**WEB BASED SUPP. MATERIAL FOR CHAPTER 2**

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There is no such thing as a single scientific method. Different disciplines have different ways of gathering evidence, performing experiments, constructing models and testing hypotheses. One crucial feature common to all sciences, however, is the rigorous interplay between theory and experience. One of the most successful methods that structure this interplay is the so-called ‘hypothetico-deductive method’. It was the philosopher Karl Popper who particularly noted the importance of this technique. The essential idea is that a hypothesis is framed to account for a particular phenomenon. The consequences of the hypothesis being correct are deduced and turned into predictions. These predictions are tested by experiment or by the analysis of other evidence and, if they are found not to hold, the original hypothesis from which the predictions were deduced is rejected or at least considerably modified. If a hypothesis successfully predicts an outcome, we can cautiously say that the hypothesis is supported (Figure 2.1).

Figure 2.1 The hypothetico-deductive method applied to evolutionary hypotheses – an idealised view.

THEORY DOWN APPROACH OBSERVATION DRIVEN APPROACH

Experimental investigation and/or inspection of the data

Design of experimental procedures

Reject or modify hypothesis

Higher Level Theory

Current ideas, theories, assumptions

Observations

Identification of pattern in observations thought to be significant

Formulation of a hypothesis

Deduction of consequences of truth or falsity of the hypothesis.

Accept hypothesis provisionally

Predications not confirmed

Predictions confirmed

A useful classification of different methods of testing hypotheses is suggested by Buss (1999), who distinguishes between ‘theory-down’ and ‘observation-driven’ approaches. The theory-down approach can be used to derive specific hypotheses from higher-level theories. The theory of sperm competition, for example, is one such high-level theory that can be used to derive subsidiary hypotheses The theory suggests that aspects of the physiology and mating behaviour of males can be understood by the fact that, in some species, sperm from more than one male are likely to be present at the same time in the reproductive tract of a female. From this, we could derive the hypothesis that in conditions where the risk of sperm competition is high, males will tend to produce and/or ejaculate more sperm. This can then be tested either within a species in variable conditions or between species with different mating habits. Further predictions also follow such as differences expected in the swimming speed of sperm and their volume (see Chapter 13 in printed text).

The observation-driven strategy is a sort of bottom-up approach and is a very useful one, partly because we may notice many patterns before we have a scientific explanation for them. It is crucial to realise that it is not simply forcing the ideas to fit the facts. In the physical sciences, a similar technique is sometimes known as ‘retroduction’. As an example, astronomers knew of Kepler’s laws of the motion of planets around the sun before a theory could explain them. Newton and others partly used the method of retroduction to decide what a higher-level explanation would have to look like in order to generate the known laws. Newton’s answer was the inverse square formula for gravitational attraction. In evolutionary theory, the method is sometimes called ‘reverse engineering’: the features of an organism can be used to infer backwards to the function for which it was designed. Pregnancy sickness, considered in Chapter 18, is an example of this type of reasoning.

If we find that a prediction made by a hypothesis is found to be the case we must not mistake this for proof. Popper and others pointed out that to suppose that the hypothesis is proved by a successful prediction is to commit the fallacy of affirming the consequent. The fallacy arises because it is conceivable that a false hypothesis could give rise to a successful prediction. Where we are more certain is in the conclusion that if the prediction is not observed, there must be something wrong with the hypothesis. This distinction was Popper’s most valuable contribution to the problem of establishing criteria for what counts as science and what is non-science – the so-called demarcation problem. The essence of science, according to Popper, is that it formulates hypotheses that are in principle falsifiable. Non-sciences (astrology may be an example here) make do with vague general statements that conveniently avoid an open confrontation with facts (Popper, 1959).

Some critics of modern evolutionary theory have suggested that evolutionary hypotheses are non-scientific since they are ad hoc and, being specific only to the trait in question (like the Just So Stories), lack generality to allow testing elsewhere. It has also been suggested that evolutionary theory is not truly predictive (as good science should be) since it refers to past events rather than future occurrences. These points, as a general critique of evolutionary reasoning, are in fact easily dismissed. Evolutionary hypotheses are often of necessity post hoc in that they refer to evolutionary processes that operated long ago when we were not there to observe them, but they are not inevitably ad hoc. In addition, the prediction of future events is not a necessary condition for a discipline to be scientific; if it were, we would be forced to re-evaluate the status of geology, palaeontology and other sciences dealing with the past. It is of course important that scientific theories predict unknown findings, but these could be in the past, present or future. Evolutionary theories, can, for example, make predictions about fossils of intermediary species yet to be discovered. In essence, evolutionary theory is in principle falsifiable, although it has not yet been falsified.

