THE COMPREHENSIVE CATEGORIES OF LIFE

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1. AN EXPLORATION OF THE PHILOSOPHY OF C. S. PEIRCE

I came to the ideas of Charles Sanders Peirce (1839-1914) through Stanley Salthe. I had been interested in the theory of hierarchies for some years and reading Salthe's *Evolving Hierarchical Systems* (1985) and *Development and Evolution* (1993), I was intrigued by his suggestion that Peirce's triadic philosophy held the key to such a theory. Specifically, Salthe draws attention to Peirce's theory of signs and his triad of object, sign and system of interpretance. In my PhD thesis, I had identified three stages to the process of classification and three founding relations – features, similarities and homologies (Wood, 1996: 43-44). In my paper for ANPA 23, I made the first attempt to describe these findings in Salthe's terms (Wood, 2002: 216-217).

Returning to Salthe's works, I was challenged to come to understand Peirce's thought better. Having started researching, I quickly found that it was not only Peirce's theory of signs that was important for me, but also his philosophy of the comprehensive categories. The categories of first, second and third, while finding expression in his semiotics, have much wider implications. It was to his metaphysical categories that Peirce turned when describing the key ideas of biology and each of the sciences.

In this paper, I show how Peirce's triadic philosophy – present in his categories of first, second and third and in his semiotics of sign, object and interpretant –illuminates the study of living things. Connecting Peirce's philosophy to the three levels of living organization described by Maturana and Varela (1987), I justify Peirce's conclusion that all living things have a primitive form of mind.

Turning to classification, I discuss different schools in terms of preference for different kinds of relation, monadic, dyadic or triadic. I reveal that Peirce discovered the triadic logic of cladistics almost a hundred years before Nelson and Platnick (1981). I describe the three stages of cladistic classification in semiotic terms, showing that each involves the discovery of a particular kind of sign.

2. FIRST, SECOND, THIRD

Firstness is freshness, life, freedom, immediacy, feeling, quality, vivacity, independence, being-in-itself, potentiality, concrete yet undifferentiated. Secondness is action, resistance, facticity, dependence, relation, compulsion, effect, reality, result, stability. Thirdness is mediation, synthesis, living, continuity, process, moderation, learning, memory, inference, representation, intelligence, intelligibility, generality, infinity, diffusion, growth, conduct. (These descriptions come from Esposito, 1980: 162-163.)

A second comes into relation with a first, and a third mediates between the two. The first is the beginning; the second is the end. The third is the process, the journey from one to the other. '… the whole organism of logic may be mentally evolved from the three conceptions of first, second, and third, or more precisely, An, Other, Medium' (Peirce in Hoopes, 1991: 184). 'The starting point of the universe, God, the Creator, is the Absolute First; the terminus of the universe, God completely revealed, is the Absolute Second; every state of the universe at a measurable point in time is the third' (Peirce in Hoopes, 1991: 192).

Firstness is all that is spontaneous and free, secondness is hard and resisting. Firstness is the fullness of youth; secondness, the face of experience. 'In youth, the world is fresh and we seem free; but limitation, conflict, constraint, and secondness generally, make up the teaching of experience.

'With what firstness
        The scarfed bark puts from her native bay
with what secondness
                                        doth she return
        With overwreathed ribs and ragged sails.

'First and Second, Agent and Patient, Yes and No, are categories which enable us roughly to describe the facts of experience, and they satisfy the mind for a very long time. But at last they are found inadequate, and the

Third is the conception which is then called for. The Third is that which bridges over the chasm between absolute first and last, and brings them into relationship' (Peirce in Hoopes, 1991: 190). Thirdness is the maturity that denies neither freshness nor experience and incorporates both into its own habits of wisdom and thought.

A single fact, or monadic relation, is something such as 'A is white,' or 'B is large.' A dual fact, or dyadic relation, expresses a relation between two, 'A is smaller than B,' or 'C is the parent of D.' A triple fact, or triadic relation, expresses a relation between three parties which cannot be dissolved into dyadic relations. Take 'A gives B to C'. There is no act of giving if we remove the giver, the gift or the recipient. What of more complex relationships, such as 'A gives B to C in exchange for D'? These can be broken down into triadic relations: 'A makes a sale, E, to C' and 'E is the sale of B in exchange for D.' (See Peirce in Hoopes, 1991: 182.)

Surely, you will say that 'A is white' implies 'X is black' or that 'B is large' implies 'Y is small'? So easily is firstness destroyed that express it and already has it gone. Firstness captures that initial feeling of whiteness or hugeness, preceding any attempt at comparison. Firstness leaps out at us from its context, and for a fleeting moment obliterates all else with its sense of uniqueness. 'What the world was to Adam on the day he opened his eyes to it, before he had become conscious of his own existence [the uroboric state of Wilber, 1996: 48], – that is first, present, immediate, fresh, new, initiative, original, spontaneous, free, vivid, conscious, and evanescent. Only, remember that every description of it must be false to it' (Peirce in Hoopes, 1991: 189).

