

# On predicting animal evolution

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## ABSTRACT

The origination of most free-living animal species is predictable. 'Light' order production in the trophic levels below is the key. Absent from the abiotic environment (pre-primary level) and prokaryotes, 'light' order consists of differences in species composition between highly-developed, species-packed communities in which extinction may be the precursor to speciation, particularly ecologically comparable tropical continental lowland ones of Africa, Australia, India, and South America. Based on but not itself of matter and non-burnable, its nil waste heat content 'compensates' for burned-up food energy. Where the amounts of it on infra-apical trophic levels form an inverted pyramid like waste heat's, occupancy of trophic levels from primary to apical is predictable (variation and selection assumed). Terminal non-inversion predicts post-apical vacancy. Examined communities were from grasslands (grasses, large grazing mammals, large carnivores), and woodlands (woody plants, butterflies, insect-eating birds, raptorial birds). Linnaeus's binomial classificational system turned out to be unexpectedly rich in new content. A new object of study, the neoLinnaean, is recognised and a new process, the neoLyellian, advanced to explain it. Relations to Darwin's and Lyell's non-predictive theories of change, to ecology and evolution, to thermodynamics, statistical mechanics and quantum mechanics, and to neurology are discussed.

Key words: ecology - extinction and speciation - 'light' v. 'heavy' order - Linnaean system - thermodynamics - trophic levels - tropical continental lowland communities

## 1. INTRODUCTION

Lyell's doctrine of uniformitarianism<sup>1-2</sup> replaced Cuvier's catastrophe theory and strongly influenced the young Charles Darwin. Both it and Darwin's theory of common descent by natural selection<sup>3</sup> supplied frameworks for ordering observations, but were weak predictively. Consequently the origin of species seemed non-predictable, a situation which the Modern Synthesis inherited but left unchanged.<sup>4</sup> The present aim is to show that the origination of most free-living animal species is predictable under carefully defined conditions.

All animals are consumers rather than producers of potential energy and trophic pyramids ideally summarise large masses of observations on the numbers and kinds of both. However, those that were actually adduced did not do this. Thus, Elton's pyramid of animal numbers<sup>5</sup> started above the primary producer level; Lindeman's pyramid of potential energy<sup>6</sup> eliminated the wealth of species altogether in favour of a common physical denominator, energy. Consequently, in spite of being imbued with time and causality, these pyramids remained predictively vitiated.

What seems unassailable beyond a shadow of reasonable doubt is that when an energy transformation and a species transformation coincide precisely in time and space, a new trophic level results. What is unknown is the necessary and sufficient conditions for this to occur. Darwinian evolutionary considerations are of little use as a guide here, because our route traverses thermodynamic territory, or at least skirts its borderland. As for the other great

division of equilibrium evolution, thermodynamics itself is hardly of more help because it aims at too low a descriptive level hierarchically to be capable of describing anything as statistically improbable as a stable population of an apex predator, where 'stable' takes in the evolution of its prey, the latter's food supply and so on, the removal of any of which would have the effect of depriving it of its stability. In short, the land that lies spread before us is, evolutionarily speaking, a terra incognita.

## 2. MATERIALS AND METHODS

Our primary material will be order. I distinguish two kinds, viz. 'heavy' and 'light' order. Species diversity is the stuff from which 'heavy' order is made. It is reducible to DNA and proteins, whereas 'light' order consists of differences in species composition only and is therefore matter-free, meaning it cannot be burned. Since it cannot be burned, it potentially contains no waste heat. Its grade purity qualifies it in some not as yet fully understood way to 'compensate' for burned-up energy losses in those ecosystems that contain enough of it. 'Enough' is here defined as: when the amounts of 'light' order on successive trophic levels make an inverted pyramid similar in shape to waste heat's additive one, with the pre-primary level or abiotic environment keeping unchanged its pre-biotic value of zero. The coefficient of inversion between any two such levels is unknown to any degree of quantitative accuracy and is replaced here by 'greater / less than.' Predicting the occupancy / vacancy of a trophic level thus turns on knowing the amounts of 'light' order on the two levels below, heritable variation and natural selection being assumed favourable in the former alternative's case. Terminal non-inversion predicts post-apical vacancy. Terminal inversion predicts the appearance of a post-apical predator, and hence of a brand-new apical level, but leaves the time unpredicted. Pyramid height, or the number of the apex predator level at any given time remains unpredicted.

