Synthetic structures and machines from DNA

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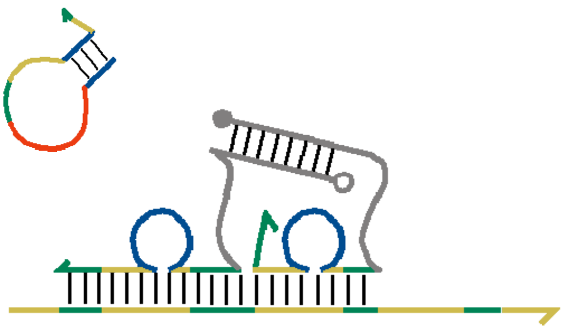

DNA is a wonderful material for nanoscale construction: its self-assembly can be programmed by making use of its information-carrying capability, and its hybridization or hydrolysis can be used as to provide energy for molecular devices. I shall describe our recent work on self-assembled molecular structures and on molecular machinery, including free-running bipedal molecular motors inspired by the motor protein kinesin. An autonomous molecular motor that does not alter its track needs an external energy source: if it uses a chemical fuel, it must be a catalyst that couples chemical change to mechanical motion. We have demonstrated the mechanism of a chemically fuelled motor that is designed to transport a load on a reusable track and to operate without intervention until it runs out of fuel. The motor is built from DNA, and the free energy required for directional motion is obtained by catalyzing hybridization of a DNA fuel. Its two-footed structure is inspired by kinesin and myosin V, protein motors with two feet (or ‘‘heads’’) that are driven along cytoskeletal filaments by ATP hydrolysis. The DNA motor’s feet are coordinated by means of competition where their binding sites on the track overlap: competition exposes different ends of the identical feet so that the left and right feet interact with the fuel at different rates. We show how the catalytic activities of the two feet can be coordinated to create a Brownian ratchet that is in principle capable of directional and processive movement.