BIOCOSMOLOGY AND BIOLOGY – THEIR FRUITFUL COLLABORATION

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ABSTRACT. *Biocosmology is based on the principle that the laws of the biological microcosm mimic the laws of the macrocosm. A number of observations show that rules governing the complexity of living beings, i.e. the principles of juxtaposition and integration leading to mosaic structures, can be found in several other fields involving complexity: memory, consciousness, language, drawing, music, technical objects, mathematics, social structures, dialectics and ethical stances. The general application of the mosaic model, valid in many areas of the human microcosm, suggests it may be relevant for describing areas of the macrocosm still being explored.*

KEYWORDS: *Biocosmology, Complexity, Dialectics, Ethics, Language, Living being, Macrocosm, Memory, Microcosm, Mind, Mosaic structure*

Introduction

For Aristotle, the basic structure of the cosmos is that of a living being (Khroutski, 2008; 2010), which, in modern terms, obviously does not mean that the cosmos is a large animal, but rather that the rules governing complexity in the universe should be the same rules that govern the most complex systems observed and analysed on earth, i.e. living beings. In other words, the laws of the microcosm (here the laws governing living beings) mimic the laws of the macrocosm. This idea can be extended to argue that Biocosmology, in the Aristotelian sense, and biology, the science of living beings, can be seen together, producing a fruitful collaboration. In the present article, I shall focus on one process that may be involved in the development of complexity and which I have called "emergence through mosaics." I shall first present a brief description of the underlying principles leading to mosaic formations in living beings (Chapouthier, 2009), then show how they can be extended to apply to fields other than biology, offering, in a Biocosmological perspective, the possibility of similar processes occurring elsewhere in the cosmos.

1. THE MOSAICS OF LIFE

As stated above, the most complex structures on earth which we can easily observe and study are living beings. A Biocosmological argument could adopt principles governing complexity in living beings as general principles of complexity.

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In previous publications (Chapouthier, 2001; 2008; 2009), I have argued that two basic principles may lead biological structures to develop complexity: the principle of juxtaposition and the principle of integration. Juxtaposition is the addition of identical entities, (it could be compared to beads forming a necklace); integration modifies the original entities, producing entities at a higher level. In such integrated structures, previously identical entities become units or parts of the new integrated unit (e.g. a necklace of substantially modified beads assembled to form a container.)

Some examples of such processes in living beings will be cited (Chapouthier, 2008; 2009). At the genetic level, there is silent duplication of introns (i.e. juxtaposition) followed by mutations of certain introns, leading to the emergence of new organs. One contemporary biologist (Ohno, 1970) argues that these processes may explain the origin of complex organs, which then survive or do not survive through natural selection. At the anatomical level, the two principles can be observed in unicellular organisms which can develop into juxtaposed organisms such as Gonium, where all juxtaposed cells have the same functions, and then into integrated organisms such as Volvox with different types of cells having different functions. Examples of more complex beings displaying juxtaposed patterns can be seen in colonies of polyps where all the juxtaposed polyps have the same functions, and with integration forming colonies of siphonophores where different types of polyps with different functions coexist. In more complex animals, juxtaposition of metamers can be observed in the earthworm, and integration produces more sophisticated animals such as the butterfly, octopus, rat and, ultimately, the human being. At supra-individual levels, juxtaposition and integration become social, with groups of similar individuals – a crowd – and integration of roles (e.g. colonies of ants and societies of apes).

All integrated levels of living beings, whether cells, polyps, metamers or individuals, still have the basic units at the lower level retaining a certain degree of autonomy, even though they are now part of a whole at a higher level, hence the mosaic model, a mosaic in art being the end result of a combination of individual tiles (tesserae). In biology, the properties at a given level form a whole, while still leaving a relative degree of autonomy to the component parts.

