metabolites, and natural products.



# Biocompatibility

**Biocompatibility** is the ability of a material to perform its desired function with respect to a medical therapy, without eliciting any undesirable local or systemic effects in the recipient or beneficiary of that therapy, but generating the most appropriate beneficial cellular or tissue response in that specific situation, and optimizing the clinically relevant performance of that therapy.

# Biocompatible material features

- Absence of carcinogenicity  
(the ability or tendency to produce cancer),
- Absence of immunogenicity  
(absence of a recognition of an external factor leading to rejection),
- Absence of teratogenicity  
(ability to cause birth defects),
- Absence of toxicity.

# Biomaterial

A ***biomaterial*** is any substance, other than a drug or a combination of synthetic and natural substances that can be used at any time, and which role is to supplement or replace an organ, or part of it or to take temporary or permanent its functions.

# Biomaterial

Biomaterials can be derived either from nature or synthesized in the laboratory using a variety of chemical approaches utilizing metallic components, polymers, ceramics or composite materials.

Biomaterials:

- Must be biocompatible,
- May be neutral for the living tissues,
- May be bioactive,
- May be biodegradable,
- Must have adequate properties (suitable for the particular application).

# Biomedical engineering

***Biomedical engineering*** is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice.

# Biomedical engineering - aims

- The acquisition of new knowledge and understanding of living systems through the innovative and substantive application of experimental and analytical techniques based on the engineering sciences.
- The development of new devices, algorithms, processes and systems that advance biology and medicine and improve medical practice and health care delivery.

# Prosthesis

**Prosthesis** in medicine is an artificial supplement the missing body part or organ. The field of science that is concerned with issues related to the implementation and use of a prosthesis is prosthetics. It is the principal department of orthopaedics, but also include areas such as dentistry and biomechatronics. Prosthesis replace organs affected by congenital disabilities and those completely lost, eg. as a result of accidents or illnesses.



● *Cosmetic prosthesis*



● *Knee prosthesis*



● *Microprocessor controlled knees*

# Implantable medical device (implant)

An ***implantable medical device*** is a medical device that:

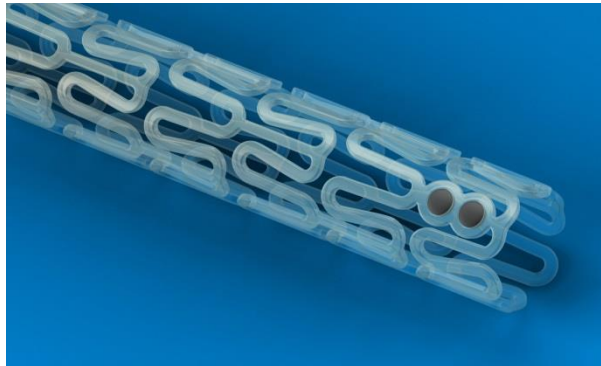
- is partly or totally inserted into the human body or a natural orifice and is expected to stay there for 30 days or more,
- is used to replace an epithelial surface or the surface of the eye and is expected to stay in use for 30 days or more.

Surgical or medical procedures are used to insert or apply implantable medical devices and surgical or medical procedures must be used to remove them.



# Biodegradable implant

- Once implanted, should maintain its mechanical properties until it is no longer needed and then be absorbed and excreted by the body, leaving no trace.
- Biodegradable implants are designed to overcome the disadvantages of permanent metal-based device.



● *Bioresorbable vascular scaffold*

# Biodegradable implant - advantages

Advantages of biodegradable implants:

- More physiological repair,
- Possibility of tissue growth,
- Less invasive repair,
- Temporary support during tissue recovery,
- Gradual dissolution or absorption by the body afterwards.

# Osseointegration

**Osseointegration** is defined as the formation of a direct interface between an implant and bone, without intervening soft tissue.

**Osseointegrated implant** is a type of implant defined as an endosteal implant containing pores into which osteoblasts and supporting connective tissue can migrate.

Applied to oral implantology, this thus refers to bone grown right up to the implant surface without interposed soft tissue layer. No scar tissue, cartilage or ligament fibres are present between the bone and implant surface. The direct contact of bone and implant surface can be verified microscopically.

# Bacteriostatic and Bactericidal

A ***bacteriostatic agent*** or ***bacteriostat*** is a biological or chemical agent that stops bacteria from reproducing, while not necessarily harming them otherwise. Upon removal of the bacteriostat, the bacteria usually start to grow again.

A ***bactericidal agent*** is a substance that kills bacteria.

# Cytotoxicity

***Cytotoxicity*** is the quality of being toxic to cells.

Treating cells with the cytotoxic compound can result in a variety of cell fates. The cells may undergo necrosis, in which they lose membrane integrity and die rapidly as a result of cell lysis. The cells can stop actively growing and dividing (a decrease in cell viability), or the cells can activate a genetic program of controlled cell death (apoptosis).

