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Biological Periodicity's Atomic Mechanism Disposes of the "Current Theory" of Evolution

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Abstract

Physics led the way in the creation of Molecular Biology by employing X-ray crystallography in the elucidation of the atomic structure of proteins and DNA. Now it is physics again, by using large accelerators of electrons and neutrons, that is transforming molecular biology into Atomic Biology. This transformation process is guided by the establishment of periodicity, a phenomenon that can now be shown to start with elementary particles, to extend to atoms and macromolecules, and to occur equally among living organisms including humans. Biological periodicity was established in the following properties: vision, regeneration, luminescence, flight, placenta, penis, plant carnivory and mental ability. Significant is that three of these properties do not start at the cell or the organism, as previously thought, but emerge already in crystals and minerals which have no genes, and where organization is decided by atomic and electronic interactions. The punctuated reappearance of a given property, which leads to periodicity, is based on its own evolution of DNA. This is demonstrated by the formation of the placenta, which in plants and in humans, is decided by the same DNA sequences. Also, vision, which appears in the simplest invertebrates as well as in humans results from the action of the same gene *Pax6*. It is this DNA homology which allows the reappearance of the same pattern, in the most different organisms. The law of periodicity which has been enunciated at the atomic level holds equally well for the periodicity found in living organisms allowing predictions.

Keywords: biological periodicity, periodicity of elementary particles, periodicity of chemical elements, atomic biology, vision, regeneration, luminescence, flight, placenta, penis, plant carnivory, mental ability, crystals, minerals, accelerators of electrons and neutrons, periodicity of universe

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PART 1. It was Physics Which Led to the Emergence of Molecular Biology

1.1. X-Ray Crystallography Opened the Way to the Atomic Structure of Proteins and DNA

Molecular biology was born from the interaction of physics with microbiology and genetics. The original impulse did not come from biological disciplines, as could have been expected, but from experimental physics.

The pioneers were: Max von Laue (1879-1960), William Bragg (1862-1942) and Lawrence Bragg (1890-1971). All three were physicists. von Laue demonstrated that X-rays were electromagnetic waves, like light, but of very short wavelength. He then realized that the atoms in a crystal were in an ordered array, in accord with their external regularity. He passed a narrow beam of X-rays through a crystal of a copper compound and obtained a diffraction pattern of spots on a photographic film.

This experiment became the basis on which the Braggs later created X-ray crystallography. The atomic layers of a crystal acted as mirrors, reflecting X-rays, with interference resulting from reflexions at different layers. It allowed them to measure the interatomic distance in crystals of diamond, copper and salts, such as KCl. The ordered atomic interior of crystals became a reality.

Subsequently John D. Bernal, after taking a degree in physics, joined W.H. Bragg in London in 1923. Bernal published works on the position of carbon atoms in graphite and on a simple method of interpreting X-ray diffraction pictures that was widely adopted. Later, at Cambridge, Bernal discovered the rich X-ray diffraction patterns of protein crystals and of viruses. He opened a new field of research at the cellular level.

Biologists tend to think in terms of complexity and, by 1936 genetics had advanced so far, that the gene was considered to consist of proteins. Nucleic acids were too simple to carry the genetic material: "The riddle of life was in the structure of proteins".

It was at that time that Max Perutz joined Bernal at his laboratory and who after 30 years of intense labor, produced the three-dimensional map of haemoglobin (Perutz 2003).

Following World War II another student of Bernal was Rosalind Franklin a physical chemist (1920-1958) who collaborated with M. Wilkins. She produced the X-ray diffraction pattern of a thread of DNA. The bold cross-like pattern that emerged was characteristic of a helical structure and this led James Watson and Francis Crick to make a double-helical model of DNA in 1953.

Figure 1: Aerial view of MAX IV accelerator laboratory which started operating in June 2016 at Lund University, Lund, Sweden.

1.2. The Contribution of Genetics and Microbiology

In the meantime, George Beadle joined Edward L. Tatum who worked with the fungus *Neurospora*. The mutations obtained, by X-rays, led them to the concept of "one gene — one enzyme".

But it was from France, that microbiologists would give a major explanation of the genetic events occurring in the cell. Jacques Monod, Francois Jacob and André Lwoff studied mutant bacteria. They were led to introduce the idea of *operons*, groups of genes with related functions, which were controlled by an *operator*. They also developed the idea of messenger RNA, which carries information from DNA to the ribosomes, where protein synthesis occurs. All their predictions were fully confirmed, not only in bacteria, but in other living organisms from plants to humans.

By the 1960s Molecular Biology came of age.

1.3. Physics is Now Transforming Molecular Biology into Atomic Biology

New technologies are now allowing to go deeper than the atom.

Over 900 scientists have been performing experiments since 2013 using synchrotron radiation of the MAX II AND MAX III accelerators from Lund University in Sweden and a still more efficient laboratory MAX IV, has been completed in June 2016 (Figure 1).

Synchrotron radiation is obtained when electrons are accelerated to a speed close to that of light. At the same time a magnetic field curves their trajectory.

X-rays may damage the materials studied. As a consequence new laboratories are being created to use instead neutron scattering to probe the structures but in addition the behavior of large molecules. For this purpose the European Spallation Source is now under construction at Lund University and is expected to open in 2023 with 3,000 scientists working per year.

Neutrons probe structure, but most important, also motion. Measurement of structure extends from micrometers to one-hundred-thousandth of a micrometer and motion is recorded from milliseconds to ten-million-millionths of a millisecond (Eriksson 2015, Andersson 2020).

PART 2. Periodicity is a Phenomenon Inherent to Matter and Energy that will Guide Physics into Novel Areas of Research

2.1. Periodicity is Already Present in Elementary Particles

Padamsee (2003) described the present view of the evolution and periodicity of elementary particles as follows.

By 1963 physicists had identified 41 new particles. By 1970 the list exploded to several hundred. Most particles were unstable and there was a bewildering array, with various masses, charges and spin.

However, further research revealed that the initial plethora of particles could be reduced to two fundamental ones: quarks and leptons, which by combination produced all the others. This result led also to the establishment of their periodicity in the form of a Periodic Table of Elementary Particles. Murray Gell-Mann (1929-2019) succeeded in elucidating from the chaotic subnuclear landscape certain underlying patterns well hidden among the new properties. As Padamsee (2003) points out: "Order does exist, although at a deeper level than immediately recognizable".

This quark model predicted new particles with very specific properties which were later found experimentally. There are six quarks altogether in three genera-

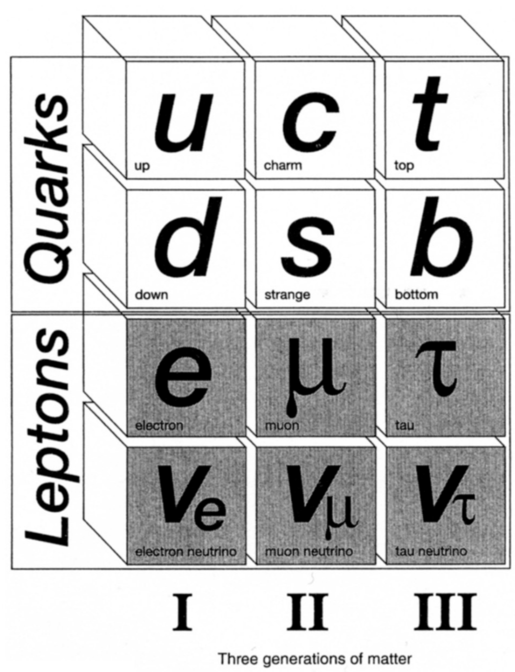


Figure 2: Periodic Table of quarks and leptons showing the three generations of matter derived from leptons and quarks.

tions of pairs: *up, down*; *charm, strange*; and *top, bottom*; and quark mass increases with generation. Each quark has an anti-quark partner. The leptons also span three generations in pairs: *electron, electron neutrino*; *muon, muon neutrino*; and *tau, tau neutrino*.

