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FANTASTIC MORPHOLOGIES: ANIMAL FORM BETWEEN MYTHOLOGY AND EVO-DEVO

Table of Contents:

Perhaps universal history
is the history of a few metaphors.
J.L. Borges, *Pascal's Sphere*, 1952.

1. Imaginary beings and the rules of form

«It is the animal with the big tail, a tail many yards long and like a fox's brush. How I should like to get my hands on this tail sometime, but it is impossible, the animal is constantly moving about, the tail is constantly being flung this way and that. The animal resembles a kangaroo, but not as to the face, which is flat almost like a human face, and small and oval; only its teeth have any power of expression, whether they are concealed or bared» [Borges 1974, 17]. With these words Franz Kafka describes a bizarre creature that appeared in his dreams: a *hybrid* in which the perspicuous characters of morphologically and ethologically different animals – such as the fox and the kangaroo – are mixed to human somatic traits, recalling ancient mythological beings [Borghese 2009, 283].

Jorge Luis Borges accurately transcribes the words of the Prague writer in his *Book of Imaginary Beings* [Borges 1974], a manual of fantastic zoology written in collaboration with María Guerrero in 1957 and inscribed in the literary tradition of medieval bestiaries. This anthology appears as «a handbook of the strange creatures conceived through time and space by the human imagination» [*ivi*, 12], a reasoned catalogue in which harpies, phoenix, satyrs and many other beings of Greco-Roman mythology are collected together with biblical figures (such as Behemot and Leviathan) and oriental mythical creatures (such as Humbaba, the legendary guardian of the Cedar Forest portrayed in the epic of Gilgameš, or Zaratan, the huge sea turtle described in the early ninth century by the Muslim zoologist al-Yahiz). The structure of all those imaginary beings is peculiar and results «from improbable combinations of parts of different animal species, as in the hippogryph and the chimera» [Minelli 2015, 33].

Since ancient times, man has shown a genuine passion for the recombination of visual elements in unusual and extraordinary forms, a skill that was already noted by the French biologist François Jacob at the beginning of the article *Evolution and tinkering.* He noted that

> some of the 16th-century books devoted to zoology and botany are illustrated by superb drawings of the various animals that populate the Earth. Certain contain detailed descriptions of such creatures as dogs with fish heads, men with chicken legs, or even women without heads. The notion of monsters that blend the characteristics of different species is not itself surprising: everyone has imagined or sketched such hybrids [Jacob 1977, 1161].

Hybrids. Crossings. Fantastic images that «embody a breaching of boundaries that at once fascinates and puzzles» [Minelli 2015, 34] and whose creative mechanism concerns the complex relationship between sensitivity, intellect, and imagination. This peculiar connection has been philosophically analyzed since ancient times [cfr. Ferraris 1996; Franzini & Mazzocut-Mis 1996, 235-247]; however, a more accurate analysis of their mutual relationship can be found in Kantian writings. It is not my intention here to examine the philosophical investigations which led Immanuel Kant to elaborate his theories; I just want to point out that the Königsberg philosopher conceives the imagination as a *faculty of mediation*, a faculty that comes into action whenever a representation is presented to the human mind through the only possible way for man, that of sensitivity and space-time intuitions. In the *Critique of Pure Reason*, the imagination is defined as «the faculty for representing an object even without its presence in intuition» [Kant 1998, 256] and it is usually used in two different ways: this peculiar faculty can be used to *faithfully reproduce* real objects – allowing us, for example, to recall in our mind the representations of past events (imagination as memorial reproduction) – or to *produce images* not derived from experience [*ivi*, 257]. These latter are the result of a "fantastic montage", an "assembly" which – as in the case of the mythological beings mentioned above – combines separate elements, creating formal novelties.

As Kant shows, «the imagination of Homo sapiens has no limits in the creation of fantastic shapes, in the recombination of experiential elements to create monsters, hybrids, wonderful creatures» [Mandrioli & Portera 2013, 267]; but, if the ancients admitted the existence of such imaginary crosses,[1] today we are fully aware that their existence is limited to the ontological domain of the "merely thinkable". This happens not only because nobody on Earth has ever come across these bizarre animals, but also because the imaginary beings created by the human mind are often irreconcilable with physical and biological laws.

