

# Complexity in Mosaic Form: from living beings to ethics

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**Abstract.** The living world is comprised of beings with degrees of complexity developing in sequential stages, ranging from cellular organelles through cells, organs and organisms to animal populations, doing so in accordance with the repeated application of two basic principles: *juxtaposition* of entities arising from the same stage, then *integration* of these entities to produce a higher stage. As for a mosaic art work, the newly formed stage still leaves a degree of autonomy for the entities of the previous stage that combine to form the mosaic. The same mosaic-type construction can be used to describe mental processes in the living world, e.g. memory, cultural habits, consciousness, language, literature and even ethics.

**Keywords:** Living being, complexity, integration, mental performance, memory, consciousness, language, literature, ethics.

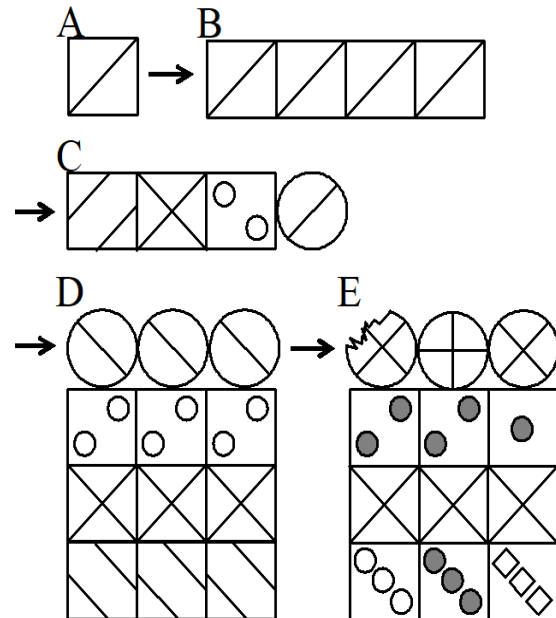
## 1 Introduction

The living world is comprised of beings made of carbon chains (e.g. bacteria, fungi, plants and animals) forming structures of different degrees of complexity. While complexity can be defined in a variety of ways, there is no need for such basic debate here as it can easily be seen that living beings are formed by developing in stages fitting one into the next (e.g. organelles, cells, organs, organisms and populations), each stage being a combination of the elements formed in the earlier stages. An organ is thus made up of cells, and a population is made up of organisms. The present article is a study of the development of this type of complexity.

## 2 Living beings in mosaic formation

In previous papers [1-3] we showed that the sequence of stages, each one becoming part of the next, could be explained as the repeated application of two key principles of development which we chose to name the “principle of juxtaposition” and the “principle of integration”. The same model for complexity in mosaic formation was used by J. Audouze, D. Laming and P.Y. Oudeyer who applied it to the complexity of celestial bodies, cities and robots [4], but for the present paper the discussion will focus on living beings. The construction of a living being is shown as a theoretical concept in a diagram (Figure 1): “A” entities are all identical and when juxtaposed form unit “B”. In the course of subsequent integration, some of the entities juxtaposed take on specific features developing into an integrated stage that is “C” and which then has the entities modified through integration functioning as component parts to make “C” operational. The parallel in art is a mosaic which features the autonomous shape, colour and sheen of the individual tesserae, and with the Stage C mosaic leaving a certain degree of autonomy to the component parts arising from “A”, hence the term “mosaic complexity” used to describe the process.

The same operation can occur over and over again by juxtaposing “C” entities to form “D” entities that are then integrated to form “E” which thus becomes a mosaic of mosaics.