Exemplary ecosystems and communities are situated in ex-Gondwana continental plates that drifted apart by seafloor spreading to form the southern continents and India.<sup>7</sup>

Although relative extinction, speciation, and dispersal rates determine comparative composition within a trophic level, examination of standing difference patterns over several levels will be our concern.

Tropical lowland woodlands, forests (no data available), and grasslands are most favourable, because their climax communities were least affected by glacial wipeout.<sup>8</sup> Within these highly-developed, very species-rich, non-insular communities, speciation may tend to follow extinction rather than precede it as new forms evolve very largely to replace those adaptively fallen behind with time and change. Both steps together are a zero-sum for biomass, whence the epithet 'light.' Each contributes a point to compositional differences between communities across the intercontinental divide that once had a common boundary and genetic heritage. A quantity of 'light' order is thus produced for no net change to biomass but a high cost genetically.

Within each tropical biome, three pairwise comparisons were made, namely and respectively: Africa (Afr) v. South America (S Am); Afr v. India (Ind); and Afr v. Australia (Aus). Afr is common, because I lack first-hand experience of the others. The grassland ecosystem comprised three trophic levels:- large carnivores, large grazing mammals, grasses. Compositional data were obtained by extracting information from existing works.<sup>9-11</sup> The woodland ecosystem comprised four trophic levels:- raptorial birds, insect-eating birds, butterflies, woody plants. The choice of the butterflies was for their specific larval host-plant preferences and the close degree of adaptation to the plant life in a locality that these imply. Compositional data were obtained by direct study of two south-central Afr savanna woodland sites over a 6-year period.<sup>12</sup> These were a 0.5 hectare area of Kalahari Sand woodland

dominated by *Baikiaea plurijuga* Harms on deep windblown deposits of Pleistocene age, and a 26 hectares area of floristically richer Escarpment woodland on stony soils over Karoo basalt. Both sites were near Livingstone, Zambia. Neither one was insular, as the first was flanked and backed and the second was surrounded by a much larger expanse of similar environment.

The width of a trophic level in a pairwise-comparison pyramid – hereafter, ‘difference pyramid’ – was defined as the percent difference in species composition at that particular level. Extremely high percentages may occur on several trophic levels at once, especially where the dispersal barriers are of great size and antiquity as they are here. Comparative examination may then take place at the next higher level of taxonomy, i.e. the genus and width be redefined as the percent difference in generic composition.

The pyramidiform shapes that resulted from vertically stacking their trophic levels as defined were described, comparisons with Eltonian and Lindemanian pyramids were made, and interesting differences were noted.

### 3. RESULTS

#### i. *Tropical lowland grasslands*

These difference pyramids differed from Eltonian and Lindemanian pyramids by being inverted in shape below, and changing to normal shape at, the apical consumer level. The latter was intermediate in width between the primary producer and primary consumer levels. In detail:-

Primary producer level.<sup>9-10</sup> Compositional similarities are numerous, at the genus level especially. Thus, out of 120 genera of grasses (Gramineae) in one south-central Afr territory, Zambia, 41 (34%) also occur in all three of S Am, Ind, and Aus and around one-half have representatives in each (S Am 46%, Ind 56%, Aus 51%).

Primary consumer level.<sup>11</sup> Compositional differences of high taxonomic rank abound. Thus Aus grazers are marsupials (kangaroos, wallabies). Of placentals, hydrochoerids (capybaras) are in S Am only, grazing suids (warthogs) and hippopotamids (hippopotami) in Afr only. Tropical Afr lacks cervids (deer), while Ind forms (Cervinae) differ at the subfamily level from S Am ones (Capreolinae). Ind and Afr share elephantids (elephants), rhinocerotids (rhinoceroses), equids (wild asses, zebras), and bovids (antelopes, buffaloes), but their genera are nearly all different.

Secondary (=apical) consumer level.<sup>11</sup> Compositional differences are low to moderately high. Crocodiles *Crocodylus* are in all four areas, great cats *Panthera* in all except Aus. Striped hyaena *Hyaena* and cheetah *Acinonyx* are common to Ind and Afr. The remainder are genus-level or higher. Thus alligatorids (as caimans *Caiman*) and the only large-sized Felinae (puma *Puma*) are in S Am only, hyaenids and acinonychine felids in Ind and Afr only. Compare S Am bovids (boa constrictor, anaconda) with Aus, Ind, and Afr pythonids (pythons), and S Am bush dog *Speothos* with Aus dingo *Canis*, Ind dhole *Cuon* and wolf *Canis*, and Afr hunting dog *Lycaon*.

