THE ORIGIN OF THE BEAUTY OF A SUNFLOWER (AND OF A WORM)

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Science in my personal experience is biology. My professional activity in science started 30 years ago with parasitic worms. These worms are still the centre of my scientific work as a parasitologist. I try to make a link to arts, because I like some aspects of art, However, my experience with art is exclusively as an amateur.

We can look upon or study plants, animals, microbes and also humans according to different disciplines, for example anatomy, biochemistry, phylogeny, physiology, or what is nowadays more fashionable: the organisation of cells and of genes. Independently of the discipline, we recognise that there is function in everything we study, there is interaction among cells or organisms, there is regulation and co-operation and chemical communication between molecules and organisms. Somewhere here are the limits of biological sciences in the self-understanding of biologists and in the available technology for research.

However, a living being is more than what is contained within these limits. We humans claim at least for us – and possibly some animals - that we are more than our biological body. We have consciousness, we may have inspiration, we may have a religion and we have beliefs.

Many people believe that there is a gap or a discontinuity between the physical and mental parts of life, between natural sciences and humanities. This gap has since long been discussed[1]. I do not share this view of a gap. Let me discuss "beauty" as a biological character of a given organism or as a way of human perception. Beauty is also one aspect of art. I will make the link between science and art through thoughts on what beauty may be, or what may create in us the feeling that something is beautiful.

First, I try to discuss the possible link between biological function and beauty. Hookworms live in the intestine of humans and can attach to the gut wall with a series of hooks. This imagination does not create a feeling of beauty. However, looking at these hooks through a special microscope may create a different impression. Someone may like the colours, someone may like the circular arrangement, and if one were not aware of the biological function of the structure, this might induce a feeling for beauty. - The shape of animals may be very clearly determined by a central function, for example the shape of pelagic fishes, of penguins and of whales are all quite similar to make them optimal swimmers. To many people these animals look beautiful. Some unicellular algae (e.g. *Radiolariae*[2]) also swim, although not actively, but passively. They possess structures, the function of which is to prevent them from sinking in the water and makes them appear to us

as beautiful. Beauty seems to be an inherent feature of these algae. - Many animals have dominant characters which help them to evade being eaten by a predator. Some butterflies look very beautiful to us. However, the function of the colours on their wings is to create fear in a bird, which will see huge eyes of an imagined big animal. Other animals hide from predators by mimicry through an unusual body shape and design. Probably we perceive them as less beautiful, but why? If we take some time to study such an animal in the details of its very strange body, a feeling may slowly arise in some of us that these creatures can also touch our aesthetic senses.

Can those structures, forms or colours, which we may perceive as beautiful, always be assigned a biological function? It is difficult to find stringent answers, in terms of a scientific proof, e.g. for the colours and design of various closely related beetles. Maybe there are hidden functions like mating signals? - The shape of leaves of any tree is generally extremely stable within an individual tree and within forests. In the prevailing theory of evolution, structures are stable because they have a function, and if structures loose their function, they are lost, e.g. the legs of snakes. To explain the exactly stable shape of tree leaves, I am not aware of any explanation in terms of strict biological function. So why is the shape stable, be it beautiful or not? If there is an explanation, I doubt whether it will come through a current concept of biology.

Some biological structures have a very obvious function. However the biological function may not be not easy to understand in evolutionary terms. A general rule, one evolutionary advantage is the economic use of energy. Yet, this does not consistently fit: An example is the giant deer which lived shortly after the last the ice age in Europe. The male had antlers which supposedly impressed the female, and the males with the larger antlers were probably the more successful ones to reproduce. This was an evolutionary trap contributing to the extinction of that deer: the antlers became giant and the animal could not easily escape in the forest from the large carnivores. Pictures of this and other ice-age animals, painted some 10 - 30.000 years ago are, by the way, evidence that humans knew their companion animals, both in terms of biological observation and in terms of art. - The structure of some orchid flowers is also very “functional”. Many people consider orchids to be among the most beautiful flowers. *Coryanthes* has possibly the most complicated form among all flowers. It attracts the males of specific flies by producing a flavour which mimics the odour of the female fly. The male flies try to reach the source of the smell by climbing up inside a tube at one side of the flower. Being many males to compete in reaching the top, the slide and drop into the “bath” formed by the lower part of the flower, and into which a liquid drops from

