Ministry of Higher Education and Scientific Research AL-Mustaqbal University College of Science
Department of biochemistry

*Biochemistry*

**Lecture 3**

# Carbon Based Nanomaterials

By

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# Types of Nanomaterials

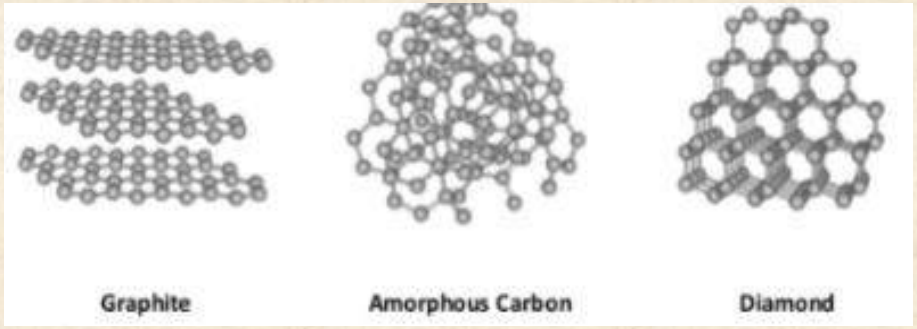
Most current nanomaterials could be organized into four types:

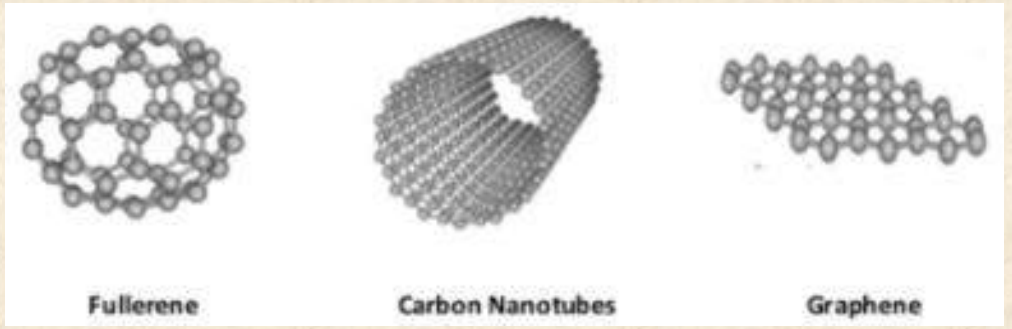
- Carbon Based Materials
- Metal Based Materials
- Dendrimers
- Composites

