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The definition of the parameters to design an Evolutionary Model

In order to comprise all the complexity of the evolutionary process and eliminate unpredictability on Design evolution, it's necessary to define not just the phenomena, but also the variables of the equation. As much as the aspects of evolution may be connected, there are particularities that must be defined and separated. Those components are related to the structure of evolutionary beings themselves.

The functional component, which represents the evolutionary intentions and the complementary functionalities among subsystems in an environment, the technical/technological component that represents the means trough which evolutionary beings perform their functions and adapt to environments and the cultural component which represents the non immediate behaviors that lead to the accomplishment of long term tasks and the establishment of overall goals. Since the beginning of design theorization, the establishment of components was already clear.

> "Tutti gli edifici devono soddisfare tre criteri: solidità (firmitas), funzionalità (utilitas) e bellezza (venustas)"

> "Every building must satisfy three criteria: solidity (finitas), functionality (utilitas) and beauty (venustas)"

> Bernhard E. Burdek
> Design. Storia, teoria e pratica del design del prodotto
> 2002
> p.29

The division of these components in design theory were repeatedly reorganized through history, sometimes establishing clear divisions among them, sometimes unifying them as a whole. The choice of names for those components varies among authors, but the basic structure of the components remain almost in every case unaltered. Burdek mentions this component

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formula as: designing, production and marketing. In a sense, this division would represent respectively, functional, technological and cultural aspects of design evolution.

> "La divisione del lavoro negli anni Settanta del Novecento ha portato giovani designer a unificare, progettazione, produzione e marketing come se fossero un tutt'uno."

> "The labor division in the 1970's led young designers to unify, designing, production and marketing as if they were one indivisible thing"

> Bernhard E. Burdek
> Design. Storia, teoria e pratica del design del prodotto
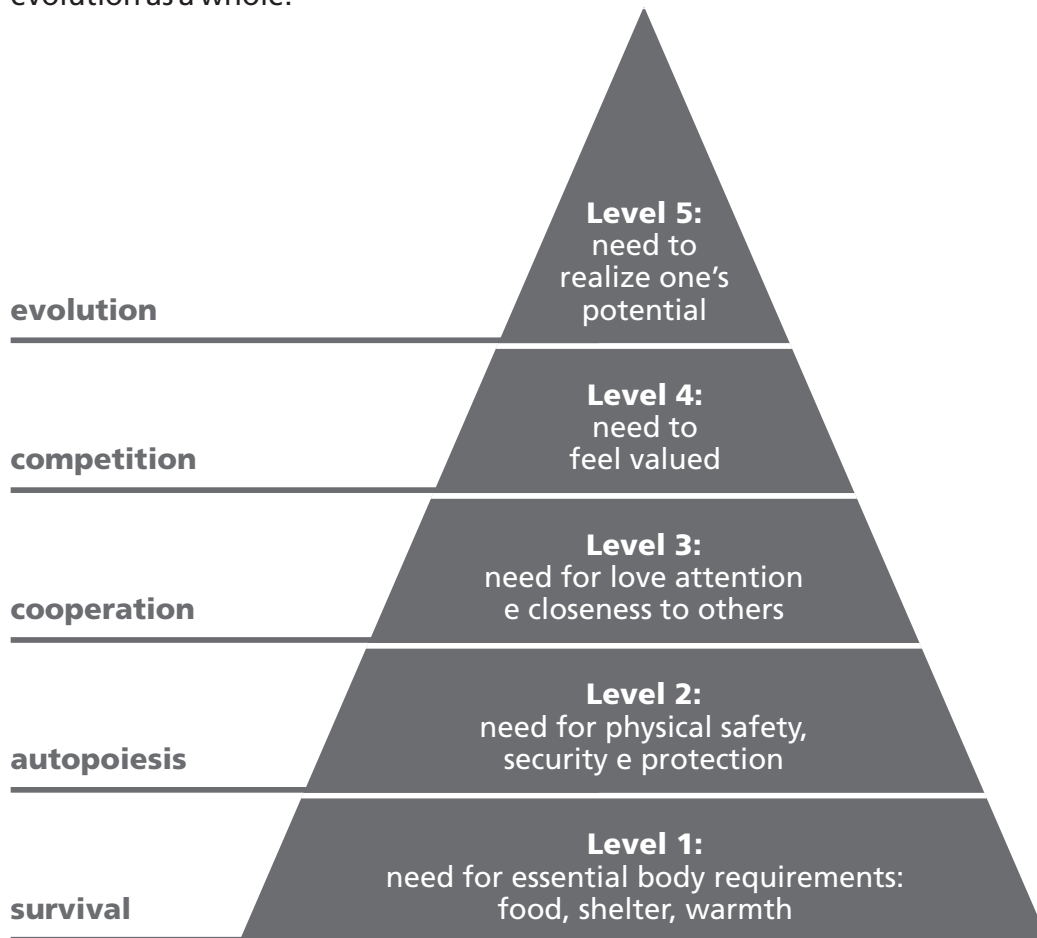> 2002
> p.30

Functional component

To understand the functional component of evolution in a grounded perspective, before speculating the role its role on a macrosystem context, it's valid to find an application of the idea in a human scale, like as the comprehension of how it would be manifested by humans.
As humans evolved, the concept of function got contaminated by derived concepts such as need, desire. these ideas are complementary, need as the urge to perdure, and desire as the urge to enhance and improve. a duality that is a consequence of the development of indirect evolutionary behaviors, the complexity overlap exemplified earlier in this paper and the phenomenon more commonly known as culture.
Notwithstanding the deep connection between these concepts, it's mandatory to establish a very clear distinction between them. Functionality must be subordinated to a very pragmatic criterion. The comprehension of the differences between those ideas is the basis for the definition of the evolution model.

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All the nuances in between those two axis were already classified by various theorists. The Abraham Maslow need hierarchy pyramid (A Pyramid of Human Motivation) is a good example of the gradual transition from basic functional needs to their most complex derivations. It's also interesting how every human need described by Maslow matches with an evolutionary behavior. According to Maslow, human necessities are divided in five categories that go from the most basic physiologic necessities to the most ethereal ones. Even though, Maslow's theory was applied to understand the evolution of a single individual during the course of his life, his principles can be applied to human evolution as a whole.

evolution

Level 5:
need to
realize one's
potential

competition

Level 4:
need to
feel valued

cooperation

Level 3:
need for love attention
e closeness to others

autopoiesis

Level 2:
need for physical safety,
security e protection

survival

Level 1:
need for essential body requirements:
food, shelter, warmth

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The first one is represented by the most basic physiological needs such as breathing, eating, procreating and self-regulation (temperature control, residuum elimination etc). This would be the human version of the most primitive evolutionary needs. In other species or in other evolutionary beings, the parameters may differ but this is a clear representation of what the word functioning would be connected to.

The second level of the pyramid is one of the requirements that determined the transition from organic matter to living creatures in the early stage of earth evolution, the autopoiesis, the capacity self preservation, to heal and avoid harm. In most living creatures, this capacity is one of the most relevant surviving behaviors, in humans, due to their social and psychological structural complexity, this is the second lowest primitive and basic necessity.

The third level theorized by Maslow is the need for belongingness, social interaction, friendship, intimacy and family.

This is still a primordial evolutionary need and can be understood as a basic functioning. It's not vital for evolutionary beings to exist, but the lack of interaction in every vertical reproduction systems annuls the being's reproduction and, evolutionarily, a isolated individual is dead. In an evolutionary level, this necessity is connected to the principle of cooperation and information exchange. Once the basic reproduction and interaction needs are fulfilled, the next evolutionary needs are related to the tendency to compete and prevail. Maslow describes them as necessity to be respected and to have self-esteem and self-respect in a group. In human society, this need is relevant that the lack of acceptance from the group leads an individual to develop psychosomatic illnesses.