special glands in the flower. The fly swims through that liquid, reaches the opposite side of the bath where the surface is rough so it can climb out, but the surrounding leaves of the flower oblige the fly to crawl through a tunnel between leaves. Here it takes up pollen from the flower and, if it has survived so far, the fly can escape. It will smell the next flower imitating its female and the path through the trap starts again. This second flower now receives the pollen of the first. If you perceive that flower as beautiful, it may offer a bridge between beauty and function. If it did not touch your aesthetic sense, it will at least leave you with the enigma of evolution of such a complex biological system: the evolution through small steps resulting from natural selection would include intermediate function-less structures, and these would not be viable if "selection of the fittest" were the driving force of evolution.

Complexity of biology is my second point of discussion, and which may lead to a more sophisticated concept of beauty, one, which includes understanding of biological interrelations an variability. Metamorphosis and morphogenesis involve aspects of complexity. The caterpillar and butterfly are the best known example of metamorphosis. These changing animals are so familiar to us that the taste of a "biological miracle" is felt only after some reflection. The caterpillar and the butterfly are frequently both highly specialised for their plant on which they feed, and with which they share a co-evolution. In fact, co-dependence, or symbiosis, has developed for some flowers and butterflies, which can no longer exist (for reproduction or for food) without the partner. – In the old Egyptian culture, the dung beetle *Scarabaeus* was a venerated animal. It collects dung to prepare a breeding chamber for its larva. The larva lives on the dung, it transforms to the beetle. This metamorphosis from faecal matter to a shiny beetle was perceived through religion as creational complexity and led to worshipping this beetle. – By analogy, the lotos plant is worshipped by buddists, not only because it has very beautiful flower, but because it grows from the mud on the bottom of a lake, thus transforming the unusable, stinking remains in water into this flower. There are other examples where understanding of animals and plants has induced mankind to perceive them as symbols. Symbolic perception adds a mental aspect of complexity to the biological complexity of an organism. However the mental truth of a symbolic character is not measurable by means of natural sciences.

Clearly, human culture or religion perceive life and living beings not only through the view of biological sciences, but also at a level which is different from "scientific biology". This perception escapes the proof of being correct or false as understood within natural sciences. This, however, does not imply that such perception could be negated or even

dismissed as wrong. Certainly, this perception does exist in humans and is part of our being. Within this perception, we may realise “plans” or “mental concepts” behind what we describe in natural science.

As third point, I will develop on “mental concepts” and principles of biology. Through those, a link to arts may become apparent. A “concept” for a plant can be illustrated in the metamorphosis of the leaves of *Paeonia*. Their changing shapes from the bottom of the plant to and through the leaves of the flower was already noted by Albrecht Dürer (around 1505) and later described by Goethe (1790) in his “Metamorphosis of the plant”. The central observation is that each individual leaf has a shape which is in continuity with its preceding and following leaf, but the full sequence includes leaves with apparently unrelated forms and unrelated functions. The morphology of *Paeonia* follows a concept, which is visible only through the entity of the organism and not by any single part alone. – Another example of a “mental concept” may be found the design of the pattern of snail shells. These patterns do appear frequently on animals living in depths of the ocean, where there is no light for any other animal to see that design (thus excluding any signal function); the design is sometimes in the interior of the shell, so it may be seen only when it is empty, i.e. after the animal has died.

In addition to a “mental concept” which is expressed in an organism, there are principles of organism design, which are apparent in the vast majority of all animals or plants. And through these principles we approach also principles of art. Thus, multicellular animals and plants show the principle of metamery or “repetition”. The simple examples are the rings of earthworms or centipedes among animals, and the alternate sequence of leaves in a bamboo. In our human body, we have ribs and vertebrae as obvious examples or repetition. Developmental biologists have shown that metamery is at the evolutionary origin also of, e.g., our heart, our major arteries and major nerves. I will dare an analogy to art: repetition is a major characteristic in art: in music we feel it as rhythm, in poetry we listen to verses. Is there a possible link between repetition in biology and art? The lowest level of explanation is that rhythm interacts with our heart beat. Less simply, verses create emotions through rhythm plus words. A very complex level of “repetition” is central to variations in musical themes, most obviously in the old passacaglias (variations on a theme of the continuo) or in jazz (repetition of harmonies). I advance the hypothesis, that metameric biological structures and our perception of rhythm in art emanate from the same “mental concept”.

