DNA's PROSPECT IN NANOTECHNOLOGY

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Today, we can chemically synthesize complex molecules such as palytoxin, vitamin or Taxol with remarkable angstrom scale precision and fabricate intricately designed micron-scale electronic components at the rate of billions per second.

Our ability to precisely position components on the nanometer scale the way nature does, and to do so in a parallel rather than a serial manner, is still limited and is a key goal in nanotechnology and materials science.

The importance of weak non-covalent interactions in biology is widely accepted. One may think, for example, of the human gene pool, made up of deoxyribose nucleic acids (DNA). These exist in our cells in the form of adouble helix that is stabilised by non-covalent interactions called hydrogen bonds.

Two strands of DNA join together in an antiparallel manner to form a double helix with the help of weak bonds which can be broken temporarily to allow transcription of the DNA into an RNA messenger, thereby allowing the synthesis of specific proteins.

We may thus conclude that the perpetuation of our gene pool rests upon the possibility of breaking and rebuilding a whole series of weak non-covalent bonds. Supramolecular chemistry is concerned with assemblies of several molecules into non-covalent constructions, in the way illustrated by biological systems. The problem here is one of molecular recognition, a complementarity of shape, size and chemical functions that may exist over short distances between several molecules. In decreasing order of interaction energy, the non-covalent forces are: complexation forces due to metal cations, hydrogen bonds, hydrophobic interactions, π interactions, and charge transfer interactions.

Self-assembly, the spontaneous association of components into organized structures using noncovalent interactions, is the chief method that nature uses to achieve complexity. Of the natural self-assembling molecules, DNA is arguably the most remarkable. DNA is emerging as an attractive tool for nanoscience as well; it is a highly promising template for organizing nanomaterials in a programmable way. Research in this area promises to allow us to use DNA to dictate the precise positioning of materials and molecules into any deliberately designed structure, thus approaching the effortless manner in which nature gen-crates complexity and function.

DNA's simple code forms our genetic blueprint for life. But the field of DNA nanotechnology has invited us to look at the code in a whole new way: as a means to precisely position materials. This code can now help dictate the specific location of materials and the structure of assemblies, creating linear, 2D and 3D assemblies. The next step will be to investigate the possibilities for making practical materials with DNA nanotechnology.

DNA's ability to guide patterning of transition metals, nanoparticles, and proteins into deliberate designs gives it tremendous potential for answering many important challenges in science.

One of the potential applications of the present study would be identification of specific genes based on the hybridization-induced change in electrical signal. Concerned as always with the nanoscale, one of the major alternatives today which will certainly continue to develop over the next few years is exogenous photonic marking, as opposed to the endogenous response of biological media. In the first case, nanoparticles of all types, endowed with diverse and identifiable physical properties, are adopted as accessories, provided that they insinuate themselves into the medium as discretely as possible, whilst providing the microscopic device with the required luminosity and spatial resolution associated with the properties of nanostructures that have been optimised with this in mind.

Since each approach has its advantages and disadvantages, they will doubtless be called upon to complement and emulate one another, rather than just to compete, over the coming years

Finally, emulating the revolution in optoelectronics over the last two decades, where fundamental and applied research have moved forward hand in hand, fundamental repercussions are expected in biophotonics from research in biotechnology, especially from the spectacular development of DNA biochips over the last ten years.

Capitalising on progress in the technology of silicon components, these DNA chips are beginning to provide fundamental research of the post-genome era with tailor-made multiple receptacles of a combinatorial nature which can be interrogated and analysed in real time by ultrahigh resolution read techniques associated with ever more powerful image analysis methods.

With little risk of error, one may predict that new types of optoelectronic component, similar to those currently being developed for information technology, will emulate the development of new generations of DNA chips provided with internal photonic functionalities, and this all the more easily in that some are already based on the implementation of polymers and functionalised molecules, thereby well-placed to cooperate with biological systems.

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