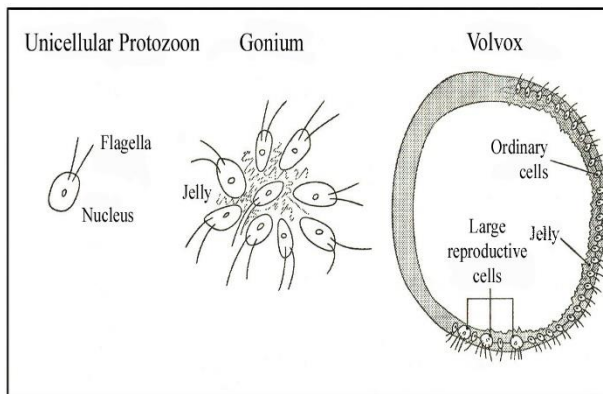


**Figure 1 : Construction through juxtaposition and integration (Adapted from G. Chapouthier, *L’Homme, ce singe en mosaïque*, published by Odile Jacob, Paris, 2001)**

The construction of the different stages of a living organism can be described through these processes. One example would be cells juxtaposed to form tissue, subsequently integrating different tissues to form an organ. For example, individuals could be juxtaposed to the point of forming a crowd in which all individuals behave the same way, or could integrate to form societies where individuals have different functions. Six or seven levels of integration can be distinguished across the range from organelle to animal population.

A limited number of cases can be cited in the field of anatomy. Unicellular organisms (Figure 2) include isolated individuals, composite groups of identical cells simply juxtaposed, and groups of different cells. To illustrate the last two cases, the examples

chosen are not animals but unicellular algae, i.e. protophytes similar in structure. In *Gonium*, identical cells are simply juxtaposed in what could be described as a jelly, while *Volvox* has different cells that may be seen as an initial phase of integration.



**Figure 2: Juxtaposition and integration in unicellular living beings (Adapted from G. Chapouthier, *L'Homme, ce singe en mosaïque*, Odile Jacob, Paris, 2001).**

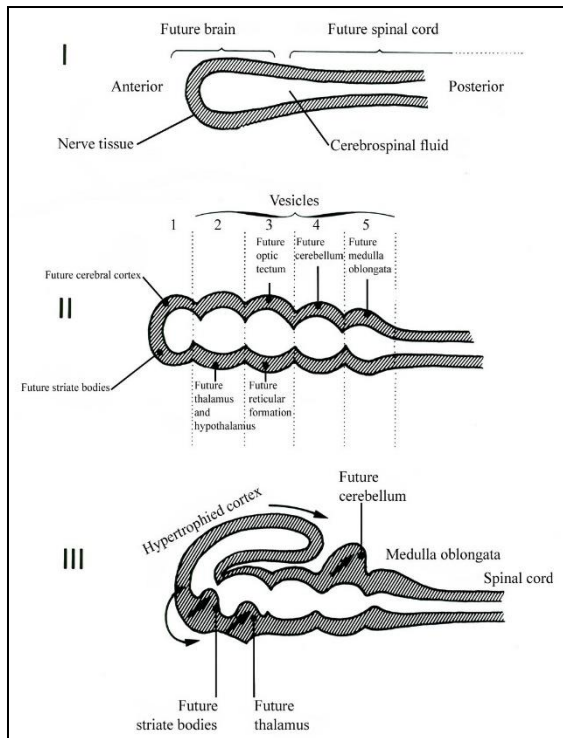
Similarly, for animals with two germ layers, there are isolated polyps, identically juxtaposed polyps as in coral reefs, and groups such as siphonophorae that are properly integrated colonies of different polyps: floating, digesting, defending and reproducing. For animals with three germ layers, certain worms form isolated entities; the common earthworm, for example, may be seen as a juxtaposition of metameres (three germ layers). With other animals, e.g. the bee and the chimpanzee, the rings or metameres are integrated as part of the organism, although there can sometimes be anatomical traces of earlier generations simply juxtaposed, as with the “rings” of the bee’s abdomen and the series of ribs and vertebrae of the chimpanzee.