Symmetry is another principle or “mental concept” in biology. Except sponges and a few other groups of organisms, symmetry determines the external appearance of nearly all

animals and plants. Symmetry is two fold (bilateral or dorso-ventral) for most animals, it is radial for most plants (exception: the flower of *Calla*). Symmetry is immediately evident in the designs of all kinds of organisms according to German Zoologist Ernst Haeckel[2]. Most importantly, this symmetry is always visible to the outside of organisms. Non-symmetric morphology is present only in the inside, the invisible parts of the body. This principle of "self-presentation of life" (Selbstdarstellung des Lebendigen) was described by the Swiss Zoologist Adolf Portmann[3]. If we look at the anatomy of humans, we are externally made of left-right-symmetrical two-fold organs. All external organs, of which we have only one (e.g. nose, mouth) are localised centrally and are themselves bilateral). However, all inner organs of which we have only one, are non-symmetrical (e.g. heart on the left, the larger lung on the right). - Symmetry is also wide-spread in, although not a consistent feature of, art. It is most apparent in architecture, and less consciously perceived in music. A surprising complexity of symmetry in old paintings (e.g. by Leonardo da Vinci) struck me as biologist, although an artist may consider this very normal. Another aspect of symmetry in art may be the "balance" between various parts of a paining, balance by colour, by structure, or through symbolic expression. What seems important to me is that we perceive art as beautiful, if they follow such rules.

What is the essence of work for scientists and for artists? Both try to discover the laws ruling life and the appearance of the world. Scientists try to formulate ever more basic laws or laws which can explain an ever increasing spectrum of observations. Albert Einstein´s formula $e = mc^2$ is a basic law governing all physics. The rules governing the order of electrons in any atom determine every single chemical reaction. The discovery of the genetic code consisting of 4 nucleotides is universally valid for every living organism. Scientists aim to describe their observations according to these basic laws until the subject of their research is fully "explainable" to themselves and, thus to others. Artists also try to perceive the object of their art in its essence. They convey their discovery in their terms. Understanding their message does not necessarily need less effort by the non-scientist than does understanding a biological message by a non-biologist. We need a trained perception for a piece of science as well as for a piece of art. Only then can we realise the governing principles. And then we will realize that we look at the same object from two independent, but complementary points of understanding.

Scientists and – as I suppose – also artists feel satisfaction, once they have discovered a law inherent of their study object. Satisfaction is greater, if the discovery is valid for a wider range of observation or perception. Both are excited, if a truth is discovered. We discover -

yet the form of flower exists whether it is understood or perceived by us or not. However, to understand, to explain or to express its appearance requires a mental process for us humans. If in addition we feel with the senses of our body a piece of art or a natural form, we enjoy this emotionally. Through intellect and emotions, we may understand the complexity and essence of an object or a living being, and we may create an representation thereof. Imagination and creativity are therefore the sources of action for both scientists and artists.

Why are our brain and our emotional structure constructed or created in such a manner that we perceive beauty or satisfaction at all? Why do we feel beauty or sense emotions in a colour, a form or a law governing a scientific or artistic aspect? The answer to these questions reaches beyond both science and art. It approaches to understanding of the consistency of the universe, for which science and art offer just two possible means of approach. As a natural scientist, I am increasingly fascinating to perceive those aspects of nature or creation, which escape my biological explanation. I invite you to find out for yourself, why the sunflowers of van Gogh are beautiful.

Literature:

[1]Charles Percy Snow: The two cultures. Cambridge University Press, 1998 (first published in 1959)

[2]Ernst Haeckel: Kunstformen der Natur. Prestel-Verlag, München New York, 1988 (plates printed between 1899 and 1904)

[3]Adolf Portmann: Neue Wege der Biologie. Sammlung Piper, München, 1960

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