The fifth and most complex human need, or rather, the more cultural need is paradoxically the most evolutionary driven behavior. The need to realize one's potential. Maslow claims that all the potential of an individual will be explored "What a man can be, he must be."(Maslow, 1954 pg 91).

Gradually, in the definition of functioning as a variable on evolutionary process, there are respectively the needs to perdure, self preservation, interaction and information exchange, prevail and compete, and ultimately

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the role in the big evolutionary scene, contributing to the overall plan.

All these behaviors are related to human intentions on design, behind the complex functioning of everything that man projects there is a primordial set of functions that are deeply connected to man's basic existing needs, man's evolutionary needs and derivations from this necessities

The main difference between the cultural component and the functional component is that cultural components are developed in an organic random and chaotic way, and may or may not be related to real evolutionary or vital functionings. Examples of these cultural behaviors can be found easily either in primitive and developed societies. The most clear non functional behaviors are the ones that not just have no practical function, but also conflict with basic functionings, cultural unhealthy behaviors such as piling up rings around women's necks in African societies, smoking, using high heeled shoes, etc. It's possible to find the root of every of those useless behaviors in human nature, but by the growth in complexity of human society that led those traits to lose any connection with real functionings.

Even though there are a big set of human behaviors that have not connection with real evolutionary functionings, there is a overall goal that is followed by men since they first appearance on earth and, it is believed to be the same for every evolutionary being. John Smart in his Lecture on evolutionary acceleration argues that some kinds of evolutions are not remarkable unexpected achievements, but instead, they are part of a set of basic evolutionary trends that would be evolved by any being sooner or later. The examples that illustrate this claim are the development of light sensitive devices in living creatures, primitive and complex light sensors were developed in more than 40 different manners in countless species. The same principle would be applied to human creativity. Cars, telecommunication systems and weapons are related to evolutionary paradigms and would be developed in any other intelligent society. The reason why some products would be invented independently from some society's creativity is that there is a ultimate goal on evolution, spread and expansion. Living and non living things must expand, it's in their very essence.

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As we may notice studying human technological evolution from the beginning of industrial revolution, the last human accomplishments have a common characteristic, automation. It's human's primordial need to go beyond his physical limits, the hammer is in this sense an attempt to achieve this goal as much as the space shuttle.

> "What sort of creature man's next successor in the supremacy of the earth is likely to be. We have often heard this debated; but it appears to us that we are ourselves creating our own successors; we are daily adding to the beauty and delicacy of their physical organization; we are daily giving them greater power and supplying by all sorts of ingenious contrivances that self-regulating, self-acting power which will be to them what intellect has been to the human race."

Samuel Butler
Darwin Among the Machines - The Press newspaper - Christchurch, New Zealand
1863

Humans seem to have understood unconsciously that the only way to go beyond physical limits is to create autonomous beings, or rather, life. This natural behavior of trying to transform itself through creativity, to go where he's not physically supposed to or to discover the truth behind nature is as old as human written history. The myth of Icarus is a good example of that.

According to the inscriptions, Icarus' father, Daedalus, a remarkable craftsman, attempted to escape from his exile in Crete, where he and his son were imprisoned by King Minos,. So Daedalus fashioned two pairs of wings out of wax and feathers for himself and his son. Before they took off from the island, Daedalus warned his son not to fly too close to the sun, nor too close to the sea. Overcome by the dizziness that flying gave him, Icarus soared through the sky curiously, but in the process he came too close to the sun, which melted the wax. Icarus kept flapping his wings but soon realized that he had no feathers left and that he was only flapping his bare arms. And so, Icarus fell into the sea.(Robert Gaves, 1955)

As in the myth of Icarus, the Tower of Babel myth demonstrates again a very

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pungent intention to understand nature and go beyond biologic limits, It seems that men had already had a glimpse of the fact that nature was not as simple as the flat ground beneath their feet and emptiness above their heads. As the biblical account tells, According to the biblical account, a united humanity of the generations that followed the Great Flood, speaking a single, came to the land of Shinar, where they decided to build a city with a tower that reached the heavens. Yahweh came down to see what they did, and was concerned: "They are one people and have one language, and nothing will be withholden from them which they purpose to do." So Yahweh said, "Come, let us go down and confound their speech." And so Yahweh dispersed them upon the face of the Earth, and confused their languages, and they left off building the city, which was called Babel "because Yahweh there confounded the language of all the Earth." (Genesis 11:5-8).

This myth is another great example of the necessity to go beyond natural biological limits, represents also the need for full comprehension of the universe. Ultimately it represents the necessity of a cultural connection as a way of transmitting information.

Some events of human actual history illustrate this phenomenon of searching for understanding. Both the development of religious beliefs in almost every human group and its replacement by scientific exploration are manifestation of the same principle. Religion always played a role as a source of information about existence, nature, physics etc. From the earliest greek myths, the old and new testaments, and basically every other religious belief dedicate a considerable part of its manuscripts to explain natural phenomena. In this sense, religion is a primitive form of science, a mix of observation and induction. Evidently, there's also a huge social, organizational and hierarchical character on all religious manifestations that can't be ignored but they don't perform quite a relevant role in our inquiry. Lynn Margulis associates the human technological development with the biological evolution. According to her, human's final goal is the expansion of the earthlings beyond terrestrial limits. In order to accomplish that goal, we've been constantly trying to improve the way we perform tasks, from the simplest to the most complex

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ones, from the less significant to the most relevant to human evolution. Those tasks would be the extrapolation of natural functions such as running faster than any animal, flying higher than any bird, living longer than any creature, going beyond any physical limit.

The same principle found in the overall evolutionary goal can be applied in a smaller perspective. It means that in design the function of a product must be analyzed as higher goal, a paradigm, not just by a product's most immediate associated function: a car is a device that serves as transport, the master scope is to transport faster, consuming less fuel, more secure, more efficient, without mechanical failures. Cars are not family vans or SUVs with four wheels and two or four doors, windows and a horn. In the same logic, a clock is not a round display with hands for minutes and hours, a watch is not a jewel-ish wrist version of the clock, it is a time counting device, and that's precisely why, since counting time became a basic side function of almost every electronic device, the use of watches declined drastically. The comprehension of the almost ethereal character of the functional component is the key to understand how evolution can be manipulated, accelerated and driven in a certain direction.

Cultural component

Culture is the behavioral component of evolution, actions or standards related directly or indirectly by evolutionary beings in order to achieve functional or evolutionary purposes. As seen previously in this paper, as evolution and systems become more complex, the behaviors may acquire a non immediate role, or rather, a behavior may not bring results immediately, but in a long term process. This indirect behavior pattern is not a component exclusively human, It's a phenomenon that most complex systems present. Examples already mentioned in this paper include the task division and planning in a beehive as well as human capacity to plant and harvest, or to plan and start the construction of complex structures as bridges years before the first benefit of the enterprise. However, since evolutionary beings adapt randomly, with the prevalence of the better option and not by a precise and

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accurate adaption, those behaviors may be more or less functional, and exist in a continuous process of adaptation.

The generally accepted idea that some information are inherently connected to the nature of an evolutionary being, and that it is not an aspect on its own (the color red, universally denotes danger because even frogs naturally avoid red snakes) ignores the fact that the formation of cultures may work as a natural learning process over generation, Frogs that are not naturally afraid of poisonous snakes don't survive much, consequently not passing forward the non Ophidiophobic gene set.