The evolution of the elementary particles results from the finding that all are derived from only two: a quark and a lepton. This is the same situation that happens later at the atomic level in which all the 118 chemical elements are derived from a single atom: hydrogen.

The periodicity is revealed by elementary particles which happen to have the same property. There are 3 types of neutrinos: electron neutrino, muon neutrino and tau neutrino with increasing mass (Figure 2). This is also the same situation that happens at the atomic level where atoms with increasing mass have the same basic properties, such as the noble gases.

Significant is that quarks and leptons are considered to have no structure — we are at the very core of matter and energy.

2.2. DNA has no Information for Iron, Zinc or Magnesium — The Importance of Single Atoms

Hemoglobin is a protein that functions as a respiratory pigment by binding oxygen reversibly. Its function is not located on the amino acid sequences which were formed, following instructions from DNA, but is carried by the four atoms of iron which occupy exact positions in the macromolecule. The ability to oxidize existed in iron before the cell was formed. It is the speed of the process that was enormously improved by the novel location within the edifice of amino acid residues.

Zinc finger is a protein motif associated with DNA-binding proteins. It consists of a loop of 12 amino acids that directly coordinates a zinc atom. These proteins intercalate directly into the DNA helix, but the main function lies in the zinc atom and not in the amino acid sequences.

Chlorophyll is responsible for light capture in the photosynthesis of plants. Each molecule comprises a porphyrin group containing magnesium. It is the magnesium atom which is responsible for its main function.

The simple atoms of iron, zinc and magnesium, are those that have the key to the functions of these vital macromolecules but DNA has no information for these atoms.

All this novel evidence points to the extreme importance of single atoms.

2.3. The Physical Rules that Predict the Atomic Behavior of DNA and Proteins Remain Elusive

At present there is a most detailed and coherent picture of the structure and function of DNA, RNA and proteins elucidating the biochemical activity of the cell. However, what are the physical rules that direct the evolution of these macromolecules? This question had been asked earlier for proteins because they are so many and diversified.

Concerning DNA and RNA we are mostly in the dark but physicists are now helping in this direction. Computer graphics and nuclear magnetic resonance have allowed a better resolution of their three-dimensional structure and function. But the picture is still far from satisfactory. As C. Branden and J. Tooze (1991) already pointed out "We shall not unravel the chemistry of life in molecular detail without knowing at atomic or close to atomic resolution the structure of biological macromolecules, especially proteins". This still applies to our present state of knowledge in proteins as well as in DNA and RNA, in which the behavior, as well as the movement of single atoms, remains to be elucitated.

2.4. The Iconic Table of the Chemical Elements Contains Many Irregularities —Biological Tables are Expected to be More Irregular but to Carry the Same Underlying Order

Scerri (2007) writes "There is a fundamental relationship between the elements" and he adds: "The periodic law states that after regular but varying intervals the chemical elements show an approximate repetition of their properties". But he also points out that "Periodicity among the elements is neither constant nor exact".

No phenomenon at the physical, chemical or biological level reveals total regularity. Already the periodicity of the movements of the planets in the Solar System contains irregularities. The eccentricity of some planetary orbits, such as that of Mercury, is not negligible (Weinberg 2015).

The Periodic Table of the Elements is accordingly irregular. Hydrogen (H) can be placed close to lithium on the extreme left side of the table, but may also occupy a position at the extreme right at the side of the noble gases. Helium (He) is an element with an anomalous position in the periodic table. The same is true of europium (Eu) and ytterbium (Yb) that belong to the lanthanide series. Other irregularities include chromium (Cr) and copper (Cu) atoms that carry 1 rather than 2 electrons on their outer orbitals.

"There is a clear line between radioactive and stable elements: everything below bismuth (No 83) is stable; everything above it is radioactive — except technetium (Tc) and promethium (Pm), which stick out like sore thumbs" (Gray 2009).

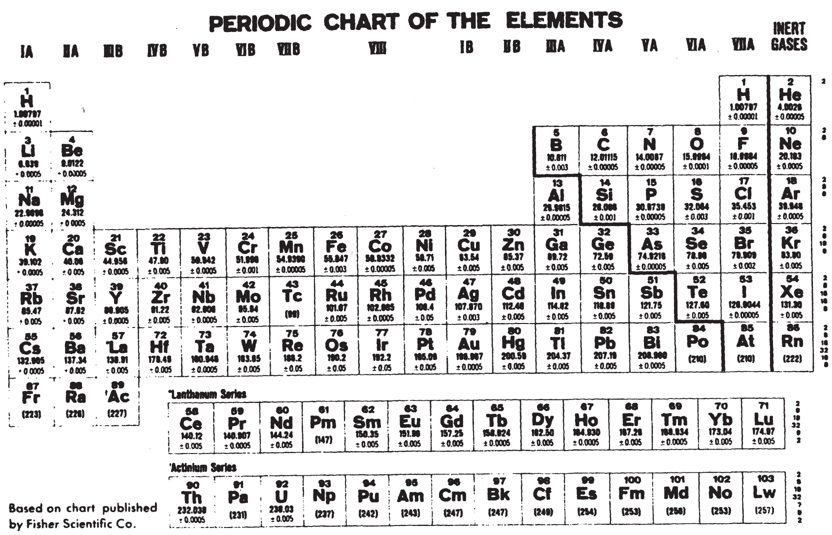
Not less than 700 different graphic representations of the Periodic Table of the Elements, with quite different configurations, have been published exposing the variety of interpretations of periodicity among elements (Mazurs 1974) (Figure 3).

As Gray points out "Chemistry is too complicated for any rule to be absolutely hard and fast".

Biology is still more complicated and as such rules are expected to be even less rigid. But this does not exclude, as is the case of the chemical elements, that there is a fundamental underlying order that pervades biological phenomena.

