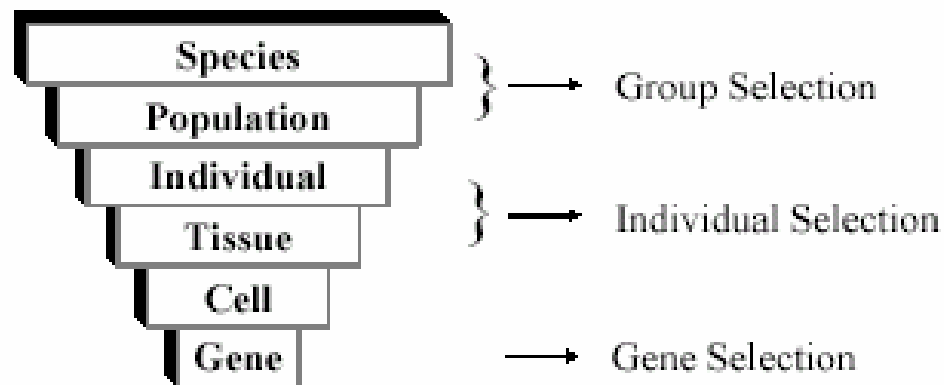


# Genic Views of Evolution



# Issues on which our authors disagree



Paul Griffiths



Kim Sterelny

# Marilyn Asks



- “Imagine that a pair of identical twins is separated at birth. Each is isolated in a room with no human contact. Everything else they need, however, is amply provided, including food, recording voices for learning and the finest schooling materials. Their controlled environment is identical. So is their DNA. When the twins are old enough, each is asked to write an essay. Would their writings be identical?”
  - Marilyn vos Savant, February 15, 2004

# Some Historical Roots: The Preformationist-Epigenesis Debate

- Preformationism: the egg (in a few accounts, the sperm) contained a little, preformed organism which just needed to be “blown up” to make an adult
  - Preformed organism in humans—homunculus
  - Each egg contained within the egg of the mother, back to Eve
- Epigenesis: development makes an organism out of undifferentiated matter
- Modern epigenesis: the genes control the differentiation (a variant on preformationism?)
- Radical epigenesis (Developmental Systems Theory)—genes are only one of several equally important factors

# The Innate-Acquired Distinction

- Innate: behavior is instinct-based
- Acquired: behavior is due to learning
- Weak interactionism: both nature and nurture contribute, and we can factor their contributions
  - 60% nature, 40% nurture
- Strong interactionism: innate endowment and experience interact non-linearly to create something that cannot be factored into its constituents

# Lorenz on Imprinting



“Selma Lagerlöf's Nils Holgersson was read to me - I could not yet read at that time. From then on, I yearned to become a wild goose and, on realizing that this was impossible, I desperately wanted to have one and, when this also proved impossible, I settled for having domestic ducks. In the process of getting some, I discovered imprinting and was imprinted myself. From a neighbour, I got a one day old duckling and found, to my intense joy, that it transferred its following response to my person. At the same time my interest became irreversibly fixated on water fowl, and I became an expert on their behaviour even as a child.” (Nobel autobiography)

# Lorenz on aggression



“We have good reason to consider intra-specific aggression in the present cultural and technological situation of mankind as the greatest of dangers. However, we shall not improve our chances to deal with it if we accept it as something metaphysical and unavoidable. However, we may succeed if we can unravel the causal chain of its natural causes. Whenever man attained the power to direct natural phenomena into a particular direction, he was able to do so because of his understanding of the underlying causes. The study of normal, species-preserving life processes, called physiology, provides the pre-requisite basis for the study of pathology.”



# Daniel Lehrmann



- Critique of Lorenz's instinct concept:
  - That a behavior appears reliably in a species does not entail that it doesn't develop
  - Even in the egg, chicks receive signals, including feedback from their own behavior
  - If something is reliably present in the environment, organism can get it from there