Said that, in theory a behaviors may be partially adapted to a functionality, as a matter of fact, either by evolutionary slowness, either by momentary or sudden environmental changes, often a behavior doesn't match perfectly with a function. In the human scenario, residual or non functional behaviors go from ownership of pets (which may have persisted as a residual connection from the ancient hunting partnership between these species), to the interest for watching sport matches (a resilient necessity to compete and war).

As a consequence of this enormous growth in complexity of the functional human structure, the behavioral component reaches a level of relevance ampler than the functionality, occasionally prescinding function completely. This aspect of human behavior is so bewilderingly strong that some authors defend that the role of design is exclusively the definition of the aesthetical and communicative functions of an artifact and that a product may and is legitimated to prescind of technical innovation (Press/ Cooper 2003).

For applicability sake, we shall project the cultural component into a human based reality, as in how the cultural component would work in human design theory. According to Jochen Gros and Richard Fischer from the Academy of Art and Design Offenbach (Germany) in their theory of product language, the study of design can be divided as: the practical functions, such as ergonomical, economical, ecological aspects, and the formal and communicative aspects, the so called product language functions, or rather, the cultural component. This theorized product language is divided in formal aesthetic functions and semantic functions. These semantic functions then, further divided in

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indicating and symbol functions.

I foresee some confusion on the naming of those subdivisions of the cultural component, once it's been used the word "function" to describe exclusively purely functional characteristics and functionalities of an artifact or an evolutionary being, but through respect for the author, I chose to preserve his original names: formal aesthetic functions, semantic functions, indicating functions and symbol functions.

```
            user  ←→  function  →  product
                        ↓      ↘
                  practical    product language
                  functions    sexual function
                                  ↓      ↘
                                    semantic function
                                      ↓        ↘
      formal aesthetic          indicating        symbol
         functions              functions        functions
```
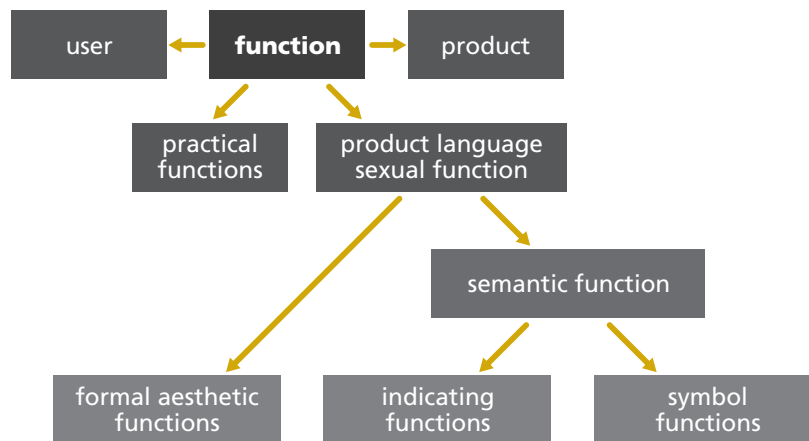
Formal Aesthetic Functions

Correspond to the syntax or "grammar" of the design concept, distinguishing two antagonistic principles: that as all the others, derive from the same set of natural phenomena, order versus complexity, and reduction of stimuli versus richness of stimuli in terms of shapes, color, texture, material etc. Those concepts, as pointed out by Rudolf Arnheim, are opposite in the sense that complexity reduces order and order reduces complexity. Gros and Steffen (2000) identified 11 principles of order and complexity of formal aesthetic functions of products in a vast perspective of design as a transversal discipline found in every human creation. Those antagonistic principles have been manifested in design, both in aesthetics and functionality, since the dawn of

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humanity in many different levels. From the form/function relationship point of view there was a macrotrend of formal simplicity and functional complexity, design paradigm went from formally complex to formally simple, and from functionally simple to functionally complex. In graphic design, the premodern-modern-postmodern-hightech sequence of aesthetical movements present a cycles phenomenon of the same antagonist principles. As much as aesthetics follow its own drift oblivious to the functional or technical evolutions, the variables and phenomena that determine its process are the same found in every evolution process.

less stimuli	**formal aesthetic functions**	more stimuli
simple	**x**	manfold
closed	**x**	open
similar	**x**	different
symmetrical	**x**	assymmetrical
clear	**x**	unclear
horizontal/vertical	**x**	anti horizontal/vertical
in balance	**x**	out of balance
familiar	**x**	new
fitting with context	**x**	in contrast to context

Semantic Functions

Indication Functions

Although most of the indicative functions of a product are arbitrary and conventionalized over time as a result of the development of a cultural structure, its role in evolution is the closest, to an actual function, a cultural component could get. It represents an artifact's potential to communicate a function to a counterpart, a functionality found not just on human designs, but also innumerably in nature, for sexual purposes (reproduction / cooperation) as well as for protection or intimidation (prevalence / competition). Those aspects are divided in nature indicators and practical function indicators.

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Nature indication

In human design, it can, willingly or not, communicate the identity (identification) of an artifact, as belonging to a known category, as in an object that communicates being a toothbrush by looking like the generally accepted shape of toothbrush, or in nature, a snake that communicates belonguing to the group of poisonous vipers by looking like one. It may also communicate the character of an artifact, how it was manufactured, the material used etc.

Indication of practical functions

The other type of indicative function is the potential to communicate how it works, like, the red button on a remote control that conventionally represents the on/off function, or the finger contoured handle with a trigger in a driller that conventionally represents the right way of wielding it.

indication functions	
indicating nature indication ex: as a chair, as a pen etc. **character** ex: material production technique patina etc.	**indicating practical functions** ex: pointing to a direction handing ergonomic appearence usability stability stableness stackability dismanting etc.

Symbol Functions

Although the word symbol was used by many authors referring to different meanings, Jochen Gros and Richard Fischer follow the concept proposed by Rudolf Arnheim and Susanne K Langer by which the meaning of symbols include either

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denotations and connotations. It's a historical naming debate over how arbitrary an information is, or how directly related to actual characteristics of an artifact or evolutionary being in general.

As Gros and Fischer believed, symbol functions refer to the associations the appearance of an object may provoke, such as belonging to the neoclassic period (period style), resembling to German design, or having a retro look, or looking like a Starck design (partial style), or even transmitting emotions such as old, new, resistant, casual, weak etc (associations).

indication functions		
period style	**partial style**	**associations**
Baroque	**look**	old / young
Classicism	ethno look	cold / warm
Art Nouveau	hightech look	natural / artificial
Art Deco	retro look	strong / weak
Modernism	**national style**	rational / emotional
Post Modernism	German Design	happy / serious
	Italian Design	extraordinary / casual
styles of the	Scandinav Design	interesting / boring
future, which	**concept Design**	
are feeded by	styling/streamline	
partial styles, as	new Design	
long as they are	metaphor Design	
in accordance	eco-semantic Design	
with cultural and	**corporate style**	
societal context	Braun	
	Swatch	
	designer's style	
	Vignelli	
	Starck	
	target Design	
	yuppies	
	seniors	

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It's important the comprehension of the differences between the cultural and functional components. This understanding becomes more clear as we realize that culture is nor human creation, nor a human exclusive ability. The capacity to develop non immediate behaviors is a characteristic of most evolutionary beings.

Culture is a consequence of information stimulation and accumulation, there is a connection between the functional and the cultural components, as a complementary functioning, but also a clear gap in between them in a way that information may be created as direct consequence of a function, but can also exist is a relative independency status. The key to understand those differences resides in the imperfections and incompatibilities that emerge from the study of those components.