2.5. The Periodicity of the Chemical Elements has Determined that of Minerals

That the periodicity of the chemical elements has determined the periodicity of the minerals is evidenced by the fact that: arsenic, antimony and bismuth are considered as both minerals and chemical elements (As) (Sb)



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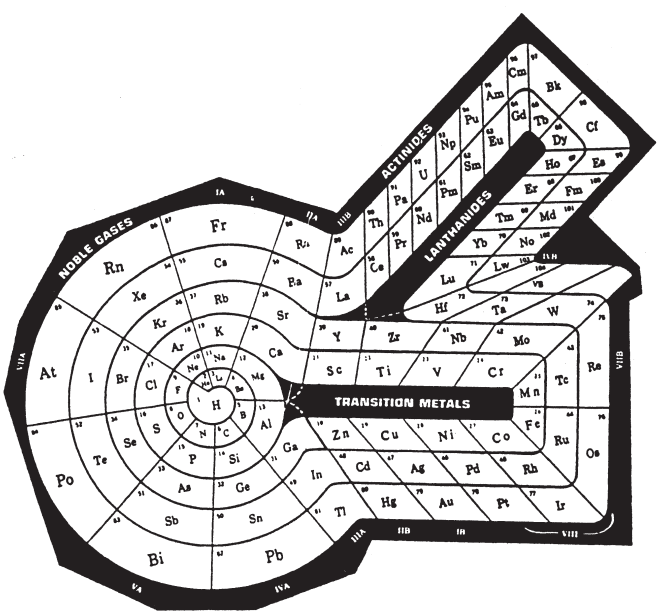

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Figure 3: (1) The periodic chart is based on the original table of Mendeleev from 1869. Since then many other chemical elements have been added according to Mendeleev's prediction (in this chart 103). The vertical columns tend to have elements with the same properties. **(2)** In this spiral representation of periodicity, hydrogen occupies the origin of the spiral, because all other atoms are known to be derived from this chemical element. Within the spiral there is full regularity but the transition metals stick out of it building a separate block. Besides, the Actinides and Lanthanides cannot be easily compressed into any representation: be it the conventional chart where they build two separate rows or this one where they protrude distinctly from the spiral. Inert gases are also called noble gases.

(Bi). Another example is the group of elements consisting of gold, silver and copper (Au, Ag and Cu) that belong to the same group in the periodic table and which are at the same time minerals. Their common properties are known to be the result of the metallic bond of their atoms. As Jaffe (1988) remarks: "Electrons govern chemical behavior of atoms, and how they may be packed into minerals"

Significant, is that the chemical elements did not change their properties as they built the cell, a fact that we tend to overlook.

2.6. Periodicity Governing the Construction of DNA and Proteins

Ohno (1988) has described in detail the occurrence of periodicity among macromolecules. They represent an intermediate stage between chemical elements and living organisms.

Ohno states "It is a mistake to regard any coding sequence as unique implying the descent from random assemblages of four bases. Instead each coding sequence is comprised of primordial and derived repeating units." The DNA periodicity is evident in segments of the human X chromosome where a 419 long coding sequence consists of four widely separated segments (phosphoglycerate kinase coding sequence) (Ohno & Ohno 1986).

In the case of proteins, with transmembrane α-helices, the primordial repeating units of their coding sequences were base heptamers.

PART 3.
The Periodicity in Living Organisms is Displayed by their Fundamental Properties

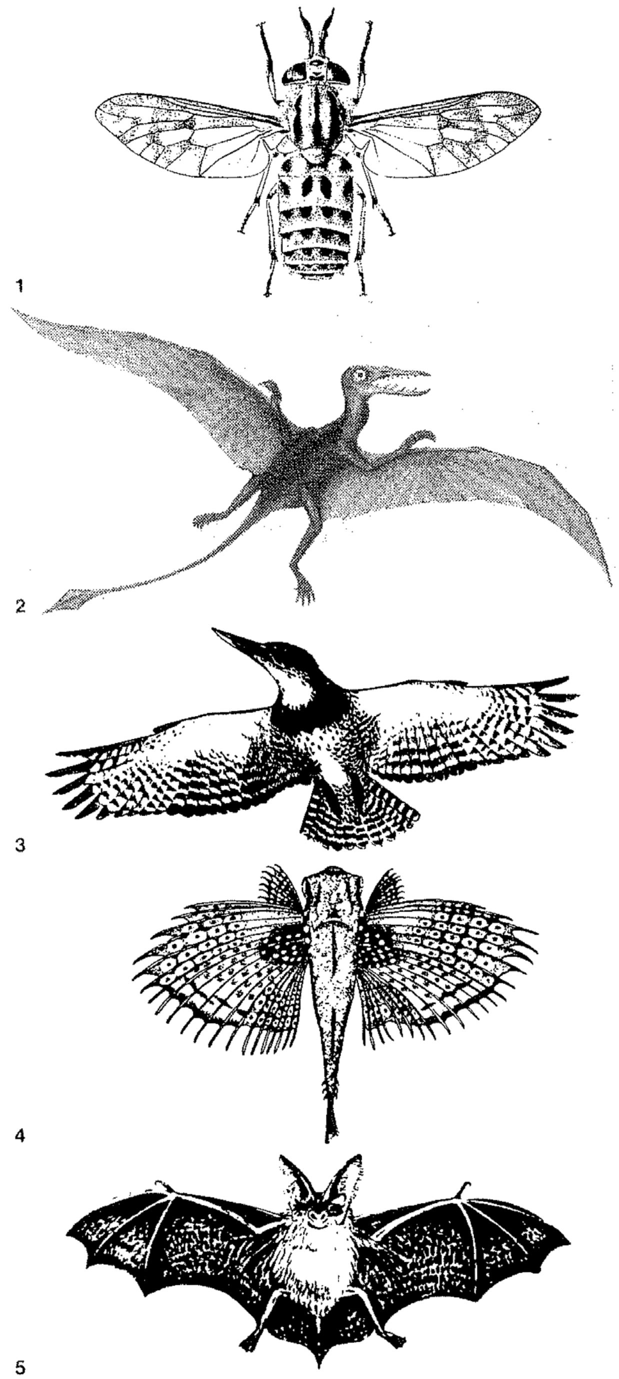
Periodicity in living organisms was established by Lima-de-Faria (1995), but the development of molecular biology, that occurred since then, allowed to treat this phenomenon more extensively and to establish it on a firm basis (Lima-de-Faria 2017). It led to the production of a *Periodic Table of Living Organisms* that covered 8 biological properties: vision, regeneration, luminescence, placenta, penis, flight, plant carnivory and mental ability.

All these properties were investigated at the molecular level, and the genes involved in them, as well as the RNA sequences that participated in their expression were included.

In this article the occurrence of biological periodicity will not be described in detail but only the main results are mentioned. The reader is referred to the above cited works for a comprehensive treatment of the subject.

3.1. Flight — Is a Punctuated Event which Arises from Species Without Wings

Flight is one of the periodic processes that is most easy to exemplify. It occurs in air in: insects, squids, fish, pterosaurs (fossil reptiles), birds and bats (Figure 4).