#### ii. *Tropical lowland woodlands*

These difference pyramids differed from Eltonian and Lindemanian pyramids by being inverted in shape below, and changing to normal shape at, the apical consumer level. The latter was intermediate in width between the primary producer and primary consumer levels. In numerical detail (Figure 1, based on information in Annexes 1 and 2)<sup>12</sup>:-

Figure 1

### 4. DISCUSSION

Of the two regularities reported here, one, the ordinally unchanging width of the apical consumer level between the primary producer and primary consumer levels, is unaccountable. The second, the repeating inverse-pyramid pattern of the infra-apical trophic levels, will therefore occupy our attention exclusively below.

The fires in the earth that power continental drift are the other major external energy source involved in producing 'light' order besides the sun. This di-energetic basis is also the source of a difference pyramid's characteristic shape, like a river's that runs through a well-watered land and gets wider by capturing tributaries before it terminates abruptly in the desert beyond. The mono-energetic Eltonian and Lindemanian pyramids resemble feederless desert streams throughout by comparison.

Considering the trophic level relation

$$\text{width} \propto 1 / \text{height}$$

of an Eltonian or a Lindemanian pyramid, the width decrease implication of a height increase implies nothing as to the probability of a higher-level consumer's evolving. Clearly, their predictive power is nil. 'Light' order, on the other hand, is highly predictive. Thus, whenever a consumer level in a difference pyramid followed a width increase on the producer levels below, it was found to be occupied (assuming the availability of heritable variation in the 'right' direction and natural selection for effectiveness in the new role); but not otherwise.

Functionally speaking, a difference pyramid is like a well-posted highway. Along it energy and, very occasionally, genes move on their passage through the ecosystem. Each infra-apical trophic level displays a green sign for 'Go.' The green signs keep the "traffic moving" as far as the apical level, where a red 'Stop' sign arrests further movement. This 'light' order perspective differs from the customary view, which (rightly) sees obstacles to the flow of energy arising at every level as the occupants come under selective pressure to evolve new and better ways of avoiding being eaten by those on the next level up. "An ecosystem, as a machine, is highly inefficient for just this reason, the impediments raised by each trophic level to the passage of energy to the next higher level."<sup>13</sup> But then where does the highway come from? For an impartial perspective, let us suppose that a military engineer plans to rebuild a bridge by using for construction material very large amounts of the same substance as that employed in much smaller amounts and with a very different end in view by the enemy, i.e., dynamite. Clearly, the replacing structure was going to be thermodynamically extremely unstable. Yet something of this sort is implied whenever the theory of natural selection *and nothing else besides* is called upon to explain how the very first occupant of any given consumer level originated.

For a serviceable highway construction (non)material, we need look no further than 'light' order. I would maintain that no amount of heritable variation and natural selection can be effective in fashioning and stabilising a new ecological role player 'vertically,' unless the ecosystem as a whole is conducive to such a perturbing of the status quo and departure from equilibrium by having ready to hand a stock of 'light' order in the right distribution and relative amounts.

It cannot be emphasised strongly enough that fashioning of tributary adaptations for this or that ecological role is not the same thing as stabilising the role player. The lion would not be a lion without its teeth and claws and strength and speed, but without 'light' order it is nowhere, unless in a kind of backstage limbo of merely potential animals for whom the onstage call never sounds.<sup>14</sup>

Similar arguments hold for the descendants of all, including the species happenstance flings together to make a functional community. These, instanced here by the lions and

zebras, tigers and deer, jaguars and capybaras, and raptors, insect-eating birds, and butterflies of the continental lowland tropics of today, might have been unable to evolve without natural selection, but I very much doubt if they could have evolved with it alone either.

In neoDarwinian theory, mutation, recombination and selection would be sufficient for animals like these to evolve.<sup>4,13</sup> The inference to be drawn from the present findings is that they are insufficient, in the specific context of the advanced stage of ecosystem growth and development which these particular species and their communities represent.

It actually is possible to demonstrate that, in this same stage of community growth and development, a certain amount of 'light' order goes into making any *one* species of free-living animal, and the amount of it moreover is measurable (in prep.).

