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Mosaic structures – a working hypothesis for the complexity of living organisms

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Abstract

The present argument, compatible with Darwin's theory of evolution, explores the development of living species and the shift to ever increasing complexity. Two basic phenomena provide the keys to evolution towards complexity: juxtaposition and integration. These operations produce structures following the mosaic principle, i.e. juxtaposition, accumulating identical units, and integration, developing into a more sophisticated version with the original units then becoming component parts. Examples cited are from genetics, anatomy and human society. The human brain and mental operations, including memory and language, are analysed as mosaic structures. In line with modern Aristotelian stances, such as Konstantin Khroutski's biocosmology, the possibility of applying this biological theory outside the field of biology is discussed.

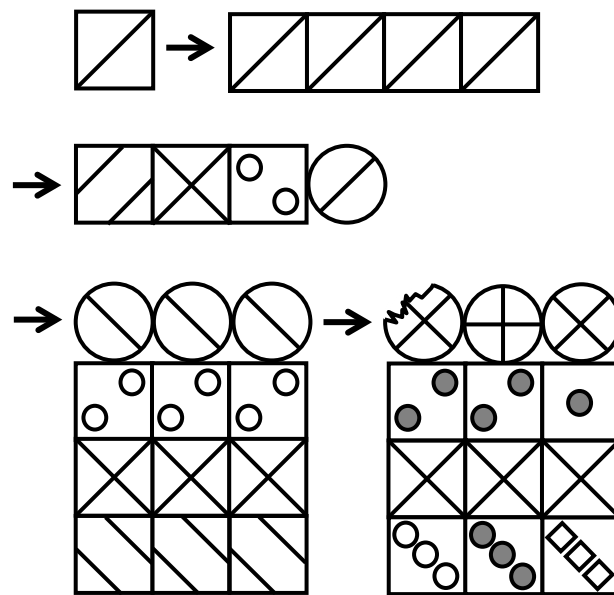
Introduction

Why has evolution given rise to beings of ever greater complexity? While it is obviously not the case of all species and organisms, as some have evolved down the “complexity hierarchy” (see, for example, S.J. Gould [1980]). But it is apparent that more complex beings exist now in earlier generations. The general trend of evolutionary processes seems to be towards *increased* complexity. I do not believe that this trend is caused solely by random processes.

The hypothesis presented here is compatible with Darwin’s theory of evolution and evolutionary reasoning, specifically with processes of natural selection as argued by Darwin. While I am clearly a Darwinian, I do not believe that Darwin’s theory explains everything. In the field a complexity, there is scope for general integrating mechanisms, as a complement to natural selection. I shall first expose these general integrating mechanisms which, I believe, are involved in biological evolution towards complexity, and shall then show how they seem to fit a more general philosophical thesis, that being the biocosmological approach propounded by the Russian philosopher Konstantin Khroutski (2008 A and B).

The principle underlying my argument is that two basic operations, juxtaposition and integration, coincide and combine in the shift towards complexity, (Chapouthier, 2001). Juxtaposition, as the term suggests, is the accumulative positioning of identical units, one next to the other (a process similar to forming a necklace with identical beads), while integration involves a process which enhances or refines the original units, thus generating entities one step up the hierarchy, comprised of the same original units which then become component parts (e.g. a necklace with beads of different colours or shapes). By further juxtaposition and subsequent integration, new higher level structures (e.g. necklaces of necklaces, or necklaces of necklaces of necklaces) are then produced. Figure 1 is an illustration of the process.