'A sign …is a First which stands in such a genuine triadic relation to a Second, called its Object, as to be capable of determining a Third, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object … Anything which determines something else (its interpretant) to refer to an object to which itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on an infinitum ' (Peirce in Liszka, 1996; see figure 1). 'The stove is black' is a sign, a firstness, a unity which can be analysed into its ground, the quality of blackness, and its object. The object comes second, prescinded of all qualities, hypothesised as that which is other to the sign. The interpretant provides the context, the way in which the sign comes to be a sign for some sign-user. The interpretant may be 'Ooh, it's an Aga' or 'My goodness, it needs cleaning.' The seemingly straightforward information provided by 'The stove is black' only flows to the user along a local logic, expressed in the interpretant. The meaning of the sign, its life, lies in thirdness, the interpretant, which is itself another sign. Signs lie within a network of other signs; they lie within an implicate sea of ideas.

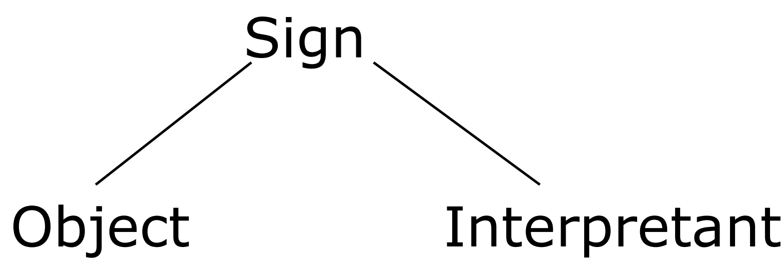


Figure 1: The triad of sign, object and interpretant

3. KOESTLER'S EXAMPLE

Arthur Koestler gave an early account of hierarchy theory in *The Ghost in the Machine* (1967). A journalist and acclaimed novelist, Koestler also published in experimental psychology. In *The Ghost in the Machine*, he attempted to find a third way between Gestalt psychology and Behaviourism. The Gestalt school looked for the monads of experience, wholes that could not be further broken down. Behaviourism divided all interaction into dyads of stimulus and response. A conversation, for example, can be reduced to a chain of mutually determining stimulus/response units.

Koestler (1967: 20-21) quotes a passage from a Behaviourist textbook, describing a dialogue between a man and a woman. He asks her the time. She tells him. He thanks her. She says 'Don't mention it' and he responds by asking 'How about lunch?' How, Koestler asks, can the man's request be determined by the woman saying 'Don't mention it'? And how can the two be regarded as a unit of behaviour? The woman could colour her words in so many ways – did she say the sentence briskly, brushing him off, or lingeringly, with a sexy smile? Whether the man asks her out is also very much affected by whether he finds her attractive, is free for lunch and can afford it.

Koestler has drawn attention to the interpretant and the whole network of other signs that bring meaning to the conversation and make it alive for its participants.

4. LIFE = SIGN = MIND

Or, the Difference between a Thermostat and a Living Cell

Cells have the ability to move towards or away from light, to sense and avoid heat, and to move towards sources of food. These responses are called taxes. What is their significance?

In each cell, there is a web of molecular interactions that gives the cell its life. This dynamic web is the way the cell makes itself, perpetuates itself and defines itself, i.e. creates its own boundary. This is the autopoietic organization of the cell (Maturana and Varela, 1987: 43-47).

Different substances enter into the life of the cell in different ways. Heterotrophic organisms, such as the bacterium *Escherichia coli*, obtain energy from external sources of food. Phototrophic organisms, such as the alga *Chlamydomonas*, obtain energy from light. *E. coli* swims towards high concentrations of glucose, a molecule on which it feeds. *Chlamydomonas* orientates itself in the direction of blue-green light, but not to red light, which it is unable to utilise.

Heterotrophic cells orientate themselves in a world according to the concentration gradients of food sources. Phototrophic cells orientate themselves in a world according to the intensity of sources of light to which they are sensitive. Each brings forth this world through the role that these sources play in the business of living.

The chemotactic response of an *E. coli* cell moving up a glucose gradient can be modelled as a feedback mechanism, as a dyad of stimulus and response. The feedback mechanism accommodates the sign of high concentration and its object, glucose. However, it misses the interpretant, namely the web of metabolic signs that is the cell's life, and that give meaning to the organism's tactic response.

'In 1891 Peirce attributed mind of a rudimentary sort to life-slimes and protoplasm. Given their reaction to certain stimuli, he argued, they feel, possessing a primitive form of consciousness, and hence they exercise the basic functions of mind' (Merrell, 1991: 131).

The law that blue-green light evokes a phototactic response in *Chlamydomonas*, and red light does not, is the cell's own, grounded in the structure of its light-capturing molecules. The cell is autonomous, defining its own laws, which are consistent with its own continued existence. A thermostat is governed by a law that has been set by an external designer. The thermostat does not make itself, renew itself or define its own boundary. It has no life within which its measurements of temperature become interpreted. It is just a mechanism.

