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The causal logic of natural selection: a general theory

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Abstract

Every change or continuity properly attributed to natural selection can be entirely accounted for as the outcome of one or more *self-emplacements* of *instructions*, where:

(i) instructions are minimal behaving structures (including, but not limited to, genes and memes); and

(ii) an instruction emplaces itself when (a) it *occurs* at a certain spatiotemporal location, and (b) it would not occur there/then had it not *behaved* at a certain prior location.

That microtheoretical formulation, as elaborated in the paper, enables the construction of explicitly naturalistic *causal-functional* explanations of many phenomena of biological and social science, including some which have resisted selectionist explanation in the past.

In particular, it leads to the idea of a *distributed predatory quasi-system*. Carried by different organisms, several instructions emplace one another, and thus maintain themselves as a mutualistic group, at the expense of the host organisms (and their other genes and memes).

A notation method is presented for depicting and analysing event sets of natural selection.

1. Introduction

(i) This article represents an attempt at a logicophysical reconstruction of Darwinism. Emphasizing, as it does, the central importance of the individual instruction (gene or meme), it is a formalization of Dawkins' *The Selfish Gene* (1976) and 'Universal Darwinism' (1983). I think, however, that it also makes certain theoretical contributions to evolutionary biology in its own right.

(a) Specification of *self-emplacement*, the generic process common to all life activities, and its relationship to more specific processes (such as replication and learning).

(b) An explicitly naturalistic explication of causal functionalism, setting forth the means by which environmental features cause adaptation, and thereby managing to be both 'purely causal' and 'adaptationist' (Lewontin 1983, p. 367) at the same time (section 13).

(c) A novel way of looking at competition and its role in evolution.

(d) Identification of a mechanism whereby an extrasomatic grouping of

instructions may seize control of one or more organisms and 'operate' them to its advantage and (probably) their detriment.

(ii) While the article emphasizes natural selection and the reconceptualization thereof, it is really about life processes in general. Indeed, from the point of view of the fundamental causal processes involved, the boundary between evolving via natural selection and simply being alive is essentially an arbitrary one.

(iii) Some of this is explicitly anthropological, indeed cultural-anthropological. As will be shown, however, a human culture is a living system, so cultural examples are entirely apposite. Indeed, there may exist some supra-human cultures, which also are living systems.

Although my primary training has been in cultural anthropology, I favour the unity of science over the uniqueness of anthropology and the unity of nature over the uniqueness of *Homo sapiens*. But I am not trying to 'reduce anthropology to biology', as some of my anthropological colleagues might believe (and derogate); rather, I am trying to expand evolutionary biology to include anthropology, both biological and cultural.

2. Organization

This article is organized as follows:

- An 'ecological scenario' (section 3) gives a hypothetical example and overview of the entire enterprise, illustrating self-emplacement at work.
- The main text (all sections between 3 and 34, exclusive) presents the theory, and its sometimes rather surprising implications, in detail.
- Novel terms and usages, and notation method, are developed logically in a *glossary* (section 34).

There are several novel ideas here, and many old ideas with novel implications and relationships; very often, full understanding of one idea depends upon understanding many, perhaps even all, of the others. For that reason, it will probably be necessary for the reader to make two 'passes' through the text, perhaps pausing between passes to read the glossary as a unit.

3. An Ecological Scenario

On a lifeless planet — not Earth, but very much like the Earth of 4 billion years ago — there is an ocean. Within the ocean is a sea like Earth's 'primordial soup': along with water, simple salts, etc., it contains an abundance of 'middle-sized' molecules — fatty acids, sugars, perhaps amino acids and nucleic acids, etc.

From time to time middle-sized molecules meet and, where conditions are just right, bond together to form large molecules. Occasionally, a large molecule includes several dozen of the middle-sized molecules; it is a

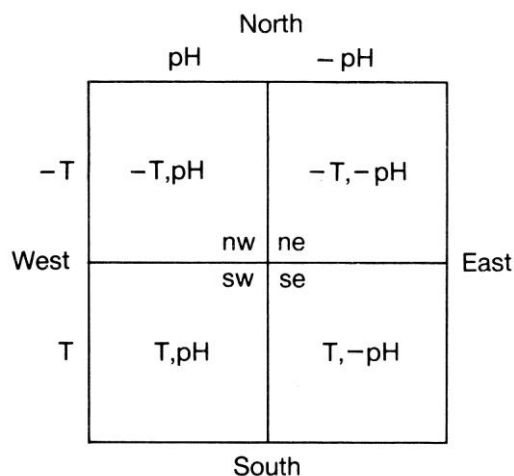


Fig. 1. The pool.

macromolecule. Macromolecules are not very stable; over most of the sea they decompose within a second or two, because one or more of the conditions necessary for macromolecular survival ('S-conditions', section 15) is absent.

Within the sea, however, there is a pool in which all of those conditions are met all of the time, except that the east half of the pool is too low in acidity (is '-pH') and the north half is too cold (is '-T')¹. Schematically, then, the pool looks like Fig. 1.

When a macromolecule happens to occur spontaneously in the southwest quadrant of this pool, then it *survives* (indefinitely, let's say). In the other quadrants, of course, decomposition promptly occurs as elsewhere in the sea.

Our interest now focuses upon spontaneously occurring macromolecules of four particular kinds called, for mnemonic purposes, *htrs*, *sours*, *glumkrs*, and *filmkrs*. *htrs*, as it happens, have the following peculiar capability: Whenever a *htr* bumps into a sugar molecule, which happens quite regularly, the *htr* binds to the sugar molecule and dismembers it, releasing its component parts and a quantum of *heat*, thus warming the soup in its immediate vicinity ('Instruction' and 'Behaviour', section 6). When a *htr* occurs spontaneously in the northwest quadrant and then behaves, therefore, it meets the only missing survival-condition for macromolecules in a small area. For a brief time, a macromolecule can survive there. Now, while other macromolecules (such as *sours*) may just *happen* to occur at the right moment in that small area ('Passive parasites', section 16), a *htr* — the one that just behaved — *always* occurs there (barring accidents), and hence survives there. So now we have macromolecules surviving in the northwest quadrant, and most of these are *htrs*.

Macromolecules now occur in the west half of the pool because all survival conditions of macromolecules are now met there. In the northwest quadrant, however, *htrs* occur disproportionately because the meeting of

¹ '-T' and '-pH' mean, respectively, that the temperature or acidity condition is *not* met abiotically in the indicated portion of the pool.

all survival conditions in that quadrant is *contingent* upon the behaviour patterns of *htrs*.

As time passes, more and more *htrs* occur and survive in the northwest quadrant. The supply of free 'precursor' molecules — middle-sized molecules of the sorts that make up macromolecules — is thus gradually diminished until spontaneous occurrences of macromolecules become very rare ('Competition', section 19) and there are practically no, macromolecules other than *htrs*².

Later on, the pool-environment happens to have changed slightly and middle-sized molecules of a new kind have become common³. When a *sour* bumps into one of these new molecules ('Cue-condition', section 6), the outcome includes an increase in the acidity of the soup in its immediate vicinity. *Sours* now survive in the southeast quadrant in the same way, and for the same reason, that *htrs* survive in the northwest.

In the northeast ($-T$, $-pH$) quadrant, however, something novel is taking place. Whenever a *htr* and a *sour* happen to occur close together at the same time, they both survive because each, by its behaviour, enables one of the two missing survival-conditions of both to be met ('Co-operation', 'System', section 16). As time passes, therefore, practically all the precursor molecules in the northeast become tied up in *htrs* and *sours* occurring in clusters (minimally, in pairs; section 17).

Without being held together physically, the instructions stay in certain spatial relations (in the example mere propinquity) so that they can continue to *function* (section 23). [In the same way, quite large groups of instructions for various gross behaviours, carried by different individuals (indeed, even individuals of different species or, in the case of humans, of different ethnic groups or classes), come into being and endure, when their behaviours collectively create/preserve an environment survivable for them all — again, without the spatial relations necessary for this being maintained physically. All that is required is (i) that there be some means by which the instructions are re-supplied (in the example, by spontaneous generation) and (ii) that instructions be eliminated if not in the requisite relationship. What follows is intended to show how these fundamental processes may lead to the physical bonding of co-operating instructions (e.g., in chromosomes) and/or their physical co-envelopment (e.g. in organisms).]

In the eastern half of the northeast quadrant, we now observe, *turbulence* sometimes breaks up the *htr-sour* pairs. Shortly after they are separated, of course, the *htr* and the *sour* both decompose. We now turn our attention to the macromolecule *glumkr*, which modifies some middle-sized molecule to make the latter bond easily to two or more macromolecules. As a result of this behaviour, *glumkrs* often survive in the northwest and southeast quadrants when they happen to occur near to and then are glued to, respectively, a *htr* or a *sour* ('Predation' section 30.1).

² Non-*htrs* may occasionally diffuse north from the southwest quadrant, of course, and survive for a second or two.

³ This environmental change is posited strictly for didactic purposes; the 'new' molecules and their effects could just as well have been present all along.

Similarly, in the west half of the northeast quadrant, they survive when they happen to occur near a *htr-sour* pair. In the eastern half of the northeast quadrant, however, macromolecules survive best in glued-up clusters which include a *htr*, a *sour*, and a *glumkr*; *in that eighth of the pool, after a time, macromolecules occur only in such clusters.*

Up to this point, of course, macromolecules are surviving only within the confines of the pool. To the north of the pool, for example, the sea of soup is so cold that behaviour of *htrs* are unable to maintain the temperature condition for survival of macromolecules. We now examine the fourth 'interesting' macromolecule, *filmkr*. A *filmkr's* behaviour facilitates the bonding together of many middle-sized molecules of a certain kind into a thin film. As the bonding process goes on, these films often form into small bubble-like envelopes. Inside such an envelope, a *htr* is able to keep the temperature at *T*, the level defining the temperature condition for survival of macromolecules. When an envelope happens to surround a *htr*, a *sour*, a *glumkr*, and a *filmkr*, therefore, the resulting structure ('Organism', section 20) and its 'tenant' macromolecules can survive outside the pool to the north. Our fledgling system has *evolved* across its first *frontier* (section 18).

As we end our little scenario, then, the relative frequencies of the different macromolecules in the biotic subregions of the sea are as represented schematically in Fig. 2.

The scenario is a parable of natural selection and of evolution through natural selection; indeed, of life processes in general. The process through which the primitive organism north of the pool succeeds, maintains itself, and (presumably) will propagate, is entirely *naturalistic*, i.e. physical and

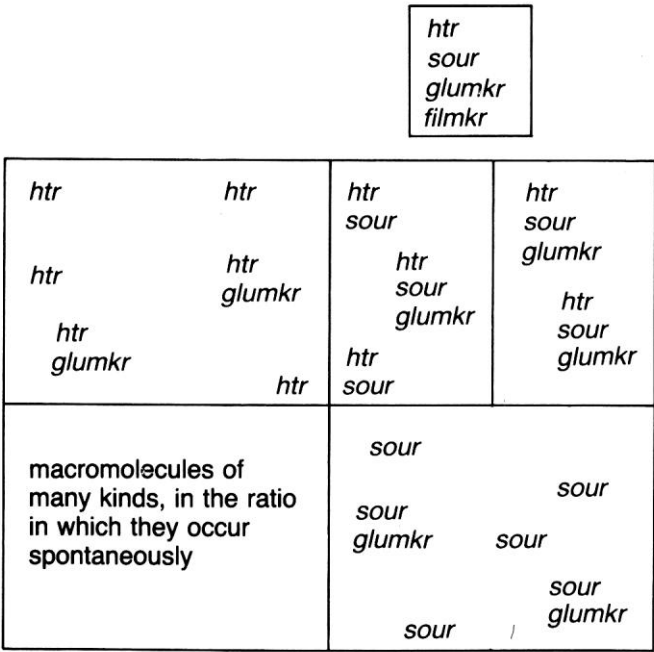


Fig. 2. The pool and vicinity at the end of the scenario.

chemical. That process, natural selection, is made up of thousands of *little* events wherein some tiny structure behaved in a particular way and by its behaviour enabled another occurrence of itself, directly and/or through enabling the occurrence of some other behaving structure(s)⁴. Such behaving structures (*htr*, *sour*, *glumkr*, *filmkr*, etc.) are *instructions*. Each time the behaviour of an instruction enables another occurrence of itself (or of an interchangeable instruction), that is an instance of *self-emplacement*, the process underlying natural selection (section 10). Any observable or inferable case of natural selection is the product of many such instances (section 22). Natural selection *per se*, therefore, does not necessarily presuppose self-replication⁵, organisms, reproduction, or competition. Indeed, since a behaving structure (instruction) of any kind may be able to emplace itself, natural selection is not confined to genes or their products.

4. Microtheory

This is a *microtheory* of natural selection (Hempel 1965, p. 259); that is, it is a theory based on the proposition that every large-scale change or continuity properly attributed to natural selection can be entirely accounted for as the outcome of many small-scale events and the causal relations among them. The latter events and relations, and the way they account for large-scale changes and continuities, are specified and described below.

5. Naturalism

Students of human conduct sometimes search for the 'laws of history'. *There are none* — except the basic laws of physics, which by definition, are never violated by human action or by any other sort of event. Remembering this can save us from all manner of metaphysical and teleological traps. But what we need mainly here is not so much those overarching and inviolate principles, approximations to which are to be found in any good textbook of physical science, as the special derivative guises in which they are manifested in the domain of life and in the narrow sector thereof which is the life of our own species. (Hockett 1973, p. 282).

The theory is explicitly *naturalistic*; that is, the small-scale events and causal relations that account for large-scale cases of natural selection are themselves accounted for entirely by citing (a) other, prior events, and (b) causal forces and principles admitted by physical science. In other words, the theory provisionally assumes that no special forces or principles, additional to those confessed by physical science, exist, or are required to explain living things, animal behaviour, or human activities. If, indeed, any such special force is required, the only reliable way to discover and verify it

⁴ Or through some other intermediary process yet to be discussed.

⁵ 'Self-replication' is actually the copying of one or more instructions by a special mechanism (section 21.2).

is by demonstrating, through rigorous application of naturalistic theories like the present one, that such theories cannot explain certain phenomena⁶.

Although most biologists apparently assume that natural selection is a naturalistic process, their actual everyday usage seems to belie that assumption. Instead, they rely on locutions such as the following:

(i) The process is expressed in non-naturalistic metaphors, using a language of teleology and even mentalism such as the 'selection' metaphor itself or the 'strategy' metaphor, wherein the organism apparently 'chooses' changes in its genotype that will enhance its selective fitness.⁷

(ii) The process *qua* process is ignored, and *outcomes* of the process are treated as if they *were* the process. 'Differential reproduction' or a synonym, for example, is often used to define or characterize natural selection (Pittendrigh 1958, p. 397; Simpson 1958, pp. 18-9; Williams 1966, p. 22; Wilson 1975, p. 589; Lewontin 1980/84, pp. 244-5; Lumsden and Wilson 1981, p. 377; etc.), but differential reproduction is *not* the process (Williams 1973/84, p. 88-9; Mills and Beatty 1979/84, p. 53; Sober 1981/84, p. 204); it is, rather, one *outcome* of the process. Natural selection deserves to be analysed for what it is and actually does; not just for what it (often, but not always) accomplishes⁸.

(iii) The causal nature of the process is recognized, but natural selection is simply left as a causal force in its own right, or probabilistic concepts like 'fitness' or 'selection coefficient' are endowed with causal efficacy (e.g. Sober and Lewontin 1982/84, p. 215).

6. Unit: the instruction

[A symbolic notation method for diagramming the causal relations inherent in biological processes is introduced in this section. Throughout the article, the diagrams do not merely illustrate the narrative text; they

⁶ For an excellent discussion of naturalism, see Nagel (1956). Naturalism is akin to physicalism [Feigl 1953; Hockett and Ascher 1964, p. 136 (fn. 5)], to mechanism (as opposed to vitalism), and to philosophical materialism (as opposed to idealism, mentalism, or spiritualism). It is reductionistic in the sense that the number of causal forces/principles is held to a minimum (four, at the most); *not* in the sense of claiming that the subject matter of one science can be deduced from that of another, more fundamental science; and *not* in the sense of claiming that sociology can be 'reduced' to psychology, psychology to behavioural genetics, etc.

