

EVOLUTIONARY COMPLEXITY IN RELATION TO GEORGES CHAPOUTHIER'S MOSAIC BIOLOGICAL STRUCTURES

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1. Introduction: Cosmic Beginnings and the Ascent of Life on Earth

The Mosaic model created by Georges Chapouthier (2001, 2008, 2009, 2012), not only challenges biological reductionism but also provides an integral approach towards understanding biological processes. The Mosaic model is posited on two inter-related and dynamic principles – juxtaposition and integration; the interplay of these patterns forms the basis of biological structures and function. Juxtaposition refers to the aggregation of units at both molecular and cellular levels. Juxtaposition is cognate with opposing beads whose symmetrical arrangement forms a necklace (Chapouthier 2009:3). Alternately, integration is based on the refinement and modification of original units that produce a “new higher level structure” (Chapouthier 2009:3). However, each integrated unit retains relative autonomy, as each piece in a mosaic pattern retains its individual characteristic (Chapouthier 2008:168).

The underlying principles of interrelatedness and connectedness in the Mosaic model can be metaphorically illustrated in the story of “Indra’s Net”, found in Hua-Yen Buddhism. Indra’s Net is a depiction of the cosmos as an all-encompassing and infinite net. At each vertex is a jewel; if one is to gaze within one of these jewels they would find contained in it the reflection of all other jewels in the net. Moreover, all other jewels contain the reflection of the self-same jewel (Cook 1977). Although autonomous, each jewel is integrated with all other jewels within the cosmic web of life.

Chapouthier’s thesis is particularly insightful as it provides an explanation for both cosmic and biological evolution. Indeed, Shubin’s recent work *The Universe Within* (2013) reaffirms Chapouthier’s idea of the intrinsic correspondence between cosmic and biological evolution, thus, providing an integral approach for understanding patterns of complexity connecting the macro and micro realms (Chapouthier 2009:9; 2012:13).

This leads to the suggestion that the laws of complexity which rule the complex systems found on our planet (i.e. living beings) could also be considered as general laws for complexity elsewhere in the universe providing an argument for what is referred to as Biocosmology (Chapouthier 2012:6).

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In relation to life processes, Chapouthier explains that the component parts of organisms, are both inter-dependent and autonomous. This is particularly insightful since western science until recently has tended to overlook both the structural and organisational interdependency within organisms and ecological systems. It was Gregory Bateson (1971, 2002) and leading systems theorists (Bertalanffy 1950, 1974; Laszlo 1969, 1996; Maturama & Varela 1980, 1987) who challenged the prevailing reductionist paradigm of modern biological science. For example, Bateson maintained that *Mind* – (the way in which life systems are constituted by interconnected networks of communication) is an immanent principle of nature. Consequently, the processes of *Mind* in nature produce and regulate the flow of bio-feedback information within organisms, and between organisms and their corresponding biomes (Bateson 2002). Similarly, Maturama and Varela (1980:79), argue that the properties of life systems are autopoietic – that is, they are self-organising and self-regulating; constituted by a “network of processes of production” in order to maintain homeostasis. Bio-feedback loops in inherent in all autopoietic systems, albeit inter-dependent, function as a unity.

The cosmic blueprint of the Mosaic model can be found at the earliest stages of the universe, with the formation of atoms from sub-atomic particles approximately 300,000 years after the Big Bang, and their consequential amalgamation into matter. From the principal element hydrogen, other elements arose which created greater complexity in the universe. In an Aristotelian sense, the early universe was fecund with creativity, from which it realised its potentiality via complexity.

In principle, elements of Chapouthier’s model of increasing complexity are synonymous with Ervin Laszlo’s notion of ‘coherency’ – the propensity for particles to amalgamate and function as a unity. Coherence is the *raison de etres* for the existence of physical, biological and social systems – constituting the integument of cosmic evolution. “An amazing form and level of coherence characterizes nearly everything in the universe, from the largest structures of the cosmos to the smallest particles of the microworld... Coherence is a precondition of life itself” (Laszlo 2006:7).

Here on earth, life had emerged only several hundred million years after the formation of the planet. While there is no scientific consensus to explain why and how life arose from the primeval earth, the emergence of life manifested higher order complexity. The bio-chemistry of the first DNA was connected with the preceding ten billion years of cosmic events. Indeed, the evolution of life from prokaryotes to eukaryotes, a transition referred to as endosymbiosis during the Paleoproterozoic period characterises the processes of the Mosaic model. Endosymbiosis increased complexity, whereby host (primitive eukaryotic cell) and symbiont (prokaryotic ancestors of mitochondria and cyanobacteria) eventually became integrated after approximately one billion years of co-evolution (Gould et al 2008; Margulis 1970, 1992). It is hypothesised that the protorezoic transition was vital in order for protorezoa to live in an oxygen rich environment.