Increasing grade of complexity	ABSENCE OF FLIGHT IN AIR	FLIGHT IN AIR OR WATER	GLIDING: REGULAR AND OPTIONAL
1	INVERTEBRATES ALL PHYLA WINGLESS EXCEPT THE ARTHROPODA	INVERTEBRATES INSECTS FLYING Most species in air but some in water SQUIDS water and air	INVERTEBRATES INSECTS Some species Optional
2	INSECTS (ARTHROPODA) Some species wingless Silverfish Fleas	FISH Most species in water Flying rays	FISH Regular *Exocoetus* AMPHIBIANS Regular *Rhacophorus*
3	FISH Most species flightless in air AMPHIBIANS All species flight-less in air	FISH Flying in water and air Bony fish	REPTILES Regular *Draco* BIRDS Some species Optional
4	EXTANT REP-TILES All species flight-less in air	FOSSIL REP-TILES Flying in air Pterosaurs	MARSUPIALS Regular *Petaurus*
5	BIRDS which have wings but are flightless Kiwis Ostriches	BIRDS Most species in air	PLACENTALS DERMOPTERA Regular *Cynocephalus*
6	MAMMALS Many species flightless in air and water	MAMMALS BATS All species in air CETACEANS SEALS Most species in water	PLACENTALS RODENTIA Regular *Petaurista*

Table 1: PERIODIC TABLE OF FLIGHT AND GLIDING Flight in air and in water, both represent active movements, by the use of wings and fins, in different media. The periodicity is revealed by the sudden eruption of flight in the most unrelated groups of animals. The expression or repression of flight capacity is known to be decided by genes that control wing development. Gliding turns out to be also a periodic event re-emerging after periods of latency. It became of general occurrence in mammals, yet at the side of gliding species "there are extremely similar ones" that do not glide.

Figure 4 (*previous page*): Periodicity of flight. (1) Insect *Chrysops discalis*. (2) Extinct flying reptile *Rhamphorhymque*. (3) The bird giant kingfisher *Megaceryle maxima*. (4) Flying fish *Dactylopterus orientalis*. (5) A bat (flying mammal).

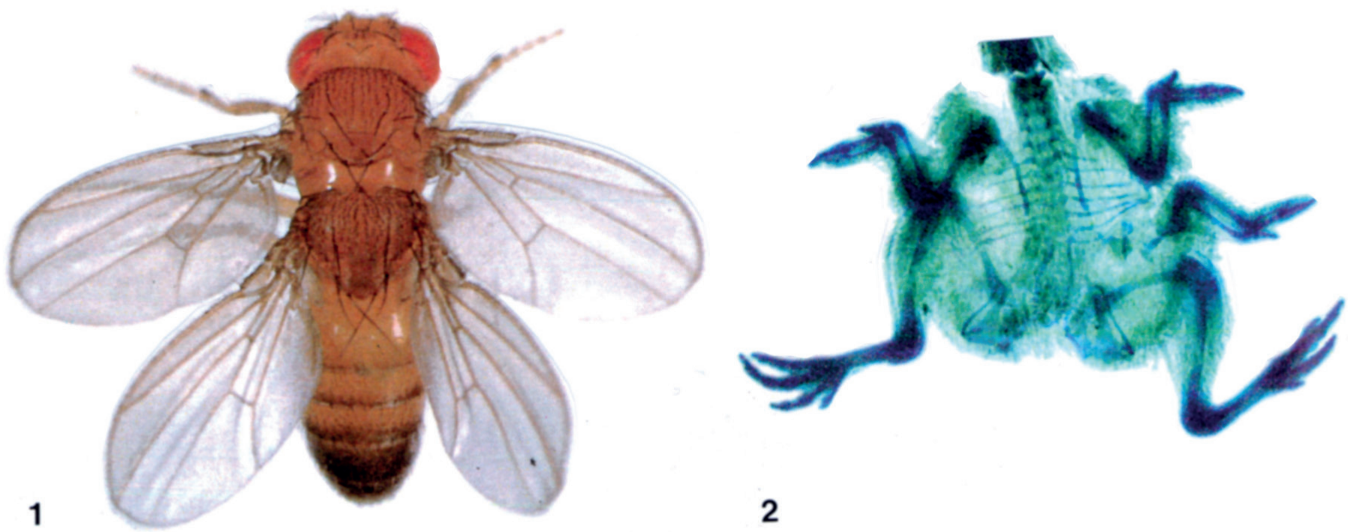


Figure 5: Production in the laboratory of flies with four wings (instead of two) and of birds with four wings (also instead of two) by genetic manipulation of DNA sequences. This was possible due to the gene similarity between invertebrates and vertebrates. (1) *Drosophila melanogaster* four-winged fruit fly produced by combining the gene mutations bithorax and post-bithorax. (2) *Gallus gallus*, chicken, genetic intervention leads to the production of a bird with four wings by modifying the location of a growth gene in the bird embryo.

It is a punctuated event, but moreover it occurs in animal species that are not related directly to the previous possessor of this property. Insects start flying without predecessors (the first insects had no wings). Moreover all other invertebrates which evolved for millions of years do not fly. Much later appeared flying reptiles that had no direct relation to insects. The birds evolved from non flying reptiles, and later the bats, had no direct relation to birds, but came from small terrestrial mammals. Some species of squids and fishes are able to move out of water and fly in air in a most advanced way. Flight is an evasion from gravity. It occurs in water, in the water-air interface, and in air. Not only marine mammals, but most fish, fly in water. Active flying is particularly evident in manta rays (a fish measuring up to 7 meters across) "swimming like a large bird on flapping wings" (Burnie 2004). Zoologists have not hesitated to call the swimming of these fish as "underwater flight" which is achieved by their large pectoral fins (Table 1).

The emergence of flight has been difficult to explain.

The hypotheses on the origin of bird flight do not apply to the origin of flight in insects and bats. Also authors agree that selection is impotent to furnish an explanation.

Instead the genetic evidence clarifies the situation. *Hox* genes are known to decide the formation of wings, as well as their suppression, and a fly with 4 wings (instead of 2) can be produced by genetic intervention without selection or successive random mutations. Also birds with four wings, instead of two, have been obtained in the laboratory (Affolter *et al*. 1990, McGinnis & Kuziora 1994, Cohn *et al*. 1997) (Figure 5). It also turns out that the same genes (*Hox*) determine the formation of insect and bird wings. Periodicity could hardly be conceived if the wings of insects and birds had different genetic origins.

What characterizes flight periodicity is the re-emergence of coherent flight capacity following long periods of latency. Gliding, which occurs from insects to mammals, is also a periodic event (Figure 6).

3.2. Placenta—Occurs in Humans but is Equally Well Developed in Flowering Plants

The placenta is a structure that interlocks the fetal and maternal tissue in animals, and in plants, is the place in the ovary where the ovules develop and are provided by nutrients (Figure 7). The placenta occurs in the most complex as well as the simplest living organisms be they animals or plants. It is found in mosses and ferns and reappears in flowering plants. It is independent of