# Carcinogen

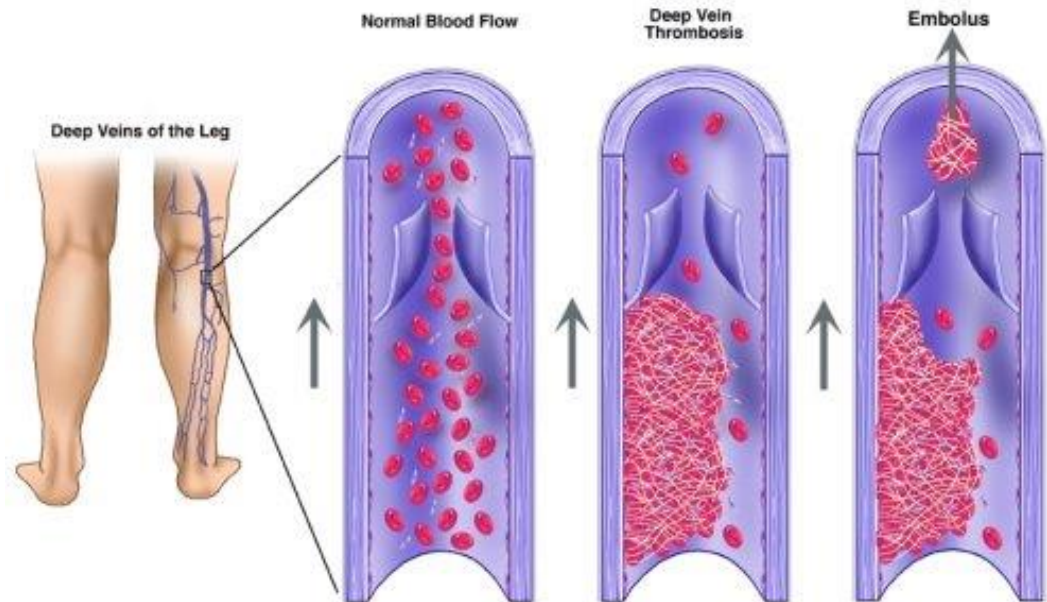
A **carcinogen** is any substance, radionuclide, or radiation that is an agent directly involved in causing cancer. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes.

- **Epigenetic carcinogen** one that does not itself damage DNA but causes alterations that predispose to cancer.
- **Genotoxic carcinogen** one that reacts directly with DNA or with macromolecules that then react with DNA.

# Thrombosis

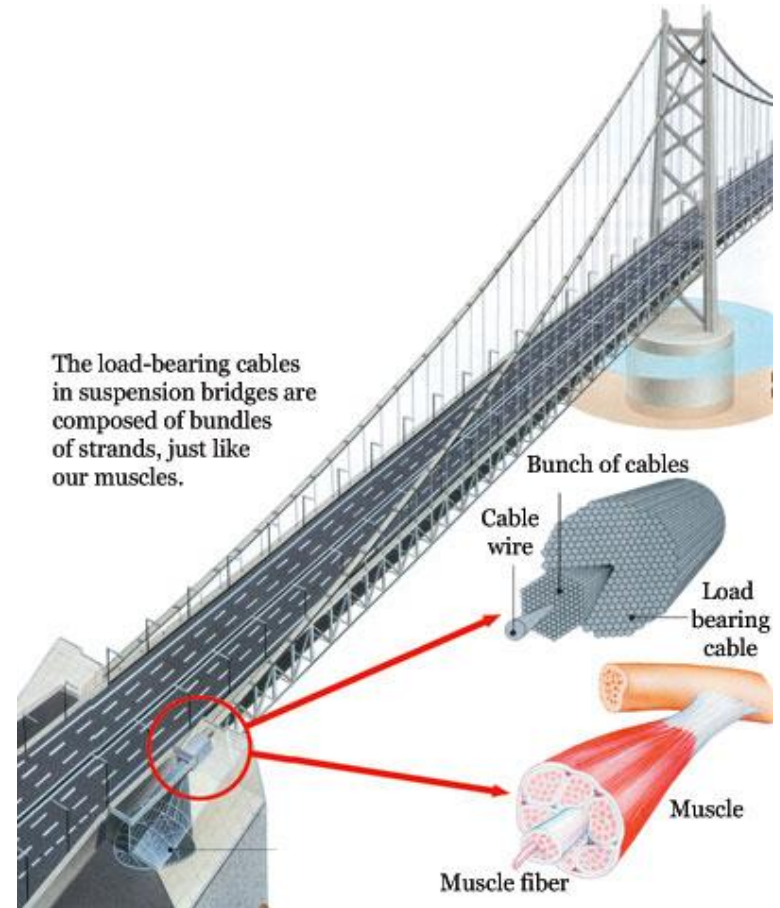
**Thrombosis** is the formation of a blood clot (**thrombus**) inside a blood vessel, obstructing the flow of blood through the circulatory system. When a blood vessel is injured, the body uses platelets (**thrombocytes**) and fibrin to form a blood clot to prevent blood loss.

Even when a blood vessel is not injured, blood clots may form in the body under certain conditions. A clot that breaks free and begins to travel around the body is known as an **embolus**.



# Biomimetics

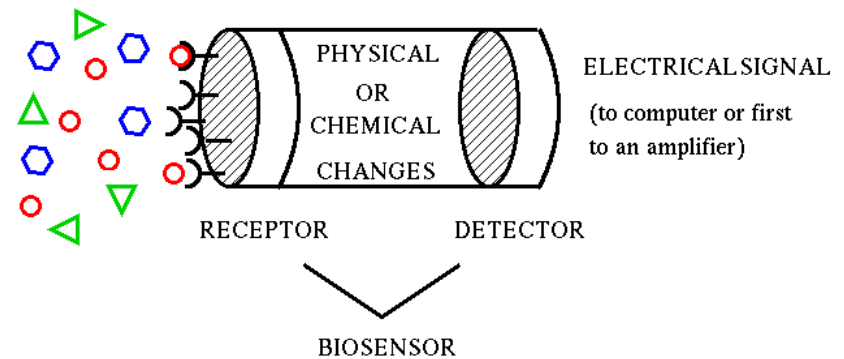
**Biomimetics** is the study of the structure and function of biological systems as models for the design and engineering of materials and machines. It is widely regarded as being synonymous with biomimicry, biomimesis, biognosis and similar to biologically inspired design.





# Biosensor

A ***biosensor*** is a self-contained integrated device, which is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element (biochemical receptor) which is retained in direct spatial contact with a transduction element.



● *Schematic of biosensor*