Lehrman's dictum: Information and explanation in biology

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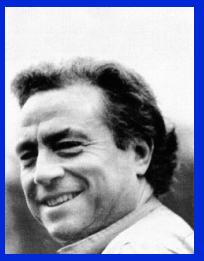
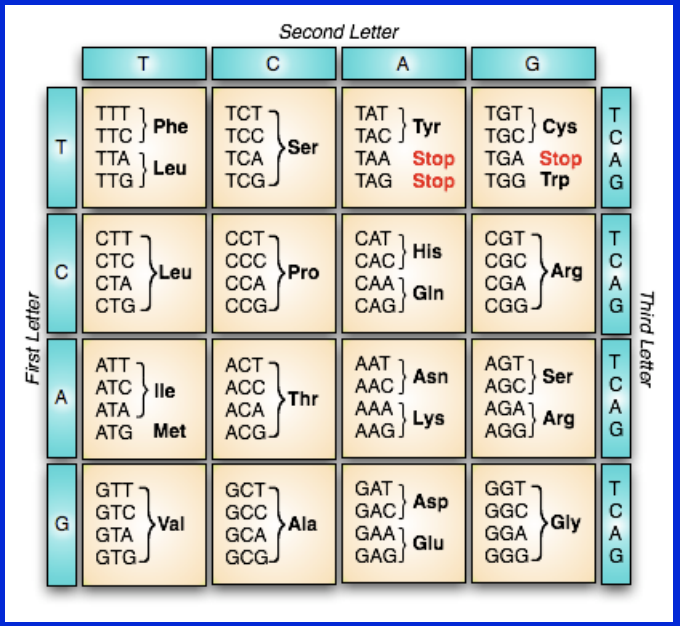
Lehrman's dictum



"…although the idea that behavior patterns are 'blueprinted' or 'encoded' in the genome is a perfectly appropriate and instructive way of talking about certain problems of genetics and evolution, it does not in any way deal with the kinds of questions about behavioral development to which it is so often applied."
Lehrman, 1970: 35

Genes and codes

- The genetic code treated as a formal language has an expressive power limited to specifying the primary structure of polypeptides
- It's effects beyond that are causal consequences of primary structure (Godfrey Smith's 'pizza argument')



Two kinds of information

- Causal/statistical information
  - ‘Natural meaning’ (Grice 1957)
  - Shannon information (Shannon 1949)
- Semantic information
  - Intentional
  - Indicatives have truth-conditions, imperatives have compliance conditions, etc

The ‘parity thesis’

- “the empirical differences between the role of DNA and that of cytoplasmic gradients or host-imprinting events do not justify the metaphysical distinctions currently built upon them.” Griffiths & Knight 1998: 254
- “...‘parity thesis,’ according to which the roles played by the many causal factors that affect development do not fall neatly into two kinds, one exclusively played by DNA elements the other exclusively played by non-DNA elements.” Griffiths and Gray 2005: 420
- Specifically applied to the idea that only genes carry ‘information’ in some sense of that term e.g. Griffiths and Gray 1994

Maynard-Smith on genetic information

"With this *[causal*] definition, there is no difficulty in saying that a gene carries information about adult form; an individual with the gene for achondroplasia will have short arms and legs. But we can equally well say that a baby's environment carries information about growth; if it is malnourished, it will be underweight.. ... Informational language has been used to characterize genetic as opposed to environmental causes. I want now to try to justify this usage. I will argue that the distinction can be justified only if the concept of information is used in biology only for causes that have the property of intentionality.... A DNA molecule has a particular sequence because it specifies a particular protein, but a cloud is not black because it predicts rain. This element of intentionality comes from natural selection."

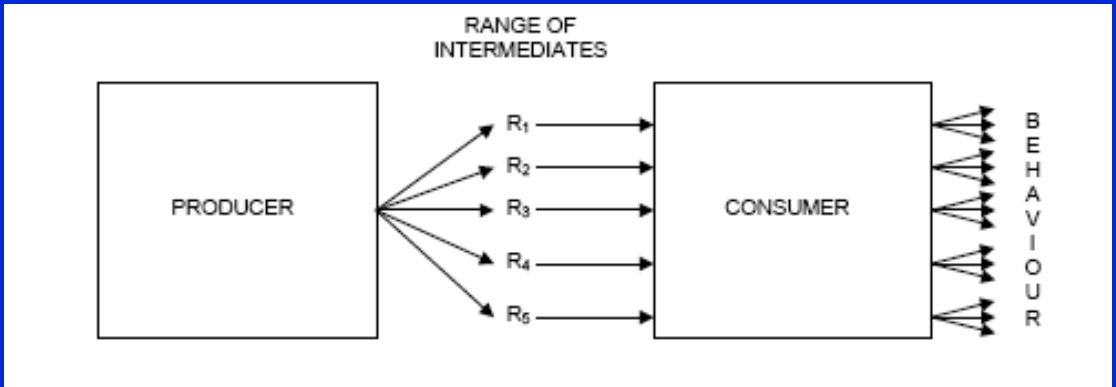
Maynard Smith 2000a, 189-190)