Could juxtaposition be hypothesised at an even higher stage as metameric entities juxtaposed with metameres already integrated, as for chimpanzees? While this may be possible, juxtaposition of such identical entities is rare, as in the case of

Siamese twins. As triploblastic animals are normally highly mobile, it is difficult to explore this any further, but juxtaposition becomes a widespread phenomenon at a social level. Birds that flock together to sleep form a group of juxtaposed beings where each individual has the same role. However, in communities of animals such as social insects or mammals, individuals acquire different functions that can then lead to the organisation of an integrated group.

The same processes, while no longer found in entire organisms, can be seen in the anatomical structure of certain organs. The evolutionary development of the encephalon in vertebrates (Figure 3) starts with the appearance of a vesicle filled with cerebrospinal fluid (I), followed by the juxtaposition of five vesicles (II) that are then integrated in a complex way, ultimately forming the brain (III). Other examples could be cited: the organisation of the cerebral cortex in mammals displays different functional areas in juxtaposition, sensory, motor and secondary, with varying degrees of integration between the areas. The mosaic of areas in the cerebral cortex is perhaps one of the best examples of mosaic structures in living beings.

There are also two (juxtaposed) hemispheres of the brain (e.g. in fish where they operate in strict symmetry, controlling the opposite side of the body, i.e. the left hemisphere for the right side of the body and the right hemisphere for the left side of the body). In certain mammals and certain birds this produces higher integration where each hemisphere has its own specific properties, for example language which is on the left for most humans, and the perception of shapes usually on the right. For birdsong, lateralisation right or left depends on the earliest experience of the bird [5], while in some monkeys and apes lateralisation of auditory stimuli depends on the novelty of the stimulus [6].



**Figure 3: Juxtaposition and integration in the construction of the encephalon in vertebrates (Adapted from G. Chapouthier, *L’Homme, ce singe en mosaïque*, Odile Jacob, Paris, 2001)**

### 3 The Mosaic of Functions of the Mind

In a work published in 1970, Jacques Monod observed that ideas retained certain properties of organisms, showing the same tendency to perpetuate their structure, reproducing it multiple times, and having the same ability to progress to fusion, recombination and/or segregation of the content, i.e. developing just as organisms do. [7] The next paragraphs of the present article will show, in line with Monod, that the same type of mosaic formation can apply not just to the anatomy of living organisms, but also to the realm of ideas, and to the output of the mental processes of such living beings, citing arguments related to memory, consciousness, culture, language, literature and ethics.

#### 3.1 Memory

Memory does not exist in the singular, but in the plural, as memories [8]. Memory is not a single attribute, but a mosaic of quite different attributes [9] of increasing complexity as acquired by our ancestors in the animal kingdom in the course of the evolution of species. This has occurred, *inter alia*, through habituation, alternance, conditioning (Pavlovian or Skinnerian), the ability to make changes and the learning of the rules of semantics. Such memory skills are basically juxtaposition, but occasionally the brain combines (i.e. integrates) them to solve a given problem.

#### 3.2 Consciousness

Nor is consciousness a single attribute or function, as distinct levels of consciousness can be identified in different animal groups. While there is no overall agreement on these levels, two main levels can be recognised: consciousness of the environment and self-consciousness. Contrary to the arguments of Descartes and his followers, animals with the highest cerebral development (in simple terms vertebrates and cephalopod molluscs) are conscious of features in their surrounding environment, but only a few animal groups are conscious of being conscious, such awareness meaning that they have achieved “self-consciousness”. The different levels of consciousness are mental elements juxtaposed with only a low degree of integration.

#### 3.3 Culture

Actions and behaviour considered to be cultural, such as the use of tools, communication, and the making of moral or aesthetic choices [10], are seen in both animals [11] and humans, and can be broken down into a series of sequential movements which when integrated make it possible perform the cultural action. When a chimpanzee uses a stone to break a nut, the integrated exercise leading to the animal breaking the nut includes the juxtaposition of a series of movements: picking up the stone and striking the nut a number of times

to break it open. Similarly, communication by a bird through a song sequence can be broken down into an ordered sequence of notes and rhythms juxtaposed to form a whole which, as integrated communication, conveys meaning perceived by another bird. When a chimpanzee makes a moral decision, choosing to help another chimpanzee who is sick or injured, such assistance can be analysed as a sequence of movements juxtaposed in time, the final result produced being integration. The same applies to choices for aesthetic reasons, and many other examples can be found.

