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What's in a Meme?
Reflections from the perspective of the history and philosophy of evolutionary biology

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Contents

Abstract

This paper is intended as a focal article to raise philosophical issues about the nature of memes and memetic theory. To bring consistency to memetic analysis, researchers need to understand and agree upon the theoretical role of memes and the generalized model of evolution in which it occurs as a theoretical term. To help this, I have traced the source of Dawkins' conception of memes from GC Williams' *evolutionary gene* and through to the Hull-Dawkins Distinction between *replicators* and *interactors* and Hull's notion of *lineages* and the idea of an individual in biology. The complexity of biological modes of evolution suggests that conceptualizing memes as disease pathogens is not an alternative to evolutionary models of memetic development. I argue for a close and strict analogy between biology and memetics. I introduce the idea of a *memetic individual* or *profile* to clarify the ontology of memes and their ecologies. Some promising methods from biology and other disciplines such as Hamming Distance and Wagner groundplan divergence methods are suggested. A glossary of mainly biological technical terms used and introduced neologisms is included.

Keywords: Meme, evolution, gene, replicator, interactor, individual, natural selection, term, mnemone, pheme, deme, ecology, epidemiology, mind virus, Lamarckism, Dawkins, Hull, Campbell, Williams

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JULIET: *'Tis but thy name that is my enemy;*
Thou art thyself, though not a Montague.
What's Montague? it is nor hand, nor foot,
Nor arm, nor face, nor any other part
Belonging to a man. O, be some other name!
What's in a name? that which we call a rose
By any other name would smell as sweet;
So Romeo would, were he not Romeo call'd,
Retain that dear perfection which he owes
Without that title. Romeo, doff thy name,
And for that name which is no part of thee
Take all myself.

(William Shakespeare, *Romeo and Juliet*, Act 2, Scene 2)

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1 Introduction

The fundamental theoretical concept of memetics is the meme[1] - the unit of cultural evolution and selection. The term is unclear in its meaning and what it denotes, and the application of evolution to culture is often based on a partial or even mistaken notion of the general structure of evolutionary explanation. In this paper I give some historical background to the origin and function of the term "meme" from the debates in evolutionary theory out of which it sprang. I argue that there is a close analogy between the entities and processes of biology and culture, although the parameters that describe each domain often differ in their rate and frequency, and perhaps in the dynamics of the evolutionary process they undergo. It is as crucial to understand what the units of evolution in culture are as it is in biology to be able to apply an evolutionary explanation, and for this reason we must be quite clear about what a cultural individual is. We can make better sense of these issues if we look first at the analogous problems of what a biological individual is, especially in the context of what the units of selection are.

Problems that bedevil memetics include classifying cultural entities and reconstructing historical developments, and these also have their analogues in biology. Resolving them depends on determining the level at which selection occurs, for it is selection that defines what is functionally important in evolution, not the contrary. The conceptual tool of most help to us here is the distinction between replicators and interactors. There are three common approaches in memetic writings - most commonly writers picture meme evolution as the spread of disease pathogens, others restrict selectionist accounts to some part of culture that is amenable to this form of explanation such as science, and I argue for a third option. We must more broadly understand the variety of biological evolutionary phenomena, so that we can see the similar patterns in cultural change. In order to assist in this, I introduce the notion of a memetic individual, and discuss the relationship this entity has with the biological organism in which it resides. In the conclusion and prospectus, I suggest some analytical techniques of biology, particularly methods of taxonomy and genetics, which these distinctions permit for memetic research.

I hope both that biologically literate readers will understand my simplifications of biology and that those not familiar with biological terminology its necessity. I append a glossary of various technical terms introduced in this paper and those that are likely to be unfamiliar to nonbiologists.

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2 The background to the problem

> *The increase of the conceptual clarity of a theory through careful clarifications and specifications is, as William Whewell observed more than a century ago, one of the most important ways in which science progresses. He called this process "the explication of conceptions" and showed how a number of theories, in the course of their temporal careers, had become increasingly precise - largely as a result of the critics of such theories emphasizing their conceptual unclarities. Many important scientific revolutions ... have depended largely on the recognition, and subsequent reduction, of the terminological ambiguity of theories*. (Laudan 1977:50)

Certain terms and notions in both the sciences and humanities are fated to be misunderstood, either because they are first vaguely formulated, or because they are so evocative they generate such immense enthusiasm and are applied to almost everything, coming to mean almost nothing. A classic example is the term of Thomas Kuhn's (1962): *paradigm*. Originally intended by Kuhn to apply to what changed radically in a scientific revolution, it came to be applied to perceptual and conceptual changes in cases of individual, social, literary, political, economic and even consumer choice. When a term of philosophy of science is used to advertise a new car design, you know it has lost any definite meaning. Eventually its author abandoned it under criticism in favour of notions and terms that were more specific, but "paradigm" is now ensconced in popular parlance, surviving both author and intended theoretical usage. The difficulty now with the term for a specialist in the philosophy and history of science is that calling a theoretical change a "paradigm shift" has become little more than a metaphor. It describes only an impression and implies only a subjective assessment.

The basic and central notion of memetics is, of course, denoted by the term meme, Richard Dawkins' (1977) term for what is transmitted in culture that is analogous to the biological gene. "Meme" is in danger of suffering the same fate as "paradigm". It is used to denote, variously, neural structures, cultural artefacts, practices, economic systems, religions, concepts, phenotypic traits, self-awareness, and epigenetic predispositions. Memes are thought by some to control behaviour, by others to be acquired through a choice or act of will. The term gets applied to all levels of social and cultural structure, from minimal semantic entities like phonemes, through more molecular entities like phrases and snatches of music, to entire traditions and world views. In this blooming buzzing confusion, the usefulness of memes as a category is being lost or degraded.

It wouldn't be the first time this sort of confusion has wrecked an emerging discipline - gene, the very term on which "meme" is modelled, has a history of shifting definition and debates in which antagonists argued past each other for more than sixty years. It took the modern evolutionary synthesis and the discovery of the structure of DNA to resolve it fully, and still, "gene" covers a range of theoretical phenomena requiring the more exact terminology of *codons, cistrons, introns, exons, operons, regulators* and *base pairs*. Even today, biologists use this term differently and inconsistently - what molecular biologists usually mean by it differs greatly from its meaning in population genetics.

A theoretical term is usually generated to denote a causal nexus in the model the theory describes[2]. On at least one recent account (Suppe 1989, van Fraassen 1980) a scientific theory is an attempt to either isolate or idealize a system - usually a physical system - in such a way that its dynamics can be reduced to a manageable number of variables (each of which is usually represented by a theoretical term) related by a mathematical description, so that the model generates a restricted number of likely outcome states. It is often neutral with respect to many of the attributes of the entities and processes it covers: Newton's theory of falling bodies does not mention their colour, for example; the equations of flow dynamics cover water, hydrocarbon liquids, and gases; and information theory covers transmission of bits by electromagnetic radiation no matter whether the medium is electrical, photic or magnetic.

One such generalized scientific theory is the theory of adaptation and evolution by natural selection. Natural selection is a process that occurs over a range of physical substrate entities: viruses, single celled clonal organisms, multicellular plants, animals and fungi, and so forth. Certain variables need to be adjusted to deal with these very different phenomena - life cycle rates, ecological behaviour, reproduction modes and so forth - but the virtue of the theory as a model is that it is highly generalizable and widely applicable. Recently, for example, natural selection models have been applied through the use of computers to a range of real world problems, and have been developed into a class of formal algorithms called Genetic Algorithms (cf. Holland 1995). Problems to which Genetic Algorithms have been applied include political and social problems, through to hard engineering of complex systems like engines and flow dynamics.

To understand the meaning of *meme*, we need to understand the history of some debates in evolutionary biology, and the ways in which evolution and culture have been thought to be related. Even before Darwin published the *Origin* in 1859, evolutionary reconceptualisations of human society and culture were common. The Lamarckian evolutionary tradition through Geoffroy, Grant and Chambers had drawn radical social conclusions based on their view of evolution as progressivist, universal and hierarchical (Desmond 1989). Not long before the *Origin*, Herbert Spencer developed his form of Hobbesian rugged individualism based on a Malthusian struggle for existence, ideas that found a parallel in Darwin's natural history work. But of interest to a memeticist is the application of natural selection models to ideas, by writers like Alexander Bain, Charles S Peirce, William James, Ernst Mach, and John Dewey, very soon after Darwinism was first promulgated through European intellectual society. In many ways, Dewey is one of the first true memeticists, declaring that we didn't so much solve problems as recover from them, appropriating both the Darwinian evolutionary metaphor and the epidemiological metaphor so popular today (Dewey 1909). Over the years, various others have used natural selection as a metaphor, or as an analogy (the distinction is significant[3]), of conceptual and social change, including Medawar, Popper, Toulmin, and even some leading Darwinians (cf. Cziko 1995 for a review).

Eugenics was a constant source of confusion and debate in the early synthesis, with Fisher and the "Oxford School" along with leading geneticists like Muller proposing that the primary role of natural selection was to trim away deleterious alleles and that the best way to organize society was to permit that process to act without impediment. Dobzhansky and others, largely in North America, argued instead that the role of natural selection was to maintain a pool of variety in populations, and that equality of opportunity would permit whatever alleles had relative advantage to be expressed (Beatty 1987). This was more significant than a clash of political or moral doctrines. Eugenicists (Darwinian eugenics was usually positive - encourage the fitter - than negative - cull the less fit - as in Spencerian social "Darwinism") held that society, or at any rate "civilized" society, acted to lessen the effects of natural selection, while those who like Dobzhansky opposed eugenics tended to see society as either neutral or ancillary to natural selection in biology. The very role of natural selection itself was the subject of intense debate, culminating during the final years of the synthesis and the early 50s. It centred on an extended debate between Fisherians, who saw it as a universal and often all-sufficient mechanism of evolutionary change, and those who like Dobzhansky followed Sewall Wright in thinking that in small populations (demes) random drift and sampling error played a greater or lesser role in the evolution of traits. Even today this is still an issue. Dobzhansky, who through his early education in the tradition of Russian Darwinism which emphasized co-operation and began with Kropotkin, was well placed to argue for Sewall Wright's notions, and by the end of the 1950s, some admixture of drift and selection was accepted by nearly every evolutionary biologist.

The point of this potted history is to show the context in which the meme-analogue "gene" arose and was debated, and to set the scene for the conditions in which memes were developed as theoretical entities; this will go to the question of the nature of memes and their theoretical role in explanation. Throughout the period of the development of Darwinism, it was agreed that there had to be hereditary factors of some kind because natural selection can only act if the traits of organisms that are selected are transmitted to future generations in a process of differential reproductive success based on what we now call differential ecological success. But it took a long time for this to be clarified. Evolutionists often spoke of new traits being "for the good of the species" even though Fisherian genetics modelled fitness as an *individual* property of heritable traits in a population. Indeed, Fisherian genetics treated genes in such an unlinked atomistic way that later writers like Mayr spoke derisively of "bean-bag" genetics, which treated genes as if any single one of them could be separated out from the others and inspected. Although Mendelian genetics had already realized that genes were often linked in their effects, and that many genes affected each trait (epistasis) and some genes could affect many traits (pleiotropy), it was unclear what natural selection acted *on* - individual genes or the traits they affected. In his 1937, Dobzhansky adopted Darwin's term "co-adaptation" to denote parcels of genes that were selected as a unit because they had evolved together to work well as a team, but there was a real epistemological difficulty in determining what genes selection actually selected.