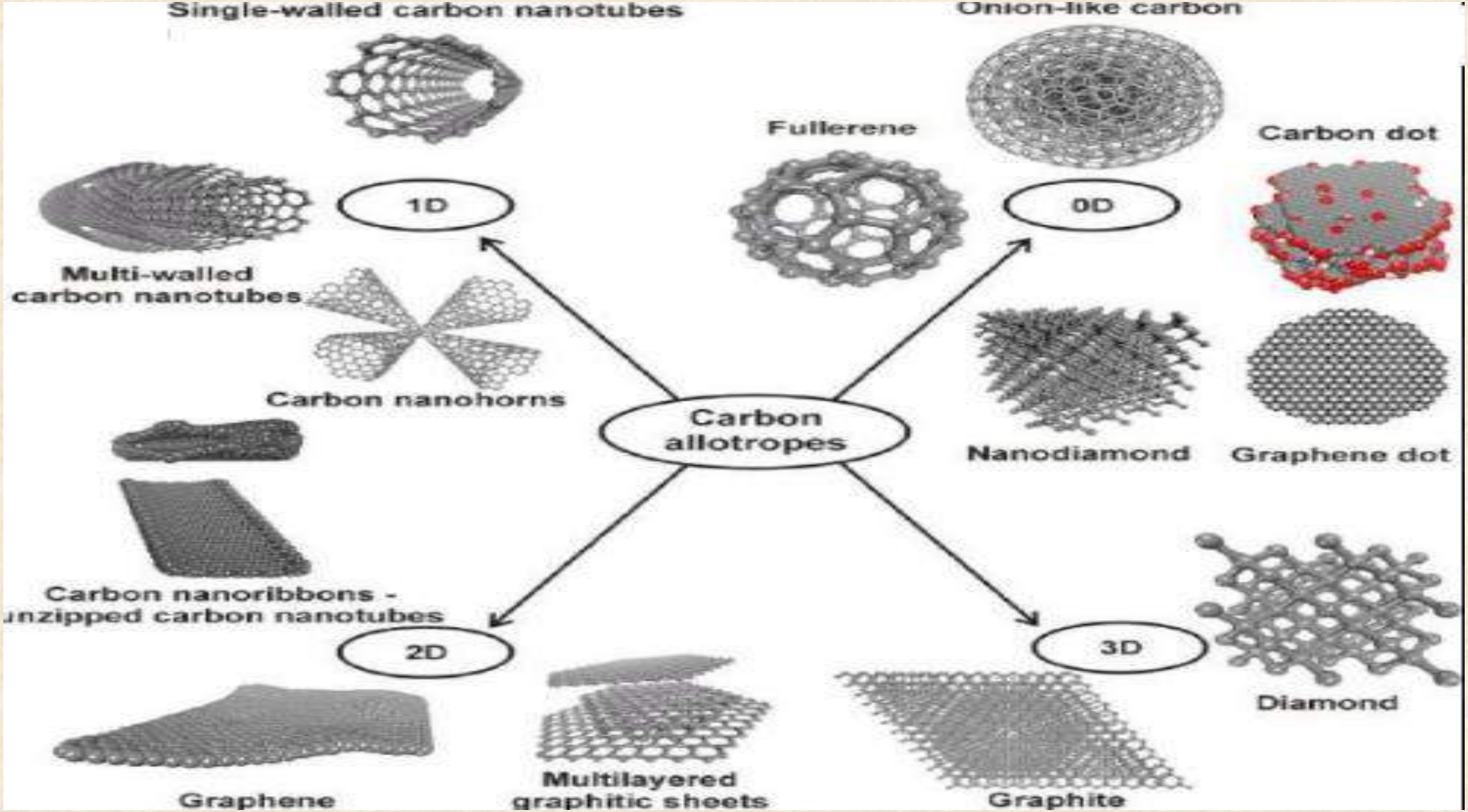
# Types of Nanomaterials

Until recently, only two natural carbon allotropes were known: **diamond** and **graphite**. All nanomaterials composed of carbon atoms are termed as carbon-based or carbon nanomaterials. The Classification of carbon-based nanomaterials is most commonly performed according to their geometrical structure. Carbon nanostructures include particles that be tube-shaped, horn-shaped, spherical or ellipsoidal.

حتى وقت قريب، لم يكن معروفًا سوى شكلين طبيعيين للكربون: الماس والجرافيت. تُسمى جميع المواد النانوية المكونة من ذرات الكربون بالمواد النانوية الكربونية. ويتم تصنيف المواد النانوية الكربونية عادةً وفقًا لبنيتها الهندسية. تشمل البنى النانوية الكربونية جسيمات أنبوبية الشكل، أو قرنية الشكل، أو كروية، أو بيضاوية الشكل.



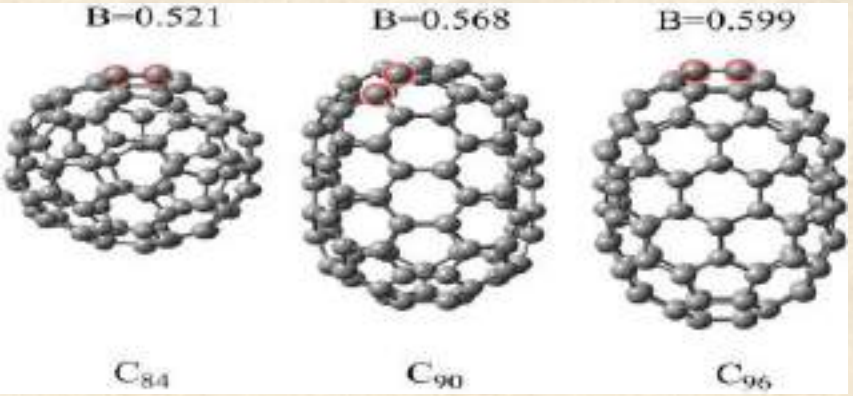




Single-walled carbon nanotubes
Onion-like carbon
Fullerene
Carbon dot
1D
0D
Multi-walled carbon nanotubes
Carbon nanohorns
Carbon allotropes
Nanodiamond
Graphene dot
Carbon nanoribbons - unzipped carbon nanotubes
2D
3D
Diamond
Graphene
Multilayered graphitic sheets
Graphite