⁷ There is another 'strategy' metaphor wherein the organism 'chooses' different gross *behaviour* (i.e., behaves differently) under different environmental conditions, as in 'reproductive strategy' (e.g. Thornhill and Thornhill 1983), 'optimal foraging strategy' (Smith 1983), etc. If the 'choice' behaviour is genetically programmed into the organism's nervous system, and if it increases the number of times the genes carried by the organism are passed along (thus, by definition, enhancing the organism's fitness), the 'choice' behaviour, and the genes that programmed it, will be selected for; indeed, the 'strategy' metaphor would not be employed if that was not the outcome. But this metaphor differs from the other in the nature of what is being 'chosen' — behaviours (or other phenotypic features) in this case, genes in the other.

⁸ Alexander combines locutions (i) and (ii) when he implicitly defines natural selection as 'the differential reproduction of genes, realized through reproductive striving of individuals' (1979, p. 63).

frequently present ideas and information not provided elsewhere. It is therefore necessary to understand each diagram and its implications before continuing to read. To make that easy, explanatory material is provided for each symbol and concept when it is introduced; and the glossary (section 34) is available as well.]

The theory is *unit-based*; that is, the 'unit of selection' is not itself being shaped by current selection, as is an organism or some collectivity or feature of organisms⁹.

The units of the theory are *instructions* of certain kinds. An instruction is a material structure so constituted that in its usual surroundings it is capable of *behaving* in just one rather simple, discontinuous way. To say that a structure behaves at some location is to say that an occurrence of it *emplaces* (enables an occurrence of) a *change* at that location. As a rule an occurrence of some other change (the cue or releaser or stimulus) is a co-determinant of the behaviour/change. In Fig. 3a each phrase (or clause) represents an event (i.e., an *occurrence* of a *thing*¹¹ at a particular location) and each arrow (→) represents 'enables'. Figure 3b shows an example, from the ecological scenario (section 3), of an instruction behaving.

A behaviour initiates a whole determinant sequence (section 11) of changes, but the word 'behaviour' is reserved for the most proximate of those changes - often a temporary change in the instruction itself, as in the contraction of a muscle protein or the firing of a neuron. A gene or an enzyme (or other catalyst) is a good example of an instruction that does not itself change when it behaves¹².

As a result of 'honing' (section 19.2), instructions that have propagated (through natural selection) are generally rather precise in their behaviours. They behave only in the presence of specific cues and the behaviour enables only a very specific change in structures of a very specific sort. Occasionally, a variation in the constitution of an instruction results in a difference in its behaviour, in which case it is a different instruction: more often, however, such a variation results either in no difference in behaviour or else in no behaviour at all; i.e. in a structure that is not an instruction. In a word instructions, like their behaviours, are *discontinuous*.

The instructions of principal interest here are 'naturally' occurring instructions such as genes, enzymes, neurons, groups of interacting neurons, and so forth. A machine instruction in a computer or a line in a cake recipe is, however, a perfectly valid example. A typical cake recipe instruction is cued by some resultant of the behaviour of the preceding

⁹ For a strong discussion of the unit of selection see Dawkins (1982), p. 81 ff.

¹⁰ The behaviour/change may or may not in turn emplace further change(s) in the structure(s) involved in the cue, i.e. there may or may not be *feedback*. Besides the cue, there is also generally a reliable *energy source*; an instruction may be viewed as a transducer, a converter or focuser of energy.

¹¹ A thing is a structure, relation, or change.

¹² It may seem odd to speak of an instruction's *behaving*. Note, however, that biologists frequently speak of a gene's *coding* a certain protein. There seems to be no doubt that genes are instructions and that coding is behaviour.

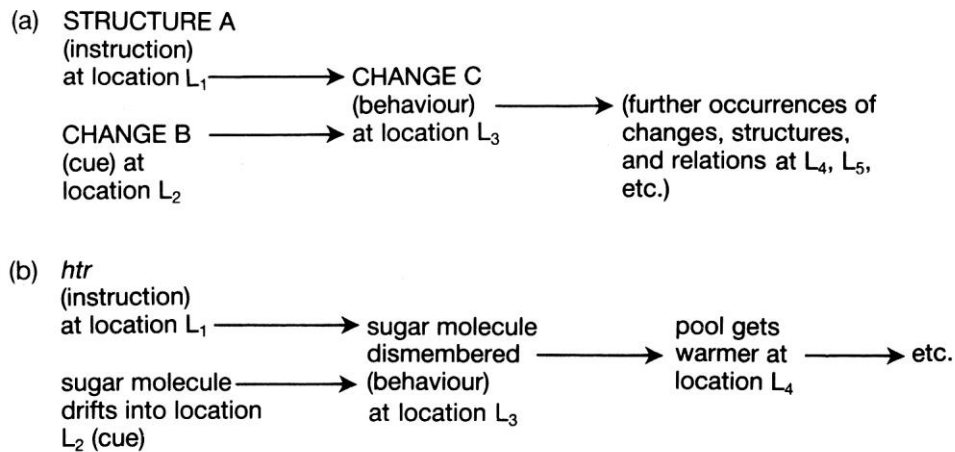


Fig. 3. (a) An instruction behaves. (b) A *htr* dismembers a sugar molecule.

instruction in the recipe; its mechanisms of execution include the baker and all his (neural) recipe-following instructions; and its behaviour is whatever happens in the baker's nervous system as a result of his reading it (Cloak 1975b; cf. Dawkins 1982, p. 175).

Since instructions are the basic units, the theory does *not* purport to explain their origin; it does, however, provide the basis for explaining *occurrences* of particular instructions in particular spatiotemporal *locations*. By explaining occurrences of instructions, moreover, the theory explains occurrences of instruction-clusters (such as genomes) and of their behaviour-products (such as organisms, their actions or 'gross behaviours', social structures, and artifacts), and it thereby explains absolute and relative *frequencies* of occurrence of instructions, clusters, behaviours, and products.

While 'anything that behaves uniquely, simply, and discontinuously' is technically an instruction, the units of principal significance for an evolutionary theory, i.e. the 'units of selection', belong to the sub-set of replicable instructions (sections 21.2 and 26) or, as Dawkins (1982, p. 83) calls them, 'replicators': (a) genetic instructions (genes) and (b) cultural instructions (memes: neural instructions replicated via observational learning or verbal tuition).

7. Behavioural outcomes and products: not guaranteed

This theory is about the *process* of natural selection — what it is and how it works. It is not about global explanations or predictions either of evolutionary outcomes in general¹³ or of human behaviour in particular.

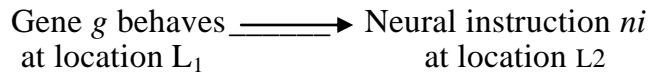
¹³ For instance, a gene may 'succeed' for an indefinite period as a result of blind luck — drift or 'hitchhiking' (Lewontin 1983, p. 367). Such cases no more refute a theory of natural selection than a boulder at rest on a ledge refutes a theory of gravitation.

Any predictive value it may have will be worked out in its applications (section 32.2).

Especially, this theory does not support so-called 'genetic determinism' or, indeed, vulgar determinism of any sort¹⁴. The 'determinant relation' or 'enabling' concept of causation — the only concept of causation to be employed in this theory — precludes any notion that an instruction's behaviour has some inevitable generalizable effect or outcome or product. If we were to speak, for example, of a 'gene for blue eyes', we could only be talking about a gene behaviours of which have been known to *enable* occurrences of blue eyes (Dawkins 1982, pp. 24-6).

Any behavioural outcome or product is invariably *contingent* not only upon the prior behaviour, but also upon a *myriad other* antecedent events (co-determinants, section 13). More particularly, in the real world every occurrence of a given product of a certain instruction is contingent upon the co-ordinated behaviour of scores of other instructions as well as upon countless abiotic events.

The fact that those other determinants have frequently been present in the past by no means guarantees that they will be present in the future and, therefore, neither the fact that instruction X behaved in the past nor the fact that its behaviour 'produced' outcome Y in the past guarantees that either of those events will happen in the future. This diagram



for example, *assumes* that event [neural instruction *ni* at location L_2] is contingent upon many many events besides [gene *g* behaves at location L_1] including the behaviour of many other genes¹⁵. Moreover, like all other expressions of this theory, the diagram assumes (in this case, explicitly) that the event-set portrayed is *singular*, being made up of singular events — occurrences of things at specified spatiotemporal locations — and singular causal relationships (but see Sober 1984b, p. 295 ff.). In order to speak generally, therefore, one must refer to event-sets *like* that shown above. Hence, the diagram can in no way be a generalization about occurrences of *ni* — not even a generalization that such events are contingent upon behaviours of gene *g*.

8. Parsimony

No cluster or product of instructions is taken as a given — clusters and products occur only under certain conditions, last only as long as those

¹⁴ Dawkins's chapter 'Genetic Determinism and Gene Selection' (1982, pp. 9-29) is an excellent discussion/refutation of the 'myth of genetic determinism'.

¹⁵ [Gene *g* behaves at Location L_1] is singled out for inclusion in the diagram because, no doubt, the contingency of [neural instruction *ni* at Location L_2] upon it is the focus of discussion. Most likely, *g*'s behaviour replaces the 'fine structure' or 'uniquely defining S-condition' (section 15) of *ni*.

conditions last, and change as those conditions change. The theory, in short, assumes only that instructions occur from time to time. It does not assume that instructions occur in clusters, or have products, of certain kinds. It does not, for example, assume that instructions occur in certain semi-rigid formats such as chromosome pairs; or that organisms or certain features of organisms, such as replicating machinery, occur at all. On the contrary, it purports to *explain* such arrangements and structures as products of natural selection¹⁶.

9. General theory

Because the theory does not make such assumptions about its subject matter, it is a general theory which can explain not only recent genetical evolution but also both the evolution of the earliest living entities and the evolution of cultural features, including the institutions of human societies.

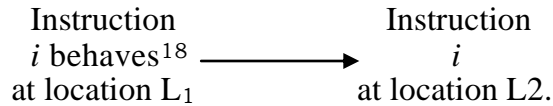
[It has been argued, by Munding (1980, pp. 200-4), Durham (1976, 1982a), Ruyle (1973), and others, that culture and genes are subject to selection processes of two quite different kinds and that, therefore, the term 'natural selection' should be reserved for genes and some other term such as 'cultural selection' or 'psychological selection' should be applied to the selection of cultural features. This article, as a whole, attempts to refute that argument¹⁷.]

10. Self-emplacement: the determinant relation underlying natural selection

Any case of natural selection is the product of instances of a simple causal relation of a particular kind: the behaviour of an instruction *enables* a subsequent occurrence of that instruction or of a functionally identical (i.e. interchangeable) instruction; in other words, an instruction *emplaces itself*. Schematically,

¹⁶ The premise of *naturalism* (section 5) establishes another parsimony, parsimony with respect to unexplained causal forces and principles ('Spooks', Cloak 1981b).

¹⁷ A more specific refutation requires the employment of terms developed in the sequel. To be sure, some routeway markers are 'specialized' for emplacing the self-emplacement of replicables of just one kind; for example, the mechanisms of meiotic drive and sexual selection for genes and the mechanisms of prestige-enhancement for memes. Such markers, however, appear always to be products of (i.e. emplaced by) sub-systems whose function is to control self-emplacement (section 21); those sub-systems have themselves evolved to operate upon replicables of just one kind. The vast majority of markers, moreover, can occur in routeways emplacing the self-emplacement of replicables of *either* type. For example, the presence of malarial parasites in people's blood has been a (despitant) marker in routeways emplacing the self-emplacement of both haemoglobin *s* (a gene), on the one hand, and the memes emplacing the clinical use of quinine and other anti-malarial drugs, on the other. Here the selection process is clearly the same for gene and meme; to call it 'natural selection' for the gene, but something else for the meme, suggests a hidden agenda of mentalism for cultural evolution.



Now to say that the one event *enables* another event is

- (i) to affirm the second event, or *resultant*; and
- (ii) to assert that the resultant is *contingent* upon the first event, or *determinant*.

Every self-emplacement therefore has *two elements*:

- (1) the instruction in fact occurs in the subsequent spatiotemporal location; and
- (2) it *would not* occur there had it not behaved in the prior location¹⁹.

Like any other *determinant relation* (i.e. relation of one event enabling another), a self-emplacement is the case *if and only if both* of its elements are the case. Therefore, any event that emplaces either element of an actual self-emplacement emplaces the self-emplacement itself²⁰.

11. Determinant sequence

As a rule, a self-emplacement is itself emplaced by a *determinant sequence*, that is a sequence of determinant relations wherein the initial behaviour of the instruction enables some event which enables some other event which enables some third event, etc. which finally enables the instruction's occurrence²¹. In Fig. 4, for example,

- (1) the behaviour of a genetic instruction (gene) carried by a certain organism enables
- (2) an occurrence of a neural instruction carried by the same organism, which enables

¹⁸ Figure 3a (section 6) analyses the behaviour of an instruction.

¹⁹ Q. Suppose a behaviour merely moves the behaving instruction from one spatial location to another. The behaviour thus literally enables the instruction's occurrence at the second location. Is that, then, a self-emplacement?

A. There are two good answers to that question.

- Yes, it is technically a self-emplacement, but since the behaviour simultaneously *prevents* the instruction's occurrence at its original spatial location, it does not contribute to natural selection of the instruction.

- No, the two events should be redefined to place them at the same 'scaled-up' spatiotemporal location, so no self-emplacement takes place [for lack of element (2)].

²⁰ The author once drove a 1960 Valiant automobile too fast through a deep puddle, splashing water on one or more of the sparkplugs. The engine shook violently for a few seconds, throwing off the water, and soon began to run smoothly again. Apparently, the running engine carried a fortuitously acquired 'shake when wet' instruction, consisting of (a) exposed sparkplugs, (b) poorly designed splash-guards, and (c) loose motor-mounts, and relying upon the spinning flywheel and the cylinders with dry plugs for its energy source. In the cited instance, the instruction emplaced itself. (Regrettably, due to a lack of replicating machinery — or, for that matter, of any repetition of the event-set — this self-emplacement did not lead to natural selection or evolution.)

²¹ Every event in a determinant sequence, including the last, is, of course, 'contingent . . . upon a myriad other antecedent events' (section 7).

Determinant sequence:

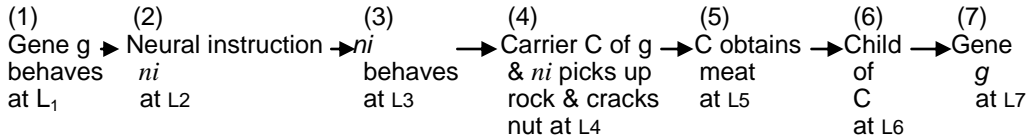
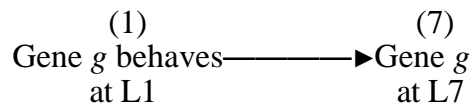


Fig. 4. Example of a determinant sequence.

(3) an occurrence of a *behaviour* of the neural instruction, which enables
 (4) an occurrence of a certain feature of feeding activity, which enables
 (5) an occurrence of a certain food item in the digestive apparatus of the organism, which enables
 (6) a subsequent occurrence of an (offspring) organism, which enables
 (7) an occurrence of the gene whose behaviour started the sequence. That determinant sequence emplaces a self-emplacement of gene g ²².



Of course, each determinant relation in a determinant sequence may itself be capable of analysis into a determinant sequence, until the entire self-emplacement is shown to be emplaced by determinant relations whose *physical plausibility* is incontrovertible.