In 1962, the modern "units of selection" debate was inadvertently kicked off by a naturalist, Wynne-Edwards, who explained the regulation by some gulls of clutch size (the number of eggs laid) during lean times as an adaptation that could only be for the benefit of the group, because individual fitness had to be lower if fewer progeny were produced. Wynne-Edwards used the notion of "group selection" which Darwin had used in 1872 to explain the existence of human moral behaviours: moral groups did better than immoral groups, and so their genes would be better represented later on than those of the others (to reinterpret Darwin's formulation in modern terms). According to Wynne-Edwards, populations that regulated clutch size survived ecological catastrophes better than those that didn't. It's an intuitively seductive idea, but this sort of reasoning was thought to be woolly headed and wrong by those evolutionary theorists raised in the more reductive panselectionist tradition. David Lack argued against the biological specifics of Wynne-Edwards' thesis, but a pivotal outcome of this book was that it spurred George Williams to publish, in 1966, *Adaptation and Natural Selection*.

Williams took an operationally reductive approach; that is, he refused to use selectionist explanations at any level higher in the biological hierarchy than was necessary. It is onerous, he thought, to explain group level phenomena in *sui generis* terms when explanation in terms of the *components* of the group and their properties will suffice. For selection of a group to occur (and contrary to popular reportage, Williams did not rule out the in-principle possibility of group selection, even identifying a case study), two criteria would need to be satisfied. One, the properties that were favourably selected would need to be the properties of the *group*, not the individuals that comprised it. Williams illustrated the difference by distinguishing between a group of fleet deer (which as a group may move slowly, though all its parts are fast moving) and a fleet group of deer (which may move quickly, as groups go, although its parts are slower than parts of slower groups). Fleet deer are individuals with properties of fleetness. Fleet groups of deer are *groups* with properties of fleetness. The second criterion that must be satisfied is that group properties had to be heritable: copies must be made if selection is to operate. Therein lay the rub for Williams: groups typically do not reproduce. But Williams went even further: neither are individual organisms usually copied. You are not a clone of your same sex parent. You may have your father's eyes, your mother's hair colour and wave, and be intermediate between them in your genetic predisposition to height. Mendelian factors are the basic unit of evolution, according to Williams, and not all of them, either. "I use the term `gene' to mean that which separates and recombines with appreciable frequency", he said (1966: 20) and he further defined an evolutionary gene (that is, one that is selectively important) as

"*...any inherited information for which there is a favorable or unfavorable selection bias equal to several or many times its rate of endogenous change*" (1966: 25).

In set theoretic terms: Mendelian factors (M) are a proper subset of heritable separating and recombining units of information (G), and include as a subset selectively biased - that is, evolutionary (E) - factors: . A Venn diagram of this relationship shows how he appeared to view it:

Ten years later, Richard Dawkins (1977) introduced the "selfish gene" metaphor based on Williams' "evolutionary gene". But the way he did so obscured the point Williams was making (not deliberately, for Dawkins had other fish to fry) - not all genes are evolutionary genes. Given that only genes can be evolutionarily relevant, what portion of those genes actually *are*? Williams is a bit of a panselectionist[4] and he tends here to brush past questions of random drift and founder effects. His answer to the question is that a gene is evolutionary just insofar as it is subject to selection that exceeds mutation. This is a definition, not a discovery. If it's favourably or unfavourably selected and heritable, it's an evolutionary gene. We are now on the threshold of memes. Williams himself realized this, noting that gene was a cybernetic abstraction, and later describing the notion of a "codical domain" of evolution, wherein the transmitted structure, no matter what its *physical* substrate, is a codex (Williams 1992). In other words, it's a message that is transmitted, and which is subjected to the same theoretical models as any other kind of message transmission, i.e., Shannon-Weaver information constraints. This means that genetic replication is one instance of a class of phenomena in Message World - and memes, like genes, are another.

Dawkins' original introduction of the term "meme" in *The Selfish Gene* mentioned in passing snatches of tunes, crazes and fads, but the paradigmatic example he gave, no doubt due to his personal experience of it, was a scientific notion passed from scientist to scientist. I shall return to this point later, but some properties of scientific notions are of immediate interest. Typically, scientific ideas are either evocative metaphors, like de Candolle's "struggle for existence" that inspired Darwin, or more or less formal models. It is the latter that concerns us here, for when metaphors reach the end of their evocation, they must be turned into formal models anyway in order to be tested against quantifiable phenomena. A formal model like Boltzmann's thermodynamic entropy is a far cry from Heraclitus' notion of flux, and it does a great deal more conceptual work. The significance of Dawkins' example is that one can, to a relative degree of exactness, determine whether and how far a part or whole of a model has spread to another scientist or textbook, or whatever one takes to be the cultural equivalent of the phenotype - for reasons I hope become clear, I shall refer to this as the phemotype, and the total distribution of co-adapted memetically constituted traits within a lineage the phemorph of that lineage. The neologisms are strained, barbarous and ugly, but I hope they will add some clarity to what is being discussed. In short, scientific examples can be quantified both in terms of their frequency in a lineage of scientists, and their relative rates of increase or decrease. This susceptibility to analysis is essential for modelling change in terms of natural selection, and evolution in general.

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3 The Hull-Dawkins Distinction and the evolutionary gene

Do I contradict myself?
Very well, I contradict myself,
(I am large, I contain multitudes.)

Walt Whitman, *Song of the Open Road*

To apply evolutionary models outside biology, you need to know what evolution as such is, no matter what the domain it is occurring in. There have been many attempts within biology to generalize evolutionary modelling, for it is a point worth remembering that even biological evolution is not all of a kind. Evolution occurs over single and multicellular organisms, over animals and plants and fungi, and over various kinds of bacteria and viruses. It applies to sexual, clonal and parthenogenic reproduction, to heredity using DNA, RNA and even cytological structure. Generalist species (*eurytopes*) and specialist species (*stenotopes*) both evolve in widespread and continuous ecologies, and in localized and isolated ecologies, and so on. Evolution is not simple in biology, and so biologists have worked to make it as general a model as possible to cover all cases. There is clearly some common thread in all these phenomena, and most find some or all of the explanation in natural selection[5]. As Weismann's and Wallace's heirs perceive natural selection, it is the differential success of the genotype due to the ecological success of the phenotype it creates. The causal arrow is essentially one way: genes cause phenes but not the reverse. As Cziko (1995), following Donald Campbell, puts it, genes are selected but not instructed. Despite all the progress since Weismann on the nature of biological heredity, his Central Dogma has stood almost without modification[6]. It is therefore important to determine whether there is an analogue in culture for these central distinctions of genotype and phenotype and whether memes are ever instructed, or only ever selected, as genes are. And if memes are instructed, does this "Lamarckism"[7] of culture obviate the need for a memetic analysis? Although it's worth remembering that Darwin was a Lamarckian on heredity, that is, he accepted that the units of heredity ("pangenes") are instructed, this does not really help us answer the question, for we already have non-evolutionary Lamarckian models of culture and the justification for taking an evolutionary perspective rests on the efficacy of Darwinian, perhaps Weismannian, models. We need to understand the ontology of a Darwinian process to come to any resolution.

Dawkins (1982) distinguished between genes as replicators - things that are duplicated with a high degree of fidelity - and bodies of organisms as the *vehicles* of genes. Vehicles reproduce, but only genes replicate. Some writers, including David Hull (1980, 1987, 1988a, 1988b, 1988c) took exception to Dawkins' characterization of bodies as mere vehicles of genes - they were, in his opinion, much more than passive and controlled robots[8]. Hull had earlier (1974) attacked explanatory reductionism in genetics, arguing that reducing evolutionarily significant traits to genes was unsatisfactory both in terms of a failure of isomorphic relations (mapping) and also of underdetermination - things happen at metagenic levels that are not, and never could be, the results of the sum of the properties of the genes[9]. He therefore rejected Dawkins' passive notion of bodies and the phenotype, and substituted instead the more ecologically and economically active notion of an interactor. Hull's general view of evolution is of a cycle of replicators coding for interactive traits, which through their interactive success acquire (or fail to acquire) the resources needed for further replication. On Hull's account, ecology makes a strong comeback, and the reproduction of organisms is a necessarily *interactive*, rather than a *replicative*, process. This cycle generates lineages of descent, which exhibit themselves in biology as species in the short term and as phylogenies and other taxonomic classes in the longer term[10].

Hull and Ghiselin, as part of their *individuality thesis* that species are historical individuals, that happen to be made up of many organisms, have also addressed the general problem of what constitutes an individual in biology and evolution in general (Hull 1987, 1988c, 1992, Ghiselin 1997). This also raises its head in memetics, and has not so far been addressed. Their view is that a biological individual, so far from being intuitively obvious (as it seems to be if we only consider obligately sexual vertebrates) is in fact a very fluid category, and their solution is that an individual is *defined* by its functional role in evolution, that is, insofar as it is a unit of selection (this applies to gene sequences as well as to organisms). So, the resultant evolutionary ontology is that replicators (replicanda in Ghiselin's terminology - structures that are replicated, Ghiselin 1987) generate interactors, which are the evolutionary individuals that are subjected to selection and whose economic success or failure biases the regeneration of the replicanda. Plotkin (1994) characterized generalized selective processes as *generate-test-regenerate* cycles, and this helps to clarify the matter (figure 1). An individual is formed at the level of testing, which feeds back into the generation stage. An inclusive hierarchy of individuals can be formed if generation to regeneration cycles occur at higher levels[11]. In biological terms, this accounts for why colonies of organisms like eusocial insects behave as individuals with respect to selection, and also why clonal lineages (genets) behave evolutionarily as individuals even if they are spatially distinct (ramets).