Thus, if the imaginary beings described by Borges seem to respect some construction rules shared by existing animals (they preserve, for example, bilateral symmetry or maintain the polarity between the front and the back of the body), however, they do not respect *other* biological regularities, constancies that must be ascribed to a small number of *architectural patterns*, some "sedimented-over-time schemes" which constitute the *memorial archive of nature*. In most cases human imagination created such imaginary beings by limiting itself in caricaturing some distinctive features of existing beings (lengthening, shortening or altering the dimensions of certain body parts) or inserting appendages (wings, additional limbs, fragments of other animals, etc.) in the basic body configuration; nevertheless, in both cases the formal laws of living beings are broken.

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[1] Jacob states that «in the 16th century these creatures belonged, not to the world of fantasies, but to real world. Many people had seen them and described them in detail. The monsters walked alongside the familiar animals of everyday life. They were within the limits of the possible» [Jacob 1977, 1161].

«The unknown artist from whose hands the chimera of Arezzo was created», says in this regard the Italian biologist Alessandro Minelli, «certainly had no concern about the rejection problems that, as we well know today, would have led to the failure of these improbable transplants» [Bruni 2015]: this anonymous artist was not aware of the physical and biological mechanisms which regulate the construction of the "goat and snake part" of Chimera body, "grafted" by our imagination on a lion shape; equally he did not know why the addition of these appendices is impossible from a biological point of view.

In view of the above, the morphologist must ask himself what biologically distinguishes imaginary creatures from some existing animals which are only apparently fantastic. In the attempt to settle this question, we asked ourselves: «the domains of forms created by imagination and the domains of natural forms are completely separate from each other» [Mandrioli & Portera 2013, 270]? What differentiates the Hydra of Lerna, the Sphinx and the Centaur from the small South American Axolotl [Henderson 2013, 2-23], the Siamese twins, the hermaphrodite creatures, the two-headed mammals and the *Drosophila* born with a pair of legs instead of the antennae? And why do these existing creatures generate in us at the same time a feeling of wonder and dismay?[2]

To answer these questions, in this article I try to investigate the reasons for animal variability and to trace «the ways and limits of formal organization» [Wagner & Laubichler 2004, 97], keeping in mind that living form is a mobile structure, a «changeable and complex phenomenon subject to regular and monstrous transformations» [Mazzocut-Mis 1995, 17]. In fact, accordingly to Charles Darwin

> The members of the same class, independently of their habits of life, resemble each other in the general plan of their organization. This resemblance is often expressed by the term "unity

[2] «From a certain point of view, the hermaphrodite is even more disturbing than a centaur or a mermaid», says Minelli. «These, in fact, obey the syntax of the body, namely the spatial and functional relationship between the different parts (head, trunk, limbs), as we know them in ourselves and in our fellow humans – a formal blueprint we take as a model when we try to decipher the morphology of other living beings, whether normal or monstrous» [Minelli 2015, 34].

> of type"; or by saying that the several parts and organs in the different species of the class are homologous. The whole subject is included under the general name of Morphology. This is the most interesting department of natural history, and may be said to be its very soul. What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include similar bones, in the same relative positions? [Darwin 2008, 319]

In this passage of the *Origin of the species*, the father of evolutionism considers morphology as the *soul* of naturalistic research (although he did not make a significant contribution to the development of this biological discipline)[3] and he testifies that nature «always works with the same materials, and that she only engages in varying forms» because «she is subject to mandatory laws, which oblige her to always make the same elements appear, in the same issue, in the same circumstances and with the same connections» [Mazzocut-Mis 1995, 35]. To understand formal phenomena, therefore, we must deal with the plasticity of organic bodies and study the external and internal laws that regulate the emergence of new morphological events in Nature because – says the German poet Johann Wolfgang von Goethe, the father of modern morphology – «discovering the rules of the form» «is the key to all signs of Nature» [Goethe 2009, 115].

[3] The historian of science E.S. Russell states in this regard: «it is a remarkable fact that morphology took but a very little part in the formation of evolution-theory. When one remembers what powerful arguments for evolution can be drawn from such facts as the unity of plan and composition and the law of parallelism, one is astonished to find that it was not the morphologists at all who founded the theory of evolution» [Russell 1916, 213].