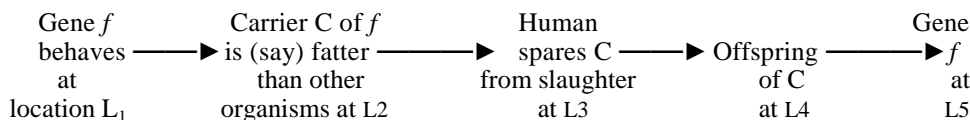
To repeat from section 10, any case of natural selection is the product of similar self-emplacements, which are invariably emplaced by similar determinant sequences. This proposition will be expanded upon in the next four sections, and demonstrated in section 22.2.

12. Activism

It is evident from the above that natural selection is not the passive process its name seems to imply. The item supposedly 'being selected' or 'undergoing selection' is in fact actively '*selecting itself*'²³. This emphasis on activism simply adds voice to the idea that the (not necessarily competitive) 'Struggle for Existence' of Darwin is a 'positive, constructive force that accumulates the beneficial' (Mayr 1967, p. xvii).

²² The determinant sequence is thus the *process* by which the self-emplacement occurs.

²³ When one adopts the self-emplacement view, the selection metaphor appears at first glance to have been a mistake on Darwin's part. In fact, however, it is perfectly apt; 'artificial' selection simply results from a self-emplacement emplaced by a determinant sequence which includes the choice-behaviour of the human 'selector':



13. Environment

It follows from sections 6, 7, 10, and 11 that any *regularity* in determinant relations, hence any regularity of determinant sequence, and hence any regularity of self-emplacement (necessary for propagation or maintenance), is contingent upon regularity of *environment*. [In all that follows, the word 'environment' refers to the salient surroundings of, ultimately, an instruction or system (section 16) or cluster (section 17) of instructions. Thus, an 'environmental feature' may as well be a feature of the organism carrying the instruction (or system) or cluster as a feature of the organism's surroundings. It may, for instance, be another instruction or behaviour or behaviour resultant (cf. Williams 1966, p. 251).]

An occurrence of a salient environmental feature operates in one of two ways to emplace a self-emplacement of an instruction: it is either a *co-determinant* or a *despitant* of some event in the determinant sequence emplacing the self-emplacement²⁴.

(i) A co-determinant (Fig. 5a) is simply another event enabling the

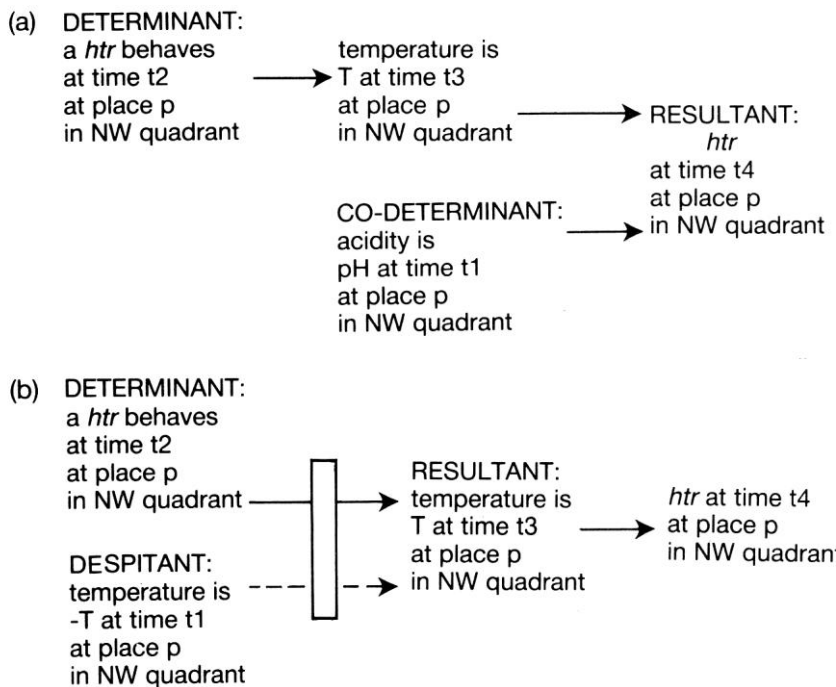


Fig. 5. (a) Event [acidity is pH at t1], a determinant of [*htr* at t4], emplaces any (other) determinant relation of which [*htr* at t4] is the resultant; here, the self-emplacement of *htr* — [*htr* behaves at t2 → *htr* (occurs) at t4]. (b) Event [temperature is — T at t1], a despitant of [*htr* behaves at t2 → temperature is T at t3], emplaces that determinant relation and, thereby, the self-emplacement of *htr*. All events at place p, in northwest quadrant of sea in ocean. Note that (a) and (b) are overlapping and co-terminous.

²⁴ Events 'in' a determinant sequence include the final event, in this case the resultant occurrence of the instruction.

event in the sequence and thus emplacing element (1) of the self-emplacement, the resultant occurrence of the instruction (section 10).

(ii) A despitant (Fig. 5b) is an event that *would have prevented* the event in the sequence, *had the instruction's behaviour not occurred*. In other words, the instruction's behaviour enables the event in the sequence *despite* the despitant environmental feature²⁵. A despitant thus emplaces element (2) of the self-emplacement (section 10): it makes the subsequent occurrence *contingent* upon the prior behaviour.

Metaphorically speaking, a co-determinant is an environmental 'opportunity' for a system of instructions; the opportunity is 'grasped' by the self-emplacing instruction in question. Similarly, a despitant is an environmental 'challenge' for the system, 'met' by the self-emplacing instruction.

13.1 ROUTEWAY

A useful construct whereby one can look at the set of environmental features salient to the self-emplacement of a particular instruction is the environmental *route*. A routeway can be thought of as a set of markers or guideposts — the co-determinants and despitants — emplacing each component determinant relation of a determinant sequence.

Fig. 6²⁶ repeats the determinant sequence of Fig. 4, but includes some of the routeway markers. Determinant sequences like this, and hence the self-emplacement of gene *g*, will be repeated periodically (let us assume) but only as long as each and every marker in the routeway is in place²⁷. (As will be demonstrated in section 22.2, gene *g* will be maintained in the gene pool only as long as it continues to emplace itself: Entropy, metabolic costs, and competition are, in a sense, 'universal despitants' in any biotic determinant sequence.)

Note particularly the despitant marker, 'nut shell is hard at B5'. Observe that if the shell were not hard at B5, C would obtain the nut protein at A6 whether or not he picked up the rock and cracked the nut at A4; the determinant sequence would be broken, so *g* would not emplace itself. *Environmental 'challenges', in short, are just as causal for natural selection as are environmental 'opportunities'.*

The principal empirical research stratagem for a selectionist explanation

²⁵ The dashed line, of course, represents a despitant relation. The tall thin rectangle, or 'collar', ties the despitant relation to a particular determinant relation.

²⁶ In this and most following diagrams, each descriptive clause or phrase stands for an event and events are, by definition, singular; each clause or phrase, therefore, includes implicitly the expression 'occurs at such-and-such location (time and place)'. Alphanumeric co-ordinates ('A1', 'B5', etc.) not only stand in for the locations of the events, but also facilitate external reference:

Q. Should I think of the behaviour of gene *g* at A1 and the occurrences of the epigenetic structures at B1 as installing and 'priming' the instruction *ni* at A2, pending the 'firing' (behaviour) of *ni* at A3 when the external cue at B2 'pulls the trigger'?

A. Yes — exactly.

²⁷ The determinant sequence is a process (footnote 22), so the relatively permanent routeway emplacing it is the *mechanism* of the process.

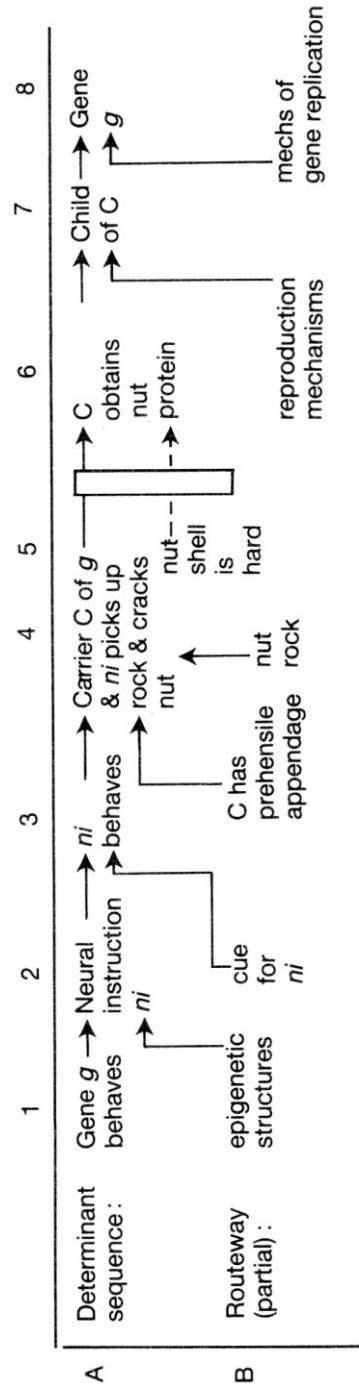


Fig. 6. Determinant sequence with partial routeway.

of the prevalence/distribution of any given instruction (and hence of its 'product') is to isolate, identify, and describe the routeway markers, i.e. the co-determinants and despitants, of the determinant sequence through which the instruction emplaces itself (section 32.2).

13.2. ADAPTATION

Whether the routeway marker be a co-determinant or a despitant, the self-emplacing instruction's behaviour and behavioural products *adapt* the instructional *system* of which it is a part (section 16) specifically to that marker, i.e. to the presence or absence of that environmental feature.

Since 'environmental' refers to the salient surroundings of instructions (see the first paragraph of section 13), it is perfectly reasonable to speak of an instruction adapting a system to a feature of its own carrying organism; e.g. gross behaviour, architecture, mechanisms of instruction-replication, reproduction, or development, etc. Much selection that is not adaptive for the organism as such (Gould and Lewontin 1979, p. 590 ff.; Wilson 1975, pp. 32-7) is, therefore, actually adaptive for the instructional system which constructs and 'operates' it (section 20) (cf. 'Teleonomy', section 24). With repeated event-sets such as that depicted in Fig. 7, for example, instruction *ps* adapts the cathedral-building system SYSCB:

- (i) to the behaviour of the artistic taste instructions of the client, and
- (ii) to the empty surfaces SYSCB leaves in the 'organism' or extended phenotype (Dawkins 1982) it constructs, i.e. the cathedral²⁸.

14. Success of instructions and their products

Adaptive success — propagation and maintenance — of an instruction takes place when, and only when, self-emplacements of the instruction outnumber the sum total of (1) exogenous displacements (accident, decay, predation, etc.) and (2) self-displacements, i.e. cases where its own behaviour actually displaces it, combined, over a period of time²⁹.

Of course, the success of an instruction's behavioural product is in turn contingent upon the success of the instruction. For example, the success of any feature of an organism, artifact, or social grouping (and therefore of the sort of organism, artifact, or grouping that is defined by that feature) is contingent upon the success of each instruction whose behaviour emplaces that feature (and, of course, vice versa).

²⁸ Figure 7, of course, represents an adaptationist *hypothesis*, not a conclusion. It is almost certainly wrong in detail, but it would prove wrong in principle only if there was no client with the power to reward and the propensity to judge. (Note that the hypothesis is exactly the opposite of that made up, and ridiculed, by Gould and Lewontin 1979).

²⁹ Haemoglobin *s*, for example, emplaces itself when it displaces some symptoms of malaria, but it displaces itself when it emplaces sickle-cell anaemia. Which of those outcomes eventuates depends largely upon the presence or absence, respectively, of a normal (*S*) allele as a routeway marker in its carrier's genome. The relative success of *s* — its frequency in a population — depends upon the frequency of those two outcomes.

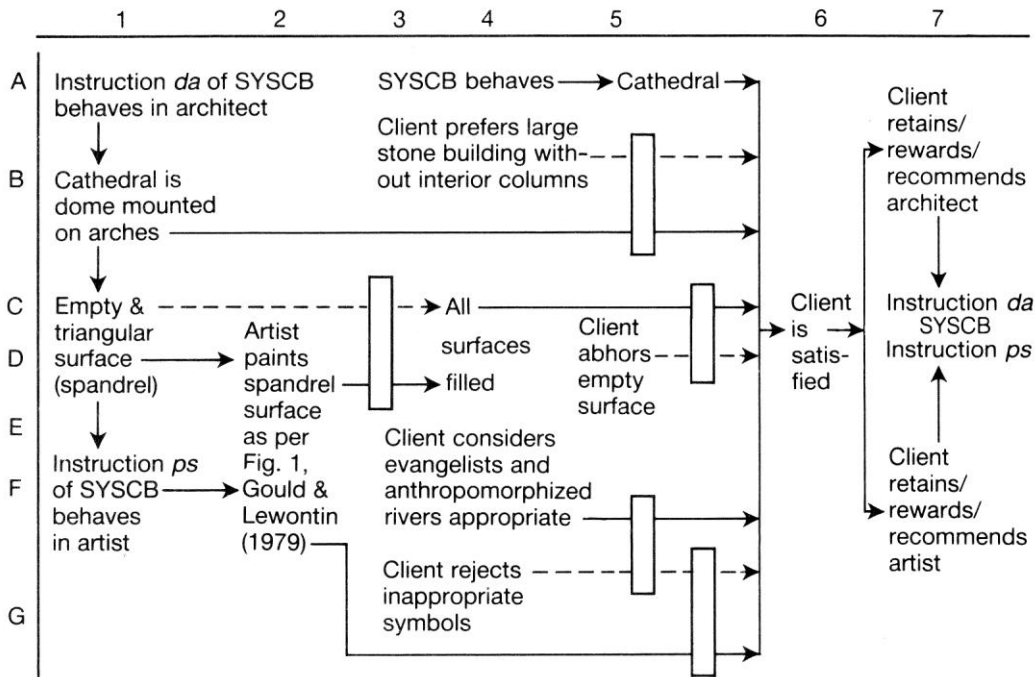


Fig. 7. Instruction *ps* adapts system SYSCB to the spandrel, a feature of the 'organism' SYSCB constructs.

15. S-conditions

For any structure, such as an instruction, to occur, the values of certain 'environmental variables' — light-intensity, temperature, moisture, acidity/alkalinity, ionizing radiation — must fall within certain ranges. Moreover, the component parts of the structure (e.g. 'precursors', in the case of a molecule) must also be present³⁰; for structures of any given kind (genes, for example, or memes) the component parts are essentially the same.

Rephrasing that, for an instruction to occur at a given location certain 'background' and 'immediate' *S-conditions*, conditions of storage and survival common to all instructions of its kind, must be met at that location.³¹

Most instructions emplace themselves by meeting an *S-condition*³².

³⁰ Therefore, the values of environmental variables must be within the ranges necessary for their occurrence, etc.

³¹ Besides (1) background and (2) immediate *S-conditions*, there is an *S-condition* of another sort: (3) the *uniquely defining S-condition*; namely, that the component parts occur in the right spatial relations to each other (section 21.2).

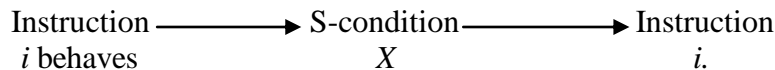
The *constitution* of a structure (e.g. an instruction) is defined by its immediate and uniquely defining *S-conditions* — its parts and the relations among them. Philosophically speaking, the *S-conditions* are individually necessary and collectively sufficient for the occurrence of the structure.

³² Certain predatory memes and segregation-skewing genes emplace themselves by getting themselves copied into locations where *other* instructions meet *S-conditions* (section 30.2).

(i) The instruction behaves, and its behaviour, perhaps through a lengthy and elaborate determinant sequence, emplaces (or deplaces) a change in relations among structures at that location or at a nearby location, and thereby brings the value of one of the environmental variables mentioned above into the range that defines an S-condition. (More accurately, the change in relations and/or the ensuing relation *is* the S-condition, and the 'values of environmental variables' are merely our means of ascertaining its presence or absence.) The structures whose relations are changed, together with any structures which are decomposed to provide energy to emplace the change, are *resources* for the self-emplacement.