Technological Component

The technological component represents the means through which functions are performed, the method used to fulfill a need or to develop new functionalities. It is basically the technical solution for a problem. In nature, there are countless examples of how a problem can be solved in different ways, or rather, how a function can be performed through different strategies.. In an environment with scarce luminance, owls developed, over generation of natural selection, big eyeballs in order to capture more light, bats developed a sonar system that performs a complementary sensitive function, prescinding luminance, and some deep water anglerfish of the bathypelagic zone, through a elaborated symbiosis with bacteria, developed a bioluminescent organ in the tip of their escas (Ross Piper 2007). All this technological solutions give for the three species mentioned a competitive differential compared to other animals, adding also secondary functional advantages such as attracting preys, in the case of the anglerfish or surprising preys with poorer sight capacities, in the case of the owl.

The fact that the same task can be performed in different ways gives us 3 important insights, the first one is the fact that some functions are up to be

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performed in every situation. If there is light and the perception of light can be used as information, sooner or later, evolutionary beings will develop the capacity of sensing it. The second one is that there are tendencies, a sequence of technological advances that occur independently from the circumstances, bows, objects of ceramic and spears were invented in every human society. The third one is that there is no inescapable option, inescapable solution for a problem, the resolution of a functional problem may happen in an enormous variety of ways.

> "Evolution works on a just good enough principle, not a perfecting principle (…) it works more like a tinkerer than like an engineer"
>
> Robert Full
> TEDTalks
> 2002

Nature is not the manifestation of an universal truth. The variety of useless genetic residua in human bodies is a compelling argument for this affirmation. Well known examples are the coccyx (residual and useless tailbone), the appendix (an organ also found in herbivore animal in a well developed form aids in high cellulose diets, is useless in human beings).

The autonomy of the technological component commences on the fact that there are more than one way of performing the same function, more than one way of perceiving light, more than one way of digesting food, and more than one way of slicing bread, move from one place to another, or communicate.

As a result of the development of human society, the technological component became increasingly rationalized, as in performed intentionally, which sped up the evolution process and gleamed the rising of the "machine kingdom". The consequence is that some technological researches got more remotely connected to the practical application of the discoveries, gaining autonomy and evolving disconnectedly from the other components.

Good examples are the study of quantum mechanics, the exploration of other planets or the search for the absolute zero.

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"It is as if man had been appointed managing director of the biggest business of all, the business of evolution ... whether he is conscious of what he is doing or not, he is in point of fact determining the future direction of evolution of this Earth. That is his inescapable destiny, and the sooner he realizes it and starts believing it, the better for all concerned."

Julian Huxley
New bottles for new wine
1957

Henry Adams, defends the theory that technology enhances and improves as a curve, in a predictable speed, progressively in phases (such as linguistic/religious phase, mechanical phase, electric phase, electronic phase and so on), in a mathematical predictable exponential rate, oblivious to social or economical events. The example used was the enormously long period of urban shrinkage and human social regression that followed the end of the Roman Empire that had little impact on the continuing of acceleration on technological progress (Lynn White Jr, 1966).

In (The Rule of Phase Applied to History, 1909) Adams speculates that a "Law of Squares" determines the average duration of each new phase in a development of technological process. He envisioned a 90,000 year Religious Phase, what we might call the "Age of Modern Humans", of complex linguistic and cultural innovation which began approximately 100,000 years ago in Africa, and led to the behaviorally modern Cro-Magnon invasion of Europe 40,000 years ago, then, a 300 year Mechanical Phase, the Industrial Information and Computer Ages, followed by a 17 year Electrical Phase, known as the Symbiotic Age, and finally a 4 year Ethereal Phase. Given the difficulty of timing the beginning of each phase, Adams suggests that the start of the emergence of the informatics era might occur anywhere between 1921 and 2025, a rather accurate forecast, considering that by the time Adams wrote his paper, there was not even a far perspective of the invention of the first electronic machine.

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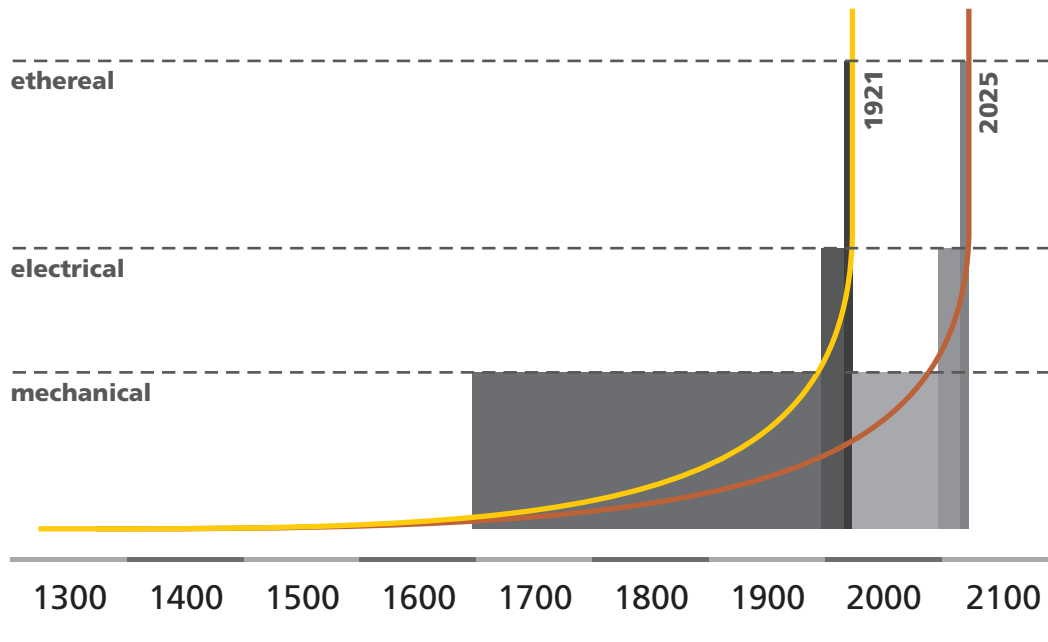
Henry Adams' Law of Squares Achievement of the Ethereal Phase between 1921 and 2025

Other theorists put this evolutionary phases in an even broader perspective, starting from physical phase, followed by chemical, biological, societal and technological phases.

How one component pushes forward the others

As Charles S. Pierce (1935) summed in his "cosmogonic philosophy", evolution is tends to gradually lose its spontaneous character. In Pierce's model, life everywhere seeks to totally order (as far as possible) and reduce the flexibility of an initially fecund universal chaos. This tendency would eventually transform the evolutionary natural process from a tinkering incidental trial and error into a conscious method.

One of this paper's purposes, is to yield to the evolutionary process a conscious character by understanding its mechanisms and flaws. The unbalance or lack of synchrony among evolutionary components is the core of most of its

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inefficiency or slowness. It means that, when on component undergoes a sudden evolutionary shift, it takes time for the other components to reach its position. The tendency of equilibrium among them exists, the components tend to find balance sooner or later, but the process is still random and chaotic.
Evolutionary Driving Phenomena
For most of human history, functional and formal ideal matched perfectly, reaching a condition of being almost the same thing. As a consequence of industrial revolution, the invention of representation technologies such as photography and cinema, the natural artistic exhaustion that came just after the achievement of all possible artistic fidelity theory (perspective, proportion, anatomy etc), art and technique split into two completely different concepts. That event determined the official birth of a very old distinction: Formal Ideal and Functional Ideal. The third piece of this scheme, the Technological Ideal, is the oblivious force that pushes forward evolution in the direction of, according to many theorists, a predetermined computational future. We don't know about that, but definitively, technology gained its own motor and advances sometimes happen independently from a previous functionality motor.

