Questionnaire:
Representing the Role of Genes in Development
(Discussion version)

Section A: Background of Respondent (cross [x] whichever applies)

1. Current Disciplinary Location	2. Area of Training
a. Medicine	a. Medicine
I. Molecular Medicine_____[ ]	I. Molecular Medicine_____[ ]
II. Oncology_____[ ]	II. Oncology_____[ ]
III. Biochemistry_____[ ]	III. Biochemistry_____[ ]
IV. Pharmacology_____[ ]	IV. Pharmacology_____[ ]
V. Infectious Diseases_____[ ]	V. Infectious Diseases_____[ ]
b. Biochemistry	b. Biochemistry
I. Molecular_____[ ]	I. Molecular_____[ ]
II. Cell_____[ ]	II. Cell_____[ ]
III. Protein_____[ ]	III. Protein_____[ ]
IV. Metabolism_____[ ]	IV. Metabolism_____[ ]
c. Biological Sciences	c. Biological Sciences
I. Genetics_____[ ]	I. Genetics_____[ ]
II. Development _____[ ]	II. Development _____[ ]
III. Evolution, Taxonomy_____[ ]	III. Evolution, Taxonomy_____[ ]
IV. Ecology_____[ ]	IV. Ecology_____[ ]
V. Microbiology_____[ ]	V. Microbiology_____[ ]
d. Agriculture	d. Agriculture
I. Agricultural Genetics_____[ ]	I. Agricultural Genetics_____[ ]
II. Animal Genetics_____[ ]	II. Animal Genetics_____[ ]
III. Animal Science_____[ ]	III. Animal Science_____[ ]
IV. Plant Breeding_____[ ]	IV. Plant Breeding_____[ ]
e. Veterinary Science_____[ ]	e. Veterinary Science_____[ ]
f. Pharmacology_____[ ]	f. Pharmacology_____[ ]
g. Other_____ [ ]	g. Other_____ [ ]

3. Disciplines of Degree

Undergraduate degree in_____ ___

Postgraduate degree other than PhD in_____ ____

PhD defended in_____ ___

4. Other

a. Gender	b. Age
i. female_____[ ]	i. 20-34_____[ ]
ii. Male_____[ ]	ii. 35-49_____[ ]
	iii. 50-70_____[ ]

Section B

(For questions 1-5: First, mark [x] every answer with which you agree in the left-hand column of boxes. Second, if you were to choose the 'best' answer, which one would that be? Mark (x) a single box in the right-hand column.) [bracketed comments added for this discussion]

1. In short: What is a gene?

1. That which makes the difference between two phenotypes[Gene$_{Predictor}$]_____ [ ]   [ ]

A nucleic acid sequence:

2. Any Nucleic acid sequence whatsoever. [EvolutionaryGeneConcept (EGC)] _____ [ ]   [ ]
3. Nucleic acid sequence with a certain characteristic structure[Struct. GC]_____ [ ]   [ ]
4. Nucleic acid sequence with a certain characteristic function[Funct. GC]_____ [ ]   [ ]
5. A carrier of heritable information[Informational GC]_____ [ ]   [ ]
6. A resource for Development[gene$_{Developmental Resource}$]_____ [ ]   [ ]
7. Other_____ [ ]   [ ]

2. What is the biological function of a gene?

1. Causing a phenotypic outcome. [Weak gene$_P$]_____ [ ]   [ ]
2. Determining a phenotypic outcome. [Strong gene$_P$]_____ [ ]   [ ]
3. Coding for the primary structure of a protein. [Classical Molecular Gene (CMG)]___ [ ]   [ ]
4. Providing a developmental resource, on a par with other (epigenetic and environmental) resources, for the construction of the organism. [Gene$_D$] _____ [ ]   [ ]
5. Channelling and reinforcing epigenetic propensities, as opposed to specifying incremental alterations in morphology._____ [ ]   [ ]
6. Releasing and biasing the expression of latent morphogenetic capacities._____ [ ]   [ ]
7. Mechanism to buffer the development of established and ecologically successful phenotypes against environmental perturbations and metabolic noise._____ [ ]   [ ]