Similar processes of juxtaposition and integration can be seen with organs, including the brain. Elements of the human brain appear as mosaic formations. The embryonic brain is built from five juxtaposed encephalic vesicles which integrate to produce the adult brain. Certain areas of the neocortex also appear to be mosaic formations, with specific areas dedicated to specific functions, e.g. sight, hearing, touch and motor control. The two hemispheres of the brain form a mosaic with only two component parts. In lower vertebrates, the hemispheres are juxtaposed and have similar functions; they become integrated in higher vertebrates with specific functions for each hemisphere, e.g. singing for birds and language for humans. In all these cases, the functioning of the whole does not cancel the autonomy of the component parts.

2. OTHER BIOLOGICAL STANCES

The biologist Richard E. Michod wrote an eloquent study of complexity in living beings. While there was no reference to my philosophical work on mosaic structures, it is interesting to note that he reached similar conclusions. Michod observed biological evolution via integration (using the term himself), going from simple individuals to individuals at a higher level of complexity. Michod focuses on anatomical complexity, while my own approach is general and speculative. Michod's achievement is to have conducted experimental studies analysing certain molecular processes involved in switches to different levels of complexity (Michod, 1999; 2009), and specifically in the aggregation of cells in the algae Volvox mentioned above.

Research by Stephen M. Modell (Modell, 2006; 2011) first focused on healthcare. Modell argues that with classical Darwinian selection there is further space for "additional laws" explaining the complexity of biological forms: "Surely there must be more than simple randomness at work." Such additional laws could ultimately lead to morphological changes in organisms. Modell refers to my hypothesis of juxtaposition followed by integration leading to mosaic structures, recognising that such "combined processes may be responsible for the emergence of complexity" in the human brain, as well as at different morphological levels in living beings.

The engineer and physiotherapist Moshe Feldenkrais has proposed a well-known therapeutic method (Beringer, 2010; Feldenkrais, 1994) involving kinaesthetic feelings where the person practising the method learns to feel distinct parts of the body separately. Analysis of the feelings then juxtaposed leads to greater integration of the person's movements.

3. AN EPISTEMOLOGICAL REHABILITATION OF ASEXUAL REPRODUCTION

Living beings have one of two modes of reproduction, sexual and asexual.

Sexual reproduction, the most recent in evolutionary terms "mixes" genes during the stage when the two gametes (paternal and maternal) form the egg-cell. Variations occur at this, the earliest stage of reproduction. Darwinian selection follows with the ability to select those variations which are useful for the survival of the organism. As sexual reproduction produces such variations at an early stage, it is very well suited to selection. In fact, sexual reproduction is the basis for most Darwinian models.

Asexual reproduction produces identical copies of one structure, first doubling to form two similar structures, which eventually separate. Examples of the process can be seen with the growth of biological tissue in organs, plant cuttings, animal polyps and also in human twins. If an event prevents two similar structures from splitting, they remain juxtaposed, and may at a later stage, be subjected to variable phenomena thus producing differences, such variations being subsequent to reproduction.

Asexual reproduction is ubiquitous in the living world and can produce complexity through the integration of both juxtaposed and non-separated structures as shown above. My thesis of complexity in mosaic formation thus stands as a clear epistemological rehabilitation of the role of asexual reproduction which is only too often overlooked. The argument is that complexity of living beings mainly arises from the non-separation of structures produced through asexual reproduction and from subsequent integration.

This model is obviously compatible with Darwinian stances, which I recognise as important for the understanding of the biological diversity produced through sexual reproduction. The mosaic model, however, is not based on Darwinian principles. My arguments could be compared to the approach of Paulo C. Abrantes (Abrantes, 2011) to Darwinian and non-Darwinian multi-level selection in evolutionary dynamics. Abrantes analyses what he calls "transitions in individuality", i.e. transitions from a simple individual level to a broader level, integrating single entities as part of a greater entity; e.g. switching from an organism to a population. He shows that to reach a higher level, it is necessary to go through lower-level processes of "de-Darwinisation", for once the lower level has become a "part" it is no longer governed by rules of Darwinian selection.

4. MOSAICS OF THE MIND

The present discussion will not extend to possible relations between the nervous system and the mind. Whichever the philosophical point of view adopted, whether materialist or spiritualistic, it is clear that the brain is involved in the functioning of the mind. What we can show here is that mind processes too can be described using the mosaic model. Several examples will be cited for mind-related functions.