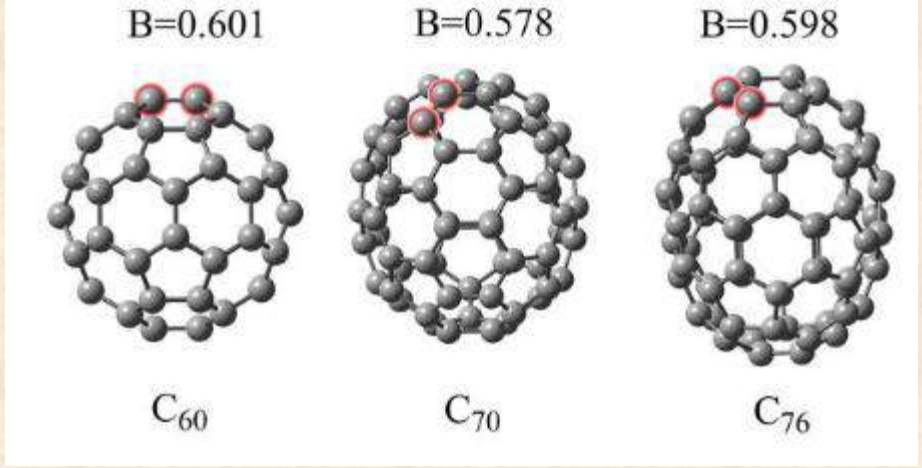
# Types of Nanomaterials

In the meantime, carbon nanomaterials have numerous technical applications including micro- and nanoelectronics, gas storage, production of conductive plastics, composites, displays, antifouling paints, textiles, batteries with improved durability, gas biosensors and others.

وفي الوقت نفسه، تتمتع المواد النانوية الكربونية بالعديد من التطبيقات التقنية بما في ذلك الإلكترونيات الدقيقة والنانوية، وتخزين الغاز، وإنتاج البلاستيك الموصل، والمواد المركبة، والشاشات، والدهانات المضادة للتلوث، والمنسوجات، والبطاريات ذات المتانة المحسنة، وأجهزة الاستشعار الحيوية للغاز وغيرها.




# Fullerenes




Fullerenes are an allotropic modification of carbon, often termed as a molecular form of carbon, or carbon molecules. The fullerene family includes a number of atomic $C_n$ clusters ($n > 20$), composed of carbon atoms on a spherical surface. Carbon atoms are usually located on the surface of the sphere at the vertices of pentagons and hexagons. In fullerenes, carbon atoms are usually present in the sp2-hybrid form and linked together by covalent bonds. Fullerene C60 is the most common and best-investigated fullerene. The spherical molecule is highly symmetric and consists of 60 carbon atoms, located at the vertices of twenty hexagons and twelve pentagons. The diameter of fullerene C60 is 0.7 nm

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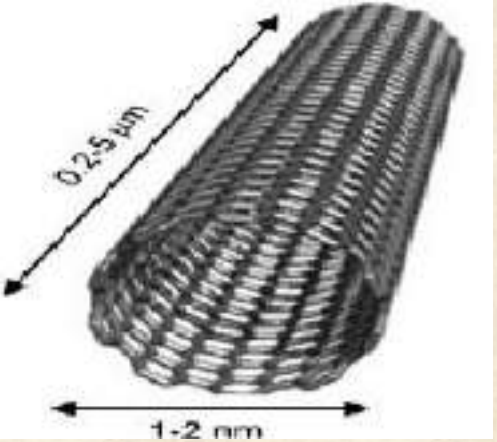
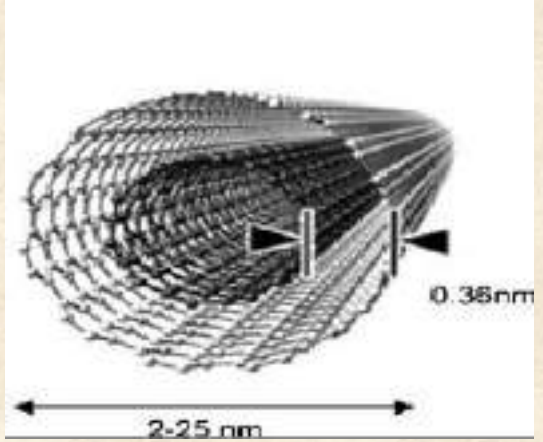



# Carbon nanotubes (CNTs)




CNTs are one of the carbon allotropes with exceptional properties suitable for technical applications. Carbon nanotubes are characterized by cylindrical structures with a diameter of several nanometers, consisting of rolled graphene sheets. Carbon nanotubes may vary in length, diameter, chirality (symmetry of the rolled graphite sheet) and the number of layers. According to their structure, CNTs may be classified into two main groups: single-walled nanotubes (SWCNTs) and multi-walled nanotubes (MWCNTs).