Three major problem areas of biology and evolution which this approach to animal evolution goes some or all of the way towards resolving are as follows:- 1. "The inherent strength of the [genetical] theory [of natural selection] is restricted by the paucity of generalizations, analogous to Kepler's laws, that can serve on the one hand as summaries of large masses of observations and, on the other hand, as logical deductions from the theory."<sup>13</sup> I imagine that among the more powerful generalisations of this sort would be the causal chain,

extinction + speciation → 'light' order → difference pyramid → trophic levels.

This permits the deductions that in those organisms in which extinction is unknown, such as the prokaryotes (bacteria, archaea),<sup>15</sup> production of 'light' order (an operational definition of which is in prep.) cannot have occurred, nor therefore can trophic levels of free-living consumers have arisen: and apparently they have not. Going extinct, producing 'light' order, and raising up trophic pyramids all seem to be specifically biparental-eukaryote phenomena. 2. "The degree of complication in biology is so discouraging that one can ... not imagine any set of concepts in which the connections could be so sharply defined that a mathematical representation could become possible."<sup>16</sup> However, the Linnaean system imposes on nature's exceedingly complicated and elaborate arrangement a relatively simple and straightforward pattern I call the *neoLinnaean* (see below) that as difference pyramids is amenable to both measurement and empirical demonstration. This implies that the true degree of complication in biology has been exaggerated. 3. "*Biology* is a label for two largely separate fields ... which may be designated functional biology and evolutionary biology."<sup>4</sup> However, Linnaeus took the first and essential contra-divisive step forward when he arranged the species – the building blocks of biology – in their natural order.<sup>17</sup> With advances in taxonomy and systematics since then, the Linnaean system now turns out to fit the structure of the ecosystem – the functional unit formed by the building blocks.

The position in biology today is basically unmoved from the deadlock as Heisenberg<sup>16</sup> and Williams<sup>13</sup> described it over fifty years ago, while Mayr's<sup>4</sup> functional and evolutionary biologies continue to dwell apart.

I would amend the above extracts in quotation marks from these authors to read as follows:-

1. The theory of organic evolution (sic) is strengthened by generalisations like these, that can serve as summaries of large masses of observations and as logical deductions from the theory.

2. The true degree of complication in biology is so slight that one can imagine a set of concepts in which the connections could be so sharply defined that a mathematical representation could become possible.

3. Biology is no longer a label for separate functional and evolutionary fields. Henceforward, it refers to one single undivided subject matter.

These benefits accrue from incorporating Linnaeism into the fabric of ecological and evolutionary science. Past failure to do so was an unforced error of monumental proportions, comparable in its consequences to the state of ignorance and helplessness that prevailed in physical science prior to Mendeleev's discovery of the periodic table of the elements.

I have termed difference pyramids 'neoLinnaean' as above, firstly because the currency common to all trophic levels is not, biologically speaking, energy as in a Lindemanian pyramid, but an organism's place in the binomial classification system of which Linnaeus<sup>17</sup> is the founding father and which is (at its best) a true reflection of common descent; and secondly because plants are present in them unlike in Eltonian pyramids.

The neoLinnaean, statistically speaking, is a tower of improbability. We have been assuming that the genus is a 'safe' informational unit from which to construct it. A moment's reflection, however, shows how *risky* this is, since each genus represents a conjecture, or hypothesis about how the world or a part thereof not only is but came to be as it is, and might conceivably be false. Future work should look at whether difference pyramid shapes other than those reported here cannot be made to appear, by applying the permutative method to the alternative generic arrangements that have been used to classify the species in the communities to which they refer. As concerns this work,<sup>12</sup> differences of opinion surround whether, e.g., *Micronisus* goshawks might not be better submerged in *Melierax*, whether *Nectarinia* sunbirds should or should not be split between *Chalcomitra* and *Cinnyris*, whether *Iolais* hairstreak butterflies would not be better assigned to *Aphniolaus*, *Epamera*, *Iolaphilus* and *Stugeta*, and whether *Senegalia* and *Vachellia* thorn trees should or should not be recombined with *Acacia*. Taxonomically possible difference pyramids whose shapes departed from the expected distribution of 'light' order would imply its probabilistic rather than absolute nature. It could even turn out that associated to any given community there is a relative frequency distribution of them. While it may be premature to engage in speculation at this stage, it is not difficult to envisage critical feedback loops of various kinds arising if taxonomists felt they were coming under pressure to produce classifications that conformed to the neoLinnaean norm. Whether this would be a good or a bad thing on the whole is an open question. Speaking as a user rather than a producer of taxonomy, I feel unqualified to answer it.