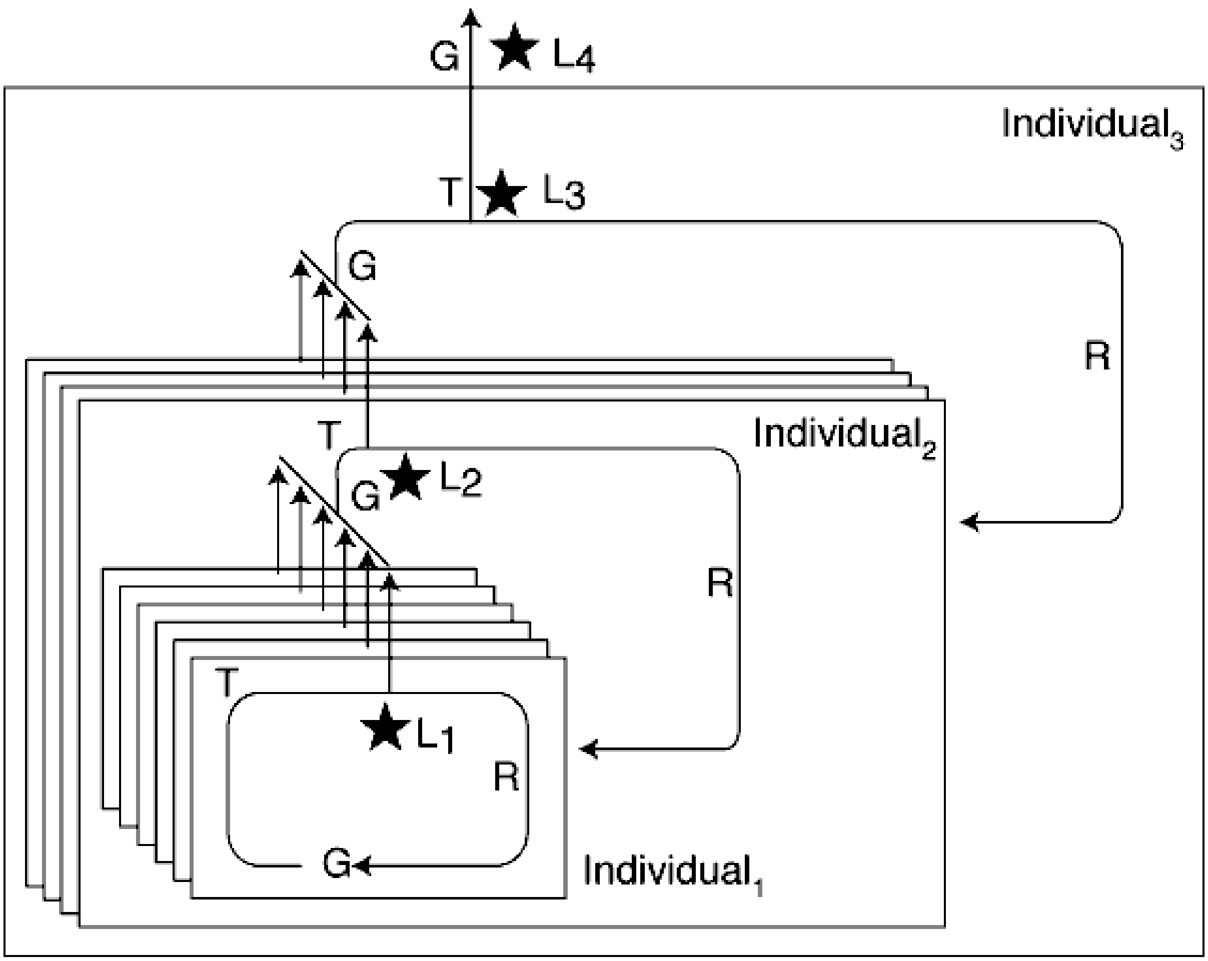

Figure 1. A generalized hierarchy of g-t-r (generate-test-regenerate) cycles in an evolutionary process. Star = Replicators relative to testing/selection bias at that level or higher

The Hull-Dawkins Distinction, as it came to be called, gained almost immediate and bipartisan support across the selectionist debate - both Eldredge (1989) and Williams (1992) accepting that replicators and interactors are the active and general entities in Darwinian evolution (interestingly, both made the now almost obligatory passing comments about these terms also applying to culture.) Dawkins' "memes" (like Campbell's mnemones, 1974, 1988) are *cultural* replicators, which, if they are to function in cultural evolution analogously to genes, must be transmitted with fidelity, and must cause some interactive traits that in turn will cause a differential replication of the memes. This also helps us with the question whether memes are instructed or selected; that is, whether they arise in response to environmental needs (are "learnt") or are generated randomly with respect to the prevailing social ecology ("random trial and error"). Unexpressed memes (memes not "visible" to the environment through their products) cannot be selected, and so the likelihood of them being prescient or anticipatory is reduced, since we would need to have *already* selected some memes as likely candidates for success in order to predict which ones will work in practice[12]. Before a meme can be assessed as "likely to succeed", it must already have passed some tests. We therefore get a regress - any "instruction" of a meme is either a case of transmission followed by selection, or it is a case of transmission of an already selectively tested meme[13]. The Central Dogma remains unshaken for memes, even if some mechanisms of instruction are shown to occur, for even learning is a selection process (Cziko 1995, chapters 11-12) at some level.

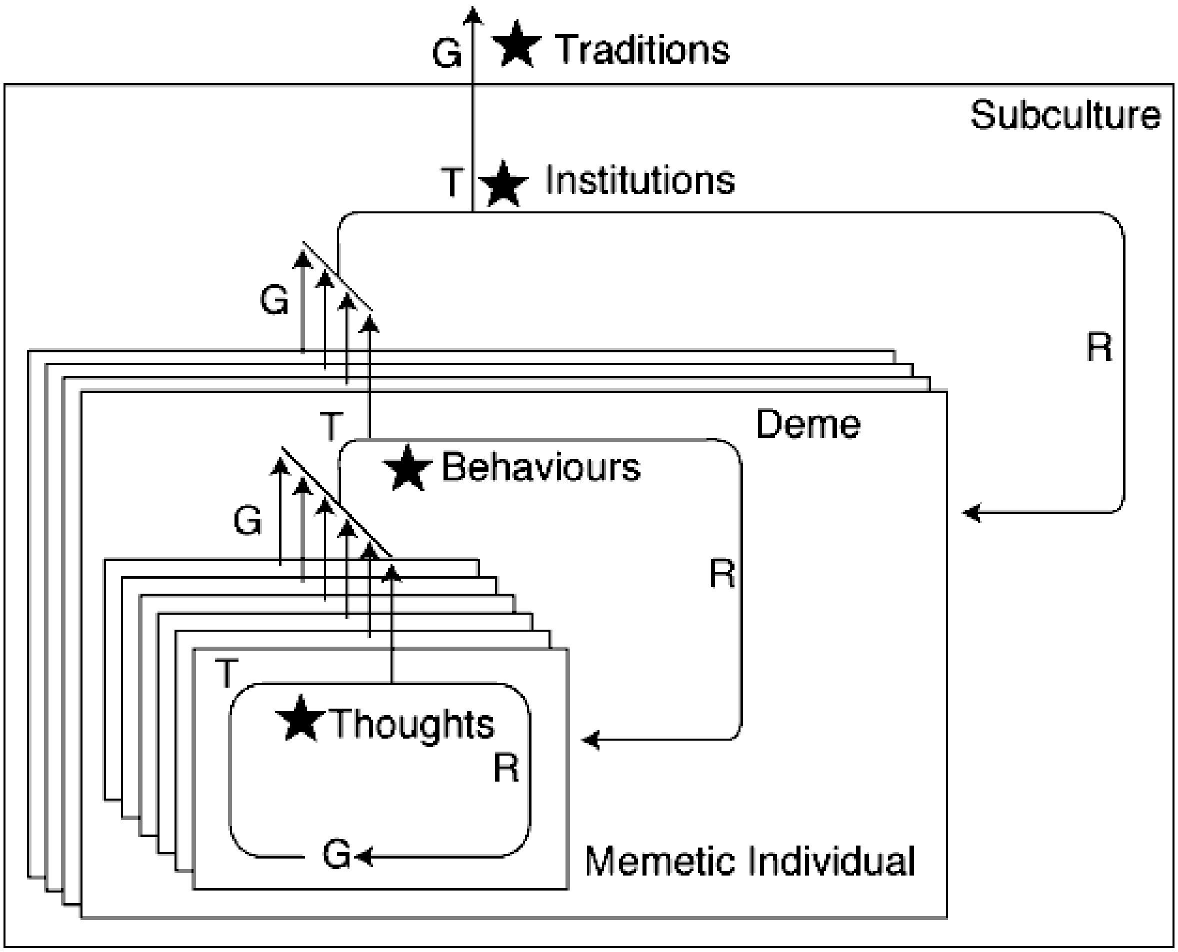

Figure 2. Memes arise as effects of a g-t-r cycle. Star = Meme relative to testing/selection bias at that level or higher

Some may object that memes must be *stored* in neural patterns in order to be considered memes, and that replication through texts, electronic media, and performances, etc., are only secondarily memetic if they affect and are stored in a central nervous system. In figure 2, it can be seen that some selectively biased cultural phenomena can exist as the emergent properties of social systems larger than the individual, and persist without being replicated at time frames far longer than an individual life span. Methodological individualism, as it is called, rejects this in favour of a more parsimonious view, just as genic selectionists like Dawkins reject any form of group selection (Williams' views notwithstanding). But on the Ghiselin-Hull view of individuality in selection, group selection is not only a possibility but an established reality, for viewed appropriately, any organism is a group of related lineages (Buss 1987) and any gene sequence a related group of molecules, and so on. Consider an historical event like the Thirty Years War or an institution like a religion. Political and religious patterns of behaviour in that war need not be stored as neural patterns, and each of the memes of a religion need not reside in at least one brain, for some of these memes are emergent properties of the entire system of acting individuals, and of which they may indeed all be entirely unaware[14]. Were Protestants aware of the linkage between capitalism and their theology during the rise of modern capitalist economies, for example? If so, why did it take a sociologist to point it out explicitly? You pays your money and you takes your choice, for the methodological individualist debate has a long history of controversy in sociological disciplines that continues till this day. However, the view I am advocating here is neither individualist, nor holist, but a view known as " emergentism " (Nagel 1961): the doctrine that the properties of a collective whole arise from the *relationships* between the properties of the components. Simply understanding the componential properties, without understanding the connections between them does not enable us to model the higher level thing they comprise.

So, what are phenotypic cultural traits, the *phemotypes* as I have called them? One answer, and the right one I think, has been given variously by Campbell (1960, 1974, 1987, 1988), Hull (1988c), Toulmin (1972) and Plotkin (1994), to name a few, is that selection acts on behaviour, or, in the language of the logician, on interpretation of the information contained in a meme. Just as a gene must be expressed in order to be selectively biased, a meme must also find expression in some way. While we often use a verbal shorthand when we say that a gene is selected at a certain coefficient, the biologist should never forget that genes are just the starting point of a biochemical process which undergoes selection at a range of hierarchical levels, from the processes of transcription in the cell to the processes of ecological interaction in an ecosystem (figure 3).