2. The hundred eyes of Argos: Evo-Devo, evolutionary plasticity and historical constraints

The concept of *plasticity* plays a central role in Darwin's essay: it adequately accounts for the evolutionary tendency of living beings because, as Friedrich Nietzsche states in a passage of his *Untimely Meditations,* it indicates «the capacity to develop out of oneself in one's own way, *to transform and incorporate into oneself what is past and foreign*, to heal wounds, *to replace what has been lost*, *to recreate broken moulds*» [Nietzsche 2007, 62]. The father of evolutionism uses the term "plastic" from the first pages of the *Origin of the species.* In the chapter entitled *Variation to the domestic state*, Darwin states that every animal body shows an intrinsic character of "openness" and "modifiability" and, therefore, «breeders habitually speak of an animal's organization as something quite plastic, which they can model almost as they please» [Darwin 2008, 26]. As we can see, the concept of plasticity allows him to articulate the relationship between the *variability* of individuals belonging to the same species and their subsequent *selection*, whether it natural (the struggle for survival) or artificial (controlled breeding practices); in fact, just the simple observation reveals a certain attitude of animals to *change their configurations in the attempt to adapt to the environment*. Therefore the term *plasticity* indicates the set of possible changes or, in other words, the structural laws which regulates all the "tolerable" morphological changes [Malabou 2010]. How is articulated the relationship between these structural laws and the natural selection process? Why is the possibility of varying almost infinite but not unlimited? What contributes to the delimitation of the domain of possibilities granted to the living being?

In the last century, the emergence of the Modern Synthesis – the theoretical orientation that, integrating Darwinian theory with the genetics of Gregor Mendel, can be considered the dominant paradigm in twentieth-century biological thought[4] – has favored the affirmation of

[4] «The "synthetic theory", or the "modern synthetic theory" […] derives from the title of a book written by the grandson of Darwin's most effective defender: *Evolution, The Modern Synthesis*, published by Julian Huxley in 1942» [Gould 2002, 503]. The term "synthesis" highlights the integration between the theory of evolution and other

an externalist interpretation of living beings [Newman 1995, 219-223] identifying in natural selection the only leading cause of evolution; in fact, as Fusco and Minelli point out, «in the context of the modern synthesis, the role of environment in organic evolution can be roughly summarized by the well-known phrase: 'environment proposes, natural selection disposes', which expresses the one-way relationship between environment and adaptation in orienting the direction of evolutionary change» [Fusco & Minelli 2010, 547].

Accordingly, the fundamental assumption of this theoretical movement is the idea that genes find direct expression in the *phenotype* (the set of all observable characteristics) and that the animal form is the visible manifestation of the *genotype*, that is, the genetic constitution of an individual [Müller & Newman 2003, 7]. The affirmation of this approach in the twentieth-century scientific debate has therefore contributed to relegate morphology – a discipline based on the observation and comparison of phenotypic forms – to a marginal role in biological studies [Cislaghi 2008, 249]; however, echoing Darwin's quotation, we can affirm that «the very mystery of life is revealed in a thousand forms, which make it manifest, and through which the intelligible can be recovered» [Mazzocut-Mis 1995, 112]: phenotypes «have autonomy that can trump that of the [genetic] programs they supposedly express» [Müller & Newman 2003, 6] and, nowadays, many biologists affirm that the approach taken by Modern Synthesis requires a "revision" and a greater opening towards the study of the external configurations of living beings.[5]

biological branches. In particular, the new Synthesis integrates the Darwinian Theory with genetics (the theory of heredity developed by Mendel), botany, systematics and paleontology. «Up to this point one could consider the MS as, in fact, a synthesis: from Fisher to Dobzhansky, it was a fusion of neo Darwinism and Mendelism achieved through the theory and practice of the new population-statistical genetics. The other major contributions, however, went beyond synthesis to actually adding new concepts to the neo-Darwinian edifice, and in some cases to even contradicting some of Darwin's own positions» [Pigliucci & Müller 2010, 7].