What raises difference pyramids well above the biological average on a predictivity scale? The relation between heat, work, and information is a topic in physics but not in biology. However, that could change. Apparently the presence of 'light' order in sufficient amounts unblocks the way for the biparental eukaryote community to ascend a time interval (feeding level). A mass rises through a height interval, given a thermal engine to lift it. In the living system heritable variation and natural selection are responsible for performing the work of ascent (common descent); in the physical system a human worker rather than genes as such is the intelligence behind the device. These differences aside, the superficially dissimilar set-ups are comparable. The interesting feature is that (taxonomic difference) information is the (non)stuff from which 'light' order is made, 'information' in the theory of that name is inversely related to waste heat,<sup>18-19</sup> heat is motion of matter,<sup>20</sup> but matter forms no part of 'light' order, which is precisely the reason why the latter is supremely well

qualified to ‘compensate’ for waste heat. The astounding feature is that prediction at this level of complexity is possible at all, when the historical nature of the subject matter and the sheer numbers of interacting variables at any one time had always seemed to be utterly and implacably opposed to it.

A difference pyramid derives its predictive strength from its juxtaposing of trophic pyramids compared two at a time, each of which has time and causality built in (e.g., grasses do not eat zebras nor the latter lions) and the empirically best attested model of how most free-living animals speciate, the geographic isolation model.<sup>4</sup> As a term for the resultant overall pattern, I prefer ‘*macrogenetic*’ to ‘macroecological’ or ‘macroevolutionary.’ ‘Macro,’ because the first step in making ‘light’ order, i.e., the extirpation of an entire genetic line has no known microgenetic basis. If such a basis existed then extinction could be regarded as a creative factor in evolution, which it is not.<sup>13</sup>

The macrogenetic process I term ‘*neoLyellian*,’ by which I mean Lyell’s principle of uniformity<sup>1-2</sup> after raising it up to an abstract plane in which the neoLinnaean replaces his steady-state principle.<sup>1-2</sup> For the former unlike the latter admits directional change on all temporal scales, namely: the *evolutionary* (as the very occasional trophic level additions to an ecological pyramid); the *historical* (as the imperceptibly slow but comparatively steady growth of difference pyramids following the null difference states that would have prevailed in Gondwana time); and the *ecological* (as the daily throughput of energy). It absorbs without a trace their lower-level component changes of opposing ‘sign’ (extinction v. speciation; eating v. being eaten) while remaining essentially unchanged itself. The neoLinnaean is in other words a *historically invariant* pattern.

The macrogenetic model of animal evolution refers to the plants *and* animals of a *named* time and place. Consequently it runs the risk of being falsified at as many places in the continental lowland tropics as invite joint botanical and zoological examination. A statistical model, it relies on fairly large numbers of species being present. Consequently it may or may not apply to inchoate and impoverished communities, including those of small islands, early stages in ecological succession, and extensive postglacial areas still in process of recovering at temperate and boreal latitudes. It could be zoologically limited, as  $\approx 40\%$  of all animal species are parasitic.<sup>21</sup> Whether or not it applies to these as well as their free-living hosts, is currently unknown. Then there are free-living forms that live off parasites, e.g. oxpecker birds *Buphagus* whose diet consists largely of haemophagous ectoparasites gleaned from large herbivores. Finally, a small minority apparently has evolved in the reverse direction to a difference pyramid’s, e.g. the giant panda *Ailuropoda* is an aberrant member of the order Carnivora that has undergone secondary reversion to herbivory. This model could not have predicted the origins of animals such as these.