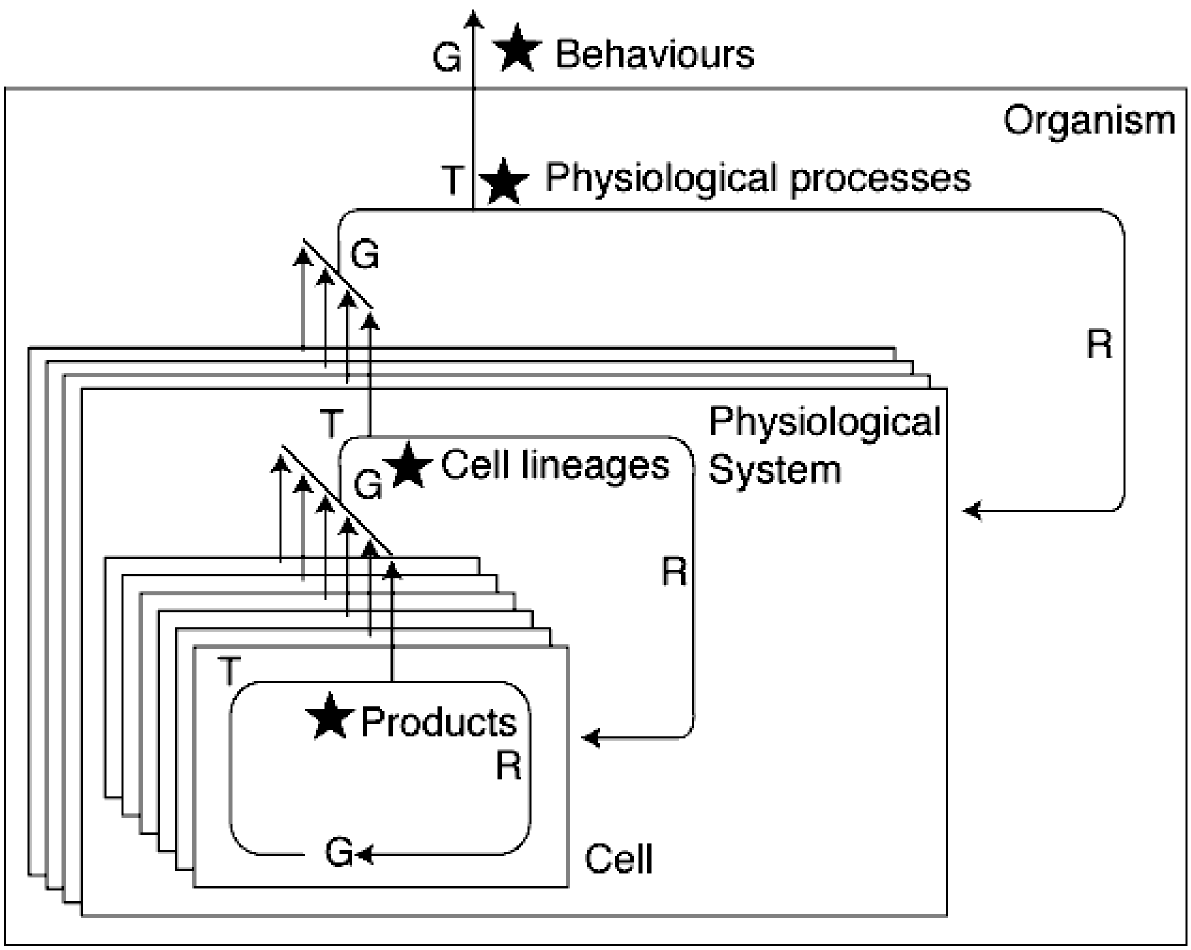

Figure 3. Individuals and replicators in a biological hierarchy

Sidebar: interactors and replicators

The terms interactor and replicator, being substantive nouns, give the impression that there are natural kinds of *things* that interact and replicate. Ghiselin (1987, 1997: 147) has argued that a better term for the Hull-Dawkins Distinction would have been between *replicanda* and interactors, that is, between those things that *get* replicated and those things that are economically biased for a range of reasons. When we understand that replication is the passing on of a message, it doesn't really matter what the medium, or substrate, of the message is, and the notion that there has to be some privileged replicator, like nucleotides or neural columns, becomes unnecessary. It is less obvious that interactors are also a functionally-defined class, but if anything interacts (and correlates closely with replicators) then it is an interactor. It could be the organism, but it could be some subsystem of an organism like a class of immunological peptide, or the immune system itself, or a visual system, or it could even be a group of organisms like a hive. There are no privileged interactors *or* replicators, in biology or culture. We would do well to remember Mill's caution:

> "*The tendency has always been strong to believe that whatever received a name must be an entity or being, having an independent existence of its own. And if no real entity answering to the name could be found, men did not for that reason suppose that none existed, but that it was something peculiarly abstruse and mysterious.*"
>
> (Cited in Gould 1981: 320)

This modifies Hull's notion of interactor somewhat, for Hull defines them as things, that is, as entities. Plotkin, on the other hand, resists the "entification" of interactors (personal communication). I do not think that Hull's own analysis requires that interactors be a unique class of entity, such as an organism, just as long as it is an *individual* (Hull 1992) with interactive (ecological, or economic) properties. Individuals are entities, but there is no need to restrict individuality to one level of entitivity, so long as the relevant interactive properties are properties of that entity and not of the system of which it is a component. However, interactors are entities even if they are not a specific *kind* of entity.

Similarly, memes are selected at many levels through their expression in behaviour, including verbal, practical, instrumental and intellectual, and this behaviour need not be the behaviour of individuals; it can be the behaviour of languages, institutions, societies and even traditions. Consider Campbell's (1974) hierarchy of selectionist knowledge processes[15]:

1. Genetic adaptation
2. Nonmnemonic problem solving
3. Vicarious locomotor devices
4. Instinct
5. Habit
6. Visually supported thought
7. Mnemonically supported thought; Observational learning and imitation
8. Socially vicarious exploration
9. Language
10. Cultural cumulation
11. Science

At level 7, minds construct models to test and select alternatives - and at this level memes are now active and give rise to trial and error without the selective costs to genetically- and biologically based interaction. Memes must result in some outcome that can achieve success or not, on the basis of which they persist over other memes, to be selected at all. The details of Campbell's schema are not important here, but memes *must* arise at some level of information processing complexity, and *must* affect outcomes at levels higher than that. And the converse is also true. Of any cultural process that involves transmission and selection, there *must* be memes that "constitute" phemotypes at that level. Take two examples - a personal attempt to try out a hitherto unlearnt linguistic form and a scientific theory. When one is learning a first language, syntax and semantics are underdetermined. A child cannot know, except through trying out combinations and seeing the results, whether a certain "hypothesis" about the use, structure and referents of a word, phrase or syntactical structure is correct. For example, consider how children first learn regular declensions of noun plurals and regular conjugations of verb tenses, and are then corrected by more competent speakers when they use a regular form of an irregular noun or verb - "I swimmed", "he runned", and so forth. Not only is there an *internal* selection process going on through increasing experience of success, but in a formal sense, these irregular abstract constructs of language are *defined* through the role that they play in the trial and error. Of course, language in itself is not a solitary pursuit, but in *individual* learning, the trial and error selection process is (figure 4, cf. Cziko 1995, chapter 11, Ghiselin 1997, chapter 9).

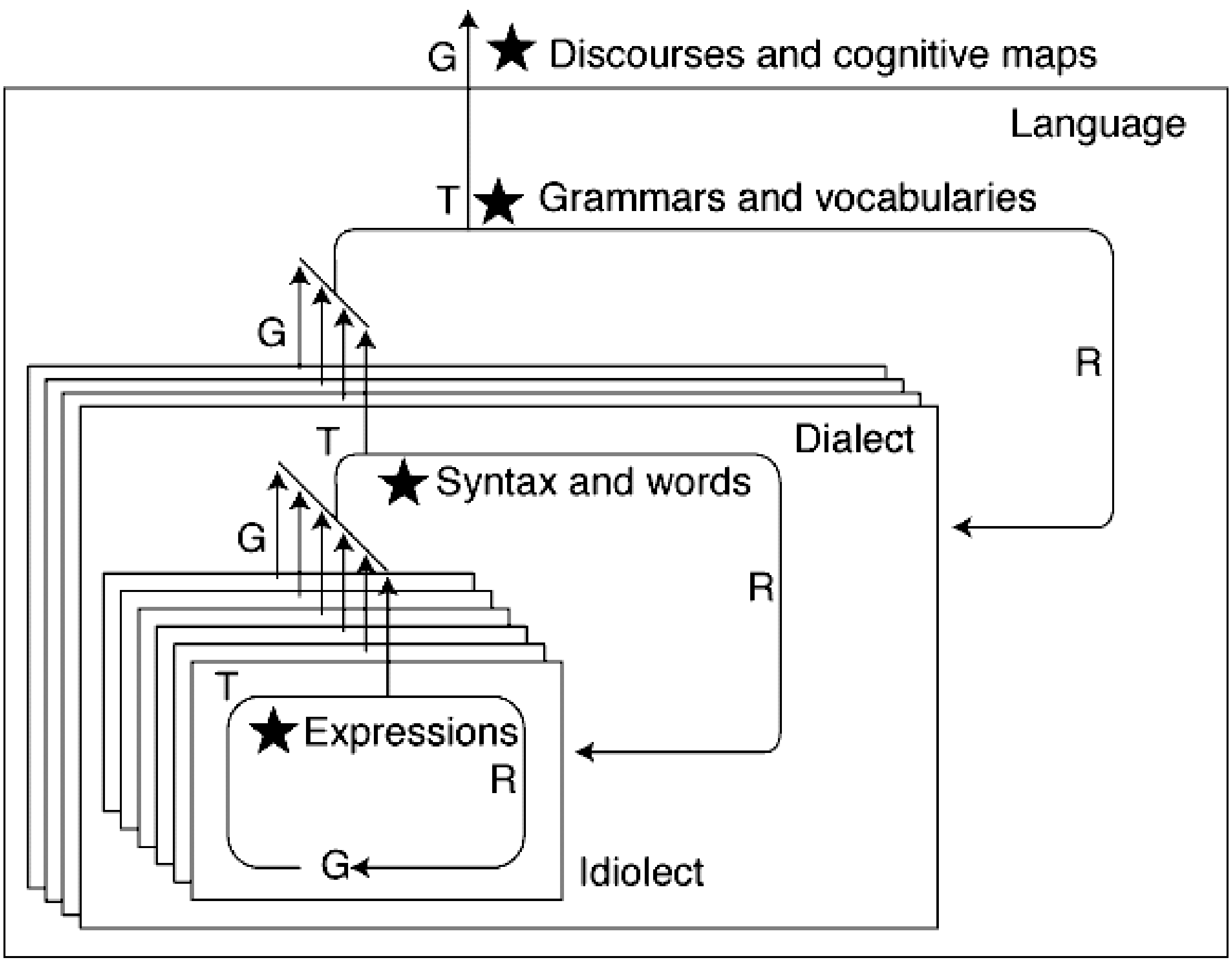

Figure 4. A selective hierarchy of language, following Ghiselin 1997

Back to Dawkins' scientific notions: whatever Mendel, or Darwin, or Newton, internally intended their theories to mean or cover, until the elements of their theories - supporting data, formalizations, explanatory rationales and so forth - were *published* (literally, made public), discussed, tested, and above all in further scientific work, they weren't scientific theories as such. What's more, their theories contained memes of which they were not aware, because they only developed when selection pressures were applied to them. "Action at a distance", or "survival of the fittest", became memes so far as they needed to be defended and supported in the scientific debate when challenged. It is the hallmark and defining characteristic of science that it is presented and tested in the public domain of fellow professionals; and this process modifies theories. Elements of them are quietly or noisily rejected, abandoned or simply never followed up (Laudan 1977). What are the memes of a theory, then? They are those elements of it that are subjected to selection through testing and co-adaptation with the rest of the theory and of the wider field of the scientific culture (Wilkins forthcoming). Theories, like Whitman, contain multitudes (and can therefore contradict themselves), but scientific work consists in large part in exploring the ramifications of a model, in order to eliminate contradictions, either in terms of self consistency and coherence, or in terms of agreement with method and observation.