[5] Cfr. Müller & Newman [2003, 3] in which the authors point out that «the appearance of specific, phenotypic elements of construction must not be taken as being caused by natural selection; selection can only work on what already exists». As a consequence, «current evolutionary theory can predict what will be maintained, but

The recent development of the *Evolutionary Developmental Biology* (or more simply *Evo-Devo Theory*) can be understood in this direction as fundamental step to a new *Extended Evolutionary Synthesis* [Pigliucci & Müller 2010]. Evo-Devo Theory is a branch of biology that brings together evolution and development and aims to discover the laws governing the birth, the growth and the morphological organization of living beings. Developmental biology was an ancient field of study but, placing the analysis of form at the core of its researches, it had not ample space in the context of the Modern Synthesis. Moreover, in the past the scientists had few technical tools to investigate animal development. Today, however, «we can open this black box and understand not only the *survival of the fittest*, as evolutionary biology suggests, but also the *arrival of the fittest*, that is, how it is possible to build, through development, the different phenotypes; once the latter are completed, they will then be screened for selection» [Bruni 2015]. We can even aesthetically observe this formal construction because, as the American biologist Sean B. Carroll suggests, «there is also a special grandeur in the view embryology and evolutionary developmental biology provide into the making of animal form and diversity. Part of it is visual, in that we can now see how the endless forms of different animals actually take shape» [Carroll 2005, 13].

The developmental biology research program can, therefore, be useful to provide answers to our questions: why some of the imaginary beings described by the pens of poets and writers could never have existed in nature? And why, on the other hand, do creatures whose composite body structure exceeds human imagination (like, for example, the platypus or the yeti crab [Henderson 2013, 354-365]) exist? Or again: why are some mythological creatures (such as the Cyclops) not in contrast with natural rules and could be the fantastic repurposing of existing animal?

In the early eighties, a group of scientists (including Christiane Nüsslein-Volhard and Eric F. Wieschaus) studied the mutations of the fruit fly (*Drosophila melanogaster*): it was noticed that, among the millions of larvae raised in the laboratory, some specimens had a pair of

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not what will appear» [*ivi*, 7].

legs instead of the antennae and some others were equipped with an extra pair of wings. These specimens had nothing to envy the Greek Gorgons or the Persian Manticore. The researchers discovered that the appearance of these "monstrous flies" did not contradict the "rules of the form" and was due to the mutation of some specific genes which oversee the formation and the organization of morphological structures [Carroll 2005, 61-74]: the *Hox* genes (short for *Homeobox*) or *architect genes* [Caianiello 2006, 48]. These are *morphogens*, because their «information content is expressed in the entire construction of animal process» [Pievani 2006, xv] and their main function is to identify in the embryo the expression of other genes determining the development of different body structures.

The secret of "animal geometry" is therefore linked to these genes: they allow to activate or deactivate the "switches" that, during the formation of an organic process, determine the number of body parts, their shape, their position and their size.

Starting from these premises, in a few decades the *Evo-Devo* has produced a huge mass of experimental data which reveal an exciting result: it was possible to demonstrate the presence of a complex of genes (to be precise a sequence of 180 pairs) that organize for the development of body pattern: these genes are the same not only in the simpler bacteria and organisms but also in the famous *Drosophila melanogaster*, the fruit fly now considered an undisputed protagonist of animal genetics research. A question spontaneously arises: bacteria? Flies? What can these tiny life forms teach us about the morphological construction of human body and, more generally, of the mammal ones? And what information can they give us on the boundary between normal, pathological and imaginary development of forms?

«The common perception», writes Carroll, «reinforced by decades of zoology and a wide cultural divide between biologists who worked on mice, rats, or other conventional models of human biology, and those who worked on "lower" forms – was that the rules of physiology and development differed enormously between mammals and bugs or worms» [Carroll 2005, 63]. The evolutionary lines of these animals diverged more than 500 million years ago and the formal differences accumulated during the geological eras are so great that for decades it has been considered “useless” to carry out speculations and experiments on these creatures in the attempt to understand something more about the genetic and morphological construction of higher animals.

Moreover, as the biologist Jonathan Slack points out with a metaphor of great impact, the discovery of the *homeobox* is comparable to that of the Rosetta stone which allowed us to decipher hieroglyphic writing by means of linguistic comparison [Slack 1984, 364]: despite the great differences in appearance and physiology, all complex animals (including humans) share a small number of regulatory genes (about ten). «If we think that the corporeal architectures of the entire animal kingdom depend on the same conductors who conduct the development dance in very different living beings such as an insect, a frog, a worm and a lion, it appears, in all its dazzling clarity, the matrix of biological and historical unity that embraces living creatures» [*ivi*, 13], a “common frame” which explains the origins of all morphological determination.