4.1 Memory

Memory is not a single entity, but a mosaic of different capabilities acquired by our animal ancestors in the course of the evolution of the species (Chapouthier, 2006). Such capabilities include simple memory skills (e.g. habituation to a repeated stimulus, and, when in situations requiring a choice to be made between two options, the tendency to choose the less familiar one), and imprinting in response to a stimulus experienced during infancy. More sophisticated memory skills include those seen with Pavlovian and Skinnerian conditioning. The capabilities ultimately include higher functions such as spatial memory and declarative memory (memory of rules and of episodes experienced in the past). Experimental data provide evidence that certain animals have only the most rudimentary form of memory, whereas higher animals, including humans, have all forms, clearly juxtaposed and weakly integrated.

The mosaic model proves useful when applied to the different types of memory. We shall focus here on what is called "episodic memory", i.e. the memory recalling experiences from the person's own life, including vivid recollections. A number of authors argue that episodic recollections form groups as "packets" or "modules" within a framework providing a weak semantic link, thus making it possible to recall

places, people, actions and events, linking them together. Within one specific episode remembered, significant details can be identified. For example, I can recall details in my grand-father's orchard: the position of different trees, the green patch of sorrel growing in the middle of the strawberries, and the gravel paths. Then, within such specific details, tiny "micro-details" can be recalled, e.g. a few plums on the first tree, the oval shape and bitter taste of the sorrel leaves and the crunching of gravel underfoot. The memory construction, with sets end subsets, can clearly be expressed in the mosaic model.

Conducting studies in the field of anatomy, Iglóia et al. (Iglóia, Doellerc, Berthoz, Rondi-Reig, and Burgess, 2010) reported on spatial episodic memory in rats, describing the juxtaposition of two different processes occurring in both the right and left hippocampus. Activation of the right hippocampus precedes allocentric spatial representation, whereas activation of the left hippocampus precedes sequential egocentric representation. These results show that, "rather than providing a single common function, the two *hippocampus* provide complementary representations for navigation, (…) both of which likely contribute to different aspects of episodic memory." Here again, we find (anatomic) memory processes juxtaposed and weakly integrated.

4.2 Consciousness

Specialists of consciousness state that human consciousness, though psychologically perceived as a whole, is actually a mosaic of several different states (Delacour, 2001)**.** In normal subjects, the distorted images of the dream state offer a different pattern of consciousness. In split-brain patients, who experienced an accidental rupture of the *corpus callosum* (a structure which normally allows communication between the two brain hemispheres), it is even possible to find two distinct states of consciousness (two decision-making centres), that sometimes even compete.

4.3 Language and drawing.

With Stephane Robert, we conducted an extensive study (Robert and Chapouthier, 2006) aimed at comparing the semantic organisation of language with that of living beings. We found that the mosaic structure is also clearly apparent in language. Linearity in language suggests that semantic units ("words") are sequentially juxtaposed in time, producing, by the end of the sentence, integration conveying meaning. The parallel with living organisms could be extended by arguing that the preliminary stage of both language and a living organism is one where units are simply juxtaposed. This hypothesis was proposed by Talmy Givón (Givón, 1998) who made a distinction between grammatical and pre-grammatical communication. The comparison of the workings of living organisms and of language shows some quite striking similarities in the different processes.

Working in a separate field, the language specialist William S.Y. Wang (University of Hong Kong & University of California at Berkeley), published an

article in 2007 with explicit use of the mosaic analogy, referring to the "language mosaic and its biological bases" (Wang, 2007). Wang's analysis focused on the developmental structure of language, describing it as a "multi-layered mosaic" of biological and cultural influences which interact in an age-dependent way, not as the semantic structure of adult language as described in the present article. His point of view is, however, clearly complementary and in line with the argument we presented with Stephane Robert.