* 1. **Orders of explanation in evolutionary thinking**

One of the great strengths of evolutionary thinking is that it enables us to answer ‘why’-style questions in a scientific and non-metaphysical fashion. Consider the questions posed in Table 2.1 . There are at least three types of answer to these questions: teleological, proximate and ultimate.

If we answer that the reason the fur of a stoat turns white in winter is to help with camouflage, we are, strictly speaking, reasoning teleologically. Camouflage is a consequence of the fur turning white; it is an effect of the change of colour, and an effect cannot be a cause. To avoid this, we might resort to identifying prior causes that triggered the change in colour, such as a hormonal response to falling temperatures and reduced daylight. This may be a correct response physiologically but is somewhat unsatisfying; all we have done is to identify a proximate causal mechanism. We have provided the ‘how’ of the process but have not explained why such processes exist. In the language of Tinbergen we have identified a causal mechanism (see Chapter 1).

The ultimate causal explanation rests in the third column of Table 2.1: genes that code for a change in coat colour exist because they conferred a survival value on the stoats that possessed them. Natural selection cannot think ahead like the teleologist and plan a set of genes to achieve some purpose. We sweat because a chance mutation in our ancestral genes conferred some fertility advantage on our predecessors; sweating is an adaptive or functional response. One of the remarkable features of Darwinism is that, for the first time in the life sciences, it provided satisfactory answers to ‘why’-type questions. Without Darwin, nothing in life really makes sense. Consider the question ‘Why are we here?’, which carries a miasma of spurious profundity. To a committed Darwinian, we are here because we carry genes that were successful at self-replication. Similar genes that were less successful are not here for us to observe: none of us is descended from sterile ancestors. The nature of genes is to make copies of themselves not with any grand plan or purpose in mind but simply because that is what they do. In a sense that is non-tautological, we are here because we are here. To paraphrase Wittgenstein, a cloud of metaphysics is thereby condensed into a drop of Darwinism.

If we compare the terms ‘proximate’ and ‘ultimate’ to the four ‘whys’ of Tinbergen considered in Chapter 1 of printed text (causation, development, evolution and function), we can note that proximate translates to causal and ultimate to functional. The distinction is important as a means to an intellectual understanding of evolution, but, practically speaking, the four questions of Tinbergen should not be treated as isolated areas of inquiry but instead as concerns that are interdependent. Natural selection has shaped behaviour to serve its present function in ensuring the survival of the genes responsible, but we must also acknowledge that natural selection has determined the way in which the causal mechanisms that initiate the behaviour begin their work. Ontogeny (development) may also be linked to function in that the precise course of development in an individual may be sensitive to local conditions in order to achieve the best adaptive fit to current circumstances.

Examples of this are discussed in Chapter 8 of printed text, where a highly important component of evolutionary thinking, Life History Theory (LHT), is discussed. Another example concerns the Westermarck effect discussed in Chapter 17 of printed text, in which the ontogeny of sexual desire is influenced by members of the opposite sex associated with during childhood. If Westermarck was right, we develop to experience no sexual desire for those whom we grew up with in close proximity. The adaptive significance of this, and hence of the incest taboo that proscribes mating between kin, is that sibling mating can reduce the fitness of offspring. Thus in this case, we see an integration of function, causal mechanism and ontogeny.

Table 2.1 Types of explanations in evolutionary thinking

|  |  |  |  |
| --- | --- | --- | --- |
| Question | Teleological | Proximate | Ultimate |
| Why does the fur of stoats (Mustella *erminea*) turn white in the winter? | To become better camouflaged | Hormonally -mediated response to day length and ambient temperatures | Advantages once ( and still) conferred : differential survival of genes |
| Why do humans sweat when hot? | To lose heat by evaporative cooling | response of sweat glands to high temperatures | Advantages once (and still) conferred : differential survival of genes |

One of the most neglected questions of Tinbergen in behavioural studies has often been that of evolutionary history – the very question that Lorenz thought most crucial. Recent studies on phylogeny are redressing this imbalance and promise to throw light on functional questions. The evolution of concealed ovulation in human females, for example, could help to elucidate the function it served and serves. Another way of thinking about the proximate-ultimate distinction is that proximate mechanisms generate types of behaviour and ultimate explanations address why they are favoured (see Scott-Phillips et al, 2011). In Chapter 5 we explore this further by examining the evolution of *Homo sapiens* from other Hominin species.