5. THE TRIAD OF LIFE

According to Koestler, a cell can be seen as both an autonomous whole and a dependent part. A cell is a holon, with the two faces of Janus, one looking in as a self-assertive whole, and one looking out as an integrated part. (See the summary in Koestler, 1967, appendix 1, sections 1 and 4.)

If we look to a cell's autopoietic organization, we see how it is the mutually sustaining web of interactions that underpins the cell's autonomy. If we look to the cell's structure, we see similar physical constituents to the environment. We see also how that structure is maintained through constant exchanges with the environment. As Schrödinger pointed out in *What is Life?* (1944), the German word for 'metabolism' is 'Stoffwechsel', or exchange of stuff. Through its organization, the cell asserts itself as distinct from its environment. Through its structure, the cell is integrated into its environment. It is the process of living – which is also a process of interpreting, a process of knowing – which reconciles the two. (For the triad of organization, structure and process see Capra, 1996, particularly chapter 7.)

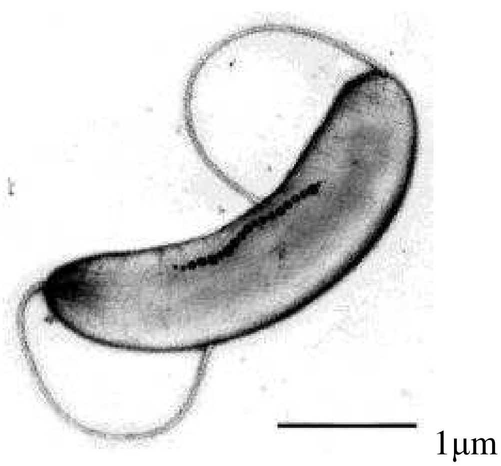


Figure 2. Electron micrograph of *Magnetospirillum magnetotacticum.*

Certain bacteria, such as *Magnetobacter* and *Magnetospirillum* (figure 2), are able to detect magnetic fields and swim in the direction of magnetic lines of force. They contain a row of particles of magnetite, which acts like a compass needle and guides the cell towards its hemisphere's magnetic pole, whether north or south. Because of the inclination of the earth's magnetic lines of force, this behaviour causes the bacterium to swim downward and thus to return to the sediments in which it lives. For an organism as tiny as a bacterium, gravity is of no consequence. So here is an alternative mechanism by which dislodged bacteria can find their way back into their normal habitat.

The physical structure of a magnetotactic bacterium is such that it interacts with the earth’s magnetic field. By orientating itself with respect to the field and choosing its direction of movement accordingly, the bacterium undergoes a recurrent interaction with the magnetic structure of the environment. This is what Maturana and Varela (1987: 75) call *structural coupling*. The bacterium has nothing as complex as a representation of its environment. It does not need one; all it needs is structural coupling.

In the slime mould *Physarum* (Maturana and Varela, 1987: figure 20), spores grow into flagellate cells when conditions are moist, but into amoeboid cells when conditions are dry. The coupling with the environment involves different structural changes depending on the external trigger. When food begins to run out, the cells aggregate. Their cell membranes break down and they form a single plasmodial mass. Here we have coupling not only with the environment, but between the cells themselves. Structural changes in one cell – movement, dissolution of the cell membrane – must be synchronised with similar changes in the other cells. Here we see the birth of a new level of organization. A cell is a first-order unity, which maintains its own boundary and undergoes exchanges across that boundary. Metacellulars, such as *Physarum*, are second-order unities. Here structural transformations of the cells are coordinated into an ontogeny of the whole.

The slime moulds such as *Dictyostelium* (figure 3, cf. Maturana and Varela, 1987: figure 21) show another stage in metacellularity. Here amoeboid cells stream together in times of food shortage to form first a mound, then a slug, in which the cells move *en masse*. The slug transforms into a fruiting body to release spores and complete the life cycle. The fruiting body is raised up above the ground on a stalk. Cells in the stalk have strong walls and large vacuoles to give it strength. Cells at the top of the stalk differentiate into the spore-forming cells of the fruiting body. So beyond structural coordination, we have structural complementarity. In truly multicellular organisms, there are a large number of different cell types with complementary functions, which result from complex ontogenetic pathways. Colonies of multicellular organisms, such siphonophores and sea mats, are also second-order unities.