Thermodynamically, to which of these models does the neoLyellian process relate more closely: Prigogine’s fluctuational-bifurcational model,<sup>22</sup> or Gladyshev’s hierarchical-thermodynamic model?<sup>23</sup> In Gladyshev’s law of temporal hierarchies, the  $t$ ’s are average life-spans of biological structures:

$$\lll t^{\text{mol}} \lll t^{\text{cel}} \lll t^{\text{org}} \lll t^{\text{pop}} \dots \lll [t^{\text{nL}}],$$

where **mol** to **pop** stand for his molecule, cell, organism, and population levels respectively and **[nL]** for neoLinnaean is my insert. The antiquity of the latter is  $\approx 10^8$ y.<sup>7</sup> Its Gibbs function<sup>23</sup> probably does not tend to a minimum, unlike most of the others’.<sup>23</sup> My ‘macrogenetic’ echoes to Gladyshev’s ‘macrothermodynamic.’ For him, all biological phenomena are reducible to non-Prigoginean, Carnot-Gibbs-Clausius-Boltzmann-Kelvin thermodynamics. However, a heat-engine model of the ecosystem with its day / night

temperature changes is ill-suited to the neoLinnaean, as opposed to its food pyramids. In contrast, the furnace in the earth is a constantly 'on' heat source that is more nearly analogous to the hot plate in the Bénard cell model.<sup>22</sup> It underpins the evolution of the neoLinnaean. Prigogine's nonequilibrium model of fluctuations leading to bifurcations<sup>22</sup> also seems to fit well the splittings of trophic levels that took place at various times during the ascent of the biparental eukaryotes, as early herbivore-like and plant-like forms separated out to form the first difference pyramids, and so forth.

'Compensation' is a macroscopic phenomenon, but what of the distribution of underlying microstates, i.e., is it reducible to statistical mechanics? We begin by showing that 'light' order is, for all its non-material character, physical. For comparison, consider a pot of tea or a jug of water: air enters in through a small perforation in the close-fitting lid and fills the empty space that is created when the tea or water is poured. As long as air enters via the hole, liquid will exit via the spout. A difference pyramid may be viewed as another kind of delivery device, for photosynthetically elaborated potential energy in its case. Like the air acting on the surface of the liquid, 'light' order exerts a 'pressure' on the goods that keeps them moving through the system. Physically speaking, air, a mixture of gases, and 'light' order, a (non)stuff that is neither gas nor solid nor liquid, both belong to *less dense phases* than the liquid beverages or energy-rich matter whose delivery they expedite: and in this *phase difference* lies the secret of their effectiveness as 'compensators.' Neither one is used up or takes part reactively in the process: mere physical presence seems to be enough to ensure effectiveness.

Next, the exact nature of this physicality needs to be established in order to arrive at a clear picture of the distribution of underlying microstates: - (i) Extinction enables the counting and statistical averaging of species and genera, by introducing a discontinuous element. Otherwise, we could scarcely have arrived at the correct distribution of 'light' order in a difference pyramid. (ii) The identical problem in the distribution of heat was only resolved when the 'cells' into which Gibbs had arbitrarily subdivided the multidimensional phase space of statistical mechanics were replaced by a natural discontinuity, the quantum of action.<sup>24</sup> (iii) The quantum of action, denoted by  $h$  and known as Planck's constant, is the connecting link between wave-like and particle-like properties of matter.<sup>22</sup> (iv) Species extinction is wave-like. (v) Species transformation, when occurring in a difference pyramid, represents a union of the change in (iv) and change of a particulate nature due to mutation, selection, etc. Hence, (vi) a species made of 'light' order is the biological counterpart to  $h$ , differing from it mainly in regard to its time relations (in prep.). It is very interesting that in arriving at this point we travelled not via the reductive route, which would have taken us through levels successively named 'genetics,' 'biochemistry,' 'chemistry,' and so on<sup>25</sup> with a prolonged and rather sticky stop at each one, but by following instead a 'looping' route which, in bypassing all the intervening non-fundamental levels including that of statistical mechanics, whisked us in one go straight from the macrogenetic level to the door of the fundamental level itself, the quantum of action.

The notion of reduction through successive levels of simpler physico-chemical components<sup>25</sup> may be of rather limited applicability here. Another notion, that of form and its corollary, function may be deserving of consideration instead. As Callendar and Andrews describe it (paragraph spaces omitted): "...the representation of the phenomena associated with heat distribution by means of multidimensional space, as initiated by Gibbs, was the beginning of a trend of thought which... shifted emphasis from the analytic to the synthetic. Thus Debye took into account the action of heat in the whole crystal, instead of treating it as atomized into independent oscillators as Einstein did. The mathematical structure of the new quantum mechanics... has emphasized still further the "aspect of the whole" as representable