Figure 1 - Juxtaposition and integration. Single identical units (A) can be added (juxtaposition, B). Changes can then occur in B juxtaposed structures to produce C (integration). By further juxtaposition (D) and subsequent integration (E), new higher level structures can be produced. In theory these processes can be repeated ad infinitum to produce ever higher levels of complexity. In practice, at least in biology, there are limits, e.g. combinations of colonies of organisms. Adapted from G. Chapouthier, *L’homme, ce singe en mosaïque*, Odile Jacob Publisher, Paris, 2001

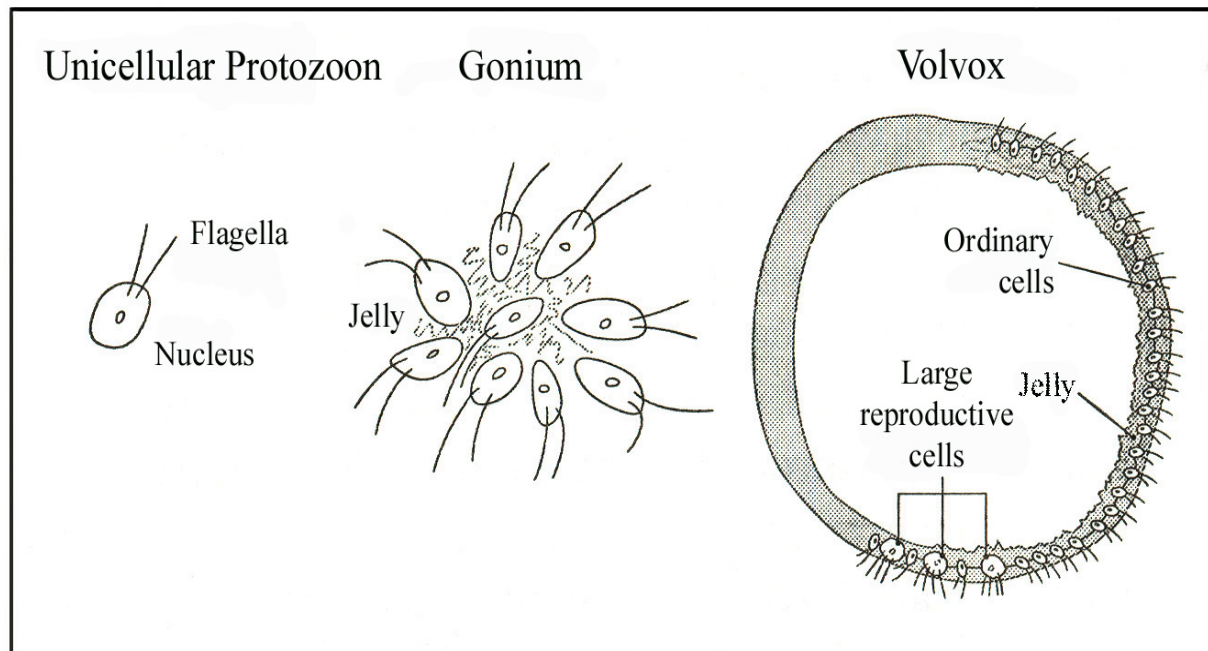


Continuing juxtaposition and integration extend the scope for forming complex structures made up of the basic units juxtaposed at different levels but, further integrated into a higher level structure, but still retaining a certain level of functional autonomy. A convenient model for these processes is the art of the mosaic where identical and non-identical ceramic tiles are juxtaposed and integrated in a mosaic to depict a figure, while each individual tile retains its own distinctive features (shape, size, texture and colour). In philosophical terms, the properties of the complete mosaic subsume the component parts but do not cancel out the autonomous existence of the properties of the component parts. The mosaic can be seen as a model to express the different levels of complexity of living beings.