# Carbon nanotubes (CNTs)

Generally SWCNTs have a diameter around 1–3 nm and a length of a few micrometres. Multi-walled CNTs have a diameter of 5–40 nm and a length around 10 μm. The structure of CNTs leads to excellent properties with a unique combination of rigidity, strength and elasticity compared with other fibrous materials. For instance, CNTs show high thermal and electrical conductivity compared to other conductive materials

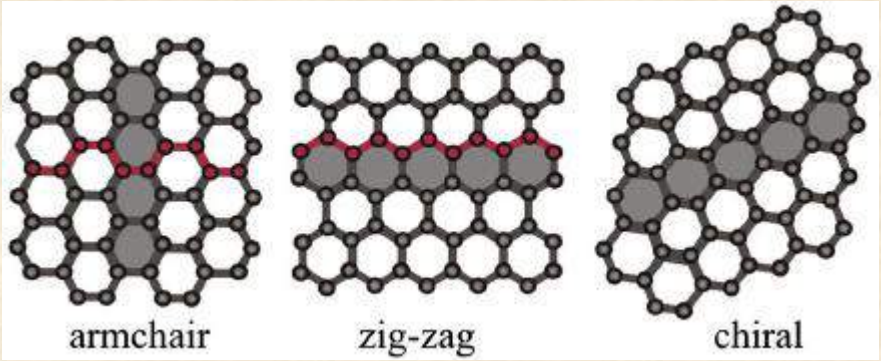
# Carbon nanotubes (CNTs)

Electrical properties of SWCNTs depend on their chirality or hexagon orientation with respect to the tube axis. So, SWCNTs are classified into three sub-classes:

(i) Armchair (electrical conductivity > copper).

(ii) Zigzag (semiconductive properties).

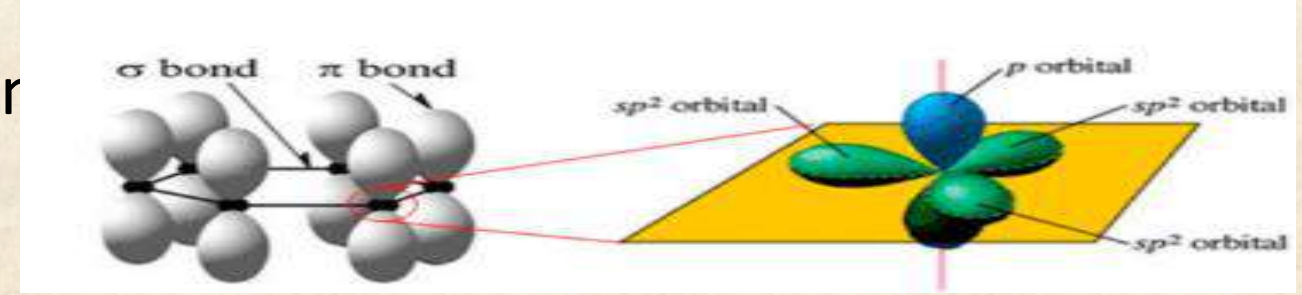
(iii) Chiral (semi-conductive properties).




By contrast, MWCNTs consisting of multiple carbon layers, frequently with variable chirality, can exhibit extraordinary mechanical properties instead of outstanding electrical characteristics.

# Graphene

Graphene is a two-dimensional allotropic form of carbon, formed by single layers of carbon atoms . In graphene, carbon atoms exhibit sp2-hybridization connected by σ- and π-bonds in a two-dimensional hexagonal crystal lattice with a distance of 0.142 nm between neighbouring atoms of carbon hexagons. Graphene also represents a structural element of some other carbon allotropes, such as graphite, carbon nar



# Graphene

Graphene has many unique physical properties, such as extremely high mechanical rigidity and a high thermal stability. Also the electric properties of this carbon allotrope are fundamentally different from the properties of three-dimensional materials.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