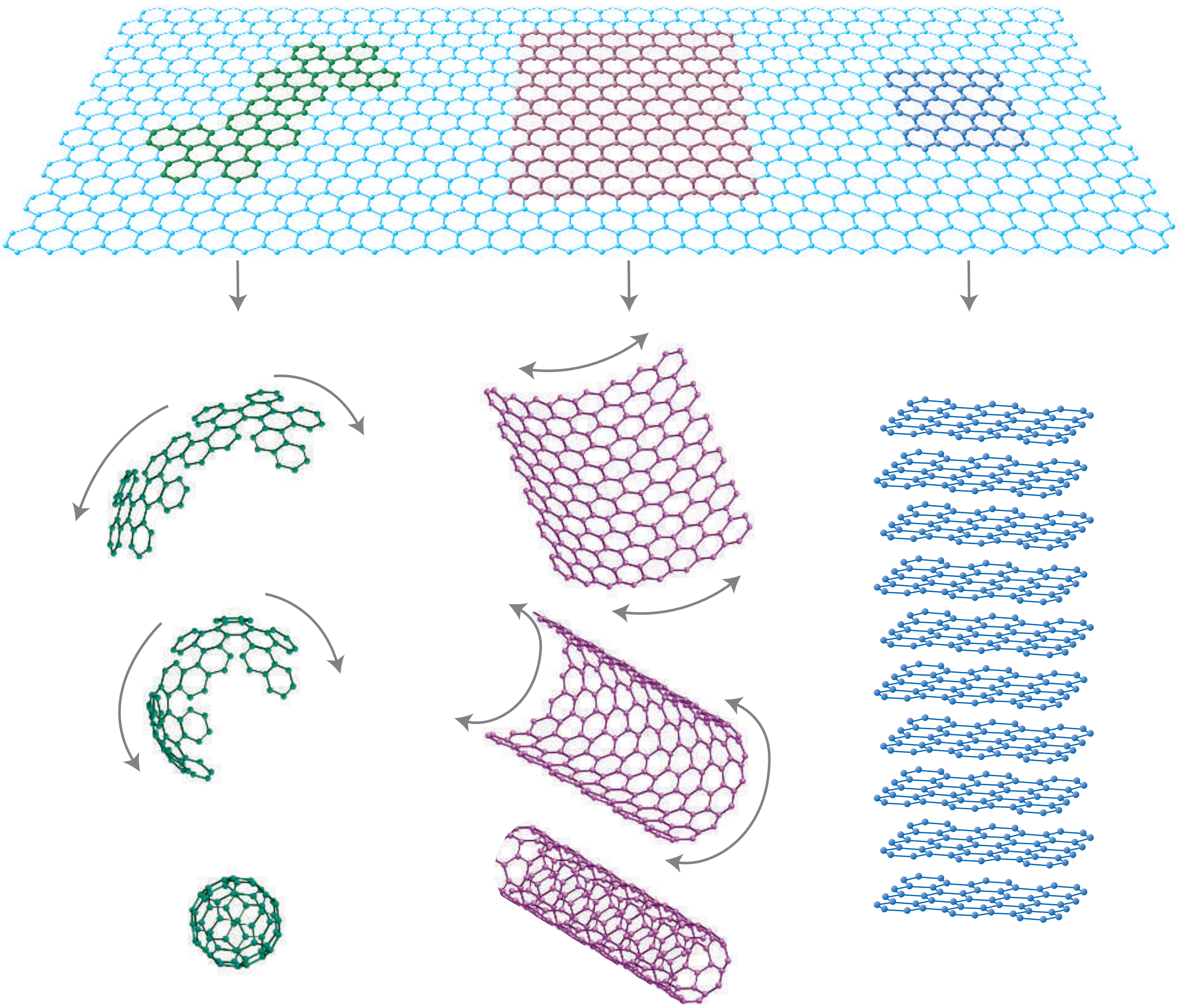

Figure 1 Mother of all graphitic forms. Graphene is a 2D building material for carbon materials of all other dimensionalities. It can be wrapped up into 0D buckyballs, rolled into 1D nanotubes or stacked into 3D graphite.

crystal, whereas 100 layers should be considered as a thin film of a 3D material. But how many layers are needed before the structure is regarded as 3D? For the case of graphene, the situation has recently become reasonably clear. It was shown that the electronic structure rapidly evolves with the number of layers, approaching the 3D limit of graphite at 10 layers[20]. Moreover, only graphene and, to a good approximation, its bilayer has simple electronic spectra: they are both zero-gap semiconductors (they can also be referred to as zero-overlap semimetals) with one type of electron and one type of hole. For three or more layers, the spectra become increasingly complicated: Several charge carriers appear[7,21], and the conduction and valence bands start notably overlapping[7,20]. This allows single-, double- and few- (3 to <10) layer graphene to be distinguished as three different types of 2D crystals ('graphenes'). Thicker structures should be considered, to all intents and purposes, as thin films of graphite. From the experimental point of view, such a definition is also sensible. The screening length in graphite is only ≈5 Å (that is, less than two layers in thickness)[21] and, hence, one must differentiate between the surface and the bulk even for films as thin as five layers[21,22].

Earlier attempts to isolate graphene concentrated on chemical exfoliation. To this end, bulk graphite was first intercalated[23] so that graphene planes became separated by layers of intervening atoms or molecules. This usually resulted in new 3D materials[23]. However, in certain cases, large molecules could be inserted between atomic planes, providing greater separation such that the resulting compounds could be considered as isolated graphene layers embedded in a 3D matrix. Furthermore, one can often get rid of intercalating molecules in a chemical reaction to obtain a sludge consisting of restacked and scrolled graphene sheets[24–26]. Because of its uncontrollable character, graphitic sludge has so far attracted only limited interest.

There have also been a small number of attempts to grow graphene. The same approach as generally used for the growth of carbon nanotubes so far only produced graphite films thicker than ≈100 layers[27]. On the other hand, single- and few-layer graphene have been grown epitaxially by chemical vapour deposition of hydrocarbons on metal substrates[28,29] and by thermal decomposition of SiC (refs 30–34). Such films were studied by surface science techniques, and their quality and continuity remained unknown. Only lately, few-layer graphene obtained on SiC was characterized with respect to its electronic properties, revealing high-mobility charge carriers[32,33]. Epitaxial growth of graphene offers probably the only viable route towards electronic applications and, with so much