SUBMISSION

To the Finance Committee on the Hazardous Substances and New Organisms (Genetically Modified Organisms) Amendment Bill/Inquiry, referred to herein as HSNO.

1. Introduction

1.1. This submission is from the University of Canterbury (UC) and the New Zealand Institute of Gene Ecology (NZIGE). Prof. Bob Kirk, Deputy Vice Chancellor, Private Bag 4800, Christchurch.

1.2. We wish to appear before the committee to speak to our submission. We can be contacted through Dr. Jack Heinemann, Dept PAMS, University of Canterbury, Private Bag 4800, Christchurch, voice 03 364 2926, fax 03 364 2083.

1.3. UC has, at present, a theoretical interest in the development of modified organisms for trial or eventual commercial release. The primary activity of this applicant is teaching and research on, or through the use of, genetically modified or new organisms. Those activities are conducted in contained facilities.

1.4. The New Zealand Institute of Gene Ecology (NZIGE) is a research centre hosted by UC (www.nzige.canterbury.ac.nz). The NZIGE has no commercial interest in genetically modified organisms for release. The membership of the NZIGE extends to those with such interests and those with vested interests to oppose the technology. Membership currently consists of research professionals employed by the UC, Institute of Environmental Science and Research, Ltd., Institute of Crop and Food Research, Ltd., Ministry of Health, University of Otago Christchurch School of Medicine, Wellington School of Medicine, Lincoln University, Rockefeller University, Brigham Young University and the Norwegian Institute of Gene Ecology. The purpose of the NZIGE is to:

1.4.1. serve as an independent place of research on the application and impact of biotechnology;
1.4.2. advocate the safe application of publicly responsible technologies; and
1.4.3. facilitate the training of New Zealanders, who participate in the development, regulation or use of new biotechnologies, in risk analysis in its broadest sense.

1.5. This submission was prepared by review of the University of Canterbury Vice Chancellor and the membership of the NZIGE.

2. We wish to comment specifically on the use and meaning of the term “heritable material” and recommend a defintion for the term.

3. We wish to make the following comments on heritable material.

3.1. Heritable material lacks a definition in the legislation. We will evaluate the range of meanings that could be associated with the term and then present what we believe to be a definition that is both scientifically defensible and true to the spirit of the HSNO Act.

3.1.1. Most risk assessments have considered heritable material to be either a gene, in the sense it has come to be understood early in the second half of the 20th Century (ie, a segment of a molecule called DNA) or as the components of organisms that are dedicated to the reproduction of that organism (eg, as used by ERMANZ in GMF99001). Because the HSNO Act is primarily legislation concerned with protecting the health of people and the natural environment, heritable material ought to be understood in a way that facilitates the intent of the Act.

3.2. What is a gene?

3.2.1. Current textbooks and the US Patent Office have adopted a focused and narrow definition of the gene, one that is not of scientific demonstration but is consistent with scientific experience. That is, the definitions (below) comply with all experiments that use DNA as genetic material, but the implication that DNA (or nucleic acids) are the only material form of genes has neither ever been demonstrated nor is it accurate [Strohman, 1997 #470; Heinemann, 2000 #774; Weld, 2001 #1017].

3.2.2. The word gene was coined early in the 20th Century as a scientific heuristic, to focus thinking on the search for the material causing traits to be transmitted from one generation to the next but without instilling a bias on what could be discovered. The inventor of the term said: “The word ‘gene’ is completely free from any hypothesis; it expresses only the evident fact that, in any case, many characteristics of the organism are specified in the germ cells by means of special conditions, foundations, and determiners which are present in unique, separate, and thereby independent ways–in short, precisely what we wish to call genes” [recounted in \Portugal, 1977 #627].

3.2.3. The industrialisation of genetics requires a precise definition of the gene. The US Patent Office uses this definition (Mapping Our Genes The Genome Projects: How Big, How Fast? OTA-BA-373, Washington, D.C.: U.S. Government Printing Office, April 1988, www.bis.med.jhmi.edu/Dan/DOE/prim6.html. Access date January 4, 1999.): “Gene: A gene is an ordered sequence of nucleotides located in a particular position on a particular chromosome that encodes a specific functional product (i.e., a protein or RNA molecule).”