Genetics and Anatomy

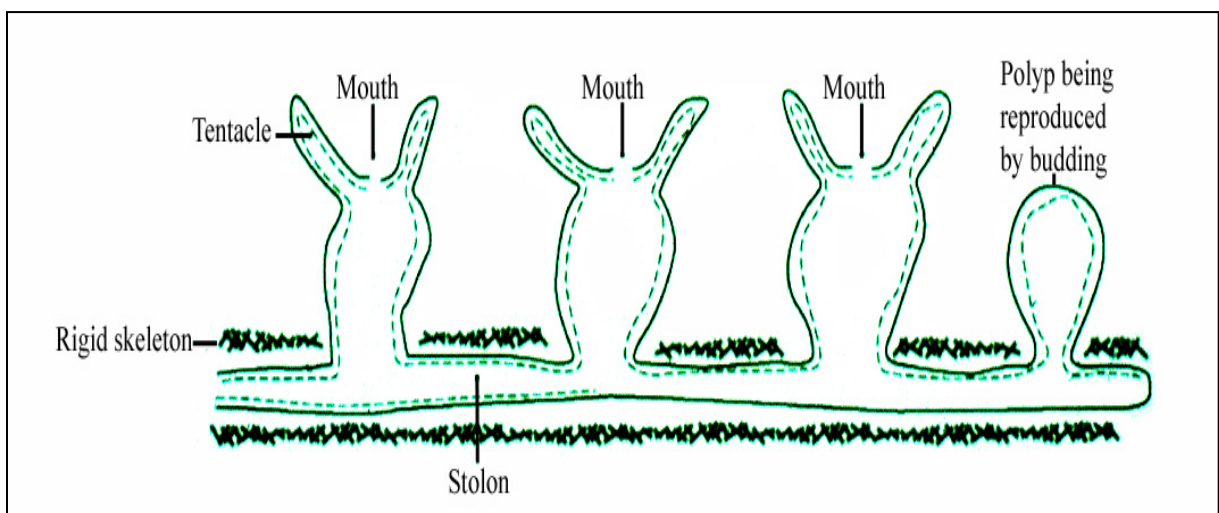
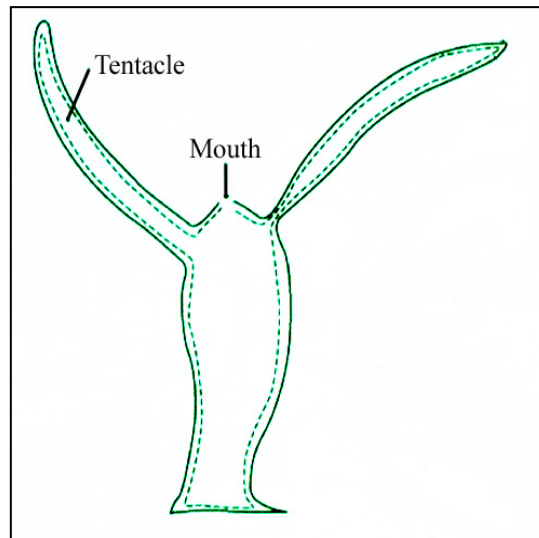
In the field of genetics, the silent duplication of introns is a form of juxtaposition of identical elements. It has been argued that juxtaposed introns may silently undergo multiple mutations over time, developing patterns (integration of component parts) that can then be expressed as functional exons and coding for new organs and/or functions (Ohno, 1970). This genetic hypothesis could be an explanation of the development of new complex organs. When observed in anatomical phenomena, the two principles can be seen at work in unicellular organisms, evolving to become a “juxtaposed” organisms, e.g. *Gonium*, or an “integrated” organism, e.g. *Volvox*, with a higher level of evolutionary processes (see figure 2).

Figure 2 - Emergence of complexity in unicellular organisms. In unicellular organisms, juxtaposition can produce structures such as Gonium, and integration can produce structures such as Volvox, these being on a higher level in evolutionary processes. Reproduced, with permission from the publisher, from G. Chapouthier, *L'homme, ce singe en mosaïque*, Odile Jacob Publisher, Paris, 2001.