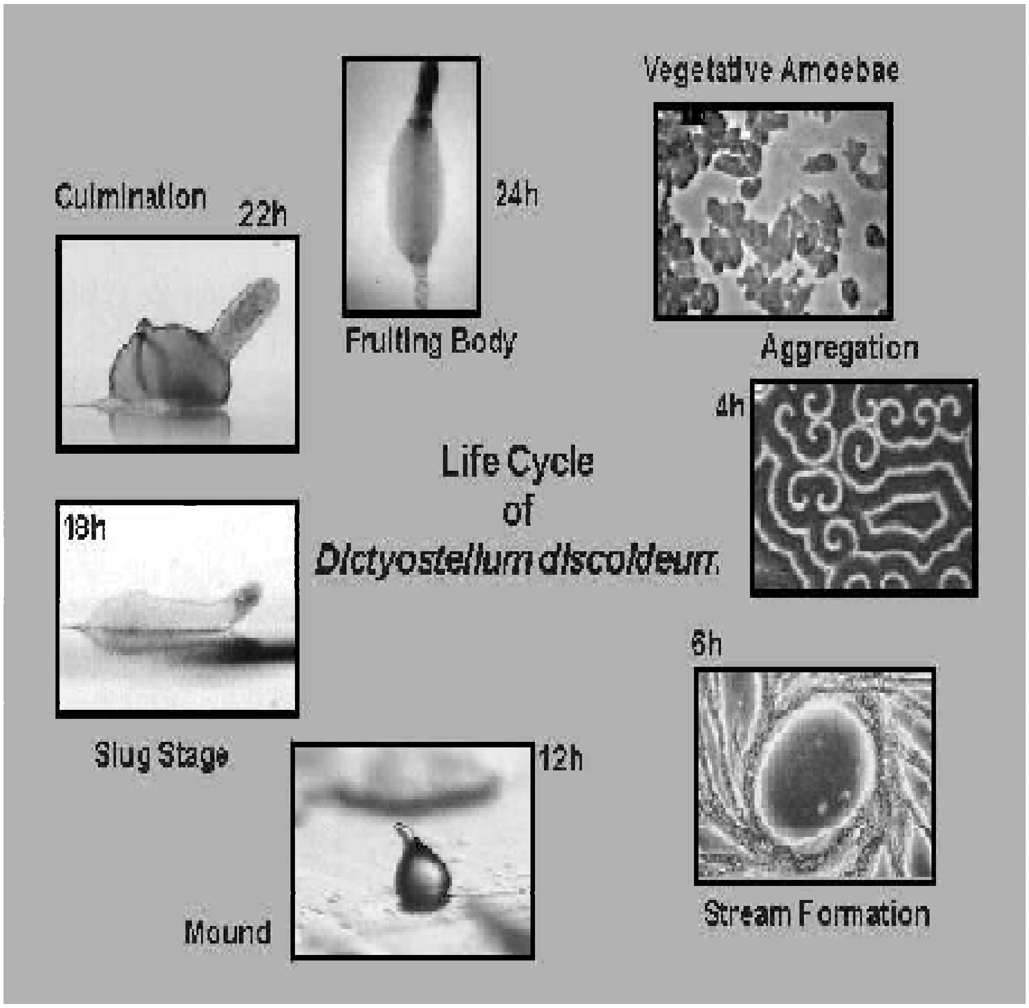


Figure 3. The life cycle of *Dictyostelium discoideum*

For a colonial organism, there is no society, since each member is identical to all others. In a family, by contrast, we have the society of male and female. Here we have two different ontogenies, which are coordinated together in the dance of sexual reproduction. Families, communities and societies of multicellular organisms represent a new level of organization, a third-order unity, defined by the co-ontogenies of its members.

