How chemicals can speed up evolution

ANDY COGHLAN

THE mystery of how human DNA evolves during someone's lifetime looks a step closer to being solved.

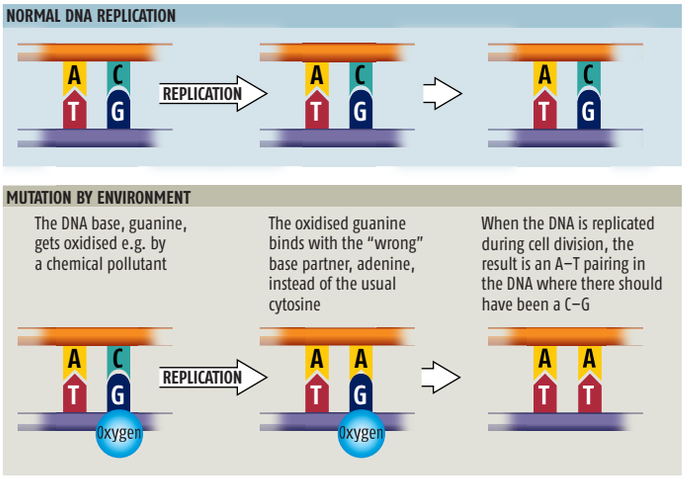
Researchers in Japan have found evidence that environmental agents that cause chemical changes to our DNA throughout life may increase the amount of shuffling and mutation that occurs within our DNA during the formation of egg and sperm cells. So exposure of our DNA to reactive chemicals may actually drive evolution by promoting genetic diversity in our children.

Yusaku Nakabeppu and his colleagues at Kyushu University in Fukuoka have shown that, if unrepaired by enzymes, a type of chemical damage called oxidation can reshuffle DNA's four basic building blocks – adenine, thymine, cytosine and guanine.

Normally, cytosine always pairs with guanine, and adenine with thymine, but unrepaired oxidation can disrupt these pairings, so that when a cell multiplies, the DNA sequence handed down to "daughter" cells is subtly altered (see Diagram). Guanine is particularly susceptible to oxidation, forming a variant called 8-oxoguanine that can pair up with adenine as well as its usual partner, cytosine. Such changes can happen in all cells, but if they occur in the precursors of sperm or egg cells, they then become heritable.

HOW THE ENVIRONMENT CHANGES YOUR DNA

Chemical pollutants can alter the way your DNA replicates



Researchers had previously assumed that such oxidation-induced changes were randomly distributed throughout the genome, but Nakabeppu's team suggest otherwise. They looked at DNA in white blood cells from four healthy individuals, and used a fluorescent chemical tag that binds exclusively to 8-oxoguanine to find out how abundant it is across the entire genome, and where it is located. Instead of being evenly scattered as expected, they found far higher amounts in areas known as recombination hotspots, where DNA is more prone to reshuffling when sperm and eggs form, and in areas rich in mutations called single nucleotide polymorphisms (SNPs), the variations that make each individual's genome unique (*Genome Research*, DOI: 10.1101/gr.4769606).

Nakabeppu suggests that accumulation of 8-oxoguanine in certain regions of a chromosome may enhance a process called meiotic recombination, in which sections of DNA are shuffled around during the formation of sperm and egg cells, potentially increasing the genetic diversity of future offspring. Although he has not repeated the analysis in germ cells, Nakabeppu cites previous work that shows recombination is promoted by repair enzymes, so the more 8-oxoguanine there is to repair, the more sites there are likely to be that undergo recombination. "I think the accumulation of 8-oxoguanine is probably the first event preceding formation of SNPs or recombination," says Nakabeppu.

> "Environmental agents may increase the amount of shuffling and mutation of DNA that occurs during sperm and egg formation"

Ryan Gregory, who studies genome evolution at the University of Guelph in Ontario, Canada, describes the findings as intriguing. Like Nakabeppu, Gregory thinks that 8-oxoguanine formation is probably the first step in genome alteration. "It may generate not only small-scale mutations, but perhaps also larger-scale recombination events, which could in turn influence chromosome arrangements," he says.

Gregory also believes that the findings could give insights into patterns of evolution in all species. "Discoveries like this shake up our understanding of how genomes are structured, how they function and how they evolve," he says. ●