Formal Ideal

Cultural phenomenon pushes forward the functional and technological components

It is the research for an ideal that tries to establish order where there is chaos, to transform natural into designed, it's a human evolutionary unconscious behavior.. As mentioned before, for a long period in eastern culture, the formal ideal was perfection, precision and fidelity to reality and adherence to detail.
Both in art, and in Design, concepts we already merged after a deductive rationalization, this ideal for centuries was expressed as the attempt to hide the flaws of the manufacturing processes. A good pre-industrialization / pre-photography painting would be a painting where you couldn't see the brush stroke, or any unnatural distortion of perspective or proportion, where light and shade were accurate and colors were realistic. In poetry, rhyme, metrics

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and rhythm would hide the spontaneity of the speech, as if no real person could talk as intelligently and precisely in a normal speed rate.

A good piece of furniture, following the same analogy, would show no joints, the counter top would be absolutely flat, the carvings would show no marks from the tools used, the floral ornaments would resemble real florals, and the proportions and symmetry would be impeccable. The goal was to surmount the physical limitations of the materials, to go beyond the physically possible, those characteristics would give and object "aura".

This formal pursuit once achieved, loses its meaning. The benefits of the development, through the phenomenon of complexity overlap, are incorporated to the design knowledge forever, but when the objective is accomplished, it loses its meaning and a new one must be found. In general, the reaction is opposed or antagonistic to the original one.

Functional Ideal

functional phenomenon pushes forward the cultural and technological components

It is the manifestation of technological or cultural goals hooked at a functional ideal. As seen previously, functions and its human version branchings are abstract necessities directly or indirectly related to both surviving and evolving, fighting and overcoming the environmental limitations.

A good study case to illustrate the disconnection among functional ideal and the cultural and technological aspects is the evolution of the time measurement devices. For millennia, the technologies and methodsused to perform this function changed completely, often with no technical cumulative improvements, from solar clocks, to hourglasses, mechanical clock to digital quartz based clocks and finally atomic.

The cultural component manifested as aesthetical functions and habitudes branched in countless forms, the product itself changed to adapt to the cultural needs of a evolving society but the functional goal remained unaltered.

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Technological Ideal

technological phenomenon pushes forward the cultural and functional components

This phenomenon maybe a consequence of a spinoff development, like a technology that was developed for one purpose, and finds answers for questions never made, or solve problems never contemplated. The classical example is the post-it glue formula, a low-tack reusable pressure sensitive adhesive, accidentally developed by Dr. Spencer Silver in 1968 and not used or applied in any product for six years. The idea for a commercial use came in 1974, from Art Fry, one of his colleagues after a seminar.

The post-it is peculiar, in the sense that it doesn't represent the majority of the cases, first because of the improbability of developing a perfectly functional chemical compound by accident, also because there was no primary goal achieved. In general those technological shifts come from successful side functional successes accomplished.

A better example, also partially incidental by the way, is the development of the polytetrafluoroethylene (a.k.a. Teflon). The primary use was the coating of pans for its anti-adherence proprieties. The secondary applications are countless, from chemical equipment coating to roof membrane coverings for buildings like the Hubert H. Humphrey Metrodome in Mineapolis or the Millennium Dome in London. NASA claims dozens of spinoffs out of its primary space exploring purposes, including tempur foam, portable cordless vacuums, freeze drying technology among others.

In the Informatics field, the technological component is very often dragging back the functional and cultural components. The continuous exponential increase in the capacity of processors sometimes find no practical response from the functional in daily life point of view . The consequence was the development of new less potent and thinner versions of the portable computers for users that perform less demanding activities as entering the internet or creating and editing simple text, spread sheets and photo documents, a downgrade phenomenon protruded by the unbalance among the technological and the other components.

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The Internet for example, was a technology implemented for the first time in the late fifties had been used uniquely for scientific experimental purposes for more than three decades. The first professionals to understand the cultural and functional potential of that technology were Marc Andreessen and Eric Bina, two computer programmers of University of Illinois.

The plastic, a sub-product of petroleum that, due to the enormous variety of chemical variants, mechanical characteristics and applications, triggered the development of a new era of Product Design, some of the products created after the invention of plastic could not even be imagined before, like food storage containers (Tupperware), electronic products' casings, disposable cups, plates and flatware, car bumpers, and so on.

Vestigium or residual form, technique or behavior
A structural trait that obliviously resists after a component evolution

Some characteristics of an system, due to cultural reasons or relative irrelevance in its the functioning may persist or even perpetuate over evolutionary changes In the Design case, as seen before, a mutation in one of the components may not be perceived and remain unaltered in the other counterpart components, as in behaviors associated to an element that loses its function over a mutation but remain active. A communication media example is the TV show format with live audience, a descendent of the variety stage show, a type of variety show that was popular from the early 1880s up to the beginning of the 1930s in Canada and the USA, comprised songs, comic acts; dancers, magicians, acrobats, trained animals, impersonators, minstrels etc. By the time that show format was conceived, the audience was the main income source of the organizers. Later, when the radio and TV were popularized, those shows started being broadcasted. A vestigium of the original show format, the presence of the audience, persisted over the mutation of the environmental context. TV station rent auditoriums and pay people to go watch the show. The source of income for the TV stations is the advertising breaks among the blocks, but the audience, by now is a indispensable part of the format. This idea is

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reinforced by a simple logic, if there hadn't happen the pre-mass media variety stage show phenomenon, the TV broadcasters wouldn't have started bringing a paid audience in the first place.

This vestigial aspect of evolution is at the core of what we would call style. A formal characteristic associated with a technical limitation or technical paradigm that gets profoundly associated with a historical period. Some examples are:

The geometricallity of modernism, a philosophical and technical pursuit for precision and cleanness, became so intimately associated with the period that today, even with all the technical precision and cleanness possibilities offered by the computer graphics advances, the use of super clean geometrical shapes evokes Modernism. The same phenomenon can be associated between the use of collage and the Russian Revolution poster design language, or between the early mechanical development of industry and new aesthetic movements such as "Steam Punk" and "Industrial Style".

Evolutionary Phenomena

Fundamental Phenomena

All of those complex evolutionary events, involving a large complexity of components and the accumulation and extrapolation of cycles over time, are a derivation of simple irreducible phenomena, expansion / reduction, division / fusion and the dominance factor. From those simple mathematical operations, repetitions and recombination, there arise all the other complex phenomena.

> "Il sesso, come simbiosi, è un'espressione di un fenomeno universale, il principio di rimescolamento e di assortimento. Due organismi, o sistemi, o oggetti, ben sviluppati e adattati si continuano, reagiscono, si sviluppano di nuovo, si ridefiniscono, si riadattano, e qualcosa di nuovo finisce per emergere. Le invenzioni umane sfruttano continuamente questo rimescolamento e

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riassortimento. Per esempio, i semplici orologi da polso fondono l'orologio e il braccialetto, i carri armati riuniscono mezzi cingolati e cannoni, i sintetizzatori combinano calcolatori e pianoforti e i velivoli ad alla rotante uniscono l'elicottero e l'aeroplano."

"Sex, as symbiosis, is an expression of a universal phenomenon, the principle of remixing and assortment. Two bodies, or systems, or objects, well developed and adapted it continue, react, develop again, redefining, adapt, and something new will ultimately emerge. Human inventions continuously exploit this remixing and replenishment. For example, the simple wrist watch blends the clock and the bracelet, the tanks gather half-tracks and cannons, synthesizers combine calculators and pianos and spinning winged aircrafts combine the helicopter and the airplane."