In the special case of memes in scientific theories, whether or not Dawkins intended it, it becomes clear that in a general evolutionary model a replicator is defined by (1) being transmitted intact, and (2) being subjected to selection. Many things are transmitted in culture that are not selected, and many things are selected that do not get transmitted[16]. I conclude that a meme is something (the "smallest" something you can identify) that gets replicated and selected in culture as a unit and therefore offer the following short definition of "meme".

> *A meme is the least unit of sociocultural information relative to a selection process that has favourable or unfavourable selection bias that exceeds its endogenous tendency to change.*

Exceeding endogenous change simply means that it gets transmitted intact more than it gets transmitted mutated (Dawkins' condition of *fidelity*); in other words, it is more information than noise. Compare this with Williams' *evolutionary gene* above.

A single memetic interactive trait, I shall call it the pheme by analogy with a *phene* or Mendelian character, is the expression through some behavioural regularity of a meme at the level of selection. "Behavioural" here refers to interactive activity at the level of expression, and so includes mental behaviour, individual behaviour, group behaviour, and so forth (figure 2). However, the behaviour must be both *causally* effective in terms of acquiring resources and must be in some manner empirically *quantifiable*. One question that memeticists should ask of any analysis is "what are the resources"? A scientific theory may gather resources of researchers' time, grants and lab space, publication space in the appropriate journals, and from what I can gather, postgraduate students appear to be a prized resource. Hull's (1988a, 1988c) mechanism is that individual scientists seek to acquire credit, either through innovation, or more probably (since innovation is rare) by inclusion in a successful research project through citation and extension of results. An idea in an individual mind will need to gather attention space, memory resources, and time, in order to out compete other ideas. Without an answer to the question of *what resources*?, and they must be measurable, any memetic account is merely anecdotal.

Sidebar: phenotypes, phemotypes and classification

A phenotype in biology, and especially in taxonomy, is the whole array of organismic characters of an organism, and is distinct from its genotype. In the taxonomic debate between cladism and pheneticism described in Hull's book, the resulting consensus was that there were no privileged features that are phenetic characters (Hull 1988c, Ridley 1992) - anything that can be measured might be used to classify organisms and reconstruct phylogenetic relationships. This argument applies just as well to reconstructions and classifications using genetic sequences as it does to skull shape and the presence or absence of feathers. Some taxonomists think that the best way to identify species is to make use of *non-adaptive* characters on the grounds that these are less likely to be the result of convergent evolution. The popular belief that it is the entire *phenotype* that is the interactor in evolution is, in my view, wrong. Interaction occurs at the level of the trait, and the "engineering" fitness of an organism - how well it makes a living overall - is the product of its various interactive traits. The analogy I wish to make is that memes result in behavioural regularities that have interactive properties, that is, which result in social successes and failures. The phe**m**otype is the array of the phemes that are the causal outcome of memes in an individual or group. Phemotypes are the basis for grouping social phenomena, that is, for classifying memetic ensembles into religions, communities, traditions and programs.

Once we have identified a meme in a particular process, though, that is not the end of the explanatory story. Memetics covers what is *common* to the spread of strategies, musical phrases, linguistic practices, ideas and theories, but it does not exhaust the research. Again the parallel with genes is instructive. Having identified that there are factors that are inherited which cause ecologically significant traits, geneticists moved on to identifying the physical processes and their effects, which turned out to be extremely complex, with genes that code for traits ranging from the sorts of proteins that a cell expresses, to genes that regulate other genes, to genes that contribute to a range of gross morphological traits at every level of the organismic structure. Identifying memes will assist in identifying the sorts of cultural phenomena that are functionally transmitted, but we should expect that these will in turn become causes of phenomena in another level of analysis.

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4 The lineages and ecologies of culture

Any chain of descent will create a lineage over time and space if ancestral entities terminate at some stage. Given that the obverse of a replicator is an interactor, an economic entity that competes in a formal sense with other interactors for the same resources, we need to identify the resources, the ecologies, of memes. On the face of it, memetic resources include neurological and behavioural time and space, much like a program can tie up the CPU cycles and screen space of a computer, but they must also extend to the more highly derived necessities of social life, including such things as credit, currency, and so forth. Selection processes define not only the replicators (the memes) and the individuals, but also the active and relevant resources of the ecology and economy of social life. The interplay between these facets of memetic evolution leads to successful and persistent lineages, as well as transitory and unsuccessful ones.

The nature of and reasons for lineages in biological evolution is a complex matter. Debates about the "Species Problem" and the relationship between "horizontal", or "non-dimensional" conceptualizations of species - known generally as biological species concepts - and "vertical" or "phyletic" conceptualizations of lineages over evolutionary time - paleontological, evolutionary and phylogenetic species concepts - have been ongoing since at least the modern synthesis, and indeed is sometimes held as the defining debate of the modern synthesis of evolution (Dobzhansky 1937, Mayr 1970, Mayr and Provine 1980). One thing that is generally agreed upon is that ancestor descendent lineages that do *not* regularly recombine (reticulate) at a scale on the order of one generation are not species, but are within-species lineages or something else; for example, what Eigen (1993) calls quasispecies in the case of viruses. In other words, species are those largest collections of biological lineages that do regularly recombine, and which do not themselves recombine with other lineages[17]. However, socio-cultural lineages appear to exchange memes on an almost unconstrained basis. Practices, metaphors, and ideas transfer from one cultural lineage, culture or tradition to another with consistent ubiquity. Autochthonous cultures the world over have adopted a range of cultural artefacts from the dominant western culture, for example, and this pattern of dominant cultural invasion recurs through recorded and archaeological history. This reticulate evolutionary pattern is touted as one of the major disanalogies between cultural and biological evolution. If cultural transmission is so fluid and free, it is thought, what use is the transfer of biological to cultural categories and modes of analysis? I shall argue that this objection rests on an incorrect assumption about biology, founded on our metazoan, vertebrate, and mammalian prejudices, and that even if it were true, it would not undermine the memetic enterprise.

Other than accepting the conclusion of this argument from disanalogy and abandoning memes as useful theoretical entities, there are three alternative responses to the difficulty it raises for memetics. The first is to shift ground, and to treat memes epidemiologically; that is, using a metaphor of disease rather than of evolution. Treating memes as pathogens, and trying to analyse the vectors and pathogenic dynamics of memes, is a strategy adopted by Goodenough and Dawkins (1994), Lynch (1996) and others (cf. Dennett 1995:364-368). "Mind virus" is itself a tolerably good meme. The second approach is to restrict memetic analysis to domains like the sciences, where there is a strong selective pressure and a good record of the spread of scientific ideas, and where lineages tend, within certain limits and until recently, to be relatively isolated and *sui generis*. The third is one that I have not seen explicitly presented but which is implicit in the work of Hull (1988a, 1988b, 1988c). This is to see that evolution produces a continuum of results from entirely isolated lineages with the "bridgeless gaps" so beloved of Mayr resulting from obligate sexual recombination through to moderately hybridizing lineages like those of flowering plants and ferns, to regularly recombining lineages - rarely if ever present in zoological biology but frequent in bacterial phylogeny and some forms of culture. Each of these approaches has its merits.

The first response, the *epidemiological model* of memes, takes into account the rapidity of transmission and mutation (relative to the observers) of certain varieties of cultural items like vernacular speech and fashions, and the varieties of strategies they evolve to invade cultural agents and populations. This view does not, however, obviate the need for an evolutionary, selectionist, account of the pathogens (cf. Ewald 1994). It's a matter of perspective. Being hosts to so many pathogens, parasites and symbiots, humans tend to conceptualize disease as sub-generational and populational events in a relatively short time scale. Nevertheless, epidemics and pandemics like malaria have evolutionary effects on humans, resulting in evolutionarily stable genetic equilibria like the maintenance of sickle cell heterozygosity in regions affected by the transmission of the malarial parasite *Plasmodium falciparum* by some species of the *Anopheles maculipennis* mosquito group[18]. But we also often overlook the fact that, from the perspective of the *pathogens*, humans and other animal hosts are just another part of their ecosystem, and our immune systems act as selective environments affecting *their* evolution. It's also a matter of degree: viruses, for example, mutate much more rapidly than the gametes of a metazoan, but this is a difference in rate rather than kind. There is a bias imposed on us by virtue of being multicellular, animals, and living at the time scale we do. Evolution has no such bias. The equations governing (or describing) epidemiology are re-castings of the Fisherian and Wrightean equations covering (or describing) natural selection (Cavalli-Sforza and Feldman 1981), which is what we should expect if we see epidemiological phenomena from the pathogenic perspective and not from the host's[19]. What this signifies for memetics is that meme epidemiology needs to clearly distinguish between human minds and memes as entities that generate their own separate lineages. More on this shortly. For now, it is worth observing that meme lineages may not be so obvious as we think, and that cross-lineage borrowing, which occurs within biology as well as culture, may be less frequent than seems the case when we view memetic evolution from the perspective of the host minds.

The second response, the *narrow conception*, is to restrict the application of memetic analysis to those cultural phenomena which are phenomenologically isolated, well recorded, or in which there is a clear selective pressure such as in technological, scientific or economic change. There is some merit to this: but it is a heuristic merit rather than a theoretical limitation. It is a bit like the situation facing early genetics. Genes were, in the heyday of the Mendelian revolution, theoretical entities that some of a positivistic bent considered mere instrumental constructs. Positivists held (and hold) that theoretical constructs have no ontological import. "Genes" were useful in calculation and modelling, but it was illegitimate to infer that any such biological entity existed. In retrospect, this made a metaphysical virtue of a methodological necessity. Once the science, and ancillary sciences and techniques such as x-ray crystallography, had developed further, physical genetic entities were discovered and described, but this was not open to the early Mendelian researchers, and in fact attempts to describe the physical properties of genes by Weismann and others resulted in failure and open speculation. Had this positivistic operationalist approach been taken seriously, the molecular structure of genes might never have been investigated and discovered[20]. It *might* be a good strategy to begin with the more accessible areas of research like the history of a science, and to develop methods and models that can be extended later as more problematic cases come within theoretical reach. In the same manner, biological concepts like "species" are often developed in relatively clear-cut cases like sexually recombining animals and plants, and then extended into cases of parthenogenic, polyploidal, clonal, viral and other "eccentric" lineages. We must, of course, beware of biting off more than we can chew, but also of not closing off any further avenues of research. Memetics, like any science, must evolve gradually.

The third response I'll call the *generalist conception*. This is to more broadly characterize biological evolution. As Hull has said, there is nothing so outlandish that an example of it cannot be found in biology somewhere. For example, take the cases of reproduction modes and speciation: memetic evolution appears to be more like the evolution of plants, which have an estimated 30-40% rate of reticulation, and fungi and single celled organisms, with monoparental or clonal reproduction, than it is like zoological evolution with which most non biologists are familiar. Nearly half of all flowering plants are the result of joined lineages rather than split lineages, and nearly all fern species. Amoeba undergo a process called conjugation where genes are exchanged every few generations, although the rest of the time they split aparentally. Amazingly, even viral RNA can be exchanged through crossover of transcriptase in superinfected cells[21]. Evolution is still cleverer than we are. These idiosyncratic forms of individual, phenotype, lineage and evolutionary behaviour are nevertheless covered by the various theories of evolution[22]. The generalization of evolutionary theory accommodates these "eccentric" cases just as well as it does the paradigmatic case of animal evolution on which it was first founded. Natural selection is an emergent process acting on ecologically interacting replicators, and obligately sexually reproducing individual organisms are just a special case, even though they are the most obvious and easily investigated form of evolution *for us*.