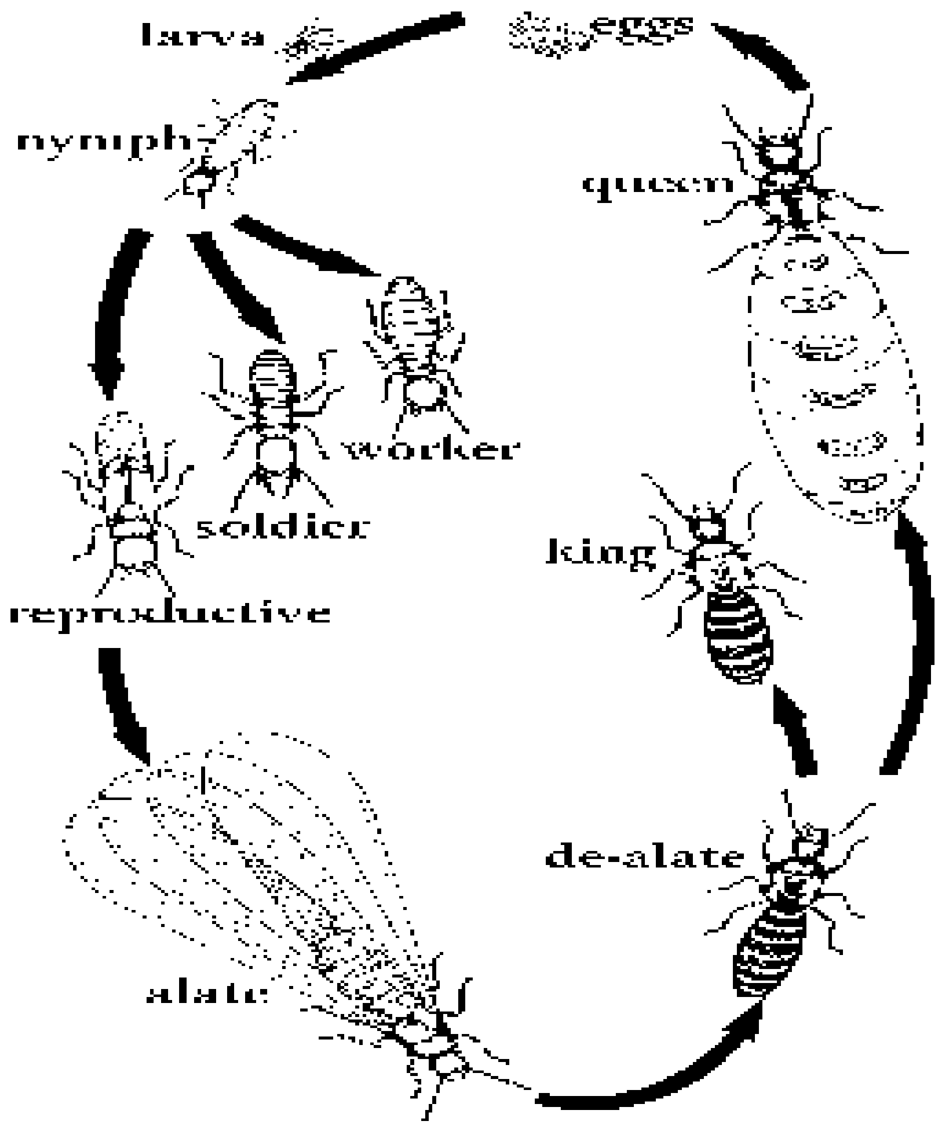


Figure 4. The termite life cycle

Insect societies demonstrate such a third-order unity most strikingly. In termites (figure 4), the immature nymphs may develop into workers, soldiers or reproductives. The reproductives develop wings and a proportion takes flight and leaves the nest to found a new colony. After a successful colonising and mating flight, the reproductives lose their wings and turn into kings and queens. Initially only a few eggs are laid and brought up by the queen herself. As the number of individuals in the colony grows, the more workers are available to help the young queen to care for the brood. Workers build the nest and galleries, they fetch food, care for the young and feed reproductives and soldiers. Soldiers defend their colony from intruders by the use of powerful jaws and/or by ejecting a white sticky repellent from an opening on their head. Soldiers cannot feed themselves; they have to be fed by workers. The reproductive and non-reproductive ontogenies are closely coordinated for the continued life of the society.

6. THREE KINDS OF RELATION

I have described single, dual and triple facts and how they express monadic, dyadic and triadic relations respectively. There are a number of different schools of how to classify living things. Each school shows a preference for a particular kind of relation.

Firstly, I would like to draw attention to a preference for monadic relations in classification. I call this classification by difference, or by strangeness: ‘Look at X!’ For example, consider the classification of gorillas, chimpanzees and humans. Johann Friedrich Blumenbach, in his *Manual of Natural History* of 1779, placed us in a separate order, Bimana, an arrangement that was followed by Georges Cuvier. Richard Owen, the great adversary of Charles Darwin in Victorian scientific circles, elevated us to a separate subclass, the Archencephala (Owen, 1858). For Blumenbach, it was our opposable thumbs that set us apart; for Owen, our enlarged brains.

This taste for the monad has influenced the classification of other groups, for example, the whales and the birds. Carolus Linnaeus, the father of modern taxonomy, placed birds as one of five divisions of animals. The whales he isolate in a separate order of mammals, the Mutica. (He was unaware that they could sing.)

A preference for dyadic relations led naturalists to say that humans are more perfect than chimpanzees or gorillas. Indeed, the whole of creation was arranged into a ladder of perfection, from the lowliest amoebae to the most elevated humans – white, European males, of course. This language of higher and lower still persists, for example, in the distinction between lower vertebrates (fish, reptiles and amphibians) and higher vertebrates (birds and mammals).

If we look at Ernst Haeckel’s famous evolutionary tree (1866; see figure 5), we see a different image to the ladder of perfection. The trunk of the tree defines the axis of progress from the monera and the amoebae to humans. The labels at the side of the tree shows the grades of perfection, through which animals have passed. But the relations are not simply those of perfection; they are ancestor/descendant relations: ‘X is the ancestor of Y.’

Monadic relations were broken down and replaced by dyadic relations of ancestry to provide evidence for evolution. Darwin (1859: 184) suggested that whales might be descended from a group of bears, after increasingly adventurous forays for food at the water’s edge. (Today, a group of hoofed mammals, the mesonychids, are the favoured candidate.) The discovery of *Archaeopteryx* broke the isolation of the birds, showing their affinity with the reptiles, in particular the dinosaurs. And what more striking argument could there be for the link between humans and chimpanzees than the picture in Darwin’s *Expression of the Emotions in Man and Animals* (1872) of an infant chimpanzee lying on its back and throwing a tantrum in the most human-like manner?

