Heredity (2003) 90, 6–7

www.nature.com/hdy

Book review

Horizontal Gene Transfer (2nd edn)

Edited by M Syvanen and CI Kado
Academic Press, London. 2002; 445 pp. $99.95, hardback. ISBN 0–12–680126–6

Heredity (2003) **90,** 6–7. doi:10.1038/sj.hdy.6800196

What's unspeakable in horizontal gene transfer?

Horizontal gene transfer is the transfer of genes across species including those in different kingdoms. It goes counter to both modern genetics and the theory of evolution. Disappointingly, little of the momentous significance of the process comes across in a volume replete with detailed examples.

GM foods – a topical area – is covered in the shortest chapter by Syvanen, who recalls how, when GM crops were first approved, the US Food and Drug Administration responded to fears of the spread of antibiotic resistance genes by denying that this could take place.

He himself, however, was just then trying to convince his colleagues that horizontal gene transfer between life's kingdoms was a natural process. If so, 'it would make more sense to defend the transgenic crop industry by arguing that gene transfer is a natural phenomena [sic] than by arguing that it does not occur'.

Syvanen claims to have screened for antibiotic resistance genes in the faeces of mice fed transgenic plant material, and found none (p 238), but no reference to any published paper is given. This chapter contains seven references; only five are peer-reviewed published papers. Another scientist's unpublished data (Schluter, 1995) is also cited as having found no gene transfer to bacteria growing on transgenic vegetables. However, actual published work from the same researcher – not cited – documented high frequencies of gene transfer in the laboratory, *which were reduced down to almost zero by arbitrary assumptions of 'natural' conditions* (Schluter *et al*, 1995).

Syvanen says experiments demonstrating gene transfer from transgenic plant DNA are because of 'high-frequency recombination'. He does not explain that such high-frequency recombination arises from sequence homology (similarity in DNA base sequence), and since transgenic DNA is highly mosaic, it would have homologies to a wide variety of bacteria and viruses, and is hence optimised, in that respect alone, for horizontal gene transfer.

He cites findings that transgenic DNA fed to mice ended up transferred to the mice's cells, but does not say that, that is something to be concerned about. Then, having failed to cite a key field-monitoring experiment that found plant transgenic DNA transferred to bacteria in batch cultures from the soil (Gebhard and Smalla, 1999), he states (pp 238–239); 'If and when experiments prove that horizontal transfer occurs between genetically modified crops and microbes in non-laboratory conditions, the implications will be debatable.'

Syvanen's reluctance to admit evidence of horizontal transfer of transgenic DNA contrasts with the readiness with which he and others in the volume indulge in speculations on how horizontal gene transfer could explain away one of the classic difficulties with neo-Darwinian theory – parallel evolution occurring independent lineages. 'We simply have not identified those genes responsible for the morphologies that characterize the major geological periods', Syvanen admits. Nonetheless, he is not deterred from presenting 'more speculative pieces that describe the explanatory power of a theory of horizontal gene transfer as it may affect a general theory of evolution.' (p 371).

I was one of the many critics of neo-Darwinism who, following D'Arcy Thompson and Allen Turing, have argued that forms can only be understood in terms of dynamic processes that *generate* the forms (Ho and Saunders, 1994). How else can I see those acts of speculation but as evidence of the intellectual decline symptomatic of the research programme of neo-Darwinian biology?

Let me describe one much more reasonable scenario based on empirical evidence presented in this book; and there are several others left as exercises for the many authors themselves.

Ferguson and Heinemann's chapter 'Recent history of trans-kingdom conjugation' describes evidence that should raise serious concerns over the release of GM crops, although the authors themselves do not address the issue.

Agrobacterium tumefaciens, the soil bacterium that causes crown gall disease, has been developed as a major gene transfer vector for plants. Foreign genes are spliced into T-DNA – part of a plasmid called Ti (tumour-inducing) – that is integrated into the plant genome; that much was known, at least since 1980. However, further analyses reveal that the process whereby *Agrobacterium* injects T-DNA into plant cells strongly resembles conjugation, or mating between bacterial cells.