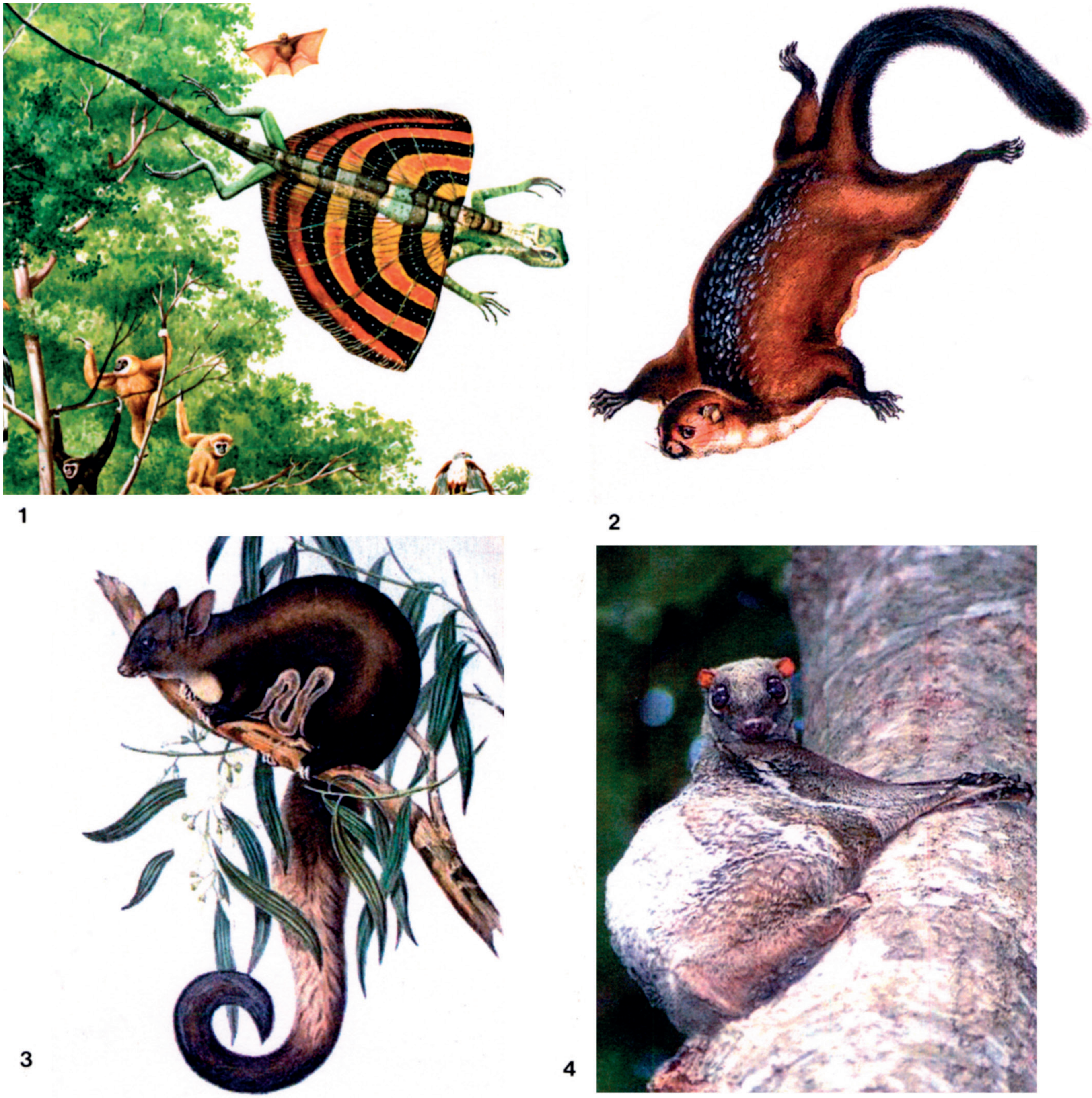


Figure 6: Gliding. (1) *Draco volans* (a reptile) glides by expanding its ribs that can be folded down. (2) Giant flying squirrel (placental mammal). (3) *Petaurus australis* (marsupial). (4) *Cynocephalus variegatus* (placental mammal).

organism complexity a feature that is evident in all properties that exhibit periodicity. It is well developed in the simplest animals (onychophorans and sponges) as well as in fish (sharks, rays and sea horses) (Table 2).

Not less than 94 human genes are highly expressed in the placenta. Remarkable is that the punctuated emergence of this organ is decided by common genes in plants and animals (Spielman *et al.* 2001). Its periodicity is evident in reptiles where it has evolved on more than 100 separate occasions (Flemming & Blackburn 2003) which is also a demonstration of its sudden emergence. This very high reappearance of the placenta is in agreement with the "hypermutation" found in vertebrates, including humans, where there is a sudden increase of the mutation rate at specific genes. An example is the immunoglobulin gene in which the mutation rate is 6 to 7 orders of magnitude greater than that of background mutations (Brown 1999).

3.3. Penis — Re-Emerges, without Previous Announcement, in Flatworms and Mammals

The penis would seem to be an organ characteristic of vertebrates, such as humans, but it occurs equally well formed already in worms (Figure 8).

It has an equally punctuated appearance neither related to the environment nor to nearly connected species.

Most birds have no penis. The genetic events leading to the elimination of the penis have been found to be dependent on the activity of the gene *Bmp4* which induces cell death in genitalia.

The penis is absent in whole groups of invertebrates (22 phyla) but it appears, without previous announcement, in marsupials and placental animals where it becomes well established (Table 3).