**2.3 The manifesto of Tooby and Cosmides**

The key principles of this paradigm are as follows:

1. The human mind is what the brain does. It is an information-processing device that receives inputs and generates outputs in a manner directly analogous to a computer. In this view, both thought and behaviour are cognitive processes. Consider the example of how to act towards kin. Kin selection theory (see Chapter 11) suggests a number of factors that must be taken into account in dealing with kin, such as the degree of relatedness of kin to the self, their reproductive value and the costs and benefits of any action undertaken. To behave appropriately requires a cognitive computational program that factors these parameters into the decision-making. Simple instincts, they argue, will not suffice.

2. The neural circuits that make up the brain were ‘designed’ by natural selection to solve problems that our ancestors faced in their environment of evolutionary adaptedness (EEA). Such problems were repeatedly encountered and, more importantly, impinged on the survivability of the organism concerned: problems to do with growth, survival, harvesting resources, avoiding predators, finding mates, reproducing and so on.

1. The way in which brains solved the vast array of adaptive problems was not through some general problem-solving device, which would probably be highly inefficient, but through the construction of a set of discrete and functionally specialised problem-solving modules. Each module is capable of responding to and solving a problem only over a restricted domain; hence they are called ‘domain-specific modules’. Tooby and Cosmides use the analogy of a Swiss army knife with numerous blades and attachments for specific purposes.
2. Cognitive mechanisms that were sculpted during the hundreds of thousands of years that humans spent in a hunter-gatherer lifestyle will not necessarily appear adaptive today: we carry Stone Age minds in modern skulls.
3. Because humanity belongs to one species, all members of which can pool genes with any other member of the opposite sex to create viable offspring, so the variability between mental organs must be limited. These domain-specific mental modules are therefore common to all people, with only superficial intergroup variation. Tooby and Cosmides use an analogy with Gray’s Anatomy:

‘*Just as one can now flip open Gray’s Anatomy to any page and find an intricately detailed depiction of some part of our evolved species-typical morphology, we anticipate that in 50 or 100 years one will be able to pick up an equivalent reference work for psychology and find in it detailed information-processing descriptions of the multitude of evolved species-typical adaptations of the human mind. (Tooby and Cosmides, 1992, p. 68)*

What follows from this is the fact that the genetic variation that exists between people and peoples will inevitably be minor and have very little effect on the cognitive architecture common to all that constitutes a universal human nature.

1. As with all manifestos, there is an enemy, the enemy in this case being the ‘standard social science model’. The only feature of this model that is accepted by Tooby and Cosmides is the idea that genetic variation between racial groups is trivial and insufficient to explain any observed difference in behaviour. From thereon, there is fundamental disagreement. The social science approach, which they admit for this purpose is a conflation of many schools of thought, is taken to suggest that the mental organisation of adults is determined by their culture. As such, the human mind has as its main property merely a capacity for culture. Culture itself rides free from any strong influence from the lives of any specific individuals and certainly free from human nature. The blank slate approach is of course an oversimplification, but Tooby and Cosmides detect in the social science literature an assumption that the human mind is akin to a computer without programs: it is structured to learn but obtains its programs from an exterior culture rather than an interior nature.

**2.4 The growth of HBE.**

Nettle et al (2013) conducted a survey on the growth of HBE as a discipline by focussing on the contents of 17 key journals over an elven year period (2000-2011) They found that HBE had experienced a significant shift away from its early concern with hunting and gathering populations towards an increased focus on humans in industrialised societies. In terms of disciplines in which the practice of behavioural ecology was observed, about 50% of papers came from anthropology, 20 % from psychology, 13% from biology and the remainder from areas such as medicine, public health, sociology and political science. In broader terms the number of papers produced doubled over the first decade of the 21st century.

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