Lynn Margulis
Microcosmo
1991
p. 176

The principles that allow physically these phenomena are:

¤ The abundance or scarcity of some resource in a given environment, and that determines if a system expands or contracts.
¤ The internal functioning of the system inside the environment, that determines if the system is going to react getting divided or found with other(s)
¤ And the relationship of the system with its competitors or cooperators which will determine in which terms and with which results the fusion, division, expansion or reduction is going to happen, the more efficient and relevant the system, the more likely to perform a dominant role in a fusion or to get autonomy in a division

Summing up, all the evolutionary phenomena are based on the principle of availability of resources (or capacity of usage of resources of an element inside

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an environment), and the relations of dominance, cooperation and competition established among the systems that, there, coexist. The matter in discussion is as ample as the disciplines studied in the formulation of this theory. The phenomena identified correspond to a set of fundamental evolutionary actions and reactions. The words element, resource, system, individual must not be necessarily associated to physical matter, nor in the study of fundamental phenomena, nor in the study of the complex ones, once the study cases are often immaterial concepts such as cultural traits, aesthetics or habitudes. Some preliminary exemplification will be presented with the definition of the phenomena, but a larger, more organized and also more focused on design table of examples will be presented in the next chapter

Expansion

The simplest kind of manifestation of this phenomenon, or better, the manifestation of this phenomenon uncontaminated by any other cumulative phenomenon is the growth of an element (system or individual) enabled by a high level of efficiency inside an environment. In other words, the more adapted to an environment, the more intense the expansion rate.. Expansion may also be part of a larger phenomena, like a cycle, as shown later in this chapter. Expansion with no side phenomena (division or fusion) happens in isolation or when the other existing systems are incompatible. In incompatibility cases the redistribution of resources will merely unbalance the system provoking the reduction of the counterpart elements.

Reduction

Presupposes the pre-existence of the element and its previous growth inside that environment. It occurs when the level of resources decline, or the existence curve of the element arrived the exhaustion point. A good example of a pure reduction phenomenon is the shrinkage of the Celtic culture as a consequence of the Germanic an Latin occupation. With exception to minor

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cultural traits, the parlances used by the Celtics did not merge or were not incorporated by the Germanic and Latin tongues.

Fusion

It represent the loss of unity and the merging of two or more elements. It is manifested when the environmental circumstances force an adaptation. Depending of the dominance factor it may be manifested as:

Neutral fusion happens when both systems are equally efficient, or have proportional exponent. The neutral fusion phenomenon is rather common convergence/divergence cycles, like the sexual biparental reproduction. An economical example is the fusion of companies with similar number of revenue, size, structure etc. The motivations for the fusion are generally the operational costs spare, in abstract terms, a reaction to external lack of resources. In these cases the resulting merged company receives a new name, a parity between the previous independent companies. Dominant fusion the assimilation of smaller and less efficient elements. The resilience of the assimilated elements' characteristics inside the assimilator's system, depends on how strong was the previous identity or efficiency.

A good anthropological example is the discovery (invasion and occupation) of America by Europeans in the 15th and 16th Centuries. Both Anglo-Saxon and Latin colonization areas underwent a fusion process with dominant character of the stronger, more technologically advanced European cultures.

The result was not a complete annihilation of the recessive cultural element, but instead, a fusion with a much stronger European character, language, social structure, governance etc. Recessive fusion is the fusion with a dominant character from the opposite point of view. Represents the assimilation of an element by another system.

the proportion of the elements' characteristics in the final merged being depends on the discrepancy of efficiency and exponent among them.

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Division

The division phenomenon is triggered by the lost of unity inside the system. It may happen by physical isolation, a expansion process that exceeds the functional resistance of the original structure, or by a drastic reduction caused by lack of resources or dissolution of the nucleon. An example as close as possible to a division with no expansion or reduction phenomenon associated is the appearance of different accents in a same tongue, like New Yorker Accent or Alabamian Accent. The dominant component of a division is expressed by the resulting character of the elements previously merged.

A neutral division would be, the perfect split of a system, after which none of the resultant elements maintain (officially or not) unaltered proprieties of the original structure, like the division of the Roman Empire into Western Roman Empire and Eastern Roman Empire. In a dominant division, a dissident minor part of the original structure gets separated leaving the main structure relatively unaltered, like dissident members of a party that create their own. A recessive one, logically, represents the other side of the coin.

Complex Phenomena

Before listing and exemplifying the complex phenomena, a preliminary consideration must be made. Notwithstanding the awareness of the coexistence and recombination of complex phenomena, some principles are, by nature, transversal, are present in every complex evolutionary process. And those are the principle of competition and cooperation, a former more elaborated form of the four basic fundamental operation. The distinction between those concepts can be deceptive, once balance is achieved by a balanced competition, and in that case, it becomes almost a cooperative relationship.

The fight for prevalence and the exchange of information and functionality in a cooperative link is the cornerstone of evolution. The categorization of the phenomena took under consideration a set of grouping rules like the

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principle of symmetry, or rather, understanding that two different phenomena are different sequence of events, or different directions of the same mathematical principle, like reduction as a reflected version of expansion, or division as a mirrored version of fusion and so on. To represent that grouping criterion, it was used the "x" symbol in the name of some of them. The use of the "/" symbol represent the grouping of two analogous phenomena or different manifestations of the same principle.

division by expansion x fusion by reduction

This phenomenon is part of the most primary evolutionary principles. The loss of integrity of a system, consequence of a growth phenomenon that exceeds the capacity of the structure. In human society, the phenomenon is the most common big city dilemma, a overgrown structure incapable of maintaining the integrity or identity. It is a natural evolutionary process, but a historical human conflict, growing infinitely maintaining the unity of the super structure.

The mirrored or opposite phenomenon manifests as the end of a cycle or when the environment presents itself more rigorous than usual, forcing independent elements to merge sharing resources and eliminating redundant tasks. The origin of pluricellular cells, with different organs is theorized to be caused by that phenomenon.

Examples of how big cities lose their identity and become faceless, a recurrent concern of Christopher Alexander. Maybe the phenomenon we're staring at is not the complete loss of identity and the creation of faceless cities, but the natural division of systems after reaching a certain development point. The fact that big developed cities like New York have arisen districts with distinct characters, like SoHo, Village and Bronx is a good argument for that matter.

fusion by expansion x division by reduction

Fusion by expansion would be naturally accompanied by the dominance factor. It is performed by an element that, in its expansion process, embodies
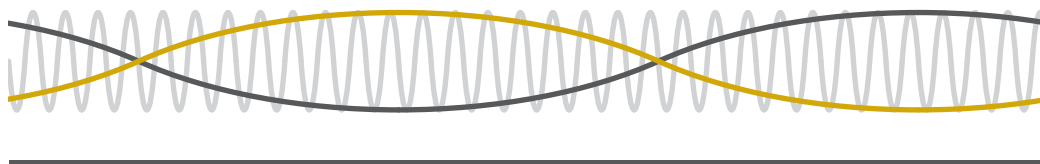
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other elements. In this case the scarcity of resources can be irrelevant, once the preponderant trigger is efficiency and the dimensions of the mentioned element. This progressive loss of diversity, which is compensated by the opposite phenomenon described next, is one of the principles of natural selection, a cyclical recount and reevaluation of the most adapted individuals. Division by reduction is manifested by the loss of unity or integrity in a system or group of individuals leading the crumbled pieces to evolve in different ways and re-propose new and more efficient mutations and adaptations

Cycle

A cycle is a repetition of a phenomenon, or the repetition of more than one phenomenon in alternation. The most primordial forms of cycle, as theorized by biologists, among them Lynn Margulis (Microcosmo, 1991) were caused by the cosmological structure of the solar system, the occurrence of cyclic events like earth's rotation movement (day and night), the translation movement (year seasons).