Why describe mechanisms as informational?

Allows generalisation across different heredity mechanisms, comparison of their properties, and formulation of evolutionary optimisation problems for such mechanisms

- Jablonka, Eva. "Information Interpretation, Inheritance, and Sharing." *Philosophy of Science 69, no. 4 (2002): 578-605.*
- Bergstrom, Carl, and Martin Rosvall. "The Transmission Sense of Information." *Biology and Philosophy (2009): 1-18.*

Shea's 'infotel semantics'

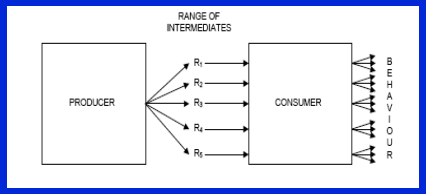


Truth conditions for **indicative** content C, of R, are given by the following:

- R's carry the *correlational information* that condition C obtains;
- An evolutionary explanation of the current existence of the representing system adverts to R's having carried the correlational information that condition C obtains; and
- C is *the evolutionary success condition*, specific to R's, of the output of the consumer system prompted by R's. That is, C is the background environmental condition that made producing X adaptive for a consumer in the past.

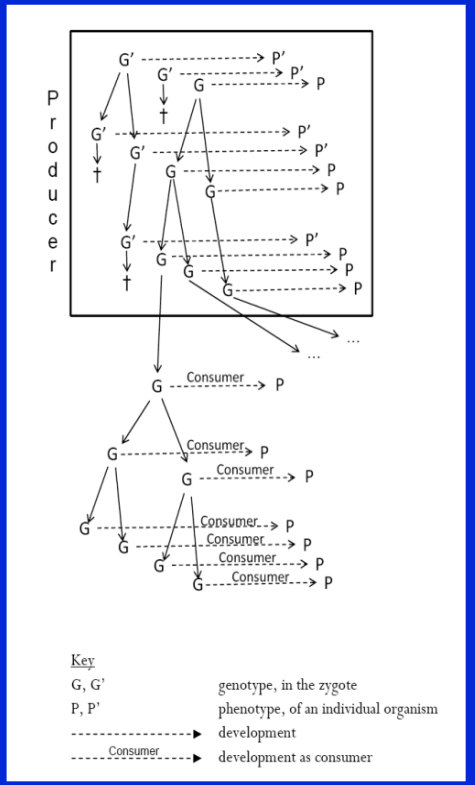
Teleosemantic transmission information for environmental signals

- Kairomones are correlated with predators
- The system evolved because kairomones are correlated with predation
- The consumer system is designed to divert resources to defense when there is increased *risk of predation*



Teleosemantics and genetic signals

- The producer system is the selective history of a *lineage* of organisms
- The representation is a DNA sequence
- The consumer system is the developmental process, including interaction with other genes and the environment



Information as a developmental cause?

- Shea claims that 'inherited representations are read in development' – the fact that a trait develops is explained by the presence of teleosemantic transmission information (TTI)
- There is a obvious problem with this – teleosemantic properties are historical and so causally inefficacious:
  - "It has often been argued that any information about phenotypes carried by genes cannot form part of an explanation of the course of individual development. However, no one has noticed why. The reason is that the semantic properties of genes are a species of selectional property... So if we seek to explain the course of individual development – the chain of processes by which an embryo becomes an adult – we should not advert to the semantic information in the genome "(Shea 2007 318-9)

Shea's 'developmental explanations'

- "We can distinguish two broad questions that can be asked about an individual episode of development: why did it arrive at a particular outcome; and how did the process unfold? This section focuses on the former, arguing that genetic representation explains some of the cases in which the outcome matches a feature of the organism's environment. We return in section 6 to questions about how the developmental process operates." Shea (In Press) ms8
- "the informational perspective can help explain why the internal mechanisms of development – developmental programs, somatic cell inheritance, etc. – take the form that they do". ms24

