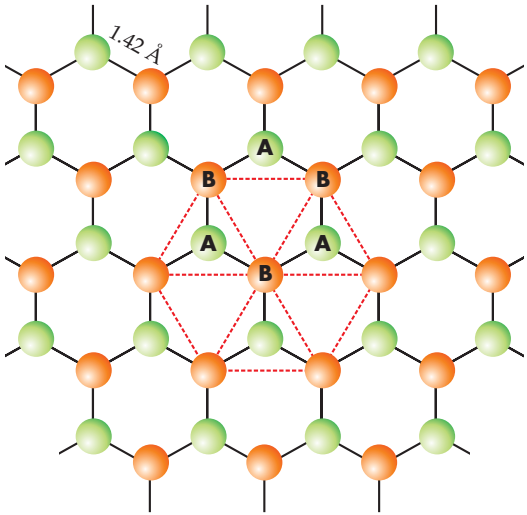
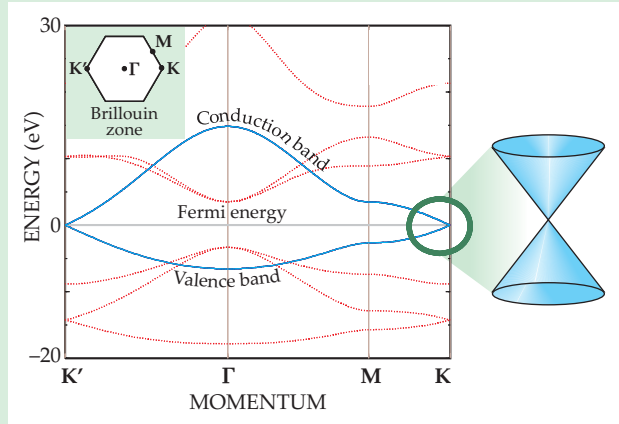
Box 1. Crystal and electronic structures of graphene

The honeycomb lattice of graphene, pictured below, consists of two interpenetrating triangular sublattices: The sites of one sublattice (green) are at the centers of triangles defined by the other (orange). The lattice thus has two carbon atoms, designated A and B, per unit cell, and is invariant under 120° rotations around any lattice site. Each atom has one *s* and three *p* orbitals. The *s* orbital and two in-plane *p* orbitals are tied up in graphene's strong covalent bonding and do not contribute to its conductivity. The remaining *p* orbital, oriented perpendicular to the molecular plane, is odd under inversion in the plane and hybridizes to form π (valence) and π^* (conduction) bands, as shown at right.





In the Bloch band description of graphene's electronic structure, orbital energies depend on the momentum of charge carriers in the crystal Brillouin zone (inset, right). The π and π^* bands (blue in the electronic structure plot) are decoupled from the σ and σ^* bands (red) because of inversion symmetry and are closer to the Fermi energy because they participate less in bonding. The Fermi energy separates occupied and empty states. In a neutral graphene sheet, this is the energy where valence and conduction bands meet (zero energy above, often referred to as the neutrality point). The bands form conical valleys that touch at two of the high-symmetry points, conventionally labeled **K** and **K′**, in the Brillouin zone. Near these points the energy varies linearly with the magnitude of momentum measured from the Brillouin-zone corners. The four other Brillouin-zone corners are related to **K** and **K′** by reciprocal lattice vectors and do not represent distinct electronic states.

Geim et al., Phys Today 2007