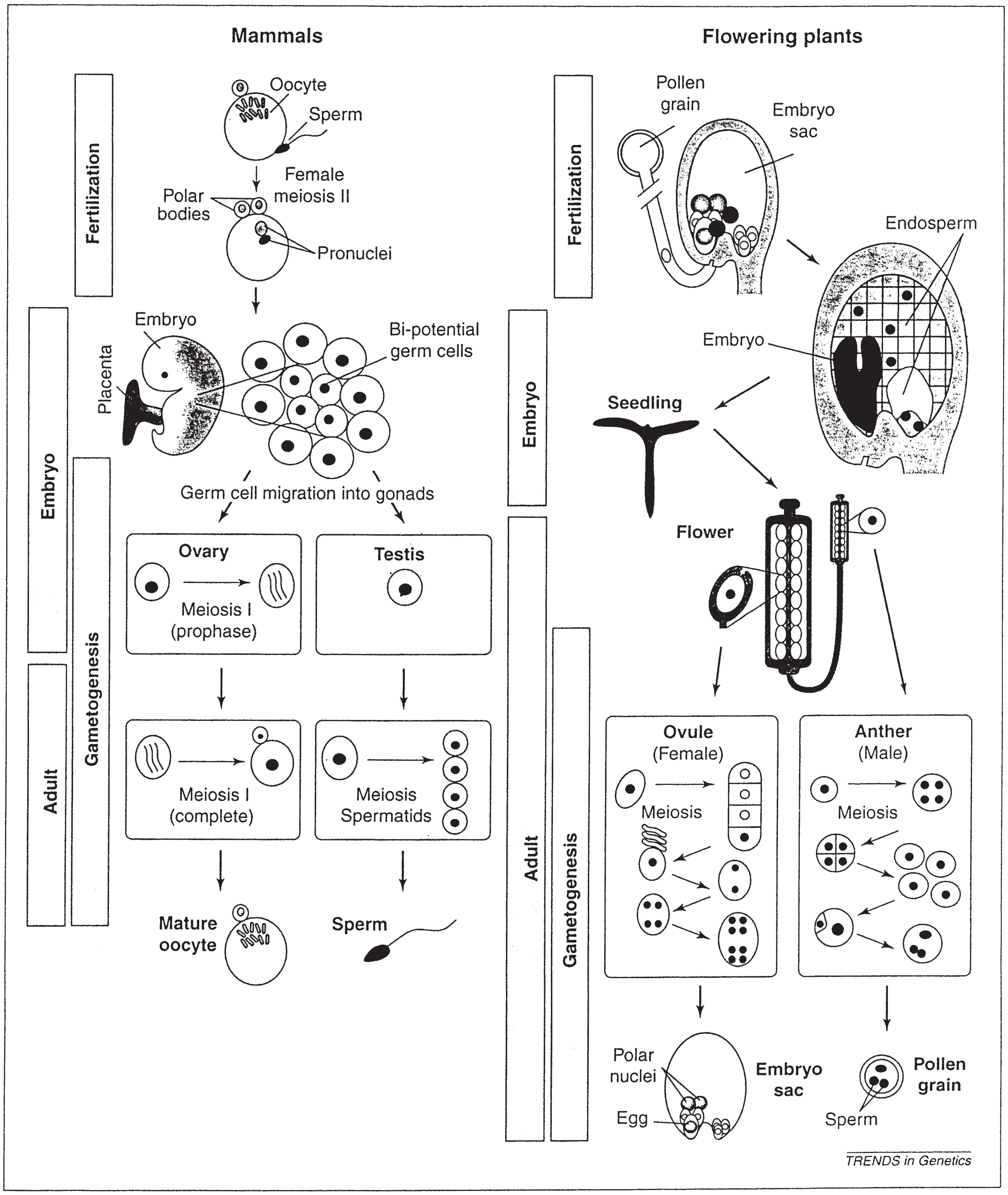


Figure 7: Comparison of the development of the placenta and other organs in mammals and flowering plants. The similarity is due to similar genes in the two unrelated groups. From Spielman et al. (2001) with permission.

Increasing grade of complexity	PRESENCE IN INVERTE-BRATES	PRESENCE IN VERTEBRATES	PRESENCE AND ABSENCE IN PLANTS
1	ONYCHO-PHORANS ENTOPROCTS BRYOZOANS	CARTILAGINOUS FISH SHARKS RAYS TELEOST FISH SEA HORSE	ALGAE Absent
2	SPONGES CNIDARIANS	AMPHIBIANS SURINAM TOAD BLACK SALA-MANDER	MOSSES Present
3	RIBBONWORMS FLATWORMS ROUNDWORMS SEGMENTED WORMS	REPTILES AFRICAN SKINKS LIZARDS SNAKES	FERNS Present
4	SCORPIONS FRESH WATER CLAMS	MARSUPIALS BANDICOOTS	CYCADALES No indication
5	COCKROACHES WASPS FLIES	EARLY PLACEN-TAL MAMMALS LOWER PRI-MATES	CONIFERS Present
6	ASCIDIANS SALPS Lower chordates	LATE PLACEN-TAL MAMMALS HUMANS	FLOWERING PLANTS Present

Table 2: PERIODIC TABLE OF THE PLACENTA. The placenta is such an important organ that it characterizes a whole animal group — the placental mammals. It interlocks foetal and maternal tissues in the uterus of animals. Surprisingly it appears equally well advanced in plants, where it is "the ovule part of the carpel and a sporangium bearing area". The periodicity is revealed by its emergence in many invertebrate species, and in vertebrates, such as the sharks, where it attained a development that rivals that of mammals. Besides, in reptiles, it emerged on more than 100 separate occasions whereas in sharks it reappeared 11 times.

3.4. Vision — is Decided by the Same Gene from the Simplest to the Most Complex Animals

Three properties are of special importance because they do not start at the organism level but appear before DNA and the cell emerged in evolution. Vision, regeneration and luminescence are already evident in crystals and minerals.

The ability to direct light to specific sites is present in crystals. The phenomenon is called double refraction. The light is divided into two polarized rays as seen in the minerals calcite and tourmaline (Wenk & Bulakh

Increasing grade of complexity	ABSENCE IN INVERTE-BRATES	PRESENCE IN INVERTE-BRATES	ABSENCE IN VERTEBRATES	PRESENCE IN VERTEBRATES	PRESENCE OF DOUBLE OR BILOBED PENIS
1	CNIDARIA CTENOPHORA MESOZOA NEMERTINA	FLATWORMS FLUKES	BONY FISH *Most species*	FISH SHARKS RAYS Modified fin	CRUSTACEANS Double
2	ROTIFERA KINORHYNCHA ENTOPROCTA NEMATODA	GNATHOSTO-MULIDA *Problognathia*	AMPHIBIANS FROGS	AMPHIBIANS CAECILIANS Penis-like organ	MOLLUSCS Double
3	NEMATOMOR-PHA ECTOPROCTA PHORONIDA BRACHIOPODA	GASTROTRICHA *Dactylopodola*	AMPHIBIANS TOADS	REPTILES LIZARDS SNAKES	INSECTS Double
4	PRIAPULIDA SIPUNCULA ECHIURA ANNELIDA	ACANTHOCEPH-ALA Spiny-headed worms	REPTILES TURTLES	BIRDS OSTRICHES DUCKS	REPTILES LIZARDS SNAKES Double
5	PENTASTOMA ONYCHOPHORA POGNOPHORA	MOLLUSCS *Buccinum* CRUSTACEANS *Balanus*	REPTILES CROCODILIANS	MARSUPIALS Most species	MARSUPIALS Bilobed
6	ECHINODER-MATA CHAETOGNATHA HEMICHORDATA	INSECTS Many species with additional structures	BIRDS Most species	PLACENTALS Most species	PLACENTALS Single

Table 3: PERIODIC TABLE OF THE PENIS. The penis is absent in a large number of invertebrate phyla as well as in most groups of vertebrates. It emerges suddenly in totally unrelated groups of simple as well as complex organisms. It establishes itself as a permanent organ in mammals. A double penis also occurs in a punctuated way among crustaceans, molluscs, insects and reptiles.