[5. + 6. + 7.= Radical epigenetic gene concepts from Mueller/Newman]

8. Functional part, written in the sequence of nucleotide bases, of a program for development. ['Developmental program' (Keller)]_____ [ ]   [ ]
9. Other_____ [ ]   [ ]

3. What makes two genes "homologous"?

1. Both have derived from a common ancestral gene (they are orthologous)[Evolutionary Homology (EH)]._____ [ ]   [ ]
2. Both have an identical sequence of nucleotides.[Structural homology]_____ [ ]   [ ]
3. Both produce functionally equivalent molecular products.[Function (Analogy)]___ [ ]   [ ]
4. Both are situated at homologous sites on homologous chromosomes.[Position gene definition from classical genetics] _____ [ ]   [ ]
5. Both are able to recombine with one another in practice. [EGC]_____ [ ]   [ ]
6. Both are able to recombine with one another in theory. [Liberal EGC]_____ [ ]   [ ]
7. Both have derived from a gene duplication (they are paralogous). [Serial Homology][ ] [ ]
8. Other_____ [ ]   [ ]

4. What is the methodological value of the gene concept?

1. A gene has instrumental utility in predicting a phenotypic outcome. [Gene$_P$]____ [ ]   [ ]

2. Central concept in evolution: allows i) shortcut definition of evolution as change in gene frequency and ii) a general conception of evolution as gene selection._____[ ]   [ ]
[Gene Selectionism]

3. Studying the biological role of a particular gene, which involves locating it within the contexts in which it is biologically active, helps to elucidate the complex molecular pathways in which it is an interactant. [Gene$_D$]_____[ ]   [ ]

4. A convenient entry point to functionally conserved multi-molecular modules as units of development, morphology, variation and innovation. _____[ ]   [ ]
[Genetic Module Concept: Moss, Gerhart and Kirshner]

5. 'Gene' functions to remind modern geneticists of what it is that makes a region of nucleic acid 'interesting', or of what constitutes 'meaningful structure' in the genome.[ ]   [ ]
[Pluralist Gene Concept Keller]

6. A gene draws our attention to a collection of useful functional domains (exons) which can be combined in different ways. [Genetic ModuleConcept]_____[ ]   [ ]

7. A handy and versatile term whose meaning is determined by the context in which it is used. [Pluralist Gene Concept, Porter, in Neumann-Held.]_____[ ]   [ ]

8. Other:_____[ ]   [ ]

5. At length: What is a gene:

1. The functional and physical unit of heredity passed from parent to offspring.____[ ] [ ]
[(Pre-) Mendelian 'Gene' Concept]

2. A stretch of DNA sequence that codes for a particular protein that has a particular function.[CMG. Official definition from 'The National Human Genome Research Institute'.]__[ ] [ ]

3. A package of information that contains and implements a particular instruction._[ ] [ ]
[Informational gene]

4. A gene is defined by its relationship to a phenotype regardless of the specific molecular sequence and the whole developmental mechanisms involved. [Gene$_P$]_____[ ] [ ]

5. A developmental resource defined by its specific molecular sequence and functional template capacity but which is indeterminate with respect to the phenotypic outcomes to which it will contribute. [Gene$_D$.]_____[ ] [ ]

6. A segment of chromosome. Some genes direct the synthesis of proteins, while others have regulatory functions.[CMG. Definition of 'Gen Technology in Australia', website of CSIRO.][ ] [ ]

7. A process that includes DNA sequences and other components which participate in the time and tissue specific expression of a particular polypeptide product._____[ ] [ ]
[molecular process gene concept, Neumann-Held]

8. Any stretch of DNA, beginning and ending at arbitrarily chosen points on the chromosome, that segregates and recombines with appreciable frequency. [ ] [ ]
[EGC - Williams]

9. A functional unit and part of the processes that specify cellular and intercellular organisa-tion, defined by the action of a complex self-regulating system for which the inherited DNA provides the crucial raw material. [GeneD, as formulated by Keller]_____[ ]   [ ]

10. Other:_____[ ]   [ ]

6. Which pairs of nucleotide sequences count as "the same gene"?

(Every question is to be considered separately. Cross those descriptions that seem to you to describe two copies of the same gene.)