in generalized space... In quantum mechanics we find probability in wave-clothing dominating the behaviour of elementary particles with a formalism isomorphic with the generalized Debye treatment of heat in crystals. In the new information theory we find probability and generalized space again, once more closely isomorphic with fundamental aspects of the theory of heat... [It was] N. Bohr who stressed the importance of this [holistic] point of view in interpreting the relationships between processes at the atomic level and at the biological level. The essential, characteristic feature of the living organism is dynamic stability. While the individual building blocks of the organism, the atoms, come and go by the trillion or more through respiration and metabolism, the structure of the organism retains its characteristic form relatively unchanged for a period of time billions or more times longer than the interval required for an individual atomic replacement. We therefore must regard this characteristic form as a dynamic energy pattern which subtly combines change with invariance. Its dynamism is heat, the warmth of life, but because this heat embodies form, there emerges a stable entity of the whole, which in its survival through time possesses a reality that dominates and transcends its ephemeral and ever-changing material parts.”<sup>26</sup>

Notice that replacing ‘organism’ by ‘neoLinnaean’ and ‘atoms’ by ‘species’ in the above passage would leave its meaning essentially unaltered. Conversely, considerations of symmetry require that an individual animal have a neoLinnaean-like object of study. As Callendar and Andrews point out, the closely related fields of heat and information meet in the physiological and epistemological aspects of the brain.<sup>26</sup> There could exist in the human brain a neurological equivalent of the neoLinnaean that escaped notice up to now because people were looking in the wrong places for it. If such a structure or form or pattern exists, its thought waves must share a common non-material ground with ‘light’ order. If mankind evolved in the African savannas, as palaeontological evidence strongly indicates,<sup>27</sup> our species must be among the macrogenetic progeny of the neoLinnaean that produced the large herbivores and flesh-eaters in the tropical grassland example (see Results). ‘Light’ order could have entered into our neurological make-up then. What I am suggesting is that in the present approach to ecology and evolution may lie seeds that if cultivated correctly could be applied to the study of the human brain and psyche.

The following ecologists are imaginary, though most real ones probably fit at least one of hats (a) to (d), if not more. (a) *‘Heavy’ order enthusiast*. This ecologist discounts extinct species absolutely, uses weighted abundances to derive species diversity estimates, and generally places biomass at a premium. In contrast, this ‘light’ order enthusiast took extinct species into account and treated the  $S$  extant species as being on an equal footing regardless of commonness or rarity. (b) *Darwinian reductionist*. This ecologist atomises the  $S$  species present into as many interacting populations and labels them ‘predator,’ ‘competitor,’ ‘symbiont,’ etc. Description is in terms of their  $\gg S$  coefficients of interaction. In contrast, this *Linnaean holist* drew on the vast reservoirs of taxonomy and systematics to group the  $S$  species into their  $< S$  genera, grouped the latter into fewer levels still of producers and consumers, and pursued it whither it led in terms of meaningful pattern emergence. (c) *Ecological web spider*. This ecologist ranks food webs high and food pyramids low (the latter rate no mention at all in one highly regarded ecology textbook). In contrast, this writer adopted the simpler idea, adapted it to make the orderly community signal stand out from the noise, and considered the trade-off in terms of understanding gained *v.* sacrifice of detail to be well worth it. (d) *Spatio-temporal parochialist*. This ecologist finds it inconceivable that communities unconnected physically since Cretaceous times can be connected in any meaningful way today. To find out if such and such a species is or is not on the cusp of evolving here in one’s local community in Africa, say, there is no idea of referring the case for judgment to some other community on the far side of the globe in Australia or India or

South America. Description involves changing the ‘playing field’ and the ‘name of the game,’ by restricting consideration to communities in which local-contemporary causation holds sway. In contrast, this macrogeneticist would see the man-made barriers between historical biogeography, community ecology, evolution, and taxonomy and systematics scattered, by remaking natural barriers into an integral part of the ecosystem to which the historical and biogeographic dimension has been added. This implies that the very concept of ecosystem itself is in need of expanding to include the ‘bigger picture’ in which the factors regulating the numbers and kinds of organisms at any given time and their changes in time appear very different to those in the ‘smaller picture’ painted by ecologists for whom hat (d) is the headgear of choice.