Moving away from features found in both animals and humans, we shall focus on matters specific to the human species.

### 3.4 Human Language

While the animal kingdom has its (proto)languages, the degree of complexity is in no way close to human speech [10]. The linguist Stéphane Robert [12] made a specific analysis of the mosaic structure of human language, considering a sentence as spoken by a person as a juxtaposition of semantic units, i.e. words, ultimately producing meaning or integration by the end of the sentence. Language is thus seen as a mosaic of semantic units constructed according to the principles of juxtaposition and integration.

Once a sentence is constructed, it may seem that each word still has the meaning it had before being juxtaposed in the sentence, before integration produced the overall meaning of the sentence, i.e. a meaning not present in any of the individual words used alone, only arising as a combined effect yet without changing the understanding of the individual elements, i.e. the words. However, this is not always the case. Any number of examples can be found of words changing meaning in the course of a sentence as it develops and the context is established. In conversation, a person might say “Have

you seen my new pen?” Depending on the setting, the “pen” may be a writing implement or, on a farm, an enclosure for livestock.

The meaning of a word can also change as the sequence of words takes on a different meaning, as seen in the following examples:

**He shot his** film in Hollywood. // **He shot his** neighbour in the head.

**He has a frog in his** garden. // **He has a frog in his** throat.

**id you see his wedding?** // **Did you see his wedding** ring?

In English any number of examples can be seen with phrasal verbs:

e.g. put up + put up with; put by, put off, put away, put back, put down, put on, put in, put out, put through etc.

**We put** the book on the shelf.

**We put up** the price of our books.

**We put up with** customers handling the books.

In such cases, the word that is the tile of the linguistic mosaic remains unchanged, while the semantic content of the mosaic sentence is radically different

### 3.5 Literature

The example chosen is original creative writing, but similar observations could be made for other art forms such as painting or sculpture. While language exists in many forms, creative writing is a key feature of human endeavour [13] and, being based on language, displays the same features as described by Stéphane Robert in her analysis of human speech.

In most novels, and specifically in the structure of the French “nouveau roman”, the plot develops around a series of events juxtaposed in time, leading to a conclusion that provides a form of integration. Modern verse can present a range of distinct and

distinctive poetic images with a semantic structure in mosaic form. Certain written styles rely strongly on structure. Japanese renga (or “renku” in the more modern form) is a striking example of this process. The writing is a collaborative venture with poets taking turns to write and respond in verse, following an approach similar to the “exquisite corpse” method. The result is a three-lined haiku or a couplet, each poet responding in their own style to the previous verse, forming a haiku after a couplet, or forming a couplet after a haiku. This “patchwork” formed through juxtaposition is gradually integrated in the reader’s mind, thus conjuring up poetic images.

An individual haiku can be broken down into elements juxtaposed and integrated. The example cited here is a haiku written in French by Jean Monod.

A traditional haiku is a sequence of three lines of five, seven and five feet in that order, and was adopted by Jean Monod [14].

*L'absente de tout  
bouquet la voilà me dit  
en se montrant l'aube.*

*(Absent one from all  
bouquet here she is  
says dawn appearing).*

The structure of the haiku is the focus here, although each of the three lines could be broken down according to the same principles, being seen as entities containing simpler semantic elements. By the end of the first verse, the deduction is that the poem refers to a woman (the mot “absente” being in the feminine form in French). Then the second verse refers to a bouquet (masculine gender), so the absent being/object may be a flower (feminine gender). Finally the third verse provides the full haiku with the meaning as conveyed through semantic integration. The reference is to the dawn breaking (“dawn”/“aube”, feminine gender), yet the

integration does not detract from the autonomy and intrinsic poetry of the woman and the flower of the first two verses.