Didermic species, at a higher level of complexity than unicellular organisms, have identical polyps juxtaposed to produce colonies of polyps (see figure 3) which, when integrated, develop into colonies of non-identical elements such as siphonophores with different types of polyps – defensive, floating, digestive and reproductive. In tridermic organisms, juxtaposed metamers become animals such as the earthworm, while integration can develop into animals such as the bee, octopus, chimpanzee or human. Integration however is not always a complete process, and vestiges of prior juxtaposition can be found in an integrated organism; segments of the bee abdomen and the segmentation of chimpanzee ribs and vertebrae are traces of prior construction by juxtaposition.

Figure 3 - Emergence of complexity in didermic organisms. In didermic species, single polyps (top) are juxtaposed to produce colonies of identical polyps (bottom). Integration (not shown here) produces colonies of siphonophores, with different types of polyps – defensive, floating, digestive and reproductive. Reproduced, with permission from the publisher, from G. Chapouthier, *L'homme, ce singe en mosaïque*, Odile Jacob Publisher, Paris, 2001.



Moving up the development hierarchy, from organisms, or groups of organisms, there are animals which are usually capable of autonomous movement; this restricts potential for development by juxtaposition alone, although there are some rare cases, such as Siamese twins.

Next comes a *social* context for juxtaposition and integration as individuals of the same species gather and form communities. Integration can mean that specialised or dedicated functions are carried out by certain “identical” members of an animal species that play distinct social roles, as, for example, in colonies of bees and communities of primates.

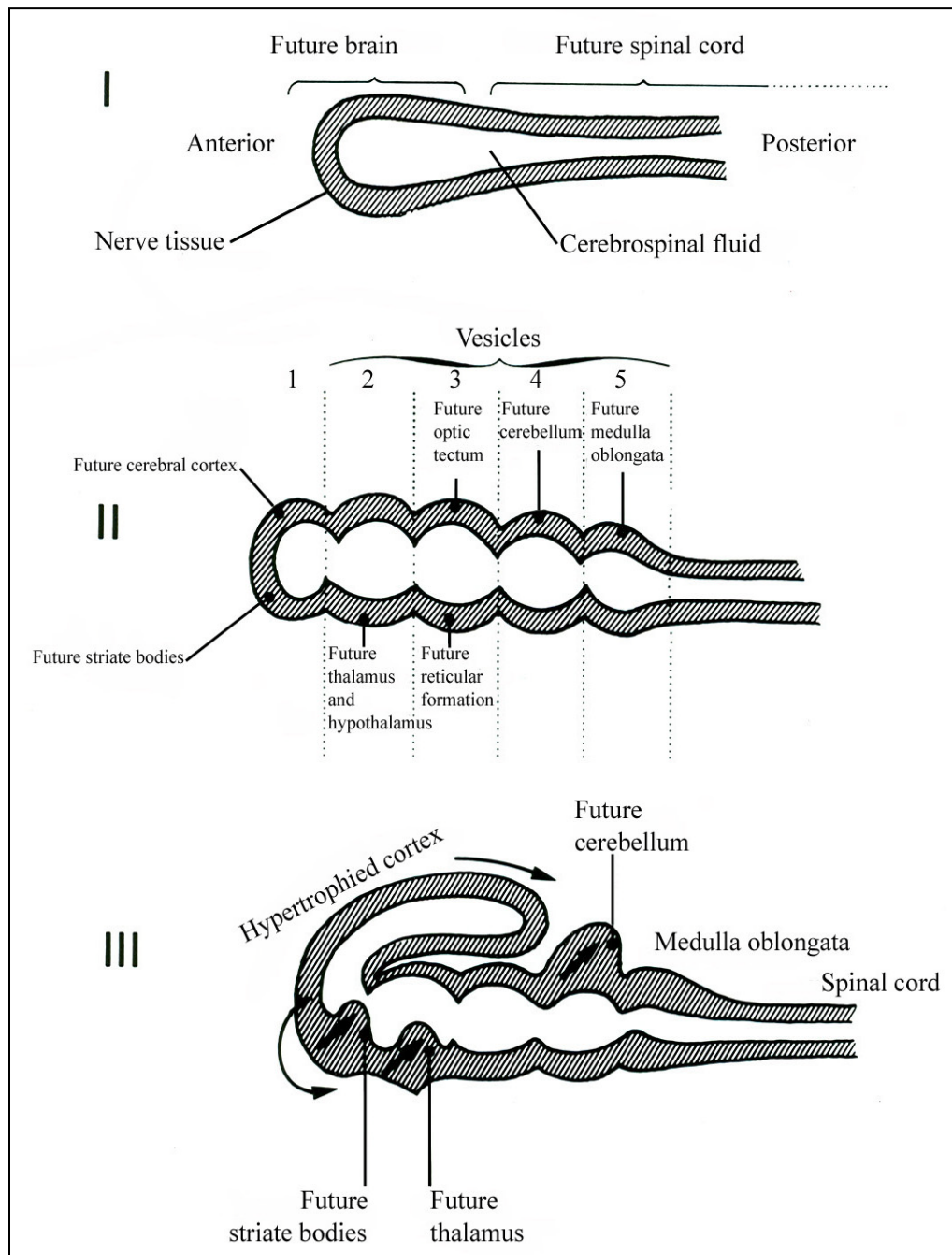
Such structural arrangements by integration at a given level still leave lower level units in a state of relative autonomy; e.g. genes have a certain degree of autonomy in the genome, as do cells in a living organism and bees in a colony. In other words the properties of the whole do not cancel out the autonomy of the component parts.