(ii) Abiotic mechanisms and behaviour of other instructions meet all other S-conditions at that location. These mechanisms and behaviours are thus environmental *co-determinants* (section 13) of the self-emplacement. The immediately prior *absence* of the S-condition met by the instruction in question, moreover, is an environmental *despitant* (section 13) of the self-emplacement, as are the determinants of that absence.

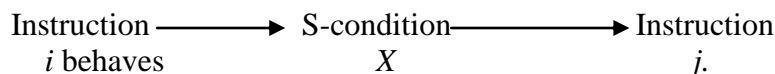
(iii) The instruction in question (or an instruction interchangeable with it) survives at or is replicated into that location, only because all S-conditions — *including the one its behaviour met* — are met there. Schematically,



To expound the activist, self-emplacement view of selection once again, an instruction succeeds not because it can passively survive under prevailing conditions, but because its behaviour *emplaces* some condition under which instructions of its general kind can (passively) survive (see the ecological scenario, section 3).

16. Co-operation: systems of instructions

Frequently, by meeting an S-condition at some location, an instruction's behaviour enables an occurrence of some *other* instruction. That may occur simply by chance, as in the ecological scenario (section 3, 'Passive Parasite'); then the event is one of simple one-way *exploitation* of the first instruction by the second:



Forms of more sophisticated and lasting one-way exploitation will be discussed in section 30. In this section, however, we introduce one form of *mutual* exploitation among instructions — *co-operation*. When the behaviours of two (or more) instructions meet one or more S-conditions, and thereby

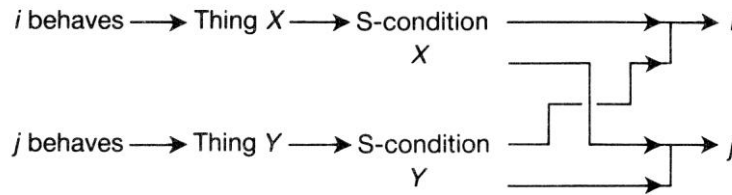


Fig. 8. Co-operation. In special cases, things X and Y, and/or S-conditions X and Y are identical.

enable occurrence of both (or all) those instructions, each instruction emplaces itself through co-operation with the other(s) (Fig. 8).

If the environment is relatively stable, such event-sets of co-operation tend to be repeated. As we saw in section 3, even in a 'primordial soup' situation where instructions float free, co-operating instructions occur in clusters (section 17) of at least one of each, thereby enabling further co-operation. In such cases, instructions which keep such clusters together (e.g. *glumkr*, section 3) emplace themselves through co-operation with the other members of the cluster. In more complex forms of co-operation, instruction-emplaced mechanisms sometimes enable co-operation over considerable distances.

Whether they occur in a cluster or not, however, a set of co-operating instructions constitutes a *system* of instructions.

For certain purposes, a mature system (i.e. a set of regularly co-operating instructions) can be viewed as if it were a single instruction. Mature systems thus emplace themselves; they even co-operate, forming larger systems.

The criterion for an event-set of co-operation between systems, as opposed to an event-set of mere mutualism (section 30.3), is that each system emplaces both itself *and* the other system, rather than the other alone. For example, a carpenter(-system) and a mason(-system) together build a house, and then live in it or sell it and share the proceeds, thus meeting their common need for shelter or money. If the house falls down or can't be sold, both systems are out of business — instructions to 'cheat' cannot succeed in such an environment.

17. Clusters of instructions

Instructions which co-operate, forming a system, tend to occur in the same or nearby spatiotemporal locations, in other words in *clusters*. This is by no means a general rule, however. Instructions of a system may occur in quite separate locations and some of the instructions in a cluster may not co-operate with the others at all, i.e. they may be parasitic. The instructions in a cluster are usually bonded together and/or contained in a protective envelope of some sort — the membrane of a cell, the skin and/or skull of an animal, etc. — and thus the cluster is easily located, identified, and defined.

$$\text{SYS} = \text{htr} + \text{sour} + \text{glumkr} \text{ (section 3)}$$

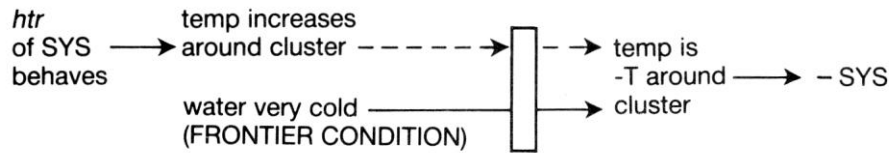


Fig. 9. Displacement of SYS in transfrontier region.

In another sense, a cluster serves as a physical *instance* of a system; for example, when a system SYS is said to occur at two different locations at the same time, there obviously are (at least) two clusters of that system.

18. Evolution across a frontier

When a system propagating through a region reaches a 'frontier' beyond which it cannot meet some S-condition, it stops propagating in that direction. Occurrences (or absences) of some environmental feature in the transfrontier region (the 'frontier condition') *prevent* occurrences of the system, i.e. *deplace* the system (Fig. 9) so frequently that it does not succeed (section 14) in that environment. If, later, it happens to acquire an instruction that enables it to meet that S-condition in the trans-frontier environment, we say it *evolves* across that frontier. After evolution of the system, the erstwhile frontier condition becomes a despitant routeway marker, emplacing self-emplacement of the 'frontier crossing' instruction (Fig. 10).

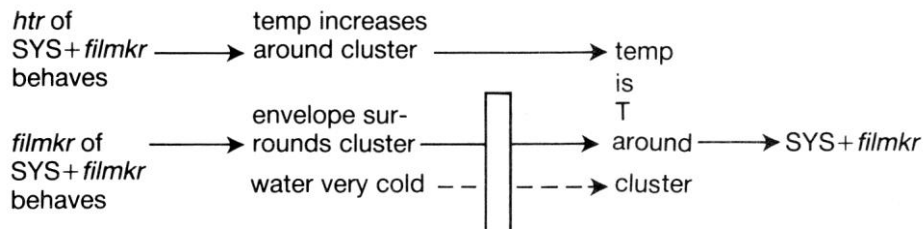
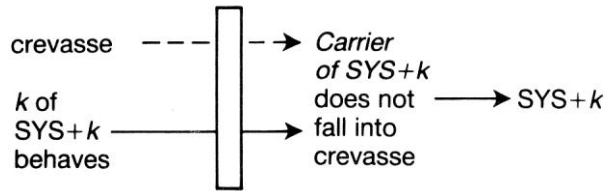


Fig. 10. Event-set in transfrontier region after evolution.

19. Competition and natural selection

According to the self-emplacement view, then, neither natural selection nor evolution is an inherently competitive process. An instruction or system may propagate itself and succeed without affecting the lot of any other instruction or system (cf. Sober 1981/84, p. 191). Such propagations occur nowadays when vacant regions are populated or repopulated, and they surely took place many times when early living systems were

Fig. 11. k emplaces $SYS + k$.

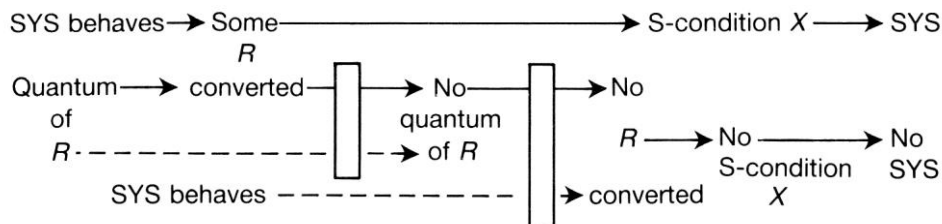
adaptively radiating. The self-emplacement view allows us to explain such non-competitive propagations, and the evolutionary modifications which enable them, as cases of natural selection.

Suppose, for example, a certain system SYS occurs fairly widely in a given region. One SYS by chance acquires a novel instruction k and k 's behaviour emplaces the 'new' system, $SYS+k$, from time to time, as in Fig. 11. k and $SYS+k$ emplace themselves. With repetitions of that self-emplacement, $SYS+k$ propagates in the region; so does 'old' SYS , at (presumably) a somewhat slower rate.

No system, however, can in fact propagate indefinitely in a region. Sooner or later, the limit of some resource R (precursor molecule, energy source, nesting site, etc.) is reached, such that on the average, each self-emplacement of the system deplaces another self-emplacement (Fig. 12). Practically speaking, emplacement of a new cluster of the system is contingent upon some R being made available by the destruction or decay of an existing cluster. Propagation is superseded by maintenance-through-replacement, and the population of SYS es is in equilibrium in the region. In effect, an 'internal frontier' has been reached by the system, the frontier condition being absence of quanta of R from certain locations.

The environmental conditions for competition ('Malthusian conditions') for R are now in place in the region. We can't say that the different clusters of SYS compete with one another, however, because for our purposes they are identical; which ones emplace themselves and which are thus prevented from doing so is, strictly speaking, a matter of chance (cf. Hockett 1973, p. 287).

SYS and $SYS+k$, on the other hand, are *not* identical. Because R is the limiting resource for both, they *are* in competition for R in the region. Besides event-sets of equilibrium like that in Fig. 12 (and, with increasing frequency, event-sets of equilibrium for $SYS + k$), event-sets like that in Fig. 13 occur. Simply by emplacing $SYS+k$, the behaviour of k emplaces a

Fig. 12. Event-set of equilibrium for SYS .

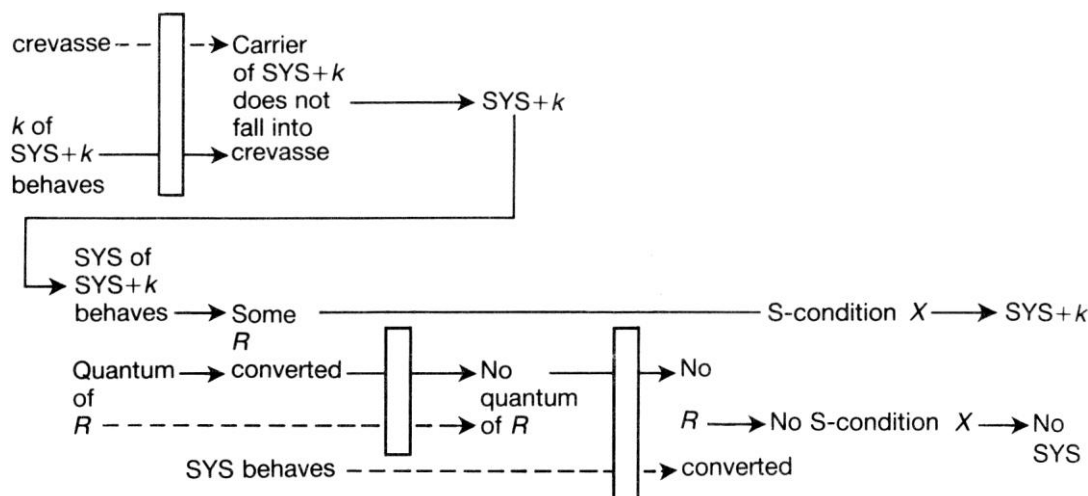


Fig. 13. Event-set of competition: $SYS + k$ outcompetes SYS .

self-emplacement of $SYS+k$ and thereby replaces a self-emplacement of SYS . In the absence of event-sets which would conversely favour SYS over $SYS+k$, the outcome of such event-sets, repeated, is that $SYS+k$ evolves 'across the internal frontier', propagates through the region 'at the expense' of SYS , and eventually replaces SYS in the region³³.

19.1 THE ESSENCE OF COMPETITION

As the example clearly demonstrates, the behaviour of the competing instruction (k):

- (i) need not interfere in any direct way with the other systems's (SYS 's) self-emplacement; and
- (ii) need not be related to the resource (R) for which the systems are competing.

The essence of competition lies not in the behaviour (or its immediate outcome), but in the Malthusian conditions, i.e. the *environment* in which the behaviour takes place³⁴.

Competition, then, can be simply defined as 'self-emplacement of one system replacing self-emplacement of another'³⁵.

On the other hand, the behaviour of k

³³ In a different region, one lacking crevasses, Fig. 13 event-sets simply would not take place.

³⁴ For example, assume that businessmen compete for *customers*. A businessman who invests in an automatic fire alarm does not thereby attract more customers, nor does he thereby in any way interfere with his competitors' sales or put them in harm's way. Yet by saving him from a disastrous fire, the alarm can enable him to continue business, to get his 'share' of the market, and perhaps — perhaps by luck alone — to put his competitor(s) out of business.

³⁵ In theory, at least, two simple instructions may compete, as in the ecological scenario (section 3). Predation (section 30) is not included under competition because, as a rule, the replacement of one cluster of the prey system merely replaces self-emplacement of another cluster.

- (i) *may* directly prevent a competitor system from emplacing itself by, for example, enabling SYS + k's carrier to escape a predator (if k's behaviour enables the predator to continue hunting, eventually to capture the carrier of some SYS); or
- (ii) *may* in fact *be* related to R — it may enable SYS+ k to gather or utilize R more effectively than SYS; or
- (iii) combining (i) and (ii), *may* enable SYS+k overtly to deny quanta of R to SYS.

19.2 COMPETITION, METABOLIC COST, K-SELECTION, AND HONING

As a general rule, the behaviour of any instruction requires, and uses up, some R (footnote 10). Acquiring a new instruction therefore imposes an additional 'metabolic cost' on the system (cf. Darwin 1859, pp. 147-8); i.e. behaviours of k not only enable occurrences of SYS+ k but also, on occasion, *prevent* occurrences of SYS +k. That fact has the following implications.

- (i) Any novel instruction which succeeds in competition must do something substantial for the system which acquires it; it cannot be neutral or near-neutral in its effect³⁶.
- (ii) Over the long term, competition may result in a larger and more sophisticated version of SYS, but in fewer instances of it, i.e. in K-selection (Wilson 1975, p. 100).
- (iii) An instruction which has the same function (section 23) as an existing instruction, but which performs that function more precisely, more effectively, more efficiently, or more reliably, may *replace* the existing instruction, thus 'honing' the system³⁷.

19.3 COMPETITION AND 'GENERAL EVOLUTION'

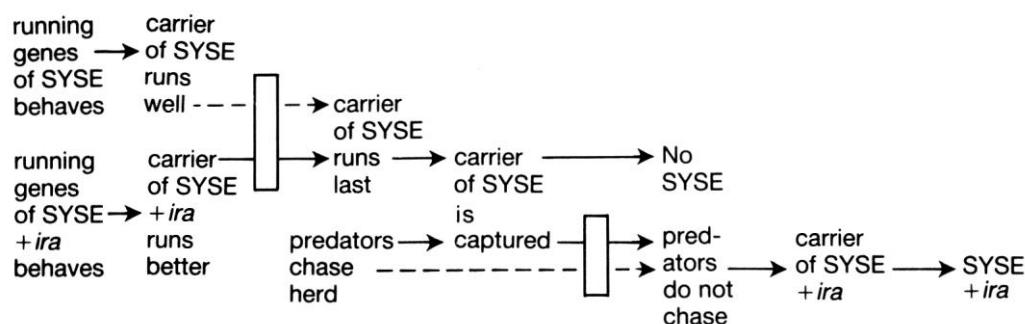
Competition most frequently occurs (in Darwin's words, is 'most severe'; 1859, p. 75) between very similar systems, as in the example of Fig. 13.

Over a long period of time, in a more-or-less stable extra-system environment there may take place a series of acquisitions of novel instructions, each instruction R-related or related to the same hazard³⁸, each acquisition followed by a period of competition and eventual fixation of the novel instruction. Cases of 'general evolution', 'universal evolution', 'orthogenesis', 'rectilinear evolution', 'progressive evolution', etc., may all be mere long-term trends occasioned by such series, and thus just special cases of adaptive ('special') evolution. If that is true, the various 'laws'

³⁶ Neutral DNA is not an instruction, because it does not behave; hence, its metabolic cost is near zero and the above does not apply.

³⁷ By the same token, an instruction which is replicated (sections 21.2 and 26) more reliably may replace an existing instruction that performs equally well.