Literature, as a natural offshoot of human language, follows the same mosaic-type construction.

### 3.6 Ethics

Ethical considerations here go beyond the basic references cited for animals and address human nature as an essential part of philosophy.

An initial observation would be that doctrines of ethics may be seen as groups juxtaposed or with a low level of integration. Three moral traditions prevail: first the Aristotelian moral tradition based on virtue, secondly ethical or Kantian morality with moral imperatives, and thirdly utilitarian moral theory for the greater happiness of all, the bases for the three approaches are quite distinct and therefore juxtaposed. For all three approaches, moral principles apply to humans only, whereas later traditions, e.g. Bentham’s utilitarianism and Schopenhauer’s ethics, aspire to include animals [15]. Other doctrines are concerned with and for the needs of the environment [16-17]. Humans, animals and the environment are thus three separate and clearly juxtaposed areas. However, more recently, certain thinkers have used elements from these different doctrines to develop a more integrated moral theory, for example the Universal Declaration of Animal Rights [18-20] which, in its different versions, has endeavoured to integrate all three approaches into a single vision.

The philosopher Vanessa Nurock [21] proposes another way of seeing mosaic formation in ethics, studying what arises from the adoption of a moral stance, and specifically the case of empathy. Nurock sees empathy subdivided into three juxtaposed levels: empathy of the agent, empathy of emotions and empathy of

situation. Empathy of the agent spreads physically, spontaneously and immediately in imitation of human actions. Empathy of emotions means the ability to notice the emotional state of another person and share their emotions. Empathy of situation is more complex, requiring the person to adopt the position embracing the person's thought processes, desires and intentions. This verges on the theory of mind whereby an individual simulates the mental processes of another person. In a "normal" adult human brain, the three levels are harmoniously integrated, but there are some exceptions where levels can be missing from the original juxtaposition. Empathy of the agent is often found in young children and in animals, while psychopaths are devoid of empathy of emotions. From these perspectives, a mosaic-like construction can be observed in the field of ethics.

While the three main approaches to ethics – Aristotelian, Kantian and Utilitarian – can coexist in their original form without any reciprocal influence, it is also true that in everyday life an individual can easily switch from one perspective to another, in other words practise more integration than simple juxtaposition. The same observation can be made when considering the hypotheses propounded by Vanessa Nurock who sees "empathy of situation" as integration rather than just juxtaposition.

#### 4 Conclusion

The living world is made up of beings of varying degrees of complexity that emerge in successive stages, and of great diversity ranging from cellular organelles to cells, then organs, groups of organs (metameres), and organisms. We have observed complexity developing through the repeated application of two key principles: *juxtaposition* of identical entities appearing at a given stage, and the subsequent *integration* of these entities combining to generate other entities which, while simultaneously different and inter-linked,

form a higher stage. As is the case for a mosaic as a work of art, the latest stage still leaves a degree of autonomy for the component entities of the earlier stage.

It should be noted that juxtaposition can take on a range of forms depending on biological elements involved. In genetics, the simplest form of juxtaposition is the duplication of genes, producing two or more identical genes. Some silent regions of the genome can include collections, and sometimes large numbers of collections, of duplicated genes. Such groups may then be affected by mutations so that the duplicated genes are no longer perfectly identical. Variations of the duplicated genes appear, leading to new properties, i.e. innovations. Before reaching the point where such new units are integrated, there is an intermediate stage when innovation emerges, triggering, as it were, the subsequent emergence of integration.

The same mosaic-form complexity can be used to describe various aspects of the mind of living creatures: memory, cultural features and consciousness as observed in humans and certain animals. It is also the case for complex language, literature and ethics applying specifically to human beings.

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