It was soon noticed, for example, that the *Distal-less gene* (involved in the development of the fruit fly limbs) has a counterpart in human DNA gene and that the same happened for other *Hox* genes, such as the *Tinman gene* that regulates the development of the circulatory system: all morphogens identified in the “insignificant” fruit fly have a human equivalent. But there is more: it was discovered that the *Eyeless gene* (so named because the mutant flies for this gene do not have eyes) has an equivalent in mammals in the so-called *Small Eye gene*, which corresponds, in turn, to the *Aniridia* human gene. The Eyeless gene was experimentally manipulated and it was shown that it could be activated in anomalous regions of the gnat’s body structure [Carroll 2005, 66]: eyes appeared on the wings and paws and, even more incredible, the same bizarre phenomenon also occurred when homologous genes of other species were introduced into the fly’s gene sequences, demonstrating the equivalence of these genes. In the light of these discoveries, the morphology of Argus, the Greek mythological creature with a hundred eyes, does not appear so bizarre and seems paradoxically to have anticipated the outcome of these experiments.

Furthermore, these discoveries led biologists to admit the existence of a common origin of living beings and to the formation of the concept of *zootype*, a term that indicates «the topographical scheme according to which different organs would be distributed along the main axis of the body of all animals» [Minelli 2009, 45]. We are faced with a «shared body syntax» [Bruni 2015] which explains why each animal can be interpreted as a variation on the theme (represented by the so-called *historical development constraints*, i.e. constraints inherited from its ancestors) or as a different combination of the building blocks belonging to the same genetic box (each living being is «the result of a constructive path that has settled in evolution for different adaptive reasons but starting from the same basic ingredients» [Pievani 2006, xiii]).

3. The wings of Pegasus: architectural constraints and morphospace

Without questioning the truthfulness of these facts, we must ask ourselves if this approach is authentically explanatory towards form and its coming into being. The Evo-Devo Theory allows us «to abandon a version of evolutionary theory based only on genes and on the quantitative variations of allelic frequencies within populations. It adds forms to genes, recognizing that the mechanisms involved in the development of forms have the same importance of other already known mechanisms» [Mandrioli & Portera 2013, 274]; however, we are once again faced with a theoretical attitude that considers phenotype development as the "explication of an acronym" kept in the cell nucleus. The current state of research leads us to affirm that «there simply *aren't enough genes* to "determine" the phenotype» [Callebaut *et al*. 2007, 29] and therefore this theory "sins of excess" because, considering itself exhaustive towards formal development, it does not invoke the help of other emerging biological theories.

In fact, the constraints affecting the development process of organic forms will be of various types: genetic and ontogenetic, physical and historical. For example, the American biologist Stuart A. Newman does not consider the organisms as the simple expressions of their genome, but as a «carnal entity» [Newman 1995]: the animal form is the viewable result of a functional adaptation to the environment, but it is also influenced by physical forces that lies «"outside" (and prior to) the specific architectural blueprints of each particular *Bauplan*» [Gould 2002, 1181]. Only later, the «innovation linked to the phenotype and the development systems that guide its formation can be fixed as a result of a genetic "program", giving rise to defined *Baupläne*» [Mandrioli & Portera 2013, 279].

The problems related to the animal form cannot be explained only tracing the phylogenetic chain of living being because the formal problems of these latter «are in the first instance mathematical problems, their problems of growth are essentially physical problems, and the morphologist is, *ipso facto*, a student of physical science» [Thompson 1942, 10]. Consequently, to understand the animal formal construction we need to analyze the "physical conditions" of our world which «imposes certain limitations on shapes and sizes of the various organisms» [Ceruti 2007, 6].

The Scottish morphologist D'Arcy Thompson underlines this aspect in his most famous work, the essay *On Growth and Form* [Thompson 1942]. He claims, for example, that the animal body shape is regulated by physical principles, such as the «Galileo's principle of necessarily declining surface/volume ratios as geometrically similar objects increase in size» [Gould 2002, 1189]: accordingly to it animals are "sculpted" by natural forces in a different way because tiny animals must dwell «in a world dominated by forces acting upon their surfaces, while large animals will be ruled by gravitational forces operating upon volumes» [*ivi*, 1190].