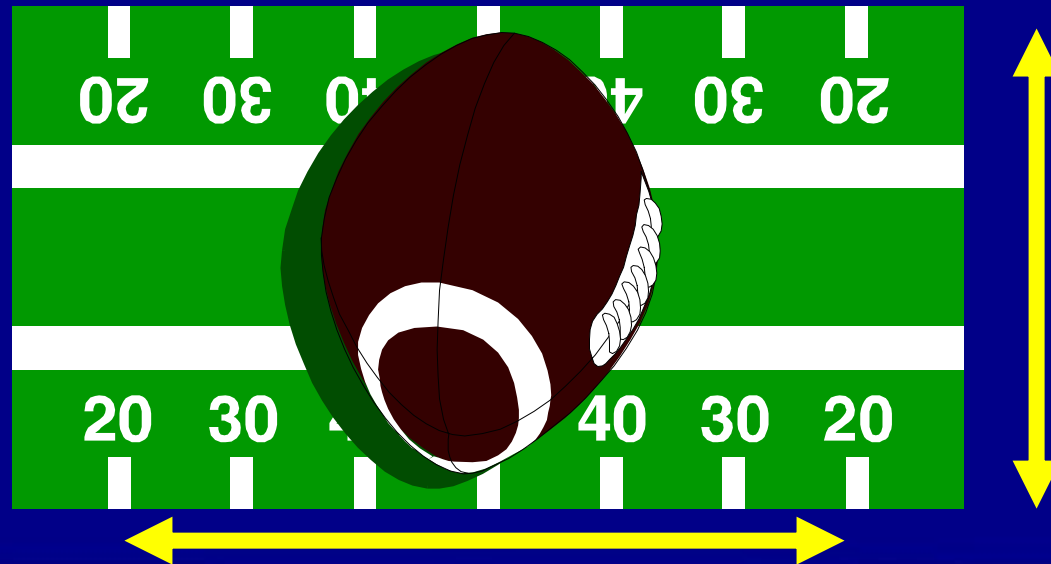


# What is Heritability?

- Within an environment, measure the correlation between the traits of parents and offspring
- Correlation coefficient measures how much of the variability in one trait is predictable from the variability in the other
  - E.g., predict the height (IQ) of an offspring from that of the parent
- False interpretation—high heritability means fixed by genes
  - The measure of heritability already screened out the role of environment by keeping the environment fixed
  - Moreover, effects of environment and genes not simply additive

# Interaction of nature and nurture

Donald Hebb (1953): “It is as meaningless to ask *how much* a given piece of behavior depends on genetic factors and *how much* depends on environment as it is to ask how much the area of a field depends on its length and how much on its width.”

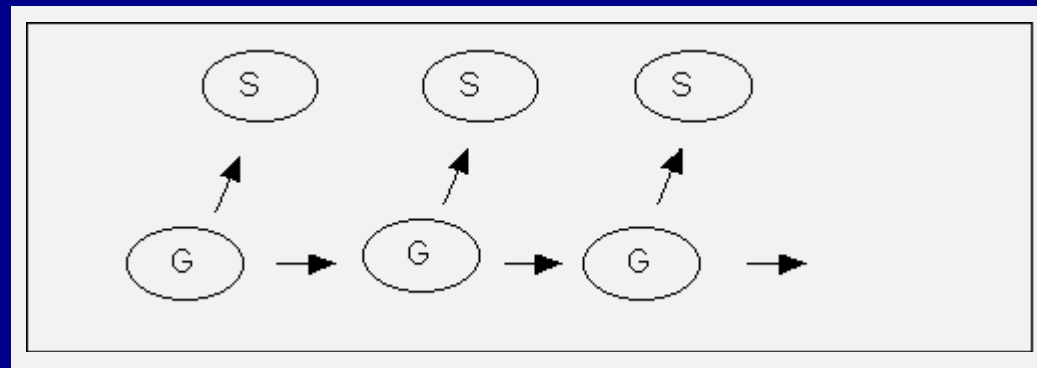


# Roots of the Genic Selection Debate

- Vero C. Wynne-Edwards (ecologist): selection for groups
  - Individuals might sacrifice for the good of the group—lemmings committing suicide when the population becomes too large
- George C. Williams (population genetics): no selection for groups—no mechanism for promoting sacrifice for the group
- Williams and Dawkins: selection only for genes
- Does selection only work at one level or at multiple levels?
  - If at multiple levels, can selection at different levels work in opposite directions?

# Replicators and Interactors

- Replicators—the entities that get copied into subsequent generations: “Any entity in the universe of which copies are made” (Dawkins 1982, p. 293)
- Interactors (Dawkins: vehicles)—the entities that engage the environment
- August Weismann’s distinction between germ line and somatic lines



# Genes and Survival Machines

- Replicators began not merely to exist, but to construct for themselves containers, vehicles for their continued existence...But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines. (Dawkins 1976, p. 21)

# The Case for Taking the Gene's Eye View

- genes *code* for phenotypic traits
  - Genes are the *form*, everything else is just *matter*—genes direct the show and get the credit
- only genes *replicate* themselves
- only genes are *inherited*
- genic selectionism is the *most general way* of representing evolution
- Even though interactors figure in the story, the gene's eye view holds that selection really operates on replicators, not organisms

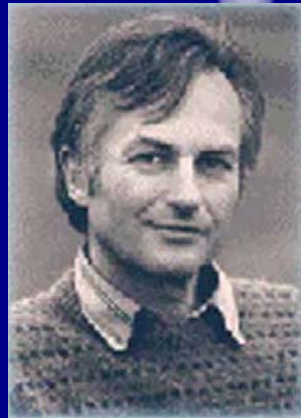
# Only replicators can be selected

- Organisms die—they do not increase in numbers
- Genes are copied—they survive
- “Phenotypes do not *persist*, they *recur*. The only biological entities that persisted in the fly culture and the beetle culture are fly genes and beetle genes” (Williams 1986, pp.116-117).
- “Differences due to nature are likely to be inherited whereas those due to nurture are not; evolutionary changes are changes in nature, not nurture.” (Maynard Smith 2000).