1. Any two identical nucleotide sequences, beginning and ending at arbitrary points, at equivalent loci on homologous chromosomes in different cells of the same organism.____[ ]
[This tested whether arbitrary sequences qualified as genes, as suggested by Williams, Dawkins. 5-8]

2.   Two transcription units of identical nucleotide sequence at equivalent loci on homologous chromosomes in different cells of the same organism._____[ ]
[Control - a clear-cut example of two copies of the same gene. 11-2]

3.   Two transcription units of identical nucleotide sequence on non-homologous chromosomes in the same organism._____[ ]
['Sequence alone' criterion: is possibility of recombination with its former alleles necessary? 4-7]

4.   Two identical transcription units of identical nucleotide sequence, which lead to the same functional protein_____[ ]

5.   Two identical transcription units of identical nucleotide sequence, which are translated into the same polypeptide chain, regardless of how it is folded._____[ ]

6.   Two identical transcription units of identical nucleotide sequence, which produce the same final transcript, regardless of what happens to this transcript._____[ ]

7.   Two identical transcription units of identical nucleotide sequence, which produce the same primary transcript, regardless of what happens to this transcript._____[ ]
[4.-7.: To test the importance of sharing functional molecular products of different proximity.)

8.   Two transcription units of identical nucleotide sequence which produce the same final transcript but contain different introns._____[ ]
[This question had a typo and was meaningless]

9.   Two transcription units of identical nucleotide sequence whose final transcript contains differently spliced exons._____[ ]
[Is an identical final transcript necessary to count as 'the same gene'?]

10.   Two transcription units of identical nucleotide sequence at equivalent loci on homologous chromosomes in different cells of the same organism, one of which has its exons scrambled in its final transcript (as happens in ciliates)._____[ ]
[Is an identical final transcript necessary to count as 'the same gene'? 7-5]

11.   Two transcription units of identical nucleotide sequence with different promoters but with identical levels of transcription._____[ ]
[Testing whether the 'same sequence' criterion extends outside the transcribed region. 7-6]

12.   Two transcription units of identical nucleotide sequence with different promoters and different levels of transcription._____[ ]
[Could external factors causing different amounts of product to be produced prevent two otherwise identical sequences from being 'the same gene'? 5-8]

13.   Two transcription units which differ only in a single silent mutation._____[ ]
[This question and the next tested whether a 'same sequence' criterion was absolute. 8-5; 7-5]

14.   Two transcription units which differ in a number of silent mutations, not affecting the level of expression._____[ ]

15.   Two transcription units which differ in a number of silent mutations, affecting the level of expression significantly._____[ ]
[Could differences in level of expression alone make two sequences 'different genes'? 3-10]

16.   Two otherwise identical transcription units containing different nonsense mutations both of which destroy the corresponding enzyme's catalytic activity._____[ ]
[Could different sequences be the same gene due to their identical developmental effect? 6-6]

17.   Two transcription units which differ so as to produce a single substitution in the amino acid sequence but with no observable developmental effect._____[ ]
[This question tested whether a 'same amino acid sequence' criterion was absolute. 5-7]

18   Two transcription units with identical sequences but which produce different polypeptides due to differences in the genetic code (eg., between mitochondria and nuclei).__[ ]
[Is base sequence or amino acid sequence more important for classifying genes? 3-10]

19   Two allelic transcription units differing in sequence, each of which has an identical phenotypic effect._____[ ]
[Is the phenotypic effect the defining character of a gene (or an allele)? 3-10]

20   Two transcription units of identical nucleotide sequence, one of which is found on a free transposon and one of which is found in normal genomic DNA._____[ ]

[Test of the importance of a sequence's context. 8-4]

21. Two identical nucleotide sequences, one is an active coding sequence, the other is split into two (non-functional) pieces by an insertion._____[ ]

[Another test of the importance of contextual effects. 2-9]

22. Two transcription units of identical nucleotide sequence that have evolved independently in different taxa through convergent evolution._____[ ]

[Is common descent necessary for two sequences to be 'the same gene'? 5-6]