From these premises it follows that, if only one of two imaginary animals exists in nature, the absence of the other is not necessarily attributable to natural selection; «rather, it may be that nature is not able to generate it, due to various types of constraints (genetic, ontogenetic, physical, structural, mechanical, functional, historical)» [Mandrioli & Portera 2013, 268]: in other words, the animal form is built respecting some *architectural constraints*;[6] some parameters

[6] The Italian term *vincolo* presents the Latin root *vincire* which indicates the act of binding, of chaining to something or someone, as still transpires today in the adjective of wide diffusion *avvincente* (compelling); although deriving from a different etymology, the English term *constraint* also conveys the same meaning, being attributable to a Latin verb *stringo* present in the Italian word *costringere* (to compel) [Gagliasso 2009, 183]. Different and perhaps more interesting, it is the German

or formal restrictions derived from the *generic properties* of organic matter.[7]

In the article *Why pigs don't have wings* [Fodor 2007], American philosopher and cognitive psychologist Jerry A. Fodor affirms that «nobody, not even the most ravening of adaptationists, would seek to explain the absence of winged pigs by claiming that, though there used to be some, the wings proved to be a liability so nature selected against them. Nobody expects to find fossils of a species of winged pig that has now gone extinct. Rather, pigs lack wings because there's no place on pigs to put them» [*ibid*.]. In this regard, Gould writes that «zebras could avoid feline predators by flying away, but even if genetic variation existed (as it almost surely does not!) for constructing a supernumerary pair of limbs in wing like form, zebras clearly exceed permissible weight limits under the venerable Galilean principle of declining surface to volume ratios in large creatures» [Gould 2002, 1029]. Pegasus, the most famous winged horse, would never have been able to fly to our planet, nor could he have accomplished the task assigned by Zeus to transport lightning strikes to Olympus, because he could not in any way free himself from the weight of gravity.

Therefore, the domain of imaginable things does not coincide with that of the possible ones and even less with that of the existing ones: nature is unable to accommodate all imaginable forms because, as Minelli well exemplifies,

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term used to indicate this concept (*Bürde*) and widespread in the scientific field by the Austrian morphologist Rupert Riedl. The latter is a synonym of "load, burden, weight" and, as Salvatore Tedesco points out, it is closely linked to the responsibility [*Verantwortung*] of a character towards subsequent modifications [Tedesco 2010], since the probability that the latter undergoes modifications «depends on the number and the importance of functions and characters depending on it» [Wagner & Laubichler 2004, 98]. For a more in-depth analysis of the notion of terminological and conceptual constraints see Sarà 1998.

7 The constraint is in fact defined by Gould as «coherent set of causal factors that can promote evolutionary change from a structuralist perspective different from – in the helpful sense of "in addition to" or "in conjunction with, and yielding interesting nonlinear conclusions in the amalgamation," rather than "in opposition to" – the functionalist logic of Darwinian natural selection» [Gould 2002, 1026].

> it is not sufficient to know the mesh size of a sieve to make forecasts about the characteristics of the flour or sand that will pass through it. It is also necessary to know what mix of materials we place in it. And one cannot tell whether in this material there are particles of all possible dimensions. […] it is probable that some fraction of small particles that would have easily passed through the sieve, but which in actuality did not, is missing from this material because it was not present in the material to be sieved in the first place [Minelli 2009, 63].

4. Conclusions: from imaginary beings to fantastic beings

At the beginning of this article, I asked myself: what makes the creatures imagined by poets at the same time dismay and marvel? What regularities has the human mind implicitly followed in creating them? And what constraints these imaginary creatures are not able to respect? In this analysis, I tried to trace the path that guided Evo-Devo scholars to identify the *genetic and historically constraints* of animal configurations. These "biological restriction" allows us to understand, on the one hand, why a mythological being like the Cyclops Polyphemus seems *intuitively more adequate* for us than Sirens, Satyrs and Centaurs; on the other hand, they help us to elucidate why nature admits the existence of "bizarre animals" (individuals with more appendages than normal or which presents body tissues in unusual sections). We have also highlighted the existence of some architectural constraints, i.e. limitations that can be attributed to the Physics of our world and are not "genetic sedimentations". Harpies and Griffons could never fly in our world because their wings would not sustain their body mass; conversely, "unusual" and "bizarre" creatures (such as the platypus, the *Aye-Aye* of Madagascar or the *Marcidus Psychrolutes*) are possible in Nature because – as Minelli says – they pass through the "sieve" of reality [Minelli 2009, 63].