³⁸ In the above example, crevasses. In the case of the evolution of the vertebrate cardio-vascular system, the hazard of running out of breath at an inconvenient moment.

Fig. 14. Self-emplacement of gene *ira*.

proposed (by White 1949; Sahlin 1960; etc.) to account for such cases can be replaced by accurate descriptions of the enduring routeways (section 13.1) emplacing them.

Indeed, the routeway itself may evolve in such a way as to *exacerbate* the evolutionary trend it emplaces, a situation of positive feedback in evolution (Bajema 1978). For a hypothetical example, populations of herding equids, living in open grasslands, are preyed upon by pack-hunting carnivores. When the hunters run down a member of the herd, they knock off for lunch and the rest of the herd escapes. The partial routeway for self-emplacement of a gene *ira*, for increased running ability (and thus predation avoidance), is illustrated in Fig. 14.

As *ira* becomes fixed in the population (and it surely will) it becomes just another 'running gene' of SYSE³⁹, a despitant marker in the routeway for self-emplacement of the next increased-running-ability gene to appear in the population. Although other markers in the routeway (speed and habits of predators, features of the terrain, etc.) may not change at all, the 'selection pressure' for running ability continually increases, because of competition. Each time a running gene is successful, it becomes an internal frontier-condition; SYSE can evolve across that frontier only by acquiring still another, 'better' running gene.

20. Organisms, etc.

Organisms have been mentioned in sections 3, 15, 17, and 18. An organism provides (i.e. emplaces) an 'S-conditioned' micro-environment for a cluster of instructions. Most of those instructions are members of a system; they emplace themselves by co-operating (1) to construct the organism around themselves and (2) to 'operate' it, i.e. to endow it with various features by which it develops, maintains its internal workings, reproduces itself, and interacts with its surroundings, thus surviving in its environment and providing the cluster with its S-conditioned environment.

Besides numerous transitory changes in relations, the organism's

³⁹Note that at the moment it becomes fixed, *ira*'s ecological status switches from 'facultative' to 'obligate'; no equid can survive without one.

interactions with its surroundings may result in various features of material structures (artifacts, dwellings, etc.) and of non-material social 'structures'. Directly or indirectly, these features also often promote the organism's survival (or perhaps reproduction); in that case, they are in a determinant sequence emplacing self-emplacement of the 'operating' instructions, carried by the organism, that built them. In short, most instructions carried by an organism are members of a system, cooperating to meet their collective S-conditions via that carrying organism⁴⁰.

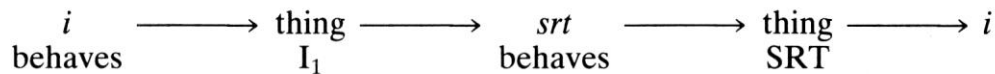
Organisms and their actions, products, by-products, etc., may, of course, emplace (or deplace) further self-emplacement of instructions of the same or different systems. In other words, they may become features of some system's environment, markers in the routeways enabling self-emplacement of instructions, or they may become internal frontier-conditions (section 18).

21. Sub-systems which control self-emplacement

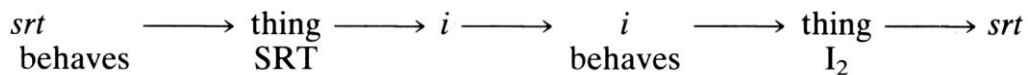
Some (sub-)systems of instructions have evolved whose specific function (section 23) is to construct an environment in which instructions with certain behavioural outcomes can emplace themselves. These systems include, but are not necessarily limited to the following.

21.1. SELECTIVE RETAINERS

When a selective retainer⁴¹ subsystem *srt* is cued by the behaviour or product of an instruction *i*, it acts to retain or store *i*, thus to make or keep *i* a member of its own cluster; so *i* emplaces itself by 'pleasing' *srt*:



srt emplaces itself if and when *i*, in turn, emplaces it:



Clearly, novel member instructions which make *srt* more accurate at discriminating *i*'s whose subsequent behaviour will in fact emplace *srt* will thereby emplace themselves (honing, section 19.2).

Experiential (operant) learning is the most obvious example of the selective retainer phenomenon. Another example may be problem solving and planning, where the behaviours of candidate instructions are simulated

⁴⁰ This is, of course, the main burden of Dawkins' (1976) *The Selfish Gene*. Durham (1976, 1982a) has consistently emphasized the contribution of *cultural* instructions (memes, section 6) to the inclusive fitnesses of organisms.

⁴¹ The ideas as well as the terminology are derived from Campbell (1960, 1965).

in the brain, and those that produce simulacra of satisfactory outcomes are retained, or at least kept on for experiential testing (Campbell 1960)⁴².

A third example is an immune system. Here *srt* discriminates the particular enzymes that attack the invading structure(s) and not only retains them, but enables their rapid propagation.

Yet another example is the sub-system of human culture which emplaces the 'artificial' selection of domestic animals and plants (see footnote 23).

21.2. REPLICATORS

A replicator sub-system meets the uniquely defining S-conditions of instructions in its immediate environment, thus emplacing replicas of those instructions. (Needless to say, the background and immediate S-conditions must already be met for that to occur; see sections 15 and 34)⁴³

One example of a replicator sub-system is, of course, the mechanism of DNA replication in practically all living forms. The members of the replicator sub-system replicate the entire cluster (genome), emplacing themselves in the process. As a general rule, however, they also cooperate with other members of the cluster who meet background and immediate S-conditions; in most real-world environments a replicator sub-system cannot emplace itself single-handedly.

Another example of a replicator sub-system is the subset of neural instructions whose behaviour enables observational learning, or modelling (Bandura 1977) and, ultimately, culture (section 26).

As a general rule, novel member instructions which make the replicator sub-system more accurate and reliable will thereby emplace themselves (honing, section 19.2).

22 Macro-level natural selection and self-emplacement

The theory presented here is 'based on the proposition that every large-scale change or continuity properly attributed to natural selection can be entirely accounted for as the outcome of many small-scale events and the causal relations among them' (section 4). This section contains first, a restatement of that proposition and second, an informal (non-rigorous) proof of it.

⁴² The 'biogenetic structures' of Laughlin and d'Aquili (1974) and the 'epigenetic rules' of Lumsden and Wilson (1981) are perhaps special cases of experiential-learning and/or problem-solving selective retainers.

⁴³ Dawkins (1982, p. 83) uses the term 'replicator' to refer to instructions that are replicated by a replicator sub-system (see section 26).

22.1. RESTATEMENT OF THE PROPOSITION

Natural selection is generally (and properly) considered to result, *inter alia*, in:

- (i) evolution, i.e. descent with modification;
- (ii) new features, varieties, and species of organisms;
- (iii) organisms better adapted to their environments ('survival of the fittest');
- (iv) changes in the inclusive fitnesses of organisms (to the population ecologist); and
- (v) non-stochastic changes in relative frequencies of replicables (to the population geneticist).

A case of natural selection, in short, results in a change or a continuity (i) in the frequency of one or more replicable instructions, thus (ii) in the frequency of some organic or behavioural feature emplaced by those instructions, and thus (iii) in the frequency of organisms of the kind defined by that feature. In conventional parlance, the instruction(s), feature, and kind have been 'selected' — 'for' or 'against'.

The change or continuity, moreover, cannot be attributed entirely to 'chance' (the arbitrary action of exogenous physico-chemical processes), but is due at least in part to the nature of the feature undergoing selection (Mayr 1967, p. xviii) and its surroundings.

This discussion will focus on things being selected *for*; being selected against means simply being out-competed in a Malthusian environment (section 19). In other words, to explain why one instruction/feature/kind succeeds is automatically to explain why its competitors fail.

That being said, the proposition cited above can be rephrased in two statements.

(1) Self-emplacement is *necessary* for natural selection. An instruction/feature/kind is selected for (succeeds) only if the instruction emplaces itself.

(2) No process other than self-emplacement is necessary for natural selection. This is *not* to say that self-emplacement always produces natural selection (section 7).

22.2. AN INFORMAL PROOF

Statement (2) is almost self-evident. If an instruction emplaces itself, via emplacing a feature, at least as frequently as it is deplaced by its own behaviour, accident, decay, predation, etc., the instruction, feature, and kind are selected for. Statement (1) reduces to two statements, according to our understanding of enabling and (self-)emplacement (section 10).

(1A) an instruction/feature/kind is selected for only if the instruction *occurs*; and

(1B) An instruction/feature/kind is selected for only if that occurrence is *contingent* upon a prior behaviour of the instruction.

Statement (1A) is obviously true because without *repeated* occurrences of the instruction, it dies out and thus cannot continue to emplace the

feature. To propagate a feature, an instruction must itself be propagated.

Statement (1B) is *not* obviously true. Why must the instruction's occurrences be *contingent* upon its behaviour if it is to be selected for?

An instruction occurs at a given location only if all its S-conditions are met there. If any S-condition is contingent upon the instruction's behaviour, so is the instruction's occurrence; it is a self-emplacer. If no S-condition is contingent upon the instruction's behaviour, then either all S-conditions are met abiotically or some are met by the behaviour of one or more other instructions.

Even if uniquely defining S-conditions are excluded, there is almost certainly no place on the planet today where all S-conditions of replicable instructions are met abiotically, and it is doubtful if there ever was such a place. Besides, if there were such a place, and instructions did survive and behave there, their 'success' and that of the features they emplace would be due entirely to chance and not in any way to the nature of those features.

So we are left with instructions some of whose S-conditions are contingent upon the behaviour of instructions, but none of whose S-conditions are contingent upon their own behaviour. Why can't such passive parasites (section 16) and the features they emplace be selected for?

The first point to be made is that such parasitic instructions must occur in clusters with the instructions that emplace them. The second point is that being a very complicated material structure, no instruction is literally, physically immortal. Sooner or later each decays (or is damaged or separated from its cluster-mates). When that happens to a self-emplacing member of a cluster, the rest of the cluster — including most particularly any parasitic members — dies (or dies out) too, *because the cluster's recurrence is contingent upon the behaviour of that self-emplacing member*. The lost cluster is soon replaced by another cluster which includes *all* members. When a passive parasite decays (or is separated), however, the cluster lives on, to propagate and compete. In a Malthusian environment (and all environments become Malthusian), therefore, the parasite-free cluster will eventually supplant the parasite-including cluster.⁴⁴ Non-self-emplacing instructions, and the features they emplace, if any, will most certainly be selected against.

Natural selection is always produced by event-sets of instructions emplacing themselves, and no other process is required for natural selection. Self-emplacement, at the micro-level, is the *fundamental process* of natural selection, at every level; Q.E.D.

22.3. UNITS, AGAIN

Because any cluster member which ceases to emplace itself becomes subject to the process of elimination described in section 22.2, a cluster or

⁴⁴ How long that will take may, of course, be a matter of chance (drift, 'hitchhiking', etc.), as well as of selection.

higher-level entity is always subject to evolutionary modification. Instructions, on the other hand, are by definition not modifiable (section 6) — they are either retained or eliminated by the selection process⁴⁵. It seems evident, therefore, that instructions are the only appropriate theoretical *units* of natural selection and evolution.

To be sure, genetic selection usually involves whole genomes (or family lines thereof, and perhaps 'higher-level' entities, such as groups, as well). The point, however, is that when — to continue the example — a genome fails (or a family line dies out) because it carries a non-feasant gene, all the rest of those genes are carried and 'passed on' by the successfully competing genome or family line, just as if selection had not taken place; the rest of the genes — and the genome (line) itself — are not selected for or against⁴⁶. So how can the genome (let alone the phenotype, the organism) be the *unit* of selection?

23. Function: causal functionalism

What is needed is a causal-functional model which can explain all varieties of evolutionary processes (Harris 1968, p. 236).

The behaviour and/or proximate behaviour-product through which an instruction regularly emplaces a system (section 16), and thereby emplaces itself, is the instruction's *function* in and for that system⁴⁷. By definition, then, the instruction occurs in a substantial number of locations (i.e. succeeds, section 14) only because it performs its function in the system. The passive parasite of section 22.2 fails not because it does not behave, and not because the system does not emplace it, but simply because it performs no *function* for the system. This is *causal functionalism*. In the only possible naturalistic sense of the expression, an instruction which regularly emplaces some system, and thereby itself, by 'xing' thereby *occurs in order to x*, and xing is its function.

Mutatis mutandis, the function concept and causal functionalism pertain to any structure, relation, or change that regularly occurs in a determinant sequence emplacing a cooperative self-emplacement — in other words, to the very behaviours and behaviour-products that are the functions of instructions (preceding paragraph). For example, see Fig. 7, section 13.2; *in and for system SYSCB*, the function of instruction *ps*, behaving at F1, is to paint the spandrel surfaces at D2; the function of painting the surfaces, in turn, is to satisfy the client at C6.

⁴⁵ Q. My recipe-line (instruction) says 'Add two egg yolks'. Why can I not *modify* that to read 'Add two large or three small egg yolks', thus adding some precision to the instruction?

A. You can, but you have actually created a new instruction which will now (presumably) compete with the old one via cakes — and indeed may have already done so, successfully, via your internal selective retainer (section 21.1) which prefers precision.

⁴⁶ Although some of them may be highly relevant as *environment* — co-determinants and despitants — of the selection-event(s).

⁴⁷ The function can be more precisely defined as the behaviour/product which enabled the system to evolve across some frontier (external or internal, sections 18, 19, and 29) and which continues to maintain the system in the transfrontier region.

One general function of any *organism*, for another example, is to provide an S-conditioned microenvironment for the instructions which construct and operate it (section 20); and the organism's various features — physiological, anatomical, and gross behavioural — mostly have the common function of furthering the development and/or survival and/or reproduction of the organism, thus emplacing the S-conditioned environment and the instructions. When that is their function, that is why they are there.⁴⁸

24. Holism and teleonomy

Causal functionalism explains why an established system will often appear systematically to acquire instructions that it 'needs' to perpetuate itself in a changing environment, controlling, in effect, its own evolution. To employ a frequently used idiom, the whole (system) actually determines its parts (instructions).

The integrated behavioural product of such a system — organism, social formation, cultural feature — thus also appears purposefully to satisfy its own needs and further its own interests — survival, reproduction, etc. (Nagel 1961, pp. 401-27). It is what Pittendrigh (1958) has dubbed a '*teleonomic*' structure.

The insights of social science about the autonomy of sociocultural systems, institutions, and 'structures' are more than mere organismic metaphor; no less than organisms, such entities 'have a life of their own', all within a strictly physical causal framework, even though the instructions which construct them are actually carried by organisms (Cloak 1975b). The self-emplacement theory of natural selection provides a naturalistic ground for testing and perhaps elaborating many of those insights (section 32.2).

25. Functional, historical, and environmental explanations

By this point, it should be clear that the success of practically any instruction, and thus of any instruction's behaviour or product such as a feature of an organism or of a social 'structure', is contingent upon its having and performing a function, and thus upon both the instruction's system and the features, abiotic and instruction-emplaced, of its present micro- and macro-environments. Those environmental features, in turn, are contingent upon past events, often including past behaviours of the system and of the instruction in question itself. Thus, the success of a feature⁴⁹ is as a rule made possible by its *function*, its *environment*, and its individual and systematic *history*. So a correct naturalistic explanation of the prevalence and/or distribution of some feature of (e.g.) social

⁴⁸*Contra* Levy (1968, p. 23). The relationship between natural selection and causal functionalism has been noted before, for example by Dore (1961/68) and by Wright (1973/84).

⁴⁹Practically every feature we become interested in explaining is a successful one.

'structure' may (and perhaps should) be conducted within all three traditional anthropological frameworks — functional, historical, and ecological (Driver 1966; Jarvie 1973; Kroeber 1948, 1952).