Therefore, it would seem that natural selection can model cultural lineages even if they do not happen to form tightly integrated populations of recombining entities. But we need to investigate *a posteriori* whether any particular kind of cultural lineage is tightly integrated like an animal species or not, and not to assume that there is, in fact, such a disanalogy. Some are, some are not. Of those that are not, selection may be a major cause of change or it may not. This is an empirical argument, not an axiomatic derivation. In other words, we should challenge the major premise of the disanalogy argument in each case. The issue of "quasi-species" (Eigen 1993) in obligately clonal bacteria and viruses illustrates this. In principle, and intuitively, every time a clone or virus generates a mutant, one gets an entirely new strain. We might expect that strains would indefinitely diverge to fill the entire space of ecological niches available. In fact what happens is that viruses tend to cluster about the "wild-type" phenotypic mean (which may not even exist in a single geneome), forming analogues to recombinant species. Natural selection accounts for this as well as it does for sexual, biparental species.

While on the topic of cultural lineages and species, let us consider the matter of speciation mode. There is a raging debate about whether sexual species speciate through allopatry (geographical isolation) or sympatry (geographical and ecological coexistence) or some intermediate state (parapatry) (Mayr 1970, Gibbons and Morell 1996)[23]. This resolves to the question whether natural selection, as well as being responsible for allele frequencies *within* a breeding population and for adaptation overall, is also responsible for *creating* lineages. Those who, like Mayr, opt for the allopatric and parapatric modes alone, consider that isolation followed by selectively neutral or decoupled drift is responsible for speciation, and they tend to see selection as an ancillary process to speciation rather than a reason for it. Sympatric speciation is a litmus test of whether one thinks selection is the main or even the only mechanism of evolution. If species can diverge in the same ecological territory, it must be because selection causes multiple modes in the one population, leading eventually to more than one species as the modes chase different adaptive peaks. If correct, this means that selection can cause speciation, and the traits of species that differentiate them are adaptive. If one denies this happens, or that it happens very much, then what differentiates species can be adaptively neutral or even maladaptive. Nobody presently thinks that selection can be dispensed with even in cases of speciation by hybridization of plants, which occurs in a single generation or even repeatedly (polyploid speciation), but the differences in the degree of the attributed importance of selection points to a deep division in modern evolutionary thought, and this is very important for memetics if memetics is based on selectively significant cultural transmits.

Hull (1988c) has addressed similar issues in scientific evolution. He uses Wright's notion of structured and relatively insulated breeding populations - called demes - to characterize research groups. According to him, scientific research arises first within relatively co-operative demes of scientists - groups within which more variation is tolerated and selection pressures are less severe than in the wider discipline. This permits new theories to be developed and articulated to the stage where they may be able to survive rigorous criticism by rival groups when published. Intriguingly, Hull does not require unanimity of opinion within the deme, but merely a desire to increase one's credit by sharing in the conceptual inclusive fitness of the deme: reputation is everything in science. Hull's view of the social and conceptual development of science is a well developed model of conceptual change, one of the most articulated memetic models yet presented, and it can be extended into other domains. For example, although Hull does not characterize demonic structure itself in this way, it can be thought of as an evolutionarily stable strategy for science to adopt - with a balance between public debate and private support, conceptual transmission in science is able to develop a great deal more novelty and yet retain more strongly tested ("more fit") ideas than was possible in the late medieval guild tradition from which it sprang. Neither a selectively moderate social ecology nor a naked selective environment where new ideas are never given a chance could provide the sort of adaptive growth science has achieved. Obviously, periods of stagnation in a discipline may be due to changes in these parameters (for example, transmission rates) and connecting them in a model based on a generalized evolutionary and ecological process is an important first step to a full memetic analysis of science. *Mutatis mutandis*, the same is true of memetic theory in general. If we are to understand how memes diversify into relatively stable lineages like religious traditions, the structures within which novelties arise and the selective pressures to which they are exposed are crucial[24].

Ecological succession is another analogue of value. It is well recognised in biogeography that niche occupiers in an ecosystem can often fend off adaptively superior invaders; the dominance of a given (say) grazer species in a locale may be due to it being there first rather than its overall adaptive excellence. We should expect that ecological succession, which is complex in biology, will be equally or more complex in culture, but there may be fruitful avenues to explore here. To understand and employ these analogues, we also need an analogue for "ecology" and "ecosystem" for a given socio-cultural domain. The ecology of science, for example, is not nearly as simple as the falsifying crucial experiments that Popperian cycles propose. The resources for which a social or conceptual structure competes will usually be fairly broad even if, as in the case of a scientific idea, storage and processing space and time in an active central nervous system is the basic resource.

5 Memetic individuals

With the clarifications and mental tools introduced above, we are now able to ask Hull's question from biology - what is an individual? - in the memetic context. What is a memetic individual? What is subjected to selection in culture? What gets "coded for"?

When Juliet bitterly but eloquently complained how Romeo's social relationships were messing up their love life, she made the interesting observation that being a Montague, and being the person she loved, were two distinct states (apparently she had more of an interest in some of Romeo's biological aspects). The instantiation of the cultural relationship "is a Montague" in a particular biological organism, denoted by the name Romeo, is a case where an individual is something other than the sum of his own memes. The converse argument was given by the idealist philosopher FH Bradley in 1876, in a landmark essay in ethics, "My Station and its Duties". Here Bradley wishes to establish that one's social location and relations determine one's moral responsibilities. To do this, Bradley argues that what we are as social beings, as moral agents, is determined by the community of which we are part. An Englishman is not his biology[25]. In each case, Juliet and Bradley recognize the distinction, often overlooked by meme enthusiasts, between the biological and the memetic. Memes don't necessarily make you more biologically fit, nor are they necessarily going to make you less fit. Memes aren't fit themselves simply because they make you live healthier lives. Memes are fit only insofar as they are propagated successfully; forget the effects they have on biology. In Toulmin's (1972) under appreciated book, he says of biological and cultural evolutionary processes that they are *decoupled*. This is not to say that the two realms do not meet and affect each other, for clearly they do; it is to say that no matter how you might be able to conceptualize cultural phenomena in biological terms (socio-biology), you can independently conceptualize them in social terms (memetics). To lift a phrase of Williams' (1992) there is a dearth of shared descriptors between the entities of biology and the entities of culture. Sometimes they may, indeed, be the same objects or processes, but you have to describe them differently in each analytic realm.

No end of confusion has been caused by ambiguous specification of the socio-cultural analogues of phenotype and genotype. An early criticism of Hull's model of models (Heyes 1988, Tennant 1988) was that scientific memes failed to *constitute* scientists in the same way that genes constituted organic individuals. By the same token, critics argue that selection against memes fails to result in the death or restricted fertility of scientists, and so natural selection is an inappropriate way to model scientific theory change. Another recurring criticism of evolutionary pictures of culture is that unlike organisms and their genes, cultural agents choose which memes they adopt, and that they modify their memes in the light of experience. Cultural change would be Lamarckian, say critics, if it evolved at all. These two attacks on memetics - the *aphenotypic* disanalogy and the *cultural lamarckism* criticism -- are closely intertwined, and have to be discussed together.

Using the relatively clear case of science as an example, we can see that any one scientist can adopt differing memetic stances over time. When Einstein was learning physics, he was probably taught the axiomatic observer independent Newtonian theories of the day. He later changed his mind about that. When the physicist Schrödinger got interested in biology, he entered into the canons and data of a new discipline (for him). Here are two exemplary cases of memetic acquisition - the replacement or supplementation of one set of memes with a whole new set. Yet, neither Einstein nor Schrödinger became different organisms with these memes. Moreover, had either of these scientists undertaken a non-scientific hobby requiring much technical knowledge and experience, such as angling, oil painting or cabinet making, the likelihood is that they would be able to keep them relatively distinct from the professional standards and methods of physics. So, how can a "physicist" be *caused* to come into being by memes, in the same way that a blackbird is *caused* by a blackbird genome?

I tacitly answered this question by inserting the word "professional" above (cf. Wilkins forthcoming). A human organism who is a member of a culture, language group, class and so forth, only achieves professional status or competency upon completing some portion of a "developmental" process of acquiring and exercising the relevant memes. A scientist, to return to our example, must acquire the standards, knowledge base and experience of the particular discipline (physics) and the sub disciplines (for example, high energy physics). There is an *aspect* or *profile* to every scientist that is (a) constituted by memes, and (b) within the distribution curve of traits exhibited by the lineage (the *phemorph*). As a scientist, an organism is distinct from other cultural profiles he or she instantiates, and the profile is a separate class of entity from any biological organism of species *H. sapiens* or any set of traits that the organism exhibits by virtue of being a member of the species. Bradley considers the thought experiment of raising the same biological organism now an Englishman in another society, or on a desert island. Clearly, says Bradley, not in these words, the *properties* of Englishness are derived from the relational and (non-biological) developmental processes of living in English society and having a locus there. In our terms, "being English" is a memetic profile derived from the acquisition of Englishness memes. We therefore have to be careful of the denotation of the terms "scientist", "Englishman", "capitalist" and so on. The scientist-as-organism is a distinctly *biological* entity, distinct from the *cultural* entity scientist-as-Englishman, or scientist-as-capitalist, which depend for their specification on the memetic profile of the scientist proper, the scientist-as-professional. In the context of a professional lineage such as a science, or other intellectual pursuits or social practices such as accounting or rap dancing, the memetic individual is the competent member of the lineage, which is developed by the lineages' professional or cultural properties to create a profile within the human (biological/neurological) individual organism. With appropriate adjustments, the notion of a memetic individual can be generalized from the case study of science into other discernible cultural institutions and traditions. In the limiting case, where the cohesion of a lineage is very loose, memetic individuality may be partial or fragmentary (like being good at using a yoyo), but if memes *constitute* anything at all, they constitute the profile of a memetic individual.