Mosaics thus provide a metaphor to depict this structural relationship in living organisms (Chapouthier, 2001), and with clear parallels. In human society, the component parts are individual beings, each one being autonomous in relation to the greater community and to society at large. This is the basic principle of freedom.

The Human Brain

The human brain is the most complex structure known to science and mosaic-like features and processes can be identified in it. A number of organs in the human brain are constructed according to mosaic principles. The brain begins as five encephalic vesicles, juxtaposed in the embryonic stage and later integrated until reaching the complex stage of the adult brain (see figure 4). The neocortex has an abundance of mosaic structures with functions extending over more than one area, e.g. sensory, motor, and language skills. Each area is both functionally specific and partially autonomous, operating as a synchronised component of the neocortex. The two hemispheres of the brain may be seen as a large two-unit mosaic with each hemisphere having distinct functions: analytical functions in the left hemisphere and amalgamating functions in the right hemisphere (for right-handed persons). With the exception of rare spilt-brain patients with impaired inter-hemisphere connections, the functionally specific and partially autonomous hemispheres operate in harmony both separately and as a whole brain, without the functioning of the whole neutralising the autonomy of the parts.

Figure 4 - Emergence of complexity in the brain. The brain begins in the embryonic stage as a single vesicle (top), and soon becomes a juxtaposition of five encephalic vesicles (middle). The vesicles are subsequently integrated as part of a preliminary stage in the final structure of the adult brain (bottom). Reproduced, with permission from the publisher, from G. Chapouthier, *L'homme, ce singe en mosaïque*, Odile Jacob Publisher, Paris, 2001.



Mental functions such as consciousness, language and memory can be seen to have similar mosaic-type features. Studies have shown that even though consciousness appears to be a single level of awareness, when analysed, it can be broken down into mosaic units, involving various states of consciousness. Conflict may sometimes occur between two consciousnesses or two decision centres in "split-brain" subjects, or even in normal subjects when consciousness is disturbed by dream states.

