Chapter 15

Macromolecules

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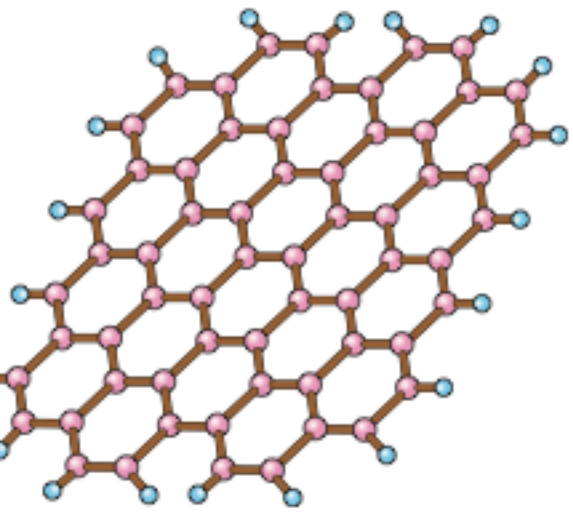
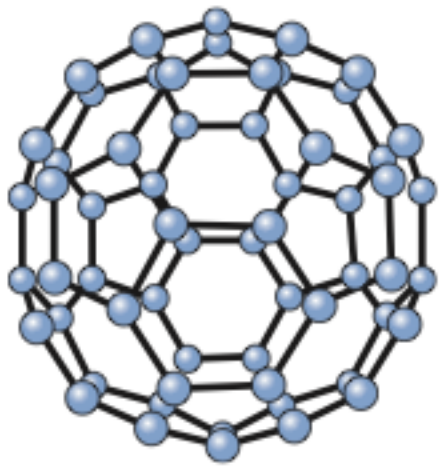
Graphenes, buckyballs, nanotubes, '100 times stronger than steel', 'the hardest substance known', electrical superconductors, nanofabrics one atom thick, single molecule computer chips. All these phrases refer to a new family of materials based on the graphite form of carbon. The development of these is happening so fast that anything written here may be long out of date by the time you read it.



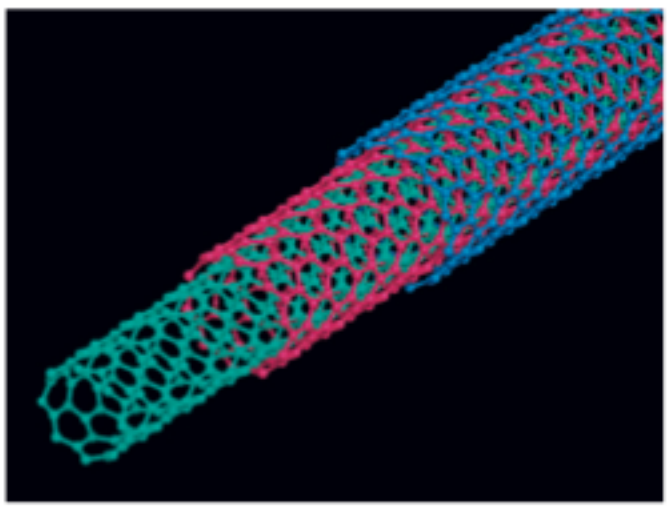
▲ **Figure 15.1**
The basis of many new materials is this chicken-wire structure made out of carbon atoms. It is called graphene and was first discovered in 2004. Carbon normally forms four bonds but these only have three. This means that there is an unused electron on each carbon. These electrons can move, so the sheet can conduct electricity well.

These unusual substances can be given even more unusual properties by modifying them slightly. A 'crystal lattice' containing buckyballs and alkali metal atoms can be made to become superconducting; this means it has no electrical resistance. **Graphene** strips a few carbon rings wide can be made to conduct like transistors, so a whole chip could possibly be made from a single graphene molecule. Single graphene sheets can be made to bind tightly to some vapour molecules, enabling them to be used as 'sniffers' in places like airport baggage security checks. We are only now beginning to discover how useful these graphene-based molecules might be.

The bonds that carbon atoms form with each other are very strong. Some of the compounds that carbon forms are quite small but most of the others, such as graphene, are large molecules; some of them are so large it is not possible to draw their structure on this page. We call them **macromolecules.**



▲ **Figure 15.2**
This structure is made out of 60 carbon atoms. It was originally called a Buckminster Fullerene after the famous American architect Buckminster Fuller, who made buildings looking like this. This became shortened officially to fullerene and, less officially, to 'buckyball'. If a buckyball is compressed to about 70% of its original size, it becomes harder than diamond.



▲ **Figure 15.3**
If you roll up a graphene layer you get a nanotube. If you roll up several, you get a series of nanotubes, one inside another. Nanotubes are the strongest fibres known. A single perfect nanotube is about 10 to 100 times stronger than steel per unit weight.