26. Cultural and genetic instructions

Any physical instance of an instruction (or any other complicated structure) must eventually decompose. If the instructions are carried by an organism, they generally decompose 'before their time', when the organism itself, inevitably, decomposes. For that reason, in any self-emplacement of evolutionary importance the behaving instruction and the resultant instruction cannot be carried by the same organism and thus cannot be the same physical instruction. Since, moreover, interchangeable analogs hardly ever occur spontaneously in the relative spatiotemporal locations necessary for self-emplacement, only instructions for which replication mechanisms (section 21.2) exist have *de facto* evolutionary importance. Instructions for which such mechanisms exist are *replicable*. On this planet environmental conditions are such that practically every self-emplacement involves a replicable instruction⁵⁰

The replicables of principal interest to social and (other) biological science are of two kinds: *genetic* instructions, or genes; and *cultural* instructions, or memes (Cloak 1975a, p. 167; Dawkins 1976, 1982, pp. 109-12).

Genes are strands of DNA which direct the assembly of protein molecules and/or cue (emplace and deplace) the behaviour of other genes.

Memes are *neural instructions* of a special kind. Neural instructions, in turn, are a species of neural *control system*. A neural control system is a collection of neurons and synapses organized in such a way that, when activated by an impulse from a control system at a higher level, it compares a present sensory input to a 'perceptual reference-standard' (Powers 1973)⁵¹ and, until or unless the input approximates the standard, sends repeated impulses to one or more control systems at a lower level. Control systems at the bottom of the hierarchy send impulses to muscle fibres (and receive proprioceptive sensory inputs from those muscle fibres).

If the control system hierarchy is adequately defined, therefore, contractions of the muscle fibres usually modify some aspect of the carrying organism's environment, or of its relation to its environment, in such a way that the organism's present sensory input comes to approximate the perceptual reference-standard of the initiating (top-level) control system. At that point the latter stops sending impulses and the entire hierarchy is deactivated (Powers 1973)⁵².

⁵⁰ That is, it is a self-emplacement either of a replicable or of an instruction, emplaced *by* a replicable, in the determinant sequence through which the replicable emplaces itself.

⁵¹ Campbell (1970), citing Baldwin, uses the expression 'criterion image'. *cf.* Campbell (1966, pp. 91-2).

⁵² As McFarland (1983, pp. 369-70) points out, use of the control system scheme for explaining behaviour does not commit one to a position in the cognitivist-behaviourist controversy.

A neural *instruction* is a special control system whose activation (behaviour) requires not only an impulse from a higher-level system (or instruction), but also a specific stimulus or cue from its environment⁵³. Like any instruction, in other words, a neural instruction has cue-conditions as well as S-conditions.

The uniquely defining S-condition of a neural control system or instruction may be met by the behaviour of one or more genes⁵⁴ and/or by learning processes such as operant or classical conditioning (section 21.1). The uniquely defining S-condition of a *meme* or cultural instruction, however, is met by *observational learning* or modelling (Hall 1963; Bandura 1977). When an animal acquires the cue-condition and the perceptual reference-standard of a neural instruction by observing the action of another animal responding to that cue by approximating that standard, that neural instruction is an interchangeable replica of the instruction emplacing the observed animal's action (cf. Reynolds 1981, pp. 209-13). Since it may thus become part of a population's *traditional* behavioural repertoire, the neural instruction so acquired is a *cultural* instruction, or meme⁵⁵. Although memes are carried by vertebrates of some other orders, they occur in greatest abundance in the higher primates and especially in human beings.

26.1 Memes and observable cultural features

Each observable cultural feature — artifact, dwelling, social interaction, etc. — is emplaced by several, often very many, actions ('gross behaviours') of organisms. Those actions, in turn, are emplaced by several, often very many, behaviours of memes, occurring in series, in parallel, and in control-system hierarchies. Practically every human being is able to analyse an observed action and store the result as memes and connections among memes, and to do that quickly, accurately, and out of awareness⁵⁶. The meme-replicator mechanism in humans must therefore be very elaborate and sophisticated.

The idea that culture consists of material structures in the brain, and the corollary idea that physical differences in the fine structure of the brain are the essence of cultural differences among populations, will seem false or trivial (or both) to many social scientists and laymen. Yet it seems obvious, from a naturalistic point of view, (1) that observable cultural features are always emplaced by behaviours of such structures, and hence (2) that

⁵³ This combination can be had within the strict control system framework by specifying the perceptual reference-standard as 'not both (cue and (not (perception of behavioural outcome)))' (Powers 1975, personal communication).

⁵⁴ The background and immediate S-conditions of neural control systems and instructions, including memes, are of course met in part (i.e. emplaced) by behaviours of genes.

⁵⁵ If the organism has the capacity to form perceptual reference-standards on the basis of verbal input, neural instructions (including memes) may also be acquired by listening or reading.

⁵⁶ Cloak (1974) attempts to simulate part of the analytical process explicitly, to identify a few memes and describe their behaviours.

variation in the frequency of observable cultural features is always enabled by variation in the frequency of such structures.

Explaining the former variation — the purpose of cultural anthropology — requires explaining the latter; this does not mean that a selectionist cultural anthropology must wait for a thorough understanding of the mechanics of memes and their behaviour, any more than selectionist biology had to wait for the development of molecular genetics. [See the discussion of 'i-culture' and 'm-culture' in Cloak (1975a, p. 168 ff.) and Mundinger's (1980, p. 190 ff.) elaboration thereof.⁵⁷

27. Genetic-and-cultural systems

A population of culture-bearing organisms is sustained by a *single system* of genetic and cultural instructions, rather than by separate systems, genetic and cultural. Consider any human activity of obvious survival-value, such as obtaining food or child-rearing: invariably, such an activity meets S-conditions of one or more whole organismic clusters of both genes and memes, and is emplaced by behaviours, complexly interacting, of *some* of those memes and *some* of those genes.

To segregate such instructions into separate interacting genetic and cultural systems (as do, for example, the contributors to Durham 1982b) therefore seems arbitrary and self-defeating. A system should not be defined or characterized by the *kind* of instructions that compose it, conventional disciplinary boundaries to the contrary notwithstanding⁵⁸.

The term 'system' refers to a set of co-operating *replicables*. A system sustaining a population of higher primates is therefore a *genetic-and-cultural system*.

⁵⁷ Flinn and Alexander (1982) explicitly reject the idea of cultural instructions, averring that cultural features are merely phenotypic *expressions* of more-or-less universal culture-bearing *genes*, so that variations in culture from one population to another can be explained entirely by variation in environment — including particularly, in this case, the learned behaviour of other organisms.

There is nothing *illogical*, of course, in this very sophisticated version of genetic reductionism (Cloak 1981a). To select observational (and perhaps verbal) learning from all the things genetically emplaced organisms do and treat it as a form of replication (they say 'transmission') is, indeed, rather arbitrary. The meme, in short, is a scientific *construct*, a useful demarcation of some neural mechanisms, not an empirical 'elementary particle' like a neuron; it will survive if and only if it proves useful for explaining the immense body of existing and future ethnographic observations and the valid insights and generalizations that have been inferred therefrom. Substituting 'biochemical' for 'neural', 'DNA molecule' for 'neuron', and 'biological' for 'ethnographic', *exactly the same thing can be said of the gene*. (See also Rindos 1984, pp. 54-5 and 78-9.)

⁵⁸ The question of whether there can be separate (and somehow conflicting) systems — a (genetic-and-cultural) system emplacing the human organisms and a (mainly cultural) system emplacing their local or regional *group* — is an interesting one (cf. Boyd and Richerson 1982; Richerson and Boyd 1978). One alternative is that the group, like larger formations, is emplaced by a distributed predatory quasi-system (DPQ-S, section 30.6).

28. Cultural integration and the concept of 'a culture'

The genetic proportions of all human genetic-and-cultural systems are pretty much alike, of course. While there is much inter-cluster (inter-carrier) genetic variation within a population, there is far less variation between populations, i.e. human populations have pretty much the same genes, but they distribute them differently. Memes, on the other hand, vary much more between human populations than within them. Therefore, when we attempt to characterize a human population and compare it to others, we emphasize its cultural features; hence the expression, 'a culture'. Besides being well adapted (section 13.2) to the system's genes and gene products — the carrying organism and its features — a system's memes are also well adapted to:

- (i) the extrasomatic environment, past as well as present; and
- (ii) each other and each other's products — tools, dwellings, social 'structures', and ideology.

It is the latter co-adaptation (ii) that gives an observer of a relatively undisturbed human system the strong sense of integration, of wholeness (Sharp 1952), the notion that a culture is 'all of a piece', a 'cup of clay' (Benedict 1946). Actually, of course, adaptation (including co-adaptation) continues. What is really observed is a snapshot of a culture undergoing gradual systematic evolution, i.e. change largely under environmental control of the culture itself (Cloak 1967; cf. Barkow 1978, pp. 9-11, and sources cited therein)⁵⁹.

Human genetic-and-cultural systems are predatory systems, effectively exploiting other systems (mainly all-genetic systems, but sometimes other human systems as well). Some human systems, however, are also *prey* to certain purely cultural systems (section 30).

29. Limits to self-emplacement; evolution of genetic and genetic-and-cultural systems

No system of instructions, and certainly no single instruction, can propagate itself indefinitely. There are always locations in space-time in which the instructions of a given system do not occur because, in general, some S-condition is lacking there and the system does not meet that S-condition there (section 15). For the same reason, environmental change⁶⁰ may keep a system from maintaining its existing population in a certain region. In the language of section 18, the system is at a *frontier*.

In particular, in certain locations some environmental feature or lack (frontier condition) may prevent a system from constructing a viable

⁵⁹ Few contemporary students would deny that the integration of a purely genetic system and its products can be explained entirely via co-adaptation through natural selection. It seems strange, therefore, that many still consider culture's integratedness to be a fatal barrier to a selectionist or other naturalistic treatment of culture, and insist instead that special causal principles are required to understand culture.

⁶⁰ Change perhaps induced by the behaviour of the system itself.

organism or tool or dwelling or social feature, or prevent the latter from surviving or from acting or from being reproduced.

From time to time, however, as a result of some quasi-random or exogenous process such as mutation, conjugation, sexual recombination, innovation, acculturation, or cultural diffusion, a system may fortuitously acquire, lose, or replace one or more instructions. When such a fortuitous change enables the system to emplace itself despite the aforementioned environmental feature or lack of it and thereby to occur in one or more locations otherwise (and formerly) closed to it, the system evolves across the frontier, becoming adapted (section 13.2) to the feature or lack⁶¹.

For example, consider again Fig. 7. The empty and triangular surfaces at C1, created by the behaviour of *da* at A1, constitute an internal frontier, and the behaviour of *ps* at F1 enables system SYSCB to evolve across that frontier, adapting it to the empty and triangular surfaces it has itself created. [The behaviour of *ps* (presumably) continues to maintain SYSCB in the region across that frontier (footnote 47).]

The initial change in the system is strictly fortuitous; a system does not *acquire* a novel instruction in order to evolve, except in the sense that the instruction may be 'generated' by a selective retainer sub-system (section 21.1). Once acquired, however, the instruction is propagated and maintained in order to perform its system-emplacing *function* in the transfrontier region (section 23).

30. Dynamic relations among systems and clusters

30.1. PREDATION

As sketched above (section 16), simple (passive) one-way exploitation occurs when one instruction emplaces another:

instruction *i* behaves —————→ instruction *j*

Simple one-way exploitation can as well occur between systems:

SYSB behaves —————→ SYSA

In a more active form of one-way exploitation, the behaviour of one instruction *a*, of a system SYSA, enables the behaviour of the instruction(s) of another system, SYSB, to emplace SYSA. *a*, in other words, is an explicitly predatory instruction (Fig. 15). Note that predation, or active exploitation, emplaces the predatory instruction itself. [In all cases of predation, a relatively small amount of effort by the predator (represented as the behaviour of one instruction in the diagram) obtains the output (Thing B) of a relatively large amount of effort by the prey system

⁶¹ The feature or lack becomes a despitant marker in the routeway enabling self-emplacement of the novel instruction (section 13.1).

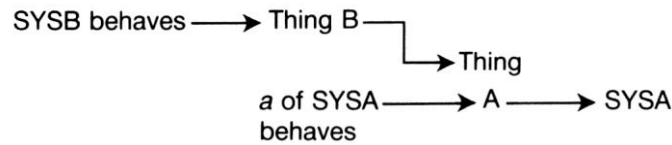


Fig. 15. Predation: System SYSA preys upon SYSB.

(represented as behaviour of the entire system). This energetic asymmetry should be kept in mind during the following discussions.]

Because of energetic considerations (metabolic costs, etc.) such exploitation frequently displaces SYSB (Fig. 16)⁶². Freedom from predation, however, is seldom the limiting resource (sic) for any system; under Malthusian equilibrium the displacement of one SYS merely emplaces another in a short time (section 19, Fig. 12).

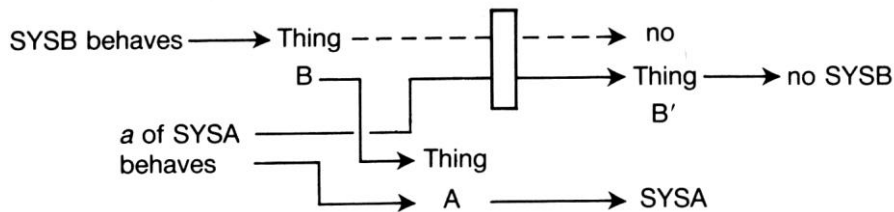


Fig. 16. Predation displaces a system.

Predation often occurs by *deception* (as in angling, trapping, nest parasitism, etc.) (cf. Lloyd 1984). An instruction of SYSA *cues* (enables behaviour of) an instruction of SYSB at an inappropriate location and thus enables predation (Fig. 17).

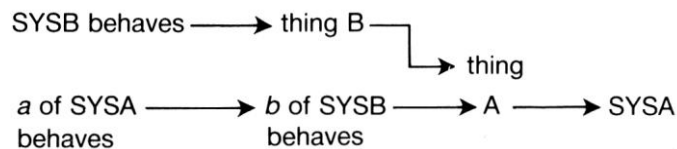


Fig. 17. Predation by deception.

The predator (exploiter) and prey (exploitee) systems may each occur in its own distinct cluster as with, for examples, foxes and geese, or horses and grass. Or the systems may occupy the same envelope, as in the case of internal parasites, or even be completely intermixed in one cluster, as in lysogeny — parasitic viral DNA integrated into the host genome.

When predation is 'internal' it may occur through deception, as when the irritation caused by a flu or cold virus 'fools' the host tissue, and cues a coughing or sneezing instruction, thus spreading the virus; or even through direct behavioural control, as when a 'brain-worm' fluke paralyses an ant,

⁶² An exception to that is the case where thing B can no longer emplace SYSB anyway, e.g. where thing **B** is a carcass or fossil.

exposing it to being eaten by a sheep, and thus continues the life-cycle of the fluke (Hohorst and Graefe 1961).

30.2. PREDATION AND SELF-EMPLACEMENT WITHOUT MEETING S-CONDITIONS

When a predator cluster maintains its own organism at least part of the time, its members truly co-operate and form a system; each instruction, directly or indirectly, meets some S-condition of the cluster. In some cases, however, predatory instructions (or clusters) emplace themselves not by meeting S-conditions, but by enabling occurrences of (replicas of) themselves at locations where *other* instructions meet all S-conditions.

The *t*-allele in the house mouse (Lewontin and Dunn 1960), like other genes that emplace themselves by skewing their meiotic segregation ratios, is a case in point. The *t*-allele is a bona fide member of the mouse genome (genetic cluster), presumably arose in it, and can have no existence ever outside it, yet it is surely a parasite-predator-exploiter of the mouse genetic system (Fig. 18)⁶³.

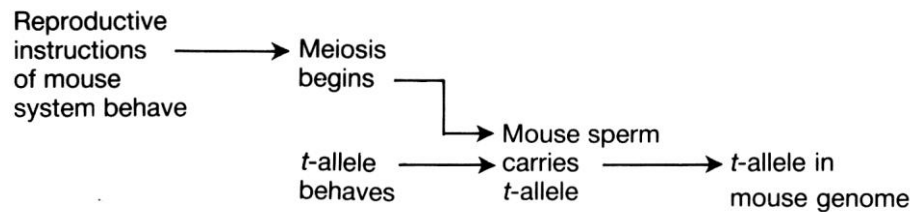


Fig. 18. *t*-allele preys on mouse system.