Similar approaches can be used with drawing, in particularly in the course of the development of the child's mind (Baldy, 2011). Baldy (personal communication) cited the example that starts with two basic visual signifiers, e.g. circle and line. When a circle and a number of lines are juxtaposed in a certain arrangement, signifiers of a higher order of complexity can be produced: e.g. a radiating shape. Depending on the context, the shape depicted may be interpreted as the sun or part of the human body, e.g. a head with hair, an eye with eyelashes, or a chubby hand with fingers. During childhood, graphic signifiers start off as simple geometric shapes (circles, lines, squares) and tend later to become more specific: an eye drawn as a circle will become almond-shaped and be more like a real eye. Throughout the process, shapes of higher order of complexity become less polysemous.

4.4 Music.

Marshall Heiser (Queensland Conservatorium of Music, Griffith University, Australia) conducted an in-depth analysis of Brian Wilson's aborted Beach Boys' album *SMiLE* (Heiser, 2012). According to Heiser, "One of the most well documented recording projects in the history of rock music is one that was never actually completed. *SMiLE* was to be the follow-up album to The Beach Boys' first million-selling single *Good Vibrations* (1966)." The project was scrapped after ten months of sessions and approximately fifty hours of tape, but a three-movement symphonic version was eventually released in 2004 as *Brian Wilson presents SMiLE*. Heiser analysed the tapes and concluded that there was clearly a "mosaic structure" to the work, where "emergent forms display characteristics not inherent within their parts." Heiser referred explicitly to our mosaic model and processes of juxtaposition and integration in describing what he called "Brian Wilson's musical mosaic."

4.5 Technical objects.

As the mosaic model can be used to describe both animal and human minds, it is not surprising that it can also be useful for describing systems based on the functioning of the human mind, i.e. technical objects. The robotics specialist Frederic Kaplan (Chapouthier and Kaplan, 2011) stated that "technical evolution also proceeds by juxtaposition and integration" (p. 17). "A new set is first created by combining elementary technical objects" (p. 17) and this system is poorly integrated. The technical construction then develops as the elements tend to swap and change, creating "a coherent and unified whole" (p. 18). After a certain time for technical

development, an object (e.g. a printer, aeroplane, motor car or computer) is more highly integrated than it was when first designed.

5. MATHEMATICS AND INFORMATION THEORY

To date, no full-scale mathematical expression of our mosaic model has been devised, but Demongeot and his fellow researchers (Tonnelier, Meignen, Bosch, Demongeot, 1999; Ben Amor, Glade, Lobos, and Demongeot, 2010; Ben Hamor, Glade, and Demongeot, 2010) working in the field of neural networks and memory used a mathematical approach to analyse mnesic evocation through the action of "populations of coupled neuronal oscillators (that) can dynamically store information in the form of a periodic attractor of large dimension" (Ben Hamor et al., 2010). These coupled neuronal oscillators, inducing bio-electric synchronization/de-synchronization phenomena described by the authors can be seen as a juxtaposition of two parallel structures of the same level of complexity, ultimately leading to mnesic evocation, which can be seen as the integration of the basic phenomena.

In the field of information theory, Ugolev and Ivashkin (Ugolev and Ivashkin, 1992) proposed a theory of elementary functional blocks where "complex functions could be reached due to the recombination and transposition of a large though limited set of molecular machines realizing elementary biological operations." The theory of Ugolev and Ivashkin could be interpreted as an extension of the juxtaposition-integration model applied to information processing.

6. SOCIAL STRUCTURES

In anthropology and in sociology a number of approaches are clearly developed on a Biocosmological basis and include mosaic features. Guja (Guja, 2008) proposed an informational anthropology where "a human being as the system/interface may be considered a fundamental component of her/his human society and the nature/cosmos system as well, just like a hydrogen atom is the elementary constituent of matter under the material form" (p. 5). Sorokin (Sorokin, 1965) called for a "new sociology" able to reconcile mutually exclusive or contradictory theories. Sorokin's argument is that "sound parts can be unified and incorporated into a more multidimensional and more adequate integral theory… (an) integral sociology to come", presenting another view with a relationship that could exist between the component parts and the whole.