Memes, like genes, can only "code for" a norm of reaction. All cultural as well as biological traits are distributed over a population curve, with the mean and the mode correlating to the memetic selection bias. As Hull observes, no two scientists even with identical theoretical commitments interpret their views exactly the same way, and it is an oft repeated half joke, half complaint, that there are as many views in a research program as there are practitioners, sometimes even more. Neither memes nor genes determine all aspects of the properties of the entities they constitute. What they do determine are the degrees of freedom and they bias and constrain the outcomes of the so-constituted system. In thermodynamic phrasing, they specify the field of states such memetic systems have a propensity to attain. Do they do this through a process analogous to the Weismannian Central Dogma, with a one way germ lineage, or through something analogous to a Lamarckian pangenesis (Hull 1988c, chapter 12) with the environment instructing the memes? Is the question even relevant? Cultural and biological evolution *are* going to be different in the frequencies of the kinds of processes they undergo. Perhaps culture does exhibit Lamarckian-style inheritance through the sort of environmental instruction that has a never, or rarely, occurs in biological evolution. One outcome of this would be that variation would come more frequently and more intensively than in a purely Weismannian process, which has to await random mutation or use stored variation from earlier mutation in order for selection to have something on which to operate (Fisher 1930). It would, however, still be Darwinian *evolution* even if *inheritance* were Lamarckian. Lamarckian *evolution*, however, is a different sort of process altogether, driven by perceived need to achieve foreseen outcomes; (see[7]). Lamarckian *inheritance* is not inconsistent with a Darwinian model of memetic evolution. Lamarckian *evolution* would totally demolish the foundations of memetic theory, and leave us with more traditional forms of cultural analysis. However, I do not think that the case has been made that memes are even acquired through instruction in the Lamarckian sense, and refer readers to Cziko's (1995) discussion for further consideration.

It is my opinion that cultural inheritance is not particularly creative, and that most "novelty" is in fact the recombination of pre-existing memes in novel ways: there is little that is new under the sun. Neither do I think that the rate of creativity rises in times of stress or great change. I speculate that what changes, and gives the appearance of memetic novelty, are such factors as selective pressure coefficients, "migration" rates, and density dependent recombination rates that vary from the "usual" background rates. Problems can persist for long periods even in the face of urgent need, and unless the appropriate combination of memes occurs, more or less at random[26], they do not get solved. This takes us back to the question of the demonic structure of culture - too great an isolation and a more optimal memetic combination is unlikely; too little isolation, and combinations are unlikely to be stable enough to undergo selection, and will be swamped. The one major disanalogy Hull accepts between biological and cultural evolution, and with which I agree, is in the rate, but not the kind, of reticulate phylogeny; that is, in the merging and crossover of memes between lineages. Again this is not so much a difference of kind as of degree. As noted above, cultural evolution resembles that of bacteria, plants and fungi more than that of animals - Marvell's "vegetable love" that grows "vaster than empires" is perhaps the better analogy, although on an evolutionary time scale, culture is anything but "more slow".

It might help to visualize the analogy I am proposing by giving examples in a table of the analogues between biological and cultural entities and processes, mapped to the Hull-Dawkins and Ghiselin-Hull ontologies (Table 1, cf. Ghiselin 1997 for a review).

Entity (e) or process (p)	***Biological***	***Memetic***	***Science***	***Language***	***Economics***
Interactor (e)	Phenotype or trait	Phemotype or Pheme	Experiment or Observation	Linguistic behaviour	Enterprise or transaction
Replicator (e)	Gene	Meme	Theory or Hypothesis	Language element[27]	Account, resource
Character (e)	Mendelian Trait (phene)	Pheme	Method, Result	Linguistic practice	Business practice
Lineage (e)	Species, phylum	Tradition, institution	Research program	Regional dialect, language group	Business, industry
Economy (e)	Ecological system	Culture	Disciplinary community[28]	Language community	Market sector, fiscal system
Reproduction (p)	Organismic reproduction	Constitution of new profile	Degree, training	Language acquisition	Establishment of new enterprise
Individual (e)	Organism, kin group, colony	Memetic individual	Scientist	Language speaker	Economic agent
Substrate[29] (e)	Organic molecules			Neural networks	
Code (p)	DNA alphabet	Semantic	Semantic and mathematical	Grammar and vocabulary	Currency
Encoding	Amino acids,	Neural structures,	Neural structures, journals, books, institutions,	Neural structures, written material,	Neural structures, computers, books, ledgers, receipts, bank

medium (e)	proteins	practices	disciplinary associations	recordings, etc.	files, etc.

Table 1 Examples of general evolutionary analogues (e=entity, p=process)

It must again be stressed that these are only some of a number of possible sets of analogues, and what functions as an interactor at one level may function as a replicator at another, so that a pheme for one level may be a meme at another, and vice versa.

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6 Conclusion and prospectus

6.1 Conclusions: My conclusions are as follows. Memes are those units of transmitted information that are subject to selection biases at a given level of hierarchical organization of culture. Unlike genes[30], they are not instantiated in any exclusive kind of physical array or system, although at base they happen to be stored in and expressed from neurological structures[31]. Many memes reside as neural net structures in the central nervous systems of humans, but many also emerge at a higher cultural level. All memes have neural substrates, but not all are encoded in those substrates. Memes are also situated in a variety of larger semantic structures, behavioural regularities, and cultural substrates. They are identified in virtue of their selective roles. Memes must be expressed in a cultural ecology in order to be selected, but it is the *class* of behaviours rather than the behaviours themselves that are memes. Memes do not control behaviour (including mental behaviour) rigidly, but bias and constrain it to a norm of reaction. Memes are the replicators of cultural evolution and the structures that bear the cultural properties they express as are the interactors, in the language of the Hull-Dawkins Distinction. They are, as Hull once entitled a paper (1987), genealogical actors in ecological roles. Packages of memetic interactive properties - phemes - constitute the phemotype of memetic individuals, or memetic profiles, that are not coextensive with the descriptors of the biological individuals in which they are instantiated, and cultural evolution is neither identical to nor derived from biological evolution. Memetic inheritance may be, but probably isn't, analogous to Lamarckian inheritance, but in any event, memetic evolution is Darwinian. Memes form ancestor descendent chains of populations that ramify and reticulate with frequencies differing from biological phylogeny, but the differences appear to be within the extremes of the parameters of biology. The models developed for biological evolution and ecology need to be understood more broadly than just vertebrate animal evolution and applied as they are suited to culture, in order to determine the general evolutionary properties of both domains.

6.2 Methods: The methodological future of memetics lies in the use of techniques drawn from information theory, modern taxonomy and computer science. By interpreting memes as messages, we can make use of Shannon-Weaver entropy (cf. Brooks and Wiley 1988), cladistics (Wiley, et al 1991), and connectionist mathematics as implemented in the Artificial Life program (Holland 1995), but as each of these requires quantification of the data or input, it is important to be able to commensurably map the memetic elements and to measure the selection biases they undergo. If, as I have argued, a meme exists in virtue of biased transmission rates, then there is no smooth reduction of memetic structures from cultural behaviour to atomic memes, just as there is no smooth reduction from phenotypic traits to single genes. The researcher seeking to explain a singular historical shift of memetic frequencies must iteratively refine the data until it becomes clear what is being transmitted at a level and how it is being expressed. The problem of classification lies at two ends of the scale - identifying cultural traditions as they exist now and over time, and identifying elements of those traditions as they persist and recombine. Although this sounds subjective, it need not be. Behavioural regularities indicate that something objective has been spread, and even if the underlying memes cannot be formulated in some universal logical language, the structure of memes can still be identified in the same way as Mendelian genes and molecular sequences, through the use of consensus maps and by noting when their absence or presence makes a difference.

The analytic tools available to us are legion, having been developed in biology over a century or more. They include Wagner groundplan methods (unrooted character similarity trees based on presence-absence matrices), Hamming Distance measures (the sum of the number of simple differences between two memes)[32], cladistic reconstruction using parsimony methods, 33 and pattern recognition methods that use neural networks and other connectionist models. Eventually, these and other methods will no doubt be incorporated into a body of canonical techniques within the memetic enterprise, and I expect they will be generalized as methods applicable in a range of social disciplines. The methods being developed for complex adaptive systems theory at the Santa Fe Institute are also likely to become important for memetics as well as other research dealing with complex adaptive phenomena (Casti 1994). However, if we lack clarity on the core ontology of a selection process in culture, the data to which we could apply these methods will be subjective and the explanations that we derive from them are in danger of being entirely vacuous.

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Glossary of technical terms used

allele
: An alternative gene at a particular locus.

allopatry
: The state of populations living apart from each other (literally "other homeland"). Hence, *allopatric speciation*.

Central Dogma
: Weismann's hypothesis that gametes ("germ cells") are passed on independently to what happens to the organism's body.

cladistics
: Taxonomic classification that reconstructs the order of the appearance of evolutionary novelties from their present distribution. Also known as *cladism*.

cladogenesis
: The origination of a new species by the splitting of a single lineage into two. See *speciation*.

co-adaptation
: The process of local adaptation of genes and their effects to each other, so that they function well as a unit.

conjugation
: In some single celled organisms, the occasional exchange of genes in otherwise aparentally reproducing organisms.

deme
: A small population that is relatively isolated from the larger species or tradition and has its own distinct genetic or memetic characteristics.

emergentism
: The metaphysical position that properties arise from the relations of objects that are not properties of the objects themselves.

epistasis
: Linkages in the effects of genes, such that a single gene may affect many traits or a single trait may be affected by many genes.

evolutionary gene
: "*[A]ny inherited information for which there is a favorable or unfavorable selection bias equal to several or many times its rate of endogenous change*" (Williams 1966: 25)

evolutionarily stable strategy
: A strategy coded for by genes or memes that does better when interacting with copies of itself than alternative strategies do, and which will tend to become the sole or dominant strategy of a population that will not then be susceptible to invasion by other strategies.

facultative
: Of an organism, the possibility to adopt variant lifestyles, one of which is the norm.

founder effect
: The evolution of a new lineage based on the sampling errors of the small starting population, which may be of different proportions to the original populations.

gamete
: The sex cell of each parent, which recombines to produce the zygote, such as sperm and egg, or spore.

gene
: The fundamental physical unit of heredity that transmits information from one cell to another and thus to successive generations.
Mendelian gene: a unit of heredity that causes a single phenotypic character or trait.
Molecular gene: a sequence of nucleotides (DNA, tRNA or rRNA) that functions as a unit during transcription and which is transmitted whole.
Evolutionary gene: see evolutionary gene.

genet
: All the clonal entities that share a genotype.

genome
: The complete complement of the genetic material in a cell or carried by an individual.

genotype
: The genetic constitution of an individual, often referring to genetic basis of some particular characters.

heterozygosity
: Carrying two different alleles from each parent at a locus.

individual
: A relatively well bounded and functionally coherent system comprised of components and their relationships. The formal opposite of a class or universal type.

interactor
: "*[A]n entity that interacts as a cohesive whole with its environment in such a way that this interaction causes replication to be differential*" (Hull 1988c: 408).

lineage
: "*[A]n entity that persists indefinitely through time either in the same or an altered state as a result of replication*" (Hull 1988c: 409).

meme
: The least unit of socio-cultural information relative to a selection process that has favourable or unfavourable selection bias that exceeds its endogenous tendency to change.

memetic profile

The array of phemes that constitutes a memetic individual.

memetic individual
: A competent member of a memetic cultural lineage, which is developed by the lineages' professional or cultural properties to create a memetic profile within the human (biological/neurological) individual organism.

methodological individualism
: The philosophical belief that collectives and their properties are just the sum of the individuals and their properties that comprise them, especially in social and historical explanation.

mnemone
: Donald Campbell's term for a conceptual replicator, roughly equivalent to meme.

norm of reaction
: The distribution curve of the phenotypic effects of a gene in a population.