Conjugation, mediated by bacterial plasmids, requires a sequence called the origin of transfer (*oriT*) on the DNA that is transferred. All other functions (called *tra*) can be supplied from unlinked sources, and are hence 'trans-acting functions'. Thus, 'disabled' plasmids, with no trans-acting functions, can nevertheless be transferred by 'helper' plasmids. And this is the basis of a complicated *Agrobacterium* – T-DNA vector system for creating numerous transgenic plants.

However, it soon transpired that the left and right borders of the T-DNA have characteristics of *oriT*, and can be replaced by it. Furthermore, the disarmed T-DNA, lacking trans-acting functions (virulence genes), can be helped by similar genes belonging to many other pathogenic bacteria. The trans-kingdom gene transfer of *Agrobacterium* and the conjugative systems of bacteria are really similar systems for transporting not just DNA but also protein.

This means that transgenic plants created by the T-DNA vector system have a ready route for horizontal gene escape via *Agrobacterium*, helped by the ordinary conjugative mechanisms of many other bacteria. This possibility was raised in a 1997 report of a UK Government-sponsored study (McNicole *et al*, 1997), showing that it was extremely difficult to get rid of *Agrobacterium* after transformation. Treatment with an armoury of antibiotics and repeated subculture over 13 months failed to get rid of it, and 12.5% of the *Agrobacterium* remaining still contained the binary vector (T-DNA and helper plasmid), and were hence fully capable of transforming other plants.

Agrobacterium not only transfers genes into plant cells; the possibility of *retro*transfer of DNA from plant cell to *Agrobacterium* is raised in Kado's chapter 'Horizontal transmission of genes by *Agrobacterium* species'. High rates of gene transfer are known to be associated with the plant root system, the rhizosphere (Sengelov *et al*, 2001), where conjugative activities are most likely. There, *Agrobacterium* could multiply and transfer transgenic DNA to other bacteria, and to the next crop.

Finally, *Agrobacterium* attaches to and genetically transforms several types of human cells (Kunak *et al*, 2001). In stably transformed HeLa cells, the integration event occurred at the right border of T-DNA, exactly as would happen when it is transferred into a plant cell genome.

References

Gebhard F, Smalla K (1999). Monitoring field releases of genetically modified sugar beets for persistence of transgenic plant DNA and horizontal gene transfer. *FEMS Microbiol Ecol* **28**: 261–272.

Ho MW, Saunders PT (1994). Rational taxonomy and the natural system – segementation and phyllotaxis. In: Scotland RW, Siebert DJ, Williams DM (eds), *Models in Phylogeny Reconstruction*, Oxford Science: Oxford. The Systematics Association Special Volume No. 52, pp 113–124.

Kunik T, Tzfira T, Kapulnik Y, Gafni Y, Dingwall C, Citovsky V (2001). Genetic transformation of HeLa cells by *Agrobacterium*. *Proc Natl Acad Sci USA* **98**: 1871–1887; also 'Common plant vector injects genes into human cells', *ISIS News* 2002, 11/12: 10 www.i-sis.org.uk

McNicole *et al* (1997). *The possibility of Agrobacterium as a vehicle for gene escape. MAFF*. R&D and Surveillance Report: 395; also 'Agrobacterium used in the production of GMOs is a possible vehicle for gene escape,' *ISIS News* 1999, **2**: www.i-sis.org.uk

Schluter K, Futterer J, Potrykus I (1995). Horizontal gene-transfer from a transgenic potato line to a bacterial pathogen (*Erwinia-chrysanthem*) occurs, if at all, at an extremely low-frequency. *Bio/Technology* **13**: 1094–1098.

Sengelov G, Kristensen KJ, Sorensen AH, Kroer N, Sorensen SJ (2001). Effect of genomic location on horizontal transfer of a recombinant gene cassette between *Pseudomonas* strains in the rhizosphere and spermosphere of barley seedlings. *Curr Microbiol* **42**: 160–167.

M-W Ho
Institute of Science in Society
PO Box 32097, London NW1 OXR, UK
E-mail: m.w.ho@i-sis.org.uk