Genes involved in sexual selection and genes promoting forcible sperm-transfer are other examples of such predation. Memes which exploit, say, the operant learning selective retainer (section 21.1) may similarly emplace themselves without meeting S-conditions, e.g. memes for use of narcotics and alcohol. Other predatory memes exploit prestige complexes (Barkow 1975).

30.3. MUTUAL EXPLOITATION

Co-operation was introduced in section 16 as one form of mutual exploitation (Fig. 19). In co-operation, each instruction emplaces both itself and the other instruction(s). Therefore, if either instruction fails to behave no instruction is emplaced; the entire process is aborted, so a lapse into exploitation of either *a* or *b* by the other ('cheating') simply cannot happen. The result of co-operation is a system; if *a* and *b* are (in) different clusters, then it is a system of two or more clusters.

⁶³ Figure 18 does not include the *t*-allele's lethal effect on the mouse system when the genome is homozygous for it.

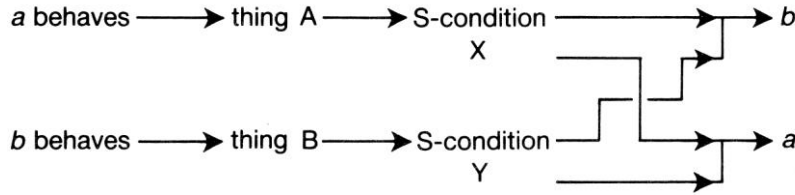


Fig. 19. Co-operation (after Fig. 8). In special cases things A and B, and/or S-conditions X and Y, are identical.

Another form of mutual exploitation is *mutualism* (mutualistic symbiosis) or reciprocal altruism⁶⁴ or division of labour (Fig. 20), wherein each of two systems emplaces the other by, say, emplacing the other's carrying organism but does not, at the same time, directly emplace itself⁶⁵.

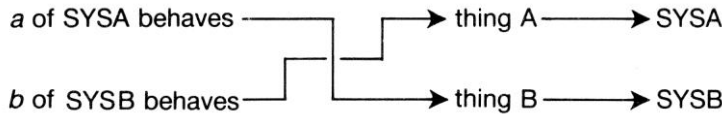


Fig. 20. Mutualism, or reciprocal altruism, or division of labour.

Mutualism is really *reciprocal exploitation*, however (Fig. 21); for example, if a SYSA occurs without *a*, or if *a*'s behaviour is suppressed, the situation reverts to one-way exploitation; i.e. SYSA 'cheats' SYSB.

When a mutualism occurs regularly its result can be called a *quasi-system*; as in a system proper, each symbiont instruction or cluster has a *function* (section 23) in and for the quasi-system.

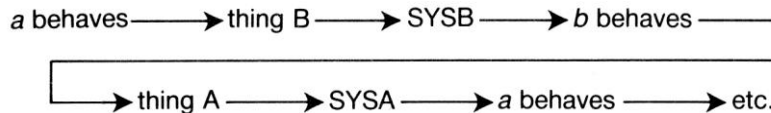


Fig. 21. Mutualism, etc., exposed. (SYSB includes *b*; SYSA includes *a*).

It seems likely that to succeed in a quasi-system, a system must include one or more instructions, in addition to *a* or *b*, whose function (in the system, not the quasi-system) is to prevent 'cheating'; i.e. to recognize a

⁶⁴ Altruism of the kin-selection variety is not a form of mutual exploitation; it is, very simply, ordinary self-emplacement:

$$a \text{ behaves (in organism } 0_1) \longrightarrow \text{organism } 0_2 \longrightarrow a \text{ (in organism } 0_2).$$

Mutualism occurs between systems, as shown, but it entails mutualism between instructions *a* and *b*. Note that in the primordial soup (section 3) only co-operation, not mutualism, occurs; mutualism occurs only between systems. The reason for that is that instructions have common background S-conditions so, in the soup, an instruction can hardly emplace another instruction without emplacing itself. In mutualism, on the other hand, *a* and *b* each meets some S-condition of the other's system in a different location, generally through a rather elaborate determinant sequence (and routeway), and does not meet an S-condition of its own system directly at all.

cheater and either cease its own carrier's mutualistic behaviour toward that cheater or somehow reinforce the cheater's mutualistic behaviour (Trivers (1971; Cloak 1976).

30.4. PREY ADAPTATION

Prey adaptation (Fig. 22) is a form of hazard avoidance, differing only in that the hazard being avoided is the product of another living system. Under conditions of competition (section 19) instruction b , which adapts SYSB to the predatory actions of SYSA+a, propagates.

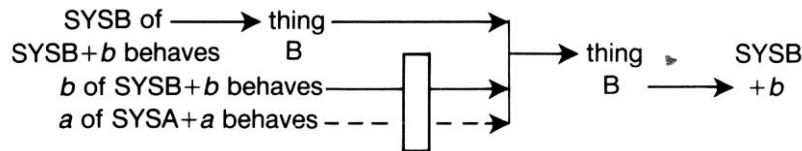


Fig. 22. Prey adaptation: self-emplacement of b .

SYSA is controlling the evolution of SYSB. a 's behavioural outcome was a frontier condition for SYSB, and SYSB evolved across that frontier by acquiring b . After evolution, a is a marker, of the despitant variety, in the routeway enabling self-emplacement of b ; a 's behaviour, therefore, actually enables the propagation of b and thus b 's inclusion in SYSB⁶⁶.

30.5 DOMESTICATION

Domestication (Fig. 23) occurs when the predatory system (SYSA) in effect turns the adaptation process of the prey system (SYSB) against it; SYSA acquires instructions a and a' (a was perhaps already self-emplaced as a predatory instruction); SYSB acquires b ; a behaviour of a' , as a co-

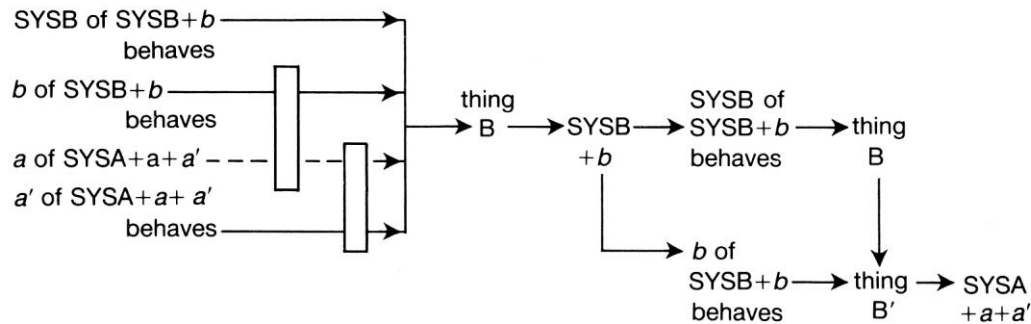


Fig. 23. Domestication: self-emplacement of b and a' .

⁶⁶ Of course that is to a 's disadvantage in the long run. By thus emplacing b , a sometimes displaces itself; indeed, if captured prey is the limiting resource R for SYSA, as it might well be, the result of prey adaptation by SYSB may well be permanent reduction in the frequency of occurrence of SYSA.

determinant, enables b 's behaviour to emplace $\text{SYSB} + b$; SYSB thus survives a 's behaviour, in the short run; later, however, b enables predation (or more effective predation) of SYSB by SYSA . (Note that once established, b plays the same role as b in Fig. 17, predation by deception.)

For example, assume a population of ants, emplaced by SYSA ; and a nearby population of aphids, emplaced by SYSB . Gene a enables the ants to prey upon individual aphids, 'milking' them for the secretions they have generated from their (plant) food. Because it is deprived of these secretions, the milked aphid is often unable to survive (or reproduce). The aphid secretion (or some ingredient thereof) is the limiting resource R for SYSA . SYSA now acquires gene a' , which stops its carrier's milking behaviour after a certain amount of nectar has been taken from each aphid; and SYSB acquires gene b , which increases the amount of nectar secreted by its carrier beyond the amount required for survival (reproduction); b therefore emplaces itself by enabling its carrier to survive milking (thing B), but its behaviour also provides the predator ants with a supply of nectar larger and more dependable than heretofore (thing B').

$\text{SYSA} + a + a' + b$ is a quasi-system. Until this sub-section, the function of each instruction has been clear: a 's function has been to enable predation upon SYSB by SYSA ; b 's function has been to prevent such predation. But in the case of domestication, b has not only that function but also another function, in and for $\text{SYSA} + a + a' + b$, of *enabling* such predation. b , in other words, is a mutualistic symbiont of SYSA . Henceforth, a and a' , together, *emplace* b , in SYSB 's clusters, in order to enable exploitation of SYSB by SYSA ⁶⁷.

30.6 A DISTRIBUTED PREDATORY QUASI-SYSTEM (DPQ—S)

The discussion in this section so far has established two things. First, the cases of lysogeny (section 30.1) and the predatory instructions of section 30.2 demonstrate that predatory instructions need not have any physical existence outside a prey-cluster. Secondly, the discussion of domestication (section 30.5) demonstrates that at least one member of a predatory quasi-system may reside in the prey-cluster, while its other members reside elsewhere. It is theoretically possible, then, that there could exist a predatory quasi-system which had no cluster of its own, but all of whose members were *distributed* over a number of different clusters of the host/prey system(s). All the members of such a distributed predatory quasi-system (DPQ—S) function as either a or b ⁶⁸. By controlling the evolution of host/prey systems, *as* force them to include *bs*; then *bs* emplace *as*.

While a distributed predatory quasi-system could theoretically be made

⁶⁷ Perhaps a and a' are not both necessary, i.e. cases of domestication could be described such that a alone, or a' alone, would provide the routeway emplacing self-emplacement of b .

⁶⁸ The only difference between a' and b , of Fig. 23, is that a' resides in the cluster of SYSA and b in the cluster of SYSB . Since in a DPQ-S SYSA has no cluster, a' is redundant to b .

up of genes, and perhaps there are genetic DPQ—Ses, the candidates that spring most quickly to mind seem to be entirely cultural; the caste system of traditional India, the class system of mediaeval Europe, and — most powerful and most subtle — today's world system of mature capitalism. The idea of a DPQ—S may render understandable the strange way people have of systematically behaving, without apparent coercion, against their own best interests — behaving, in short, like domestic animals⁶⁹.

31. Community evolution

As mentioned previously (section 24), a system can control its own evolution and thus become bigger and better adapted, becoming better protected against exogenous environmental perturbations, etc.

In fact, the older and bigger a system is the longer it is likely to survive and the bigger a perturbation would have to be to damage it⁷⁰. The underlying process, of course, is natural selection, and hence, self-emplacement. Clearly, the same process can yield the same results when a quasi-system, rather than a true system, is involved. Can the same process yield the same results when an entire biotic community, or ecosystem, is involved?

The key premise to an argument for 'community selection' (Aarssen and Turkington 1983) is that the community's environment is practically all biotic, i.e. it is almost entirely the resultant of behaviour of the instructions of community members. Each member system of a mature community is highly adapted to its neighbours; their behaviours are co-determinants and despitants in the routeways of its instructions' self-emplacements, and *vice versa*. Acquisition of a novel instruction whose behavioural outcome is on balance destructive to its neighbourhood very quickly redounds against a system; the system loses out in competition with its kindred (cf. Wilson 1976, 1980) and thus the novel instruction fails. On the other hand, a novel instruction that improves the neighbourhood, which is to say makes it 'more so' is at least fairly likely to be adaptive for the system that acquires it, and thus to be propagated. The effect of that is that the ecosystem as a whole successfully 'competes' with all other likely ecosystems — 'likely' in

⁶⁹ Note that such behaviour is 'altruistic' in a sense not commonly dealt with by sociobiologists — the alter is not another organism, but the DPQ-S itself (Cloak 1976; cf. Barkow 1978, pp. 11-2).

The idea of a cultural DPQ-S has resonances with Robert Redfield's 'Great Tradition', Edward Sapir's 'Spurious Culture', Jules Henry's 'Culture Against Man', A. L. Kroeber's and Leslie A. White's 'Superorganic', Karl Marx's 'False Consciousness', and Antonio Gramsci's 'Cultural Hegemony'.

In the hierarchical political economies mentioned, there is probably an uneven distribution of the DPQ-S instructions, with the rulers/elites/haves carrying more as and the ruled/plebeians/have-nots carrying more bs. But the idea is not that one group or class of people domesticates another. Rather, the DPQ-S domesticates the human genetic-and-cultural system of every group and class.

⁷⁰ Paradoxically, it also becomes ever more likely to *cause* a long term secular change that it cannot adapt to. The resonance here is with Marx's 'dialectic'.

the sense that they could come about as the result of a series of random micromutations and adaptations or by gradual encroachment of instructions/systems from neighbouring regions⁷¹. Communities, therefore, will often evolve gradually and adaptively, along with their component telenomic systems⁷². *Mutatis mutandis*, the same goes for a modern urban society where, again, the environment is emplaced almost entirely by the behaviour of the memes carried by the society's human members — including memes both of their human systems and of the cultural DPQ—S that domesticates them (Cloak 1976).

32. Closing words

32.1. SUMMARY

(i) Instructions and their behaviours are the basis of life, action, and culture.

(ii) As a rule, instructions occur frequently only if they emplace themselves frequently, i.e. only if they are selected for.

(iii) Self-emplacement depends upon the environment, i.e. upon co-determinants and despitants in environmental routeways.

(iv) The co-determinants and despitants include, most especially, other instructions and their behaviours and products, in event-sets of cooperation, competition, exploitation, mutualism, etc.

(v) Those event-sets, in turn, of course, require self-emplacement of those instructions.

(vi) The result is continuing evolution of enormously complex and interesting features of life, action, and culture.

32.2. APPLICATIONS

A general theory cannot be expected directly to provide specific predictive hypotheses of the 'under such-and-such environmental conditions organisms will have such-and-such features' variety. What it can do is (1) help to clarify existing propositions of social science and biology, making them more naturalistic, specific, and concrete; (2) provide the means to convert those propositions into testable hypotheses; and, from these activities, (3) suggest new or alternative hypotheses and propositions.

For example, from observations and reports of human action, anthropologists and sociologists infer propositions about social and cultural forms, institutions, ideologies, etc. From such observation- or report-based propositions they infer more general and/or abstract propositions, in a recursive, hierarchical process eventuating in propositions imputing to culture and society such global characteristics as:

⁷¹ By definition, then, the introduction of rabbits to Australia was unlikely.

⁷² Of course, making the ecosystem 'more so' might very well, in the medium or long run, subject it to the paradox mentioned in footnote 70, to the point where an actively evolving member system could put the community — and itself — out of business.

- (i) autonomy (superorganicism, social facts)
- (ii) integration (patterning, themes, holism)
- (iii) self-regulation (teleonomy)
- (iv) functionalism (adaptation)
- (v) general evolution (progress, dialectics).

In some cases, at least, the general/abstract propositions are then erroneously employed to *explain*, deductively, the more specific and concrete propositions, and ultimately, the observed and reported actions.

As suggested in sections 24, 25, 27, etc., the self-emplacement theory of natural selection can be used alternatively to explain actions directly, and to do so in such a way as, frequently, to explain and/or test the propositions inferred from them.

This alternative, selectionist kind of explanation requires one to frame statements much more specific and concrete even than most statements 'directly' descriptive of observations. After establishing the (sorts of) actions from which the proposition in question has been inferred (however indirectly), the selectionist determines the (sorts of) instructions that emplace those actions. Then, for each instruction, he/she asks

- (i) through what determinant sequence does emplacing that action emplace the instruction itself; and
- (ii) What routeway underlies that determinant sequence, i.e. what are the co-determinants and despitants (including other instructions/behaviours) of the self-emplacement?