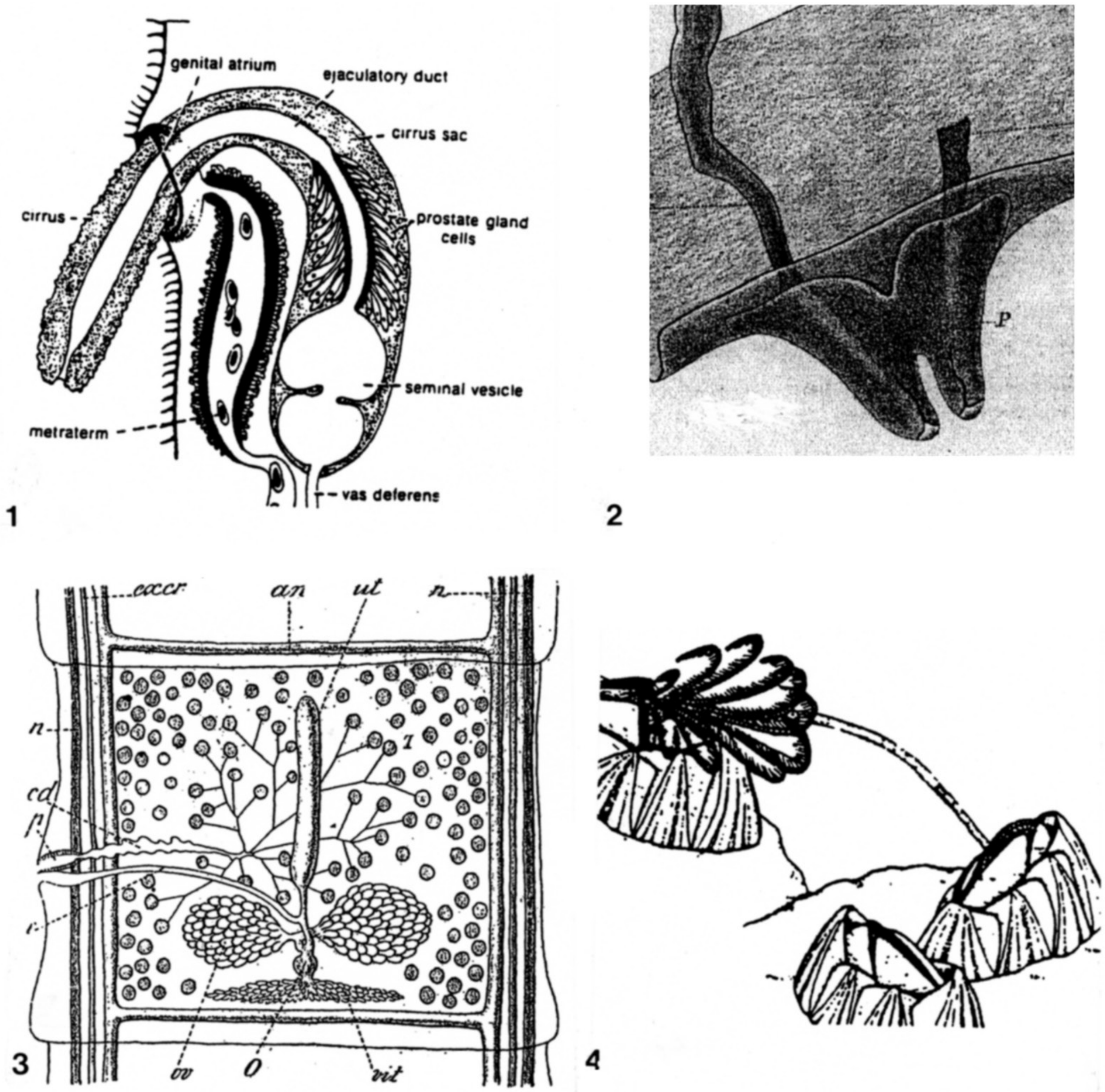


Figure 8: Penis in worms and crustaceans. (1) Flatworm, *Fasciola hepatica*, the penis has a seminal vesicle, a prostate gland and an ejaculatory duct. (2) Crustacean, *Cymathoa aestroides*, penis and part of ventral wall. (3) Flatworm, *Taenia saginata*, body segment showing ovaries (ov) and penis (p). (4) Crustacean, copulating Barnacles. The long penis of the individual on the left is inserted on the individual on the right (based on a photograph by R. Sisson).

2004). The cornea and the lens of the animal eye are the two structures that bend light rays to focus images on the retina. It turns out that in the eye of living brittle stars (echinoderms) the lens is made of calcite (Björn 2015), and in the mollusc chiton the eye lens is made of the mineral aragonite. This means that vision is anchored in the mineral world (Figure 8).

Typical of periodicity is that the complexity of the eye is not related to organism complexity. Bacterial cells act as spherical lenses and their vision is considered similar to that of the human eye (Schuergers *et al.* 2016). Moreover in molluscs eye organization becomes close to that of the human eye (Table 4).

Repression and expression of the same genes appear as the source of eye absence and reappearance. Larvae and adults of Annelid worms have the same genes yet larvae have eyes whereas adults lack them.

Ubiquitous genes and identical regulatory molecular cascades have shaped the eye throughout its evolution. Gehring and collaborators (2014) have shown that most animals "share the same master control gene, Pax6, and the same retinal and pigment cell determination genes". The loss of *Pax6* gene function, led to animals without eyes, in both mammals and insects, revealing again the identity of the genetic pathways which are at the basis of the periodicity (Figure 10).

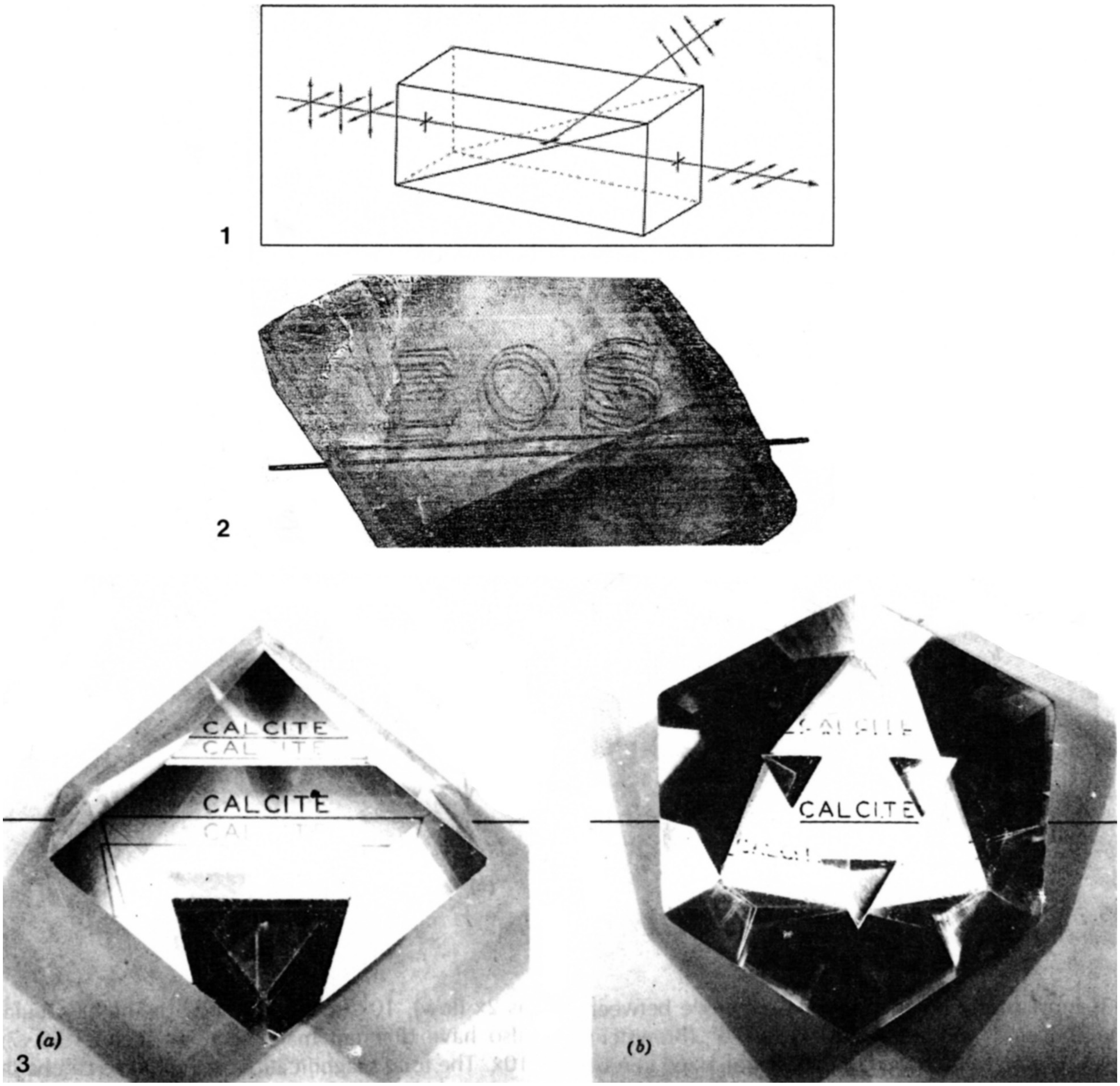


Figure 9: Mineral crystals deviated light before eye lenses did it. (1) Double refraction in calcite showing the splitting of the light into an ordinary and an extraordinary ray. (2) Transparent crystal of calcite in which one sees clearly the double refraction of the letters *EOS*. (3a) Calcite, viewed normal to the rhombohedron face. (3b) Calcite showing no double refraction, viewed parallel to the c axis.