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Theoretically, this geological propriety is responsible for not just the phenomenon of inspiration and expiration, but also the recombination of genetic material among living creatures, fusions, divisions and consequently biparental sex, life and death. According to Margulis, the first cellular divisions, happened during moments in which resources are more scarce (night or winter) and those simple creatures shirked and got rid of all disposable parts in order to survive. The recombinations, would have happened during abundant periods (day or summer). That was the first primordial version of genetic recombination, the biparental sex.

Tom Kirkwood proposed that the principle of a life cycle is an evolutionary attempt, an energy investment on adaptation and mutation, rather than applying energy on the maintenance of the individual structure, an investment that simple life forms tend not to make, but rather common on complex organisms' cells (Evolution of Aging, 270:301-304). The link between these two facts might signify that the whole biological evolutionary process is a consequence of those primordial cycles, and that evolution is not a voluntary investment on adaptation and mutation but instead a behavior acquired over environmental imposition.

The principle of cycling is present basically in every evolutionary process, It's often manifested as the natural exhaustion of an element and the growth of its counterpart, like cyclical inspiration and expiration processes, or even the alternation of aesthetical trends, rationalism and non-rationalism, cleanness and grunginess etc. The life-cycle phenomenon itself (birth, growth, reproduction and death) is performed not just by living creatures, every existing thing looks to follow that principle, civilizations, languages or aesthetical movements, the principle is omnipresent.

The neutrality of the cycle determines the rate and intensity of the evolutionary (mutation) process, if the cycle is absolutely neutral, in other words, if one element of the system compensates perfectly the action of its counterpart, the cycle is perfect, the is not environmental mutation, the cycle lasts always the same amount of time and the process remains in balance. An unbalanced process, which is probably the case of every existing cycle, leads to
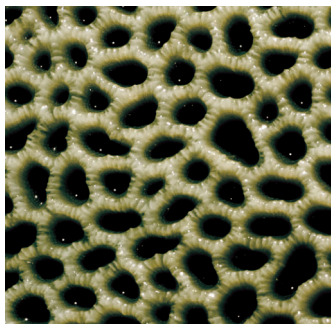
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slow abnormal behavior, acceleration of cycles, excessive growth of one system and eventual rupture

horizontal reproduction

This is the simplest most primitive form of reproduction, it's based on continuous cycles of expansion and division. It is manifested in not very demanding environments, where an adapted system or individual is able to reproduce exponentially. In the microcosm, bacteria and simpler organisms reproduce mostly that way. It is the reproduction of the same original organism, in a sense, the most efficient reproduction form, but also the least evolutionarily driven kind of evolution.
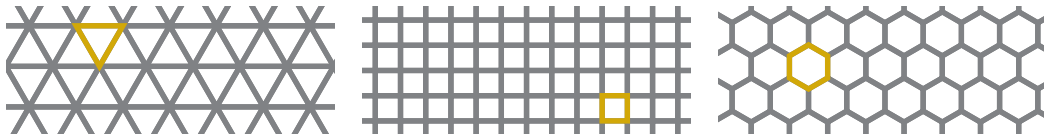
It occurs when no environmental characteristic imposes no limitations or restrictions to the development of an element. The reproduction rate is exponential till the moment it saturates. It maybe a combination of opposite complementary cycles that change gradually the environment.

coral reef
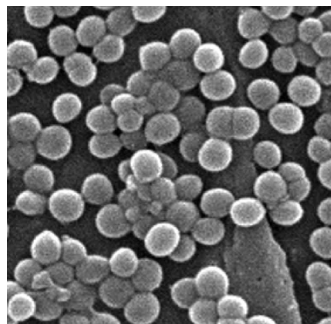
staphylococcus bacteria
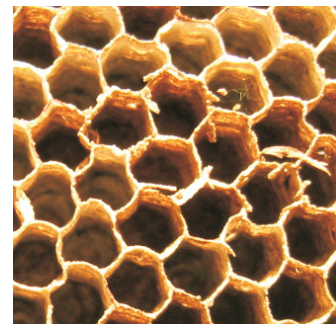
beehive

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A microcosmic example is the expansion of cyanobacteria, a primitive kind of alga that during the early stages of earth evolution took advantage of the oxygen rich atmosphere and spread exponentially in all earth's crust. An anthropological similar phenomenon was the exponential growth of human populations in the scarcely inhabited and yet highly hospitable lands of America after the European colonization. The original populations were apparently just enough adapted, another biological evolutionary principle, and did not expand as fast.

vertical reproduction / complexity overlap

It is the indirect recombination of information, the current elements remain unaltered, the recombination of information is manifested in the subsequent generations. This is not just the most common reproduction procedure in complex creatures, but also the process that allowed the growth in complexity in natural world and what still allows the progressive growth in complexity in human evolution.

It represents the gradual complexity enhancement of an element over time. Good examples are all pluricellular creatures, with different organs, tissues, skeleton, skin, circulatory system, etc. In machine evolution, all the technological perfection is based on that principle.
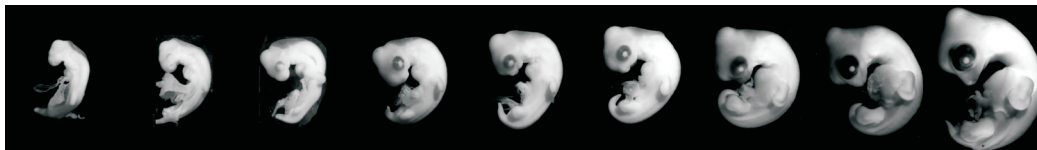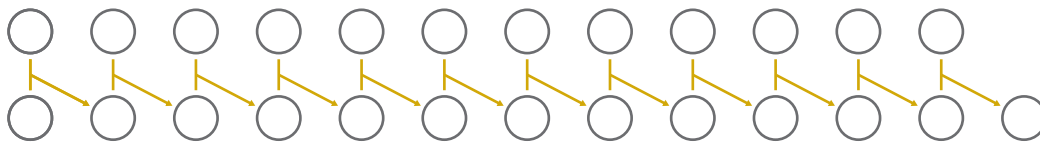
development of a fetus from a fertilized egg

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hierarchical reproduction / deceleration/gravity

It is one of the three forms of fractal growth, being the first kind, the horizontal repetition of the same proportion infinitely, like honeycombs, the second, a growing repetition of the same geometry, like seashells and the third kind, the branching of the structure in smaller proportions.

This form of expansion, the third one, presupposes two movements, the branching and the overall growth of the whole structure, initial section included. This is supposed to be the most efficient, but slowest, form of expansion. The best example is the human expansion in Europeans cities after the second world war, progressive improvement of the original structure, the center, and a slow and restricted branching. The result is that most European modern cities present a stable and decelerating growth of the population and a well administrated, valorized and organized central area. It is a manifestation, in human microcosmic society, of the largest phenomenon, the theorized Big Bang and the opposite restricting force,

Gravity responsible for the organization of galaxies and solar systems, cyclical orbits, the formation of spherical rotating planets and ultimately black holes. Gravity is the force of keeping things in order and avoiding entropy. Regarding the principles of thermodynamics, it consists on gathering energy, organizing structurally elements, what would allow the formation of systems and the overlap of complexity.

roman brocoli

tree growth simulation
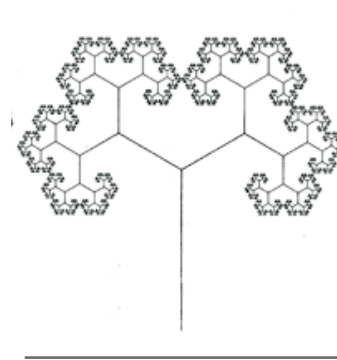
fractal model

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anti-hierarchical reproduction / spread/acceleration

This phenomenon along with the gravitational force are believed to be not just repeating evolutionary phenomena, but the main physical opposite forces of nature.