These reflections lead us to a paradoxical outcome: nature allows the existence of individuals whose formal configuration has nothing to envy the most famous mythological creatures. However, if this morphological structure can be explained from a biological point of view, it is not equally clear why we instinctively experience a feeling, at the same time, of amazement and fear observing these creatures: why does a mutant fly intimidate us more than the description of Cerberus? Can aesthetic reflection be useful to find an answer to our questions by combining literary suggestions, scientific experiences and philosophical considerations?

In the work *Le Change Heidegger. Du Fantastique en Philosophie*, French thinker Catherine Malabou confronts the theme of *fantastic*, strongly influenced by the reflections of Roger Caillois in the essay *Au cœur du fantastique* [Caillois 2004].

To clarify the importance of this theoretical reference, it is first of all necessary to analyze the definition of the term "fantastic". In his writing Caillois gives an unusual definition of this term: it does not indicate the "fruit of the imagination", the "supernatural" or, more generally, something different from "the photographic reproduction of reality" (i.e. the unreal of fairy tales or the bizarre creatures of mythology); the fantastic is instead the "impossible that comes suddenly", «break in the acknowledged order, an irruption of the inadmissible within the changeless everyday legality» [*ivi*, 152].

To mark the difference between the unreal fairytale and the shocking fantasy, Caillois distinguishes two literary genres dominated by imagination. The first one is the world of the *fantastic declared*: this is characterized by the deliberate invention of an alternative environment, with different laws from the terrestrial ones. In this world Pegasus, the Minotaur, Medusa and other famous literary creatures are *logically possible* and *not biologically in contrast* with the surrounding reality. In this context, warns the French thinker, it makes no sense to speak of something "unusual" or "extraordinary" because the exception is everywhere and indeed constitutes the rule. The second one, the fantasy that emerges "by leaps", is perhaps more interesting: it derives from everyday life and not exceeds the laws of our world; however, it reveals a contradiction inherent in our existence and, for this reason, it is *sublime* (in the Kantian sense of the term) because at the same time it excites and frightens us. Even Tzvetan Todorov – one of the best-known theorists of the structuralist movement – agrees with this theoretical perspective, addressing the defining problem of "fantastic" in a 1970 essay entitled *Introduction à la littérature fantastique*. In this work, the Bulgarian critic is ideally connected to Caillois and defines the fantastic as «the hesitation felt by a being who knows only natural laws, in the face of a supposedly supernatural event» [Todorov 1988, 28]. Therefore, for both authors, the fantastic is something "extraneous in the same": it is the inexplicable that, precisely because of its being anchored to reality, arouses a feeling of uneasiness in us.

In our opinion, the "bizarre but natural" creatures described in this article are of this type: formal modifications which, however amazing, took place in a "customary universe" and these strange living forms testify that evolutionary biology «gives us a richer and more rewarding sense of the nature of existence than a view informed by myth and tradition alone» [Henderson 2013, XV].

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Key words

Morphology; Imaginary beings; Evo-Devo Theory; Constraints; Fantastic

Abstract

Since ancient times, man has shown a genuine passion for the recombination of visual elements in unusual and extraordinary forms; but, if the ancients admitted the existence of mythological creatures, today we are fully aware that their existence is limited to the ontological domain of the "merely thinkable" because imaginary beings are irreconcilable with physical and biological laws. In this article I try to elucidate what differentiates from a morphological point of view the imaginary beings described by the pens of poets (such as Sphinx, mermaids and centaurs) from bizarre but existing animals (i.e. the small South American Axolotl, the Yeti Crab, etc.) or from some specimens belonging to common animal species, but which present strange morphologies due to genetic errors. In dialogue with some positions of contemporary biology and literary criticism, I tried to investigate the rules of form to understand how historical and architectural constraints can influence the morphology of the living and why these existing creatures generate in us at the same time a feeling of wonder and dismay.

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