obligate
: Of a parasite, the forced mode of living or the necessary host. In general, the lifestyle that an organism is forced to adopt.

pangenesis
: Darwin's theory of heredity, a use inheritance view, in which parts of the body were supposed to throw off "gemmules" that were carried to the reproductive organs, and which carried information about the body's experience to the next generation. This view was discredited by August Weismann in the 1880s.

panselectionism
: The view that all characters of an organism have an adaptive reason for evolving.

parapatry
: The state of living in adjacent regions with or without some overlap ("bordering homeland"). Hence, *parapatric speciation*.

parthenogeny
: Asexual reproduction through unfertilized eggs of a lineage that evolved from a sexually reproducing ancestral state. Adj. *parthenogenic*.

pheme
: A single memetic interactive trait which is the expression through some behavioural regularity of a meme at the level of selection. It is the least type of selectively biased behaviour relative to a culture.

phemorph
: The normal distribution curve of traits exhibited by a cultural lineage.

phemotype
: The array of the phemes that are the causal outcome of memes in an individual or group.

phene
: A Mendelian character or trait. Adj. *phenetic*.

pheneticism
: Taxonomy based on the groupings of phenes, without respect to evolutionary lineages.

phenotype
: The observable features of an organism, which develop according to its genetic code (genotype). Adj. *phenotypic*.

pleiotropy
: The state in which one gene affects two or more phenotypic traits not otherwise directly related.

polyploidy
: The fusion of three or more complete sets of chromosomes, sometimes from distinct species, usually in plants.

quasi-species
: Manfred Eigen's term for clusters of related clonal organisms that mimic species in the way they

remain similar.

ramet
: An entity that is one of a number of genetically identical organisms.

random drift
: Sewall Wright's model of random allele frequency changes in small populations without the operation of natural selection.

reductionism
: *Explanatory reductionism*: the philosophical doctrine that a complete explanation of a complex whole is given by enumeration of the components of that whole and their properties, especially in scientific explanation.
Genetic reductionism: a form of explanatory reductionism that has developed into a research program, which holds that all phenotypic properties of organisms and their evolution can be understood in terms of genes and their fitness levels.

replicator
: "*[A]n entity that passes on its structure largely intact through successive replications*" (Hull 1988c: 408).

reticulation
: The recombination of distinct phylogenetic lineages. See *speciation*.

selection
: "*[A] process in which the differential extinction and proliferation of interactors cause the differential perpetuation of the relevant replicators*" (Hull 1988c: 409).

spandrel
: Gould's and Lewontin's (1979) term for a trait or structure that is a necessary by-product of some other adaptive feature, and which is not therefore explained in terms of selection in favour of it.

speciation
: The process of the evolution of a new species, through splitting from an existing species (cladogenesis). Also used of hybridization of existing species to form a third (reticulation).

species
: The largest collections of (sexually reproducing) biological lineages that do regularly recombine, and which do not themselves recombine with other lineages.

sympatry
: The state of coexisting in the same region ("same homeland"). Hence, *sympatric speciation*.

use-inheritance
: Also called *soft inheritance* (Mayr 1982: 691). A view held by Darwin (*Origin* chapter V) that "use ... strengthens and enlarges certain parts and disuse diminishes them, and that such modifications are inherited". Sometimes called "Lamarckian inheritance", although Lamarck was not the first to propose this view, which is a folk belief of long standing. In Darwin's theory of pangenesis, use-inheritance is responsible for modifying the frequency and novelty of variation, and therefore evolution. Fisher (1930) discusses the problems of use-inheritance for Darwinian evolution, and the arguments against it.

Notes

1. Technical terms are linked to definitions in the glossary and discussed, where relevant, in the body of the paper.

2. That is, it represents something causally significant in the theory, like an electron.

3. An analogy between two domains depends on a common etiology. A metaphor can only suggest

limited and vague similarities. For instance, the term "analogy" in phylogeny refers to convergently evolved traits through adaptation to similar conditions of life. If selection of culture is an analogy, it has theoretical weight; if a metaphor, we can abandon or modify it when we find it difficult to apply.

4. And Dawkins is a *lot* of a panselectionist. Panselectionists tend to find selective explanations for every feature of organisms, for instance asking what the adaptive significance of the human chin is, when chins are just the result of two growth fields interacting.

5. By "evolution" I mean the generation of variations and adaptation. I am not committing myself to the claim that natural selection is, or is not, responsible for new species through cladogenesis.

6. Weismann was the first researcher to show that gametes (he called them "germ cells") are passed on independently of what happens to the organism's body. His Central Dogma, as it became known, was an attack on use-inheritance, the time honoured belief (shared by Darwin among others, cf. Mayr 1982: 687-694, Richards, 1992: 172) that those features of an organism that are most needed and most used will be more frequently inherited. Even after the period of the development of Mendelian genetics, the Central Dogma was not universally accepted by biologists until the middle of this century and the molecular revolution in genetics.

7. The term "Lamarckism" is very ambiguous in the way it is used in biology. Much historical injustice to Lamarck was done by those who called themselves "neo-Lamarckians" in the late nineteenth century. Only two sense of "Lamarckism" are relevant to this paper: *use-inheritance* (see previous note), also known as the inheritance of acquired characteristics; and the belief that novelties evolve to meet the *needs* (sometimes interpreted as the desires) of the organisms when their environment changes. A third form often and more historically accurately referred to is that evolution is progressing to some form of perfection. The charge that evolution of culture is Lamarckian (cf. Gould 1993: 216, 1997: 222) generally refers to use-inheritance (for rebuttals, see Hull 1988: 452-457, Cziko 1995).

8. More recently, Ghiselin, with whom Hull collaborated on the so-called individuality thesis, has reviewed the arguments both have made against the "entification" of replicators, including noting that genes, in the population (or Mendelian) genetics sense, can include *deletions*, that is, the *loss* of a sequence can have population level effects. In his view, this is a *reductio ad absurdum* of Dawkins' genetic reductionism (Ghiselin 1997: 143-148).

9. But it is worth noting that they can be the *product* of the properties of genes. In algebra, sums are linear and additive, while products are non-linear and multiplicative. Non-linear products can be extremely complex, and are so-called because their functions do not result in a straight line on log log graphs.

The Kolmogorov theorem shows that between any two arbitrarily large sets there can be at least one mapping so long as there is an intermediate set of links, an important result for connectionist systems research. These Kolmogorov mappings are non-linear products, and applied to genes and memes the theorem means that while there is no simple reduction from interactive characters to genes/memes a mapping relation does exist, even if it is extremely complex.

10. See Rosenberg's 1994 discussion and clarification of the Hullian entities as they apply to biological processes, and also his discussion of Hull's problem of reductionism. See also Ghiselin 1997.

11. To avoid unnecessary confusion, it should be noted that any number of hierarchies can occur in a single domain like biology or culture. There may be a genetic hierarchy leading to species, but there may also be a hierarchy leading to ecological patterns, and these need not be the same hierarchy. (Eldredge

1989) This figure and the following figures are not intended to represent *the* hierarchy of that domain, but only one of a possible many.

12. However, this does not deny that a selection process based on a mental model of the states of affairs can occur in an individual mind. In terms of figure 2, the memes here are the entities that are selected in a mental environment, that is, what makes sense to the thinker, and which when expressed will become memes in a higher level process [cf. Dennett 1995, chapter 12].

13. One possible exception to this bifurcation is when a meme is a spandrel, that is, a by-product of some *other* meme that *is* selectively favoured, and with which it inevitably must be transmitted (Gould and Lewontin 1979, Gould 1997).

14. This resembles the Marxist-Leninist doctrine of false consciousness in some ways, but with no presumption that any part of society will instantiate a "true consciousness" of social reality.

15. Discussion in Cziko 1995: 140-149.

16. For example, a practice may spread just *because* it is selectively neutral. Junk DNA can be transmitted because it does not generate products that are "visible" to selection. Kimura's theory of neutral DNA shows that biassed transmission without selective advantage is a biological reality. And any trait at the interactor level can be selected for or against, in a sense, even if it is not heritable. A blacksmith may do well biologically because of his strength, but that will not (necessarily) be bequeathed to his progeny.

17. As we shall see below, this is not a complete picture; but it captures the initial intuitions of taxonomists.

18. Interestingly, identifying the five or six distinct, but hitherto unrecognized (*cryptic*), species of *A. maculipennis* was accomplished through analysis of their being vectors for *P. falciparum* or not (Cain 1954).

19. I am of the philosophical school of thought that laws and equations merely *describe* dynamic patterns rather than *govern* phenomena (instrumentalism), but that is not germane to this essay. See Rosenberg 1994 for a discussion of instrumentalism and biology.

20. Because the resources required are rather significant, which is an interesting memetic point.

21. This is not a mistake, despite its contradiction to textbook biology. The result was announced in a recent paper (Boerlijst, Bonhoeffer and Nowak 1996).

22. It is worth remembering that Darwinian, or rather synthetic, evolution, is modelled by a number of theories (common descent, natural selection, sexual selection, biogeographic distribution, Mendelian genetics), and should not be considered a single theory on its own.

23. Allopatry is the state of populations living apart from each other (literally "other homeland"), sympatry that of coexisting in the same region ("same homeland"), and parapatry of living in adjacent regions with or without some overlap ("bordering homeland"). When speciation occurs in these states, then it is called allopatric speciation, and so forth. Many now think that parapatric speciation occurs, but the frequency is still at issue.

24. Dobzhansky's concept [1937] of "co-adaptation" (a term initially used by Darwin, I believe) is significant at this point of the argument. If memes at first arise within restricted domains, all they need at

this early stage to adapt *to* are the other memes within the deme, or some part of it. Co-adapted memes may play a role in storing memetic variation until the fitness of variants rises to significant levels. Moreover, it would explain why apparently maladaptive memes can persist in a tradition. In the end, the final selection event is extinction, and maladaptive memes may persist because they are fitter within a tradition than on their own, even if they make the lineage phemotype less adaptive overall.

As an example, consider the meme of common property in the fideist traditions such as the Mennonites and the Shakers. This meme was a core belief and tradition in these communities, and was well adapted to the rest of the memes shared by the communities, but it was maladaptive during the most aggressive period of the rise of modern industrial capitalism, and these communities eventually faded away.

25. An early shot at proto-sociobiological notions, although I think Bradley underestimates how much biology affects one's *place* in a culture. Imagine the role of a Chinese child growing up in Victorian England.

26. Random with respect to the selection process, that is.

27. Phonemes, words, syntactical structures, etc.

28. Funding for research is peer reviewed, even if it derives from governments, and so the primary economic resource is standing in that community, cf. Hull 1988c.

29. Supporting physical entities of the code.

30. Genes also include and require RNA of various kinds, so even this generalization is not absolute.

31. At least, until artificial intelligences become a reality.

32. Interestingly, Hamming Distance was first formulated in the context of information theory, and adapted for use in genetics after the molecular revolution. See Gabora forthcoming for a treatment of Hamming Distance in memetics, but one that I think is overly reductionist.

33. Cladistic reconstructions rely on an absence of reticulation, and so should be used with care in the memetic context. Cf. Wiley et al 1991.

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