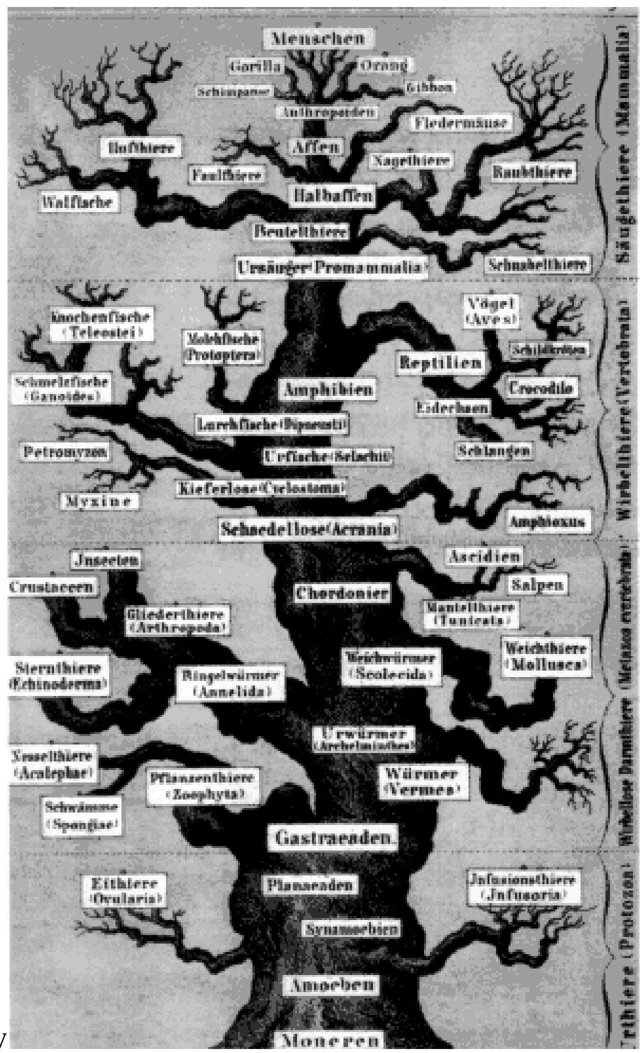
w 

Figure 5. Haeckel’s evolutionary tree

One thing you will notice about Haeckel's tree is that it has side branches. We do not have a straight chain of descent from amoebae to humans. Lying hidden here in Haeckel's iconography are triadic relations. It fell to German entomologist Willi Hennig to clarify them. He proposed classification through sister group relationships: 'X is more closely related to Y than either is to Z.' X and Y are said in this case to be sister groups (Hennig, 1966: 139). So, crocodiles are more closely related to birds than they are to other reptiles. A dyadic relation – reptiles are ancestral to birds – is replaced by a triadic relation. Similarly:

1. 'Hoofed animals are ancestral to whales' is transformed into 'Mesonychids are more closely related to whales than they are to other hoofed animals.'
2. 'Great apes are ancestral to humans' is transformed into 'Chimpanzees are more closely related to humans than to other great apes.'

This is the substance of the revolution in thought that Hennig brought about.

Hennig himself still used evolutionary language to justify the triadic relation. An ancestral species was thought to split into daughter species, each the ancestor of a particular sister group. 'Evolution in this sense (transformation) is also connected with speciation: if a species (reproductive community) is split into two mutually isolated communities of reproduction ... there is always a change (transformation) of at least one character of the ancestral species in at least one of the daughter species' (Hennig, 1966: 88). If X and Y are sisters, with respect to Z, then X and Y share a common ancestor that is more recent than either shares with Z.

As Hennig's ideas were being digested by students of classification, Gary Nelson and Norman Platnick, at the American Museum of Natural History, came to realise that they had no need of Hennig's evolutionary ontology (Nelson and Platnick, 1981). The necessity of triadic relations to classification was implicit in the logic of branching diagrams itself. They dispensed with ideas of perfection and ancestry and pared the science of classification down to the following relations:

1. Monadic: 'X exists'
2. Dyadic: 'X is related to Y'
3. Triadic: 'X is more closely related to Y than either is to Z'

The monadic and dyadic relations listed hardly qualify as the basis of classification. Any two organisms can be related in some way. Only when we introduce a third do we have a classification. Classifications of more than three organisms are to be composed of a number of triadic relations. Nelson and Platnick's cladogram isolates this triadic aspect of a classification: for an example, see figure 6.