A clear example of social mosaics can be found with games and playing, and specifically for human beings, as reported by authors observing human behaviour to be juvenile and playful (Chapouthier, 2009; Morris, 1967; Tinland, 1977). Here we shall quote a book on rugby written (in French) by Christophe Schaeffer: *Le Rugby expliqué à mon fils ou l'art de rester lié* [Rugby explained to my son or the art of bonding) (Schaeffer, 2012). While the book obviously has no specific reference to the mosaic model, the overall argument could be presented in terms of mosaic structures. Schaeffer notes that a rugby match needs harmonious integration of all players and compares the team to the parts of a house, the house being as big as the world (p. 61), with the component elements spatially juxtaposed and functionally integrated, from

the foundations – the forwards – to the draughts of air rushing through – the wings. Every member of the team must make a distinctive contribution and provide what is required of him (p. 40). At the level of the tesserae comprising the mosaic, the difference is what makes teamwork so productive, whether in society or a rugby team (p. 41). "The difference between people is creative of life and joy" (p. 108). Teamwork is what is being celebrated, and no matter what happens, through bonding the individuals remain together (p. 109).

At a more philosophical or social level, I wish to cite the theses of the Japanese philosopher Naoshi Yamawaki (Yamawaki, 2009). Yamawaki's objective was to define social rules applying to trans-national public ethics. He observed that such rules cannot be determined by either local or global considerations and coined the term "glocal" to describe the "correlation between the global character of the problems and the culturally and historically defined locality where each human being lives", the correlation being interdependent. Here the dialectics of the whole and the parts, in the context of human civilisation, provides an excellent example of integration between different levels of complexity and is well suited to the mosaic model.

7. DIALECTICS

The dialectics of the whole and the parts leads to the original concept of dialectics, dating back to ancient Greek philosophers and developed in its modern form by Hegel, applying it to the mind, and by Engels and Marx applying it to the realm of material events (dialectical materialism). The concept of dialectics is based on a series of contradictions between two opposing processes (thesis/antithesis), thesis and antithesis being at the same logical level (Hegel) or material level (Engels). The contradiction is then solved or overcome (synthesis); in other words there is integration of the two opposing processes, those processes being the parts, while the synthesis becomes the whole in the mosaic model.

8. ETHICAL STANCES

In the field of ethics, the French philosopher Vanessa Nurock (Nurock, 2011) has argued that ethics can be seen as a construction of three juxtaposed processes: agentive empathy (putting oneself in the position of another being), emotional empathy (simulating the feelings of another being) and situational empathy (understanding the cognitive situation of another being's life and behaviour, also known as the Theory of Mind). Integration of the first two processes could produce a basic concept of ethics, while full integration of all three processes could produce a full dimension of human ethics. In certain human disorders, some processes may be absent: autism might involve a deficit in situational empathy, while certain psychopathic disorders could involve a deficit in agentive and emotional empathy. When using the mosaic model, further (sub)levels could be added. For example (Nurock, 2012), the first agentive level may be the initial result of two or more units being juxtaposed: the sense of what the right action is (putting oneself in the place of

the other person and considering the other person's well-being) and the sense of justice (putting oneself in the place of the other person with consideration for cooperation and/or reciprocal actions). Looking beyond the cognitive architecture of morals to see the practical applications, Corine Pelluchon (Pelluchon, 2011) endeavoured to integrate three separate and juxtaposed moral stances: human ethics, animal welfare ethics and environmental ethics, proposing "vulnerability ethics" whereby human beings have a clear a moral responsibility towards all other beings, including non-human species and ecosystems. This is mosaic integration of conventionally juxtaposed moral duties.

Conclusion

In the present article, I have presented examples showing the rules governing the complexity of living beings according to the principles of juxtaposition and integration and leading to mosaic structures. This has been seen in a range of fields involving complexity: memory, consciousness, language, drawing, music, technical objects, mathematics, social structures, dialectics and ethical stances. No analysis has been presented on the functioning of stellar bodies, an area where contributions from astrophysicists would be invaluable. The fact that the mosaic model can already be applied to a range of different fields may suggest that a model valid in so many areas of our microcosm could be a relevant tool for describing areas of the macrocosm needing to be studied. A biological stance could thus lead onto a Biocosmological approach and prove to be a fruitful collaboration for both Biocosmology and biology.

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