# Selection for genes

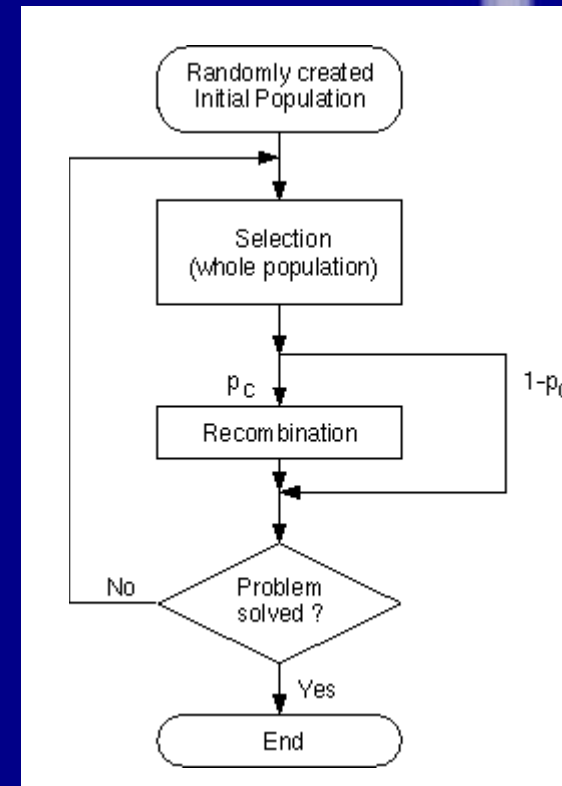
- “The natural selection of phenotypes cannot by itself produce cumulative change, because phenotypes are extremely temporary manifestations. They are the result of an interaction between genotype and environment that produces what we recognize as an individual. . . .” George Williams
- “Individuals are not stable things, they are fleeting. Chromosomes too are shuffled into oblivion . . . But the cards themselves survive the shuffling. The cards are the genes.” Richard Dawkins
- Only genes really win or lose in the evolutionary game—everything else is transitory



# Bean Bag Genetics



- Treat the genome as just a collection of genes
- Selection independently promotes one or another gene
- Application to computer programming: Genetic algorithm
  - Start with random sequence of symbols
  - Select the sequences that perform best
  - Allow small random mutations
  - Evaluate the resulting sequences



# Competition at the replicator level

- Outlaw genes--replicators that promote their own replication at the expense of others
  - Meiotic drive—increase the frequency of a gene getting to the gametes
  - Segregation distorter (drosophila)
    - Allele of a gene that somehow manages that during meiosis, cells that contain the homologous chromosome with the second allele of the gene are not functional (sperm with broken tails)
    - Any successful fertilisation will produce offspring with the segregation distorter allele
    - Good for gene but reduced fertility (bad for individual)
- Infrequent—most competition between genes occurs via interactors—e.g., organisms



# The bookkeeping argument for gene selection

- Genes are a common currency
  - Selection directly on genes
  - Selection on individuals
  - Selection on kin groups
  - Selection on species

all result in changes in gene frequency



- “I don't think one can say there is a unit of selection. Any selection process selects on units at various levels, starting with ultimate replicators such as the gene, the individual, the community in which the individual is. All these things could be considered units of selection that are being selected simultaneously, and all of them are changing the frequency of the ultimate atom of selection, which is the gene, but it is not possible to say that the gene is the sole unit of selection.” W. D. Hamilton

# So, what is a gene (again)?

- Evolutionary gene concept: any reasonable short piece of DNA that is potentially immortal—will pass on copies of itself
- What about single nucleotides?
  - Dawkins—too short
  - Must have a phenotypic effect
  - Rules out evolutionary gene concept
- How to spell out phenotypic effect?
  - Molecular gene concept—structure that gets expressed
  - Functional gene concept—difference makers

# Molecular Gene Concept

- Challenge—avoid cutting too finely so that each nucleotide becomes a gene
- But the molecular details of the gene often don't matter in terms of effects, since alternatives do just as well
  - “If we require that gene replication be robustly explained by its adaptive effects, then it is likely that many molecular genes will be excluded. It is not at all obvious that there is a way of formulating the notion of phenotypic effect that meets our three conditions: (1) it counts molecular genes as having phenotypic effects; (2) it excludes impostors like individual nucleotides; (3) the phenotypic effects of genes explain their replication propensity” (Sterelny and Griffiths, pp. 86-87)



# Functional Gene Concept— Difference Makers

- Must be context sensitive, since in different contexts may have different effects
- Characterized in terms of the propensity, when in the right circumstances, to produce the effect
- But will this functional role equate to any specific molecular type that forms a lineage”
  - As opposed to anything that might produce the effect
  - Objective: to be “tracking a constant underlying difference maker or set of difference makers” (p. 89).
- Further, will what it picks out be have the same adaptive significance in all individual
- Faces both a conceptual and an empirical risk