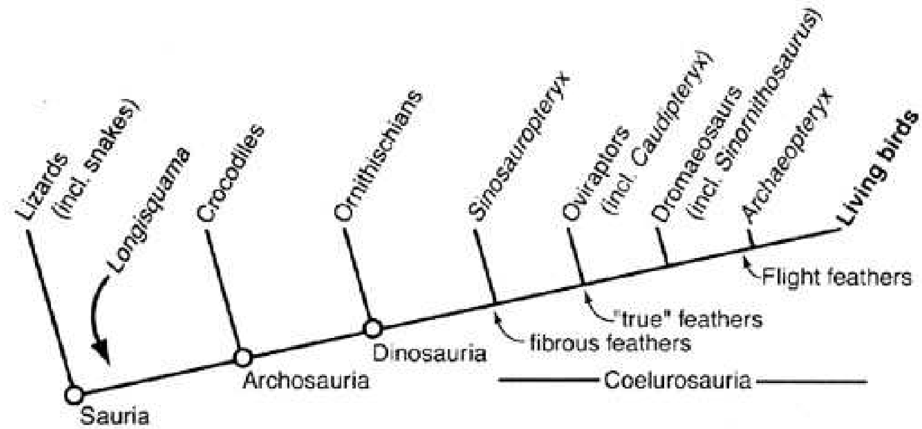


Figure 6. The cladogram of birds

The cladogram summarises the distribution of feathers in the different dinosaur groups (Padian, 2000). *Sinosauropteryx* has fibrous feathers, which form a thick, relatively short and dense covering of the entire body. True feathers, which have a central shaft, two vanes, and barbs, attach only to the forelimbs and tail. They are found in the oviraptor *Caudipteryx*, the coelurosaur *Protarcheopteryx* as well as *Archaeopteryx* and living birds. Feathers that confer the power of flight are restricted to *Archaeopteryx* and living birds, where they occur in the same pattern. In each, slightly different feathers (the primaries) attach to the hand from those (the secondaries) that attach to the forelimb (Perrins in Burn, 1980: 169).

Nelson and Platnick's conclusions would come as no surprise to Peirce. In *A Guess at the Riddle*, written c. 1890, he adopts the branching metaphor of a network of roads to explain how all multiple facts may be reduced to triple facts. Any number of termini may be connected by roads with a fork – triadic relations – but only two termini may be connected by roads without a fork – dyadic relations.

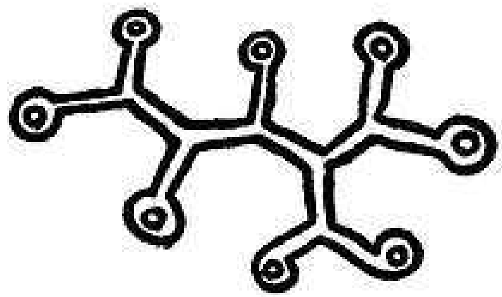


Figure 7. Peirce's diagram of roads

'See the figure [figure 7], where I have drawn the termini as self-returning roads, in order to introduce nothing beyond the road itself. Thus, the three essential elements of a network of roads are *road about a terminus*, *roadway-connection* and *branching*; and in like manner, the three fundamental categories of fact are, fact about an object, fact about two objects (relation), fact about several objects (synthetic fact)' (Peirce in Hoopes, 1991: 182-3). Peirce's fundamental categories are equivalent to the three founding relations of classification (Wood, 1996, 2002), namely features, similarities and homologies. Features are firsts; they exist in one species considered alone. Similarities are seconds; they relate one species to another. Homologies are thirds; they show that two species are more closely related to one another than they are to a third. The third species reveals the thirdness of the sister species; it provides the context within which the other two find their relationship.

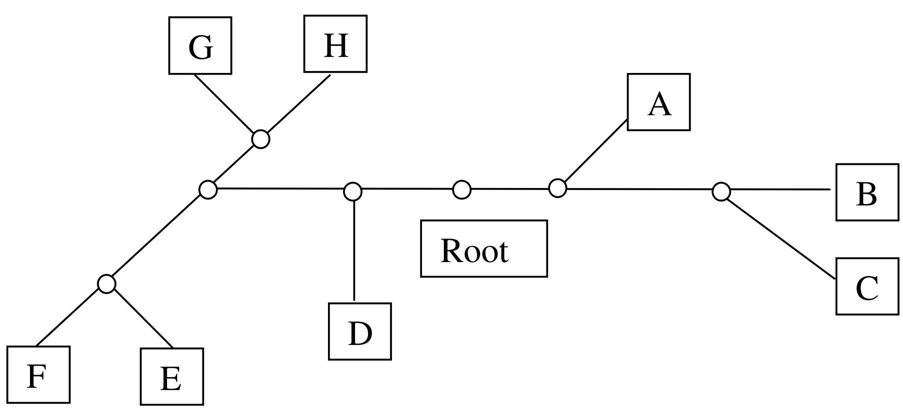


Figure 8. Peirce's diagram as an unrooted tree, with labelled termini.

Peirce's diagram of roads is equivalent to an unrooted tree. If we provide a root (Figure 8), we can identify the termini with those of a cladogram of vertebrates (Figure 9). Peirce discovered the triadic logic of cladistics almost a hundred years before Nelson and Platnick!

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              !----------------- A  snakes and lizards
      !-------!            !---- B  crocodiles
      !       !------------!
      !                    !---- C  birds
------!
      !       !----------------- D  platypus, echidna
      !-------!
              !            !---- E  kangaroos
              !      !-----!
              !      !     !---- F  koalas
              !------!
                     !     !---- G  whales
                     !-----!
                           !---- H  humans
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Figure 9. A classification of vertebrates with the same topology as Peirce's diagram of roads.