The anti-hierarchical expansion in nature can be the repetition of the same initial geometry in a larger scale or just the exponential expansion of an element. According to Margulis, expansion and reduction, acceleration and deceleration, are the most powerful evolutionary motor.

"questa è una caratteristica illuminante del microcosmo che gli avvenimenti dirompenti del passato geologico non abbiano mai portato alla totale distruzione della biosfera. In verità, come un artista, la cui miseria "catalizza" la creazione di splendide opere d'arte, sembra che estese catastrofi abbiano sempre immediatamente preceduto importanti innovazioni evolutive. La vita sulla Terra risponde alle minacce, agli oltraggi e alle distruzioni con innovazioni, con lo sviluppo e la riproduzione."

"It is an enlightening characteristic of the microcosm that disruptive events of geological past have never led to the total destruction of the biosphere. In actuality, as an artist, whose misery "catalyzes" the creation of beautiful works of art, it seems that extended disasters have always immediately preceded important evolutionary innovations. Life on Earth responds to threats, challenging and destruction with innovations, with development and reproduction. "

Lynn Margulis
Microcosmo
1991
p. 254, 255

Acceleration is in the basis of every evolutionary process. It can be the result of a non neutral cycles, as described before, a phenomenon characterized by opposite cycles that don't break even over time, accumulating disequilibrium.

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In human cultural and technological development process, it is manifested by the velocity with which every successive process is performed, like the already mentioned Adam's rule of phase, or the speed with which even the least physical phenomena occur, like the duration of aesthetical movements, the progressive acceleration of beat rate in music etc.

The tendency to reduce cycling durations may reach a point in which opposite cycles are not even in alternation, but instead contemporarily, like the crumbling of aesthetical periods from Gothic, Baroque, Romanticism into short lasting aesthetical movements like impressionism and expressionism and ultimately the entropic mass of contemporary art.

A sub-phenomenon, which could be pretty much seen as a super sized version of a life cycle's end is the rupture, the exhaustion of a period. In biology the quote placed above illustrates perfectly this phenomenon, the gradual end of an era and the beginning of another more adapted, more complex and more evolved.

Maybe the creative crisis in Hollywoodian cinema, symptomatically exposed by the recurrent production of hypertrophic remakes of old successful films is a good sign of the end of this exhaust cinematographic era and the beginning of something new.


sea shell

sea shell growth simulation
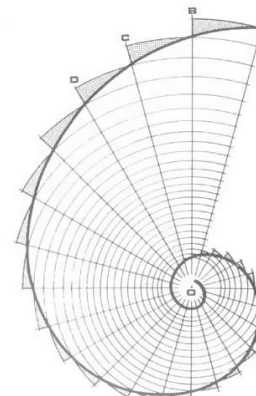
fractal model

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divergence x convergence

Divergence is the manifestation of a physical division followed by isolation and mutation. A phenomenon perpetrated by elements that for internal or external reasons, split and develop autonomously mutations. Every existing creature underwent a similar process, considering, for example that all vertebrate animals are in some level relatives, and share a common origin, or that the DNA RNA language is shared and manifested in different manners by all living creatures.

aquatic vertebrate

bird

bat

human

lion

horse

frog

whale
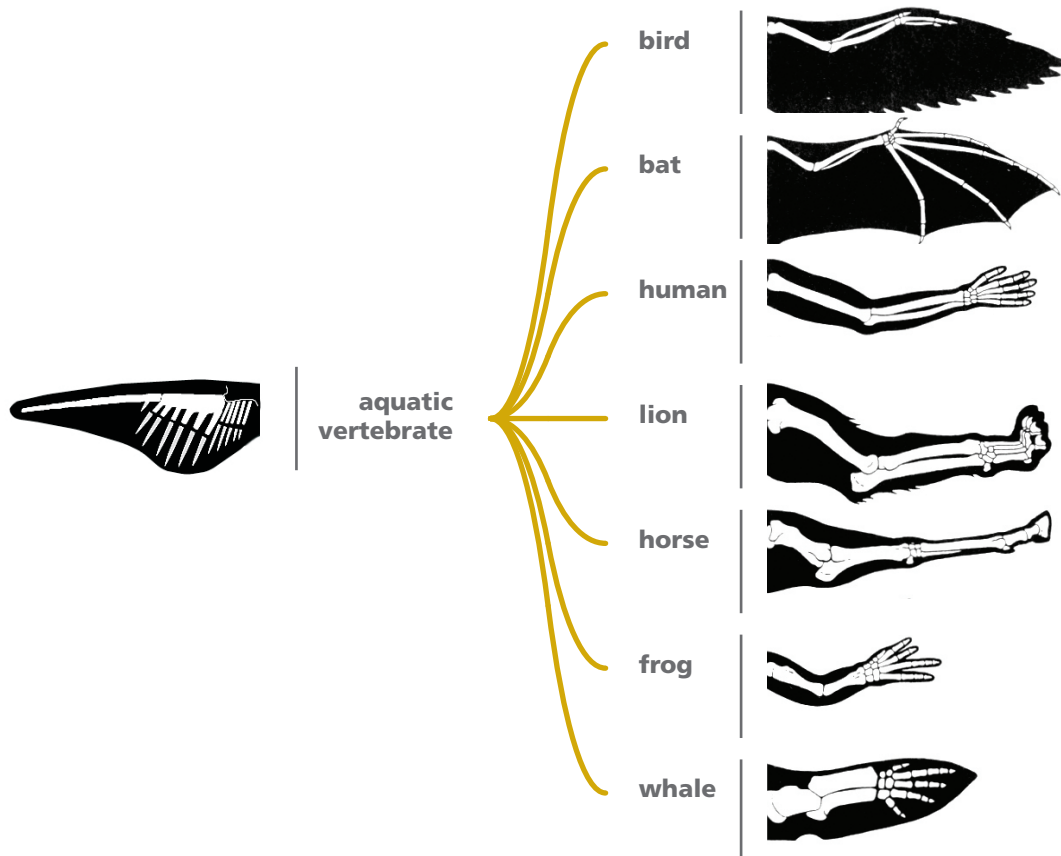
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The opposite phenomenon would be characterized by the already exemplified development of similar solutions by different elements, like eyes, legs, beaks, camouflage etc. A good example of this phenomenon in Human culture is the divergence of knowledge. In the dawn of scientific thinking, there emerged the discipline that comprised the study of everything. Philosophy, was "the" science of the ancient man. Eventually, when scientific thought got more developed, knowledge was categorized, Philosophy got divide into all the existing sciences, Mathematics, Physics, Geometry, Medicine, Sociology, Psychology etc. The opposite phenomenon, also in human knowledge is the convergence of the knowledge of the composition of matter and the atom and the space exploration got more advanced, some common principles emerged pushing scientists of many areas to look for a master theory, a simple formula that would explain everything. That would be the convergence of sciences like quantum mechanics, physics, mathematics and astronomy.

The convergence, divergence phenomena are complementary, work as all the others cyclically performing mutations and evolution.

The bee eye, the squid eye and the horse eye, developed separately.

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Evolution as a Master phenomenon

Evolution in the micro perspective is guided by those simple principles, and the accumulation of all of them, not in an alternated way, but in a single master tendency. It means that spread and gravity would cause cycles to happen, forcing elements to follow these cycles, dividing and recombining themselves, expanding and contracting, and thus, growing in complexity. Some subsystems under gravity force would grow more hierarchically and decelerate while others would develop in an accelerative rate, also influenced by action of mastercycles of acceleration and deceleration. Over time random production of variations would provoke divergence and the impositions of the system would force different individuals to converge, finding universally efficient ways to react to an stimulus.