Discovery could be key advance for nanotechnology

by Pui Shing Ho & David Stauth

CORVALLIS â€“ Biochemists at Oregon State University have discovered that a little-known type of chemical bond called a â€œhalogen bondâ€• can be used to control and manipulate the three dimensional shape of DNA, opening the door to new types of engineering at the atomic level.

The findings, just published in Proceedings of the National Academy of Sciences, a professional journal, may be a significant step forward for the emerging science of nanotechnology.

The study found that halogen bonds, which ordinarily are not part of biological molecules, can be incorporated into them in ways not found in nature, in the process providing ways to control the shape and ultimately the function of the molecules.

â€œHalogen bonds can give us something that resembles a molecular switch or magnet to help molecules align, and thereby change the shape of DNA and other biological molecules,â€• said Pui Shing Ho, professor and chair of the OSU Department of Biochemistry and Biophysics. â€œBiological molecules have unique abilities that we canâ€™t always duplicate in the chemistry lab, so this will provide a new tool to do biological engineering.â€•

Most of the chemical bonds that hold together the DNA base pairs of living molecules are hydrogen bonds, described over 50 years ago by Watson and Crick, the co-discoverers of DNA. OSU alumnus and two-time Nobel laureate Linus Pauling also did pioneering work in the study of chemical and biological bonds.

Three years ago, however, OSU scientists â€œre-discoveredâ€• and characterized the halogen bond â€“ a novel form of electrostatic bond that can help hold molecules together but had been largely forgotten for decades in the dust bin of chemistry, and never explored for its value in medical or pharmaceutical research.

Itâ€™s now understood that this arcane type of chemical bond, which is based on bromine, iodine or chlorine instead of hydrogen, may have characteristics that could be tapped for a new approach to biological engineering.

â€œNatural biological molecules have some powerful capabilities that we might like to take advantage of, such as the ability to convert biological energy to mechanical energy with incredible efficiency,â€• Ho said. â€œBut to do that, we need ways to carefully control their behavior, movement and function. The halogen bonds might allow us to do this.â€•

Among the possibilities could be computers that operate at the size of biological molecules, a molecular â€œwalkerâ€• that could control the movement of molecules at the nano-scale, or molecular scissors that provide a way to cut molecules. Such systems done with biological materials would act like extraordinarily small machines, and might also be more environmentally friendly.

The understanding of halogen bonds and their function is very limited, Ho said, and sufficiently obscure that they are not even a part of most chemistry programs. OSU studies have helped explain their role, especially in an unusual structure of DNA called a â€œHolliday junction.â€• It has also been learned that halogen bonds are key parts and essential to the function of many drugs such as antibiotics.

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