7. THREE STAGES OF CLASSIFICATION

In Wood (1996), I describe three stages of classification: fundamental, derivative and general. The fundamental stage of classification involves the collection of representative specimens of the species to be studied. In the derivative stage, characters are conceptualised and the character states for particular species recorded. The general stage is the generation of a classification as the most economical summary of the data and the discovery of the defining characters of taxa.

Each stage of classification involves a different kind of pattern. A fundamental pattern consists of the observed features of all morphological variants of a given species, which are at this stage not yet conceptualised. A derivative pattern is a pattern of similarity shared by a number of species. A general pattern describes the pattern of homologies inherited by organisms. Sharing is meaning in the derivative context, and congruence, the nested hierarchical relationship between patterns of similarity, is meaning in the general context.

Character concepts begin life in the fundamental stage as features identified in single species. The derivative stage of character conceptualisation is the clash between firsts. Character concepts are tested against specimens of different species, and if found not to be applicable are modified or abandoned. The general stage is the clash between seconds. Similarities that are not congruent with the most economical pattern are meaningless. They are homoplasies not homologies, confusing rather than revealing thirdness in the study group.

Each stage of classification involves the discovery of a particular kind of sign. In the context of a given stage, features, similarities and homologies are signs, in the sense of Peirce, with particular objects and interpretants. In the fundamental stage (figure 10), the sign is that a particular object specimen has a distinctive feature, for example '*Sinosauropteryx* has fibrous feathers.' The interpretant is '… as opposed to true feathers', which brings in the whole web of anatomical comparisons that embeds the study. The interpretant creates a character, a relation of exclusion: 'feathers fibrous or true.'

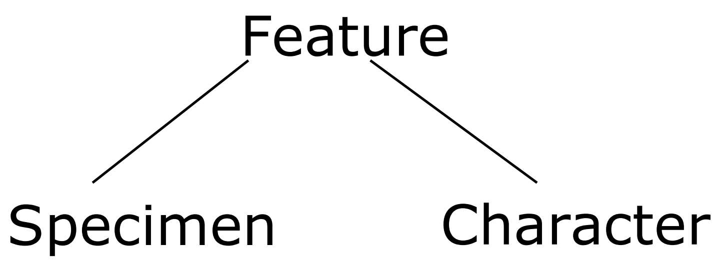

Figure 10. The fundamental stage of classification.

In the derivative stage (figure 11), different specimens are brought into relation. Hence the features of the oviraptor *Caudipteryx* and living birds signify that the two are similar in an object 'having true feathers'. The interpretant here is the whole data matrix, which described the distribution of similarities across the whole study group. This character matrix forms the basis of the cladistic analysis of relationships, often performed with the aid of computerised algorithms.

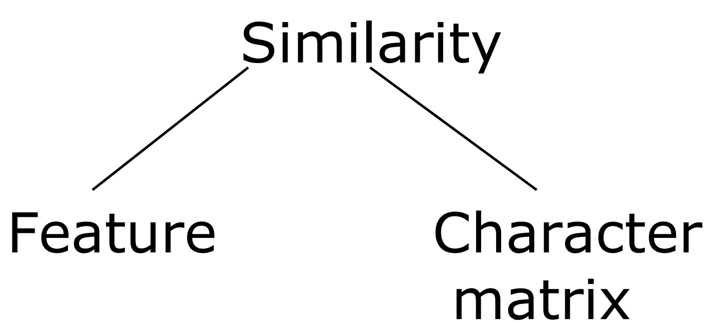

Figure 11. The derivative stage of classification.

In the general stage (figure 12), the analysis of the data matrix reveals that certain similarities function as homologies at some level of generality. In other words, these similarities identify sister groups relationships and define taxa within the classification.

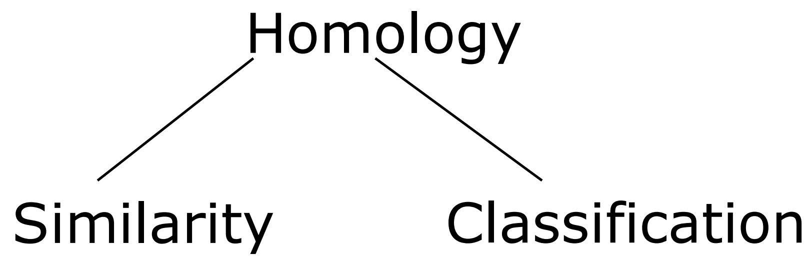

Figure 12. The general stage of classification.

The presence of feathers, whether fibrous or true, defines the Coelurosauria, which includes living birds. *Archaeopteryx* is similar to living birds in having flying feathers, but cladistic analysis also reveals that 'flying feathers' is a homology, identifying *Archaeopteryx* as the sister group of living birds.

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