A further parallel is found in language where ordered semantic entities comprising a sentence form relationships to express an overall idea in the sentence. In a previous paper we described the mosaic structure of sentences (Robert and

Chapouthier, 2004). I will therefore cite only one example here: the haiku by the French poet Jean Monod (Antonini, 2003): *The absent of all / bouquets here she is / says the appearing dawn*. At the end of the first verse, the reader assumes the poem is about a human being (in French, the feminine gender infers it is a woman); by the end of the second verse, it is about a flower (also feminine gender), but it is not until the last verse that the complete meaning, i.e. the whole, can be grasped: the image being conjured up is of dawn breaking, an image expressed with poetic references evoking a female being or entity and a flower. Finally the whole haiku can be understood as a harmoniously integrated mosaic of the different semantic parts of its three verses.

Human memory, often believed to be a whole, is a collection – a mosaic – of various memories including habituation, conditioning, spatial memory and cognitive memory; it has developed over the ages dating back to our animal ancestors. The different parts (diverse memories) remain autonomous within the whole which we call “our memory” (Chapouthier, 2006). Three key psychological functions – consciousness, language and memory – are thus mosaic units of the human mind, operating both individually and as an integrated mind.

In short, observations of structural and functional complexity in living organisms, in both genetic and anatomical structures, tally with the organisational features of mosaic structures. The same can be said of the configuration and operation of both the brain and thought processes. It is thus particularly interesting to observe that the two distinguishing features which are the pride of the human race, i.e. the brain and highly complex thought, are built on the same basic foundations as the rest of the living world – juxtaposition and integration.

Mosaic structures and Khroutski's biocosmological approach

The approach Aristotle applied to the universe as organic (or in modern terms, biological), not physical. The modern Aristotelian view, as expressed by Konstantin Khroutski in his biocosmological approach (Khroutski, A, B), has the same focus. There are "complex beings very different from terrestrial ones" and "other parts of the universe." Aristotle's universe is one whole organic cosmos, every entity of which is subjected to purposeful forces that are basically the subject's *causa finalis* and *entelecheia*, and are ultimately ruled by the *Nous* - cosmic logos. Place and function are inherent, playing a part as an entity (microcosm) in one whole macrocosm. Following the same reasoning, and therefore the Aristotelian-Khroutskian stance, we may speculate as to whether the structure of complexity and its construction through juxtaposition and integration (as defined here for biological entities, with the whole leaving the parts autonomous, could also apply to other entities in the universe, such as stellar objects or social structures.

Konstantin Khroutski's biocosmological approach suggests this should be the case. If Khroutski's (2008, A), biocosmological view is in harmony with the ontological and gnoseological approach of Aristotle realism, perceiving the world (cosmos) as a biological or organic whole, then the model of the mosaic would be valid outside a biological context. Khroutski's biocosmology has been applied to informational anthropology (Guja, 2008): "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). A dialectical relationship between the whole and its parts is clearly seen in Guja's model which is set in the unitary biocosmological system described by Khroutski. In information processing, 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." In the field of sociology, Sorokin (1965) speaks of a "new sociology" able to reconcile mutually exclusive or contradictory theories. Sorokin argues that their "sound parts can be unified and incorporated into a more multidimensional and more adequate integral theory... (an) integral sociology to come."

This return to Aristotelian views, as seen with Khroutski, could offer a broader scope of application for the mosaic thesis described above, applying it to the specific case of living beings on the planet Earth. Modell (2009) has suggested that the same principles could be applied to healthcare, catering to the complex structure. Khroutski's fundamental universalism and the fact that the same rules apply to both microcosm and macrocosm may extend the mosaic model beyond biology. In analytical terms, I would argue that the mosaic model, with its juxtaposition and integration phases, may provide a basic level of functioning for Khroutski's broad cosmic views, with arguments explaining how complexity arises at different levels of the universe.

It is important to stress that both Khroutski's stance and mine expressly preclude the possibility of evolution centered on humans alone, as in the notorious "anthropic principle" (Carter, 1974) which sees complexity solely in the specific case of human beings and their highly specific world, our world. Both Khroutski and I see universal "anthropocentrism" and are categorically opposed to the anthropic principle, it being anthropocentric, and not the Aristotelian-way cosmo-centric approach.

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