Proximate and ultimate

- Shea's examples of 'genetic information read in development' are *evolutionary* explanations
- They explain why development has been designed in a particular way (ultimate)
- They do not explain how development manages to proceed in that way (proximate)

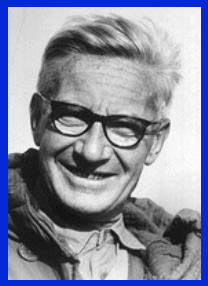
Parental effects

- *Campanulastrum americanum* is more likely to germinate in the autumn and grow as an annual if the seed comes from a plant growing in high lighting conditions.
- From an evolutionary point of view, pollen disperses over a larger distance than seeds, so it makes sense for the plant's life-history strategy to reflect the maternal environment and ignore the paternal environment.
- The offspring acquires TTI about the environment in which it will develop from its parent.

Proximate and ultimate

- Shea's examples of 'genetic information read in development' are *evolutionary* explanations
- They explain why development has been designed in a particular way (ultimate)
- They do not explain how development manages to proceed in that way (proximate)
- Obvious when you consider a non-genetic factor with teleosemantic content: "increased seed mass causes late germination by transmitting to the mechanisms of development the information that the plant is likely to grow in high lighting conditions"

Tinbergen's Four Questions

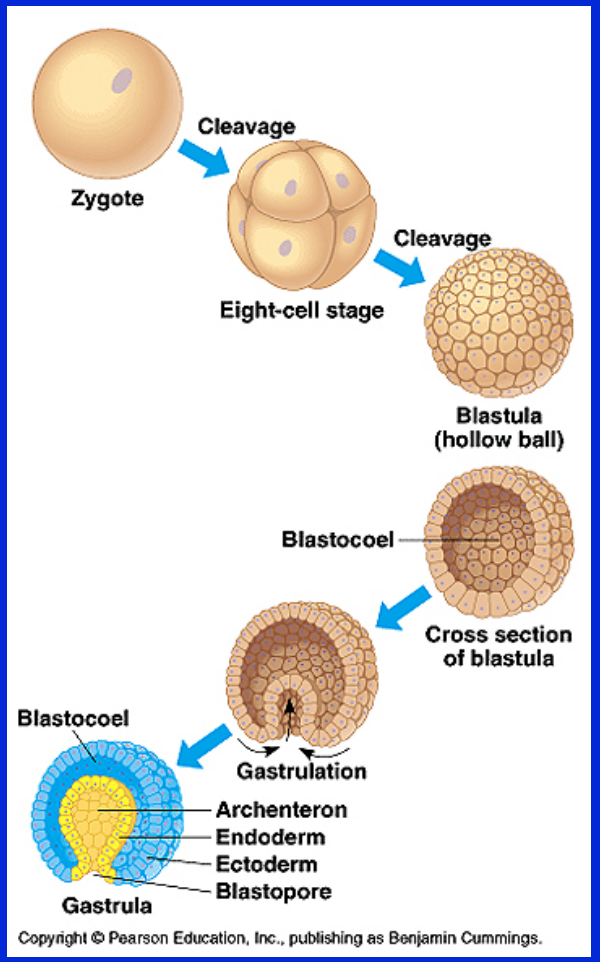


- Causation
- Survival value
- Ontogeny
- Evolution

Where do explanations of *ontogeny itself* fit into this framework?

Four questions about gastrulation

1. Causation: the molecular and cellular mechanisms by which cells in the blastula migrate and differentiate to form the gastrula
2. Survival value: ‘how survival is promoted and whether it is promoted better by the observed process than by slightly different processes.” (Tinbergen 1963, 118)
3. Ontogeny: the development of the blastula, and especially of the specific factors that will cause it to gastrulate
4. Evolution: the phylogeny of gastrulation and an explanation, perhaps adaptive, of why this stage arose and was preserved



Why is what was obvious for seed mass less obvious for genes?

- A state that carries causally inert teleosemantic information can also carries information in a causally active sense. For example, if a gene carries TTI, it will also still carry information in Crick's sense – the precise determination of nucleotide sequence.
- But this is causal information, not semantic
- Insofar as they causally explain development, the 'information' and 'signals' that flow through gene-control networks are also causal information

Conclusions

- Lehrman's dictum stands
- But Shea has identified a neglected area for the study of biological explanation, the application of the proximate/ultimate distinction or more sophisticated alternatives to developmental processes