3.2.4. Interestingly, however, the Patent Office has a significantly different definition for genetics, the science of the gene: “Genetics: The study of the patterns of inheritance of specific traits.” We note that some institutions are

adopting contradictory terminology for genetic concepts, for example, as seen by the way the definition of gene is not tied to the definition of genetics. In our view, this reflects a confusion in how the gene is used by scientists as well [Lewontin, 2001 #1027; Fox Keller, 2000 #1024; Heinemann, 2002 #1028]

3.2.5. The term gene is defined by an influential molecular biology textbook as a "segment of DNA involved in producing a polypeptide chain; it includes regions preceding and following the coding region (leader and trailer) as well as intervening sequences (introns) between individual coding segments (exons)" [Lewin, 1997 #619]. This definition is consistent with that used by other textbooks and the Patent Office, but ignores many kinds of material that can "create patterns of inheritance of specific traits", such as the proteins of Mad Cow Disease and other epigenes, which are now widely regarded as the heritable material of important and common traits [Lewin, 1998 #624; Klar, 1998 #669; Keyes, 1999 #861; Heinemann, 2000 #774; Strohman, 1997 #470; Jablonka, 1995 #659; Holliday, 1989 #704; Petronis, 2001 #925].

3.2.6. Thus, we advocate for an inclusive definition of the gene that accurately includes all material that forms the basis for inheritable traits, rather than its formulation in terms of one type of molecule that is the basis of some inheritable traits.

3.2.7. We draw this distinction to the Committee's attention so that they may better interpret submissions that use the term gene or heritable material.

3.2.8. As the association of DNA with the term gene is now almost inseparable in practice, having been institutionalised in the way biology and molecular biology are taught worldwide, we are heartened by the forethought among those who drafted the original HSNO legislation in adopting the term "heritable material".

3.3. What is heritable material?

3.3.1. In their decision to approve with controls the field trial of genetically modified pine trees (GMF99001), ERMANZ considered heritable material to be that which "could be passed on". In the case of trees, that material was considered to be pollen and seeds and not vegetative tissues (although all tissues contain DNA). DNA was also considered in terms of transfer from vegetative material to soil microorganisms.

3.3.2. The ERMANZ decision enshrined two views of heritable material, that which might be equated with the DNA gene and that which is a larger, multi-component structure such as pollen or a seed.

3.3.3. The inclusion of recognised structures that are normal intermediates in reproduction is warranted considering that these retain their potential to transmit traits when combined with the appropriate co-factors (eg, pollen with embryo; fertilised seed with soil and water), just as DNA retains the potential to be passed on when inside a cell that can replicate the molecule.

3.3.4. We believe ERMANZ acted responsibly by including these large structures in consideration of heritable material and that innovation should be preserved in any formal definition of the heritable material.

3.3.5. Again, however, it is now well recognised that other types of molecules and structures carry inheritable information (ie, epigenes). It is also known that some molecules and structures essential for a property to be "passed on", are themselves not maintained in an organism even though their effect remains heritable and regular. Examples of this include RNAi, where upon introduction into a cell the nucleic acid causes some genes to stop participating in the production of proteins (ie, post-transcriptional gene silencing). The effect of RNAi is heritable from cell to cell in the development of the affected organism and is transmitted through the germ line. However, there is no evidence that the instigating nucleic acid is preserved in descendants. Thus, the heritable material in this case is not the nucleic acid.

4. Taking into account the discussion above, we offer for consideration the following definition of heritable material.

Heritable material refers to:

- genes, molecules (eg nucleic acids) capable of serving as templates for the production of replicate molecules;
- epigenes, molecules with the potential to heritably transmit or heritably alter (eg, through recombination of components, or establishment or maintenance of auto-catalytic loops) a character or trait;
- or components or tissues (eg, sperm, eggs, pollen, seeds) of organisms with the potential to form descendants of organisms.

5. We recommend that a scientifically defensible and epistemologically comprehensive definition, consistent with the spirit of the HSNO Act, of heritable material be adopted.