2. Mosaic Model and Human Brain Regulation

Chapouthier offers various examples of mosaic structures in vertebrates and invertebrates of contrasting complexity. His most intriguing example is the developmental stages of the human brain, a highly complex structure subsuming iterative processes of juxtaposition and integration. The embryonic brain begins in the first trimester with the formation of the three major vesicles prior to week five. These are the fore-brain (*procencephalon*), mid-brain (*mesencephalon*) and hind-brain (*rhombencephalon*). These foundational vesicles are further divided to form five integrated vesicles by week five. These are, *telencephalic* vesicles, *diencephalon*, *mesencephalon*, *metencephalon*, and *myelencephalon*. The neo-cortex is a complex mosaic structure composed of columns of interconnecting neurons that remain partially autonomous yet function as a synchronized constituent of the neo-cortex (Chapouthier 2009:7).

The human brain's embryological development is characterised by a bottom up approach, beginning with the formation of the *archipallium* (*pons*, *medulla oblongata*) between weeks three and four. By week four the *cerebellum* and *mesencephalon* regions are formed. It is pertinent to note that the aforementioned cerebral regions are referred to by MacLean (1990), as the 'primitive brain', since they co-ordinate autonomic regulation. These regions represent the most archaic cerebral structures in the vertebrate brain, thus, sharing an evolutionary phylogeny amongst all vertebrates. By week seven the *paleopallium* and *neopallium* are formed; these regions co-ordinate affective and high level cognitive states. The *archipallium*, *paleopallium* and *neopallium* are synchronically integrated, albeit, semi-autonomous – a mosaic structure of elegant complexity.

At this point I would like to continue discussing Chapouthier's idea of integration as since the human brain manifests this aspect *par excellence*. The five encephalic vesicles of the foetal brain are juxtaposed during embryological development and integrated over the span of childhood, adolescence and early adulthood. Synaptic pruning is particularly expedited during adolescence, a time when cognitive learning and affective behaviours are consolidated. Synaptic pruning plays a vital role in neuronal modification and regulation (Chechik & Meilijson 1999). Synaptic pruning is probably an evolutionary mechanism indicative of the longer adolescent growth spurt in ancestral hominins which was already evident in *H. erectus* (Smith 1993; Bogin & Smith 1996; Antón 2003). Adolescent synaptic pruning also characterises the high degree of neuro-plasticity of the human brain that is a required feature for extensive cognitive learning (Bjorklund & Pellegrini 2000:1692). As stated, the process of synaptic pruning is concomitant with the increasing learning rate during adolescence in extant hominins. It has been shown that at the time of adolescence there is a seeming synaptic overgrowth which is followed by "judicial pruning", and that this developmental process is necessary for memory consolidation (Chechik & Meilijson 1999). A recently discovered function of synaptic pruning involves the localisation of complement proteins in the central nervous system (CNS) (Stephan et al 2012). These complement proteins are

responsible for the removal of unwanted cellular material by probable microglia (motile phagocytic cells) (Paolicelli et al 2011). One area of examination is the role of dysregulated synaptic pruning and the onset of psycho-pathologies such as schizophrenia, bi-polar and anxiety disorders, which often emerge during adolescence (Kessler et al 2005; Giedd et al 2008).

Another feature vital to brain integration is the extra cellular matrix (ECM) which mediates many structural and functional interactions between neuronal and glia cells (Gundelfinger et al 2010). In the adult brain the ECM is important for restrictive neuro-regeneration, neuro-protection and myelin specializations (Galtrey & Fawcett 2007; Susuki & Rasband 2008; Fawcett 2009; Frischknecht et al 2009; Gogolla et al 2009; Gundelfinger et al 2010; Hrabetova et al 2009; Sim et al 2009). In the adult brain the ECM contributes to brain stability post synaptic pruning stage (Gundelfinger et al 2010). However, there are still unknown questions in relation to differences in ECM function in relation to memory acquisition between juveniles and adults (Gundelfinger et al 2010:2162).

3. Conclusion

Mosaic biological structures found in nature are products of natural selection and informed by epigenetic variation and other micro-evolutionary forces which have yet received ample theoretical attention. Chapouthier recognises this. The theme of evolutionary complexity which is at the heart of Chapouthier's model is considerable and has only been briefly explained here. Complexity is an inherent feature of evolution, evident in both cosmic and biological processes. Moreover, a characteristic feature in shaping evolutionary complexity has been its indeterminacy. Evolution shows that the tree of life is multifarious, uneven, and marked by intermittent periods of species collapse and speciation. "Between 90 percent and 99+% of all living species are extinct" writes Kimball (2002: 79). Evolution's "branches and twigs are covered with the short, terminal fuzz of birth-death without further issue" (Dennett 1995, p. 91). On this theme Raup notes that "somewhere between five and fifty billion species have existed at one time or another" (1991:3). Within the cycle of species, proliferation and demise is a constant. To what degree different mosaic biological structures have arisen and become extinct in evolutionary history is a subject for future research.

Chapouthier's Mosaic model is holistic and non-reductionist, recognising that biological and cosmic processes follow Aristotelian causes. In relation to Aristotle's *causa finalis* living systems are able to potentialise themselves not only via reproduction, but also by their interactions within ecological niches. I would suggest that Aristotle's *Nous* may also be understood as *Mind*, in the Batesonian sense – the kaleidoscopic creativity immanent throughout the cosmos, constituted by relationality.

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