Quite the most important of these differences is that between the proponents of nonequilibrium and equilibrium descriptions.<sup>22</sup> First, the fossil record shows that nearly 100% of all biparental eukaryote species are now extinct.<sup>28</sup> It follows from the uniformitarian principle<sup>1-2</sup> that a description of a many-species system that is based on equilibrium notions is doomed from the start. Second, numbers and kinds of organisms are not separable, because change in number is very often the cause of change in kind or qualities, and vice versa. However, they were separated. As Thomas Park relates, early in the history of population biology the population ecologists got the numbers and the population geneticists got the qualities.<sup>29</sup> But after the cooking was over the result was not one whole loaf nicely risen, but two rather leaden lumps each corresponding to a different equilibrium description. Third, adding to the biomass-rich dough a leaven of ‘light’ order is the remedy. Without it, the trophic level widths in Fig. 1 either would have remained at 0, their common Gondwana equilibrium value or else (and more likely) increased from 0 but without making an orderly pattern. Fourth, the resulting whole loaf is easily digestible. Only thus can one begin to convey how the neoLinnaean assimilates species and genera *in their hundreds*<sup>12</sup> with an absolute minimum of effort. With any other recipe the glut would be thoroughly indigestible.

NeoDarwinian description involves narrating a plausible-sounding story about how natural selection may have guided the course of evolution in one population, and then making the same story stretch *mutatis mutandis* to cover that of the rest by the procedure known as extrapolation. But of the switch from ‘heavy’ order production to ‘light’ order production there is not so much as a hint, let alone a description. The qualitative nature of the phase transition is indeed difficult to account for in neoDarwinian terms, whether teleonomically or as a fortuitous side-effect of something else.<sup>13</sup> This in turn makes it difficult to see how extrapolation in the neoDarwinian mode can be made to cover the evolution of the ‘rest’ – the whole of free-living consumer life generally and of animal life particularly.

Evolution is an elastic enough term to cover the ‘upward’ phase of ecosystem-level growth and development as well without serious risk of confusion with discredited notions of ‘group’ selection.<sup>13</sup> I consider that it would be of great benefit to evolutionary discourse if neoDarwinians could be equally punctilious in calling the ‘upward’ phase by its specific name, i.e., neoLyellian, macrogenetic, and having the neoLinnaean for its end-product. NeoDarwinian and (micro)genetic it is not, nor is the extant community simply the sum-total of what worked better in an adaptive sense<sup>13</sup> in the past. For stabilising the highly ordered complex superstructure of the neoLinnaean and preventing its collapse to states of lower order from moment to moment, are the statistical reverberations of forebears now vanished because they chanced to become terminally ill-adapted earlier on in the same phase.

## CONCLUSION

Linnaeus<sup>17</sup> invented the scientific language with which to describe a cross-section through the evolutionary tree of life as it exists at any given moment in its history, such as the present.

NeoDarwinism provides the underlying mechanism<sup>4,13</sup> and molecular phylogenetics the investigative tools to explain how the tree grew up. So far these last have proceeded as if they had the description firmly in their grasp, meaning, of course, the familiar icon of the evolutionary tree itself. But the cross-sectional figure of the neoLinnaean is orthogonal to the latter. So the number of descriptions has gone from one to two: the one ‘vertical’ and sending out ‘horizontal’ branches in an apparently haphazard manner in morphological space, the other ‘horizontal’ and sending up a ‘vertical’ pattern of orderly growth and development in trophic, energy-transforming time. Both describe common descent, the one imaginatively, by narrating past events which no human being ever actually experienced or possibly could have; the other demonstratively, by pointing to objects of immediate experience in the form of orderly patterns made up of genera and species that are very much alive today. The one examines gradual change to gene frequencies in a more or less continuous population,<sup>4,13</sup> the other overarching patterns of disappearance and appearance of entire species and higher taxa in a polysystem comprising three biotically distinct areas of uneven age of which the youngest is a central barrier of immense size and age. The one applies to all living things at all times, the other to a subset of a subset of relative latecomers. The one is static and afunctional, the other dynamic and functional. The one is non-predictive, the other predictive. In the end, the futility of arguing for the ‘superiority’ of either description will be evident. They are complements, not alternatives: both are necessary to a complete evolutionary description. And yet when all is said and done only the neoLinnaean imposes severe restrictions on the possible states of affairs, both systematic and systemic. It is the only one to expose itself nakedly to refutation by being thus and so and not otherwise; and the opportunities for comparing it with experience are practically endless.

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#### COMPETING INTERESTS

I have no competing interests.

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