Some of the answers to those two questions will be directly implied by, or easily inferred from, the proposition being explained (e.g. Fig. 6); others, however, may have to be supplied by the analyst — revealing, perhaps, hidden assumptions about the environment (e.g. Fig. 7). Each marker, then, is examined to see whether it, in turn, requires explanation; this is especially likely if the marker is an instruction or an instruction-emplaced feature.

As these questions are answered, of course, the answers are plugged into an event-set diagram like those used in this essay. Each determinant and despitant relation is tested for physical plausibility as it is added.

The above process may well yield some unexpected results, in themselves useful for clarifying the proposition being explained; for example, some hitherto unrecognized feature of culture may prove to be required for populations to whom the proposition applies.

When the diagram is complete, the events in it must be tested, singly and collectively, for empirical support. In other words, is there evidence that these events occur, in the correct temporal and spatial relations, frequently enough to support the proposition? If a crucial empirical test fails, an attempt may be made to reformulate the analysis without certain events, or the proposition itself may require revision or rejection. If, however, the event-set diagram stands up under analysis, empirical verification, and (presumably) collegial criticism, the proposition may be declared provisionally (1) confirmed and (2) explained, via the event-set diagram, by (the self-emplacement theory of) natural selection.

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Besides the broad propositions of traditional cultural anthropology and sociology, the above method may be used to 'naturalize' and clarify more specific predictive hypotheses such as those of evolutionary ecology (Smith 1983): foraging strategies, mating systems and life-history strategies, spatial organization and group formation, niche theory, population dynamics, and community structure⁷³.

33. Acknowledgements

Many of the ideas in this paper are borrowed, in whole or in part. Where possible, I have tried to provide at least representative citations. In many cases, however, I no longer remember where I first ran across them. Here, therefore, is a list of people and/or works that have had significant influence on the thinking that has gone into this paper: Morton Beckner (1968); Donald T. Campbell (1960, 1965); V. Gordon Childe (1951); Edward T. Hall (1959, 1966); Garrett Hardin (1959); Marvin Harris (1966, 1968); Harry F. Harlow (1958); Carl G. Hempel (1953); Charles F. Hockett (1948, 1960); Hockett and Ascher (1964); William James (1907/1963); A. L. Kroeber (1948, 1952); Ralph Linton (1936); Konrad Lorenz (1965); Jacques Monod (1972); Ernest Nagel (1956, 1961); William T. Powers (1973); Bertrand Russell (1959); Marshall D. Sahlins (1961); Sherwood L. Washburn (1951; Washburn *et al.* 1965); Leslie A. White (1949); and George C. Williams (1966).

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34. Glossary

Since the glossary develops progressively, each term often being defined by previous terms, the terms are not in alphabetical order; an alphabetical index is provided herewith for quick reference.

abiotic.....	34.3.12	causal relation.....	34.1.13
adapt, adaptation	34.3.6	change	34.1.3
behaviour	34.3.1	cluster	34.3.14
biotic	34.3.12	co-determinant.....	34.1.16
carry, carrier.....	34.3.15	competition	34.3.13

⁷³ A forthcoming article (Cloak, 1987, in preparation) will use the method to 'naturalize' and clarify some life-history strategy hypotheses.

constitution	34.2.7	mechanism	34.3.6
control system (neural)	34.3.2	meme	34.3.2
co-operation	34.3.7	mutualism	34.3.20
cue	34.3.1	natural selection	34.3.4
cultural instruction	34.3.2	negative feedback.....	34.1.14
deplace	34.2.2	neural instruction.....	34.3.2
despitant	34.1.12	occur, occurrence	34.1.6
despitant relation	34.1.12	organism.....	34.3.15
despite	34.1.11	overdetermine.....	34.1.15
determinant.....	34.1.8	physical plausibility	34.1.8
determinant relation	34.1.8	population.....	34.3.16
determinant sequence	34.1.9	positive feedback.....	34.3.11
division of labour	34.3.20	predation	34.3.19
domestication	34.3.19	prevents	34.1.10
emplace	34.2.1	process	34.1.9
emplace(s) self	34.3.3	propagated.....	34.2.4
enables.....	34.1.8	quasi-system.....	34.3.20
event	34.1.7	reciprocal altruism	34.3.20
event-set	34.1.17	relation	34.1.2
evolution.....	34.3.9	replicable	34.3.18
exploitation	34.3.19	replicator	34.3.18
feedback, negative	34.1.14	resource	34.3.5
feedback, positive.....	34.3.11	resultant	34.1.8
frontier.....	34.3.8	routeway.....	34.3.6
frontier conditions	34.3.8	S-conditions	34.2.6
function	34.3.10	selected against	34.3.13
homeostasis	34.1.14	selected for	34.3.4
instruction.....	34.3.1	selective retainer	34.3.17
instruction, neural.....	34.3.2	self-emplacement	34.3.3
interchangeable	34.2.8	structure	34.1.1
location	34.1.5	succeed, success	34.2.5
maintained	34.2.3	system.....	34.3.7
markers	34.3.6	thing	34.1.4

34.1 FUNDAMENTAL CONCEPTS

34.1.1. Structure (unqualified or qualified as 'material): an atom or a group of structures with relatively stable relationships among them maintained, as a rule, by chemical (electromagnetic) bonding.

34.1.2. Relation (unqualified or qualified as 'spatial): the relative location(s) in three-dimensional space of two or more structures; expressed in such terms as 'above', '10 km west of', 'completely surrounded by', etc. More or less, a relation defines a structure, e.g. a certain relation between a handle and a head defines a hammer⁷⁴.

34.1.3. Change (unqualified): a change in a relation; invariably ends in a new relation.

⁷⁴ To say that a relation occurs implies the occurrence of the related structures.

34.1.4. *Thing*: generic term for a structure, a relation, a change, or a causal relation (Def. 34.1.13).

34.1.5. *Location* (unqualified or qualified as 'spatiotemporal'): a point or a bounded region of space-time identifiable by its coordinates in some four-dimensional coordinate system.

34.1.6. A thing *occurs* when it takes place or happens or 'shows up' at a certain location.

34.1.7. *Event*: an occurrence of a thing.

34.1.8. Event x *enables* event y : (1) event y is the case, and (2) event y would not be the case were event x not the case. Event x is prior in time to event y . Schematically,

$$x \longrightarrow y.$$

Event x is the *determinant*, event y is the *resultant*, and event x and event y are in a *determinant relation*. A determinant relation is the case only if *elements* (1) and (2) (above) are both the case. To confirm a determinant relation, one must verify empirically the occurrence of determinant and resultant, and establish the physical *plausibility* of element (2), i.e. be able to show how the contingency between the two events requires assumptions of nothing other than generally accepted physical processes and verified or reasonably likely intervening events.

34.1.9. Determinant relations are often enchain in a *determinant sequence*, wherein the resultant of one determinant relation is the determinant in the next. Schematically,

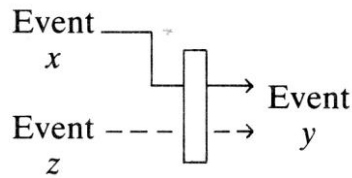
$$x \longrightarrow y \longrightarrow z.$$

Often, but by no means always (Def. 34.1.14), a determinant sequence enables an occurrence of a determinant relation between the initial event (x) and final event (z) in it. When it does, it is the *process* by which x enables z .

34.1.10. Event x *prevents* event y : event x enables non-event y , i.e. event y is not the case and event y would be the case were x not the case. Schematically,

$$x \longrightarrow \neg y.$$

34.1.11. Event x enables event y *despite* event z : event y is the case, and event z would prevent event y were event x not the case. Schematically,

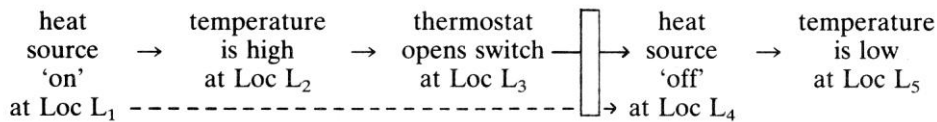


If z were negated y would not be contingent upon x ⁷⁵. Hence, *event z enables an occurrence of the determinant relation $x \longrightarrow y$.*

34.1.12. In the previous definition, event z is a *despitant* of the determinant relation; a *despitant relation* prevails between event z and determinant relation $x \longrightarrow y$.

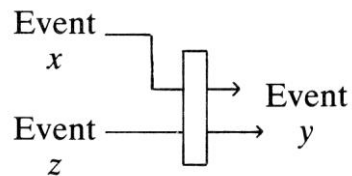
34.1.13. *Causal relation*: generic term for a determinant relation or a despitant relation.

34.1.14. If there is a despitant relation between two events in a determinant sequence, that determinant sequence does *not* enable an occurrence of a determinant relation between its initial and final events; instead, it enables an occurrence of *negative feedback* or homeostasis. To use the traditional example of the thermostat:



(For another example of negative feedback, see the determinant sequence beginning 'predators chase herd' in Fig. 14.)

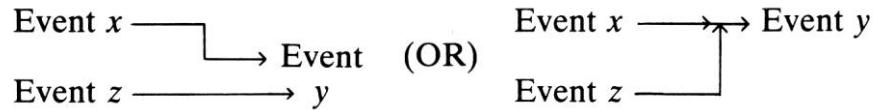
34.1.15. On the other hand, event y may be *overdetermined* by event x and event z ; i.e., event y is the case and event y would not be the case were neither event x *nor* event z the case. Thus, neither x *nor* z is alone a determinant of y . Schematically,



(Note that if negated, a despitant becomes an overdeterminant.)

34.1.16. Any event has a myriad of determinants, of course. If two or more of these are discussed at the same time, they are referred to as *co-determinants*. Schematically,

⁷⁵ The 'collar' linking the despitant-arrow and the determinant-arrow must be there to indicate *which* determinant relation, of all the determinant relations in which y is the resultant, z is related to.



34.1.17. *Event-set*: a collection of events and the causal relations among them, as portrayed in an event-set diagram.

34.2. DEFINITIONS FOR CONVENIENCE

While the following definitions do not introduce new concepts, they do help to reduce the length of statements.

34.2.1. Thing t_1 *emplaces* thing t_2 : an occurrence of thing t_1 enables an occurrence of thing t_2 .

34.2.2. Thing t_1 *deplaces* thing t_2 : an occurrence of thing t_1 prevents an occurrence of thing t_2 .

34.2.3. Thing t is *maintained*: thing t occurs at a constant number of spatial locations over time.

34.2.4. Thing t is *propagated*: thing t occurs at an increasing number of spatial locations over time.

34.2.5. Thing t *succeeds, is successful*: thing t is propagated and maintained; thus, its frequency of occurrence becomes and remains high over time.

34.2.6. The conditions of survival, or *S-conditions*, of structures of a certain kind, are severally necessary and collectively sufficient for their occurrence (section 15)⁷⁶. S-conditions can be conveniently divided into three classes.

(1) *Background* S-conditions — the ranges of values of environmental variables under which the structures' component structures and relations can occur;

(2) *Immediate* S-conditions — the actual occurrence of the component structures; and

(3) *Uniquely defining* S-conditions — the relations among the component structures (unique for each structure of the kind in question).

34.2.7. The *constitution* or 'architecture' of a structure is its component structures and the relations among them.

34.2.8. Two structures are *interchangeable* in an event-set when replacing each with the other would not affect any outcome of the event-set.

⁷⁶ The S-conditions of any given structure can always be completely reduced to occurrences of *things* in certain specified relations to each other.

34.3 THEORETICAL CONCEPTS

34.3.1. An *instruction* is a material structure so constituted that in its usual surroundings it is capable of *behaving* in just one rather simple discontinuous way. To say that a structure behaves at some location is to say that an occurrence of it emplaces a change at that location. As a rule an occurrence of some other change (the *cue* or releaser or stimulus) is a co-determinant of the behaviour/change. (See section 6 for a complete discussion of instruction, behaviour, and cue.)

34.3.2. A neural *control system* is a collection of neurons and synapses that, by mediating its carrying organism's actions (gross behaviour), controls the organism's perception (Powers 1973; section 26). A control system that is activated by a cue from its environment is a *neural instruction* (cf. *instruction*, section 34.3.1). If a neural instruction is emplaced by observational learning or verbal tuition, it is a *cultural instruction* or *meme* (and thus a replicable, section 34.3.18).

34.3.3. When a behaviour of an instruction emplaces that instruction or an interchangeable instruction, the instruction *emplaces itself*. (See section 10.)

34.3.4. When an instruction succeeds by emplacing itself more frequently than it is deplaced (by its own behaviour and exogenous factors), it is *selected for*; i.e., *natural selection* takes place.

34.3.5. Instructions emplace themselves most frequently by meeting S-conditions. As they do so, various structures — *resources* — are altered.

34.3.6. A *roueway* is a series of environmental markers; i.e., of occurrences of things that are co-determinants and despitants of events in a determinant sequence (section 13.1). If the determinant sequence is a process (Def. 34.1.9), the underlying roueway is the *mechanism* of that process. If the process emplaces self-emplacement of an instruction, and the instruction belongs to a system (section 34.3.7), the instruction's behaviour and/or behavioural products *adapt* the system to the roueway and/or its component markers (section 13.2).

34.3.7. When the behaviours of two (or more) instructions meet one or more S-conditions of both (all) and thereby enable occurrence of both (all) those instructions, each instruction emplaces itself through *co-operation* with the other(s). A set of co-operating instructions constitutes a *system* of instructions. (See section 16.)

34.3.8. For any system, sooner or later, an occurrence or absence of some environmental feature prevents it from meeting some S-condition and thus from emplacing itself in some location. The occurrence or absence is a *frontier condition*, and the system is at a *frontier*. The frontier is 'internal' when surrounded by occurrences of the system.

34.3.9. *Evolution* occurs when a system acquires (or loses) an instruction and is thereby enabled to propagate across an internal or external frontier. (See sections 18 and 29.)

34.3.10. The behaviour and/or proximate behaviour-product through which an instruction regularly emplaces a system, and thereby emplaces itself, is the instruction's *function* in and for that system (section 23). The behaviour or behaviour-product also, thereby, acquires a function.

More precisely, the function of an instruction is the specific behaviour product through which it emplaces the system despite an occurrence of an erstwhile frontier condition, i.e. through which it enabled the system to evolve at some time in the past.

34.3.11. *Positive feedback* takes place when an event-set of evolution emplaces another, similar, but more 'challenging' frontier, and the system again evolves across that frontier (Fig. 14).

34.3.12. Things emplaced by the behaviours of successful instructions are *biotic* things; all other things are *abiotic*.

34.3.13. *Competition* occurs when self-emplacement of one system prevents another system from emplacing itself, because the quantity of some resource is limited (section 19). The two systems are *selected for* and *selected against*, respectively.

34.3.14. Instructions which regularly occur in the same or nearby locations thereby form *clusters* (section 17). In another sense, a cluster serves as a physical instance of a system.

34.3.15. An *organism carries* a cluster of instructions, providing the cluster with an 'S-conditioned' microenvironment. Most of the instructions, in turn, construct and 'operate' the organism, thereby emplacing themselves (section 20).

34.3.16. *Population*: a group of similar clusters of instructions such that two (or more) clusters can pool their instructions (or replicas thereof).

34.3.17. *Selective retainer*: a subsystem of instructions whose function is to emplace instructions whose behaviours meet certain criteria (section 21.1).

34.3.18. *Replicator*: a subsystem of instructions whose function is to meet the uniquely defining S-conditions of other instructions by copying them (section 21.2). An instruction so copied is a *replicable*, i.e. a gene, or a meme (section 34.3.2).

34.3.19. *Exploitation* occurs when one instruction or system enables an occurrence of another (section 30). When an instruction explicitly enables its carrying system to exploit another system, that is *predation* (section 30.1). When one system preys upon another by controlling the latter's evolution, that is *domestication* (section 30.5).

34.3.20. *Mutualism* (reciprocal altruism, division of labour) occurs when two systems alternatively exploit each other, forming a *quasi-system* (section 30.3) (cf. co-operation).

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