Increasing grade of complexity	ABSENCE OF EYES	RUDIMENTARY EYES	COMPLEX EYES
1	MINERALS EUBACTERIA PROTOZOA Most species CNIDARIANS *Hydra*	CYANOBACTERIA PLANT CELLS PROTOZOA *Euglena* CNIDARIANS *Aurelia*	CNIDARIANS *Tripedalia* ANNELIDS *Vanadis*
2	PLACOZOA PORIFERA EUMETAZOA MESOZOA GASTROTRICHA ACANTHOCEPHALA	RHYNCHOCOELA ROTIFERA KINORHYNCHA NEMATODA	CRUSTACEANS *Homarus* Most species INSECTS Most species
3	GNATHOSTOMULIDA POGONOPHORA ECHIURA PRIAPULIDA PENTASTOMIDA	SIPUNCULA TARDIGRADA	MOLLUSCS SQUIDS CUTTLEFISH OCTOPODS
4	PHORONIDA BRYOZOA ENTOPROCTA BRACHIOPODA	FLATWORMS *Planaria* ANNELIDS MARINE WORMS	FISHES AMPHIBIANS
5	MYRIAPODS Many species ANNELIDS EARTHWORMS Most species	CRUSTACEANS Some species MYRIAPODS Some species SPIDERS	REPTILES BIRDS
6	FLATWORMS CESTODA Some species ECHINODERMS Sea urchins	MOLLUSCS *Patella* ASCIDIANS	MARSUPIALS PLACENTALS

Table 4: PERIODIC TABLE OF VISION. Thousands of species in invertebrates have existed, for millions of years and survived efficiently, without eyes. At the same time the eye attained a high degree of complexity even in the simplest invertebrates. There is an increase in eye complexity that tends to follow the organism's phylogenetic position. After being a punctuated event in invertebrates, the eye became a permanent feature of vertebrates. Periodicity is elucidated by the finding that the *Pax6* gene is present in all species that have eyes and even in those that lack eyes. This indicates that gene expression and repression are responsible for its periodic emergence.

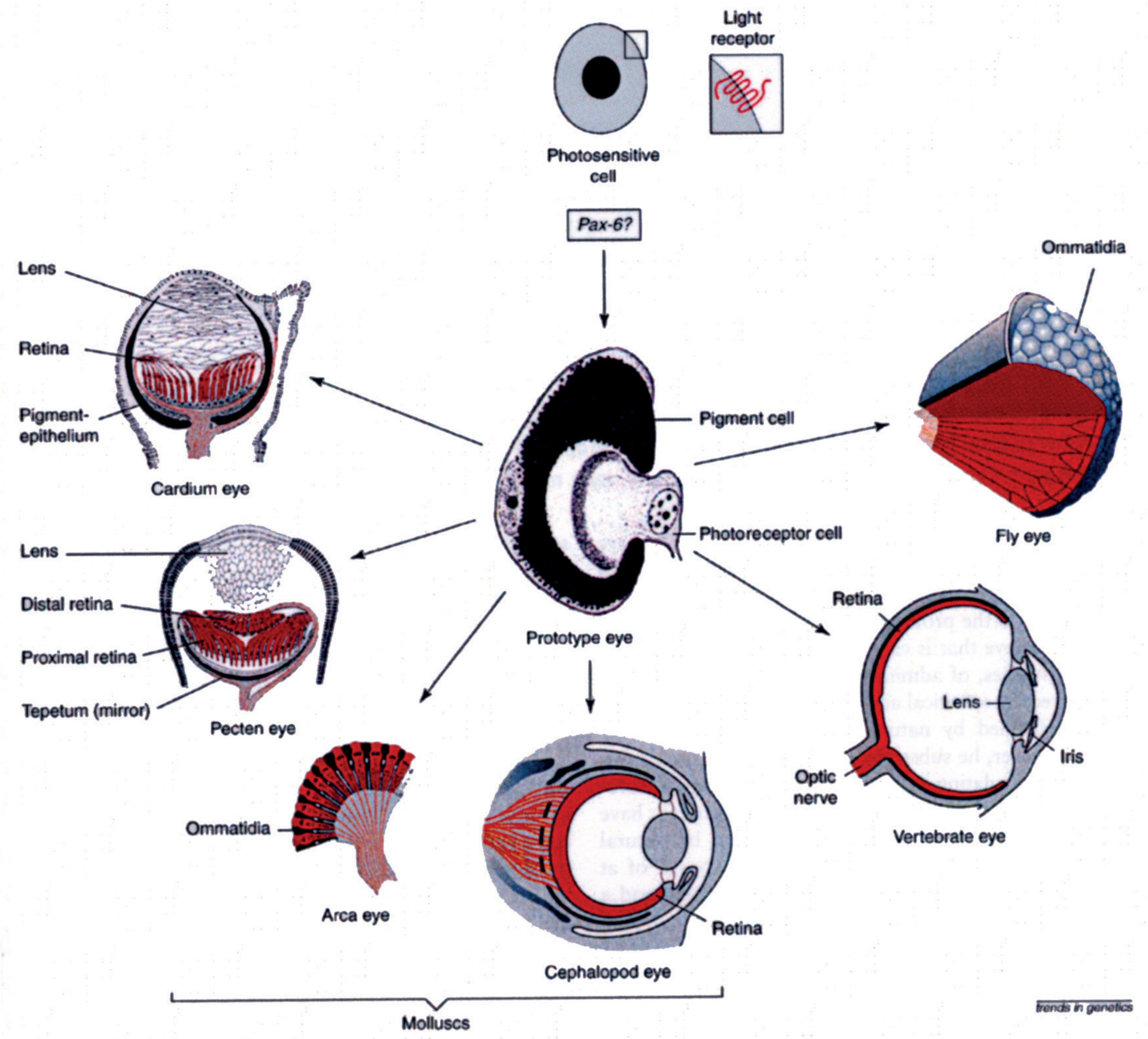


Figure 10: General scheme of eye evolution. Evolution of various eye-types from a common ancestral prototype. Under the control of the Pax6 gene the photosensitive cell assembles with a pigment cell to form an organ, the prototype eye. This generates the various eye-types from the eye of simple molluscs (Cardium, *Pecten*) to insect eyes, the complex eye of Cephalops (advanced *molluscs*) and the vertebrate eye (including humans).

3.5. Regeneration — Starts in Crystals, Expands in Plants, but Slows Down in Vertebrates

Regeneration is characterized by the ability to produce, without external intervention, the original pattern. It is actually based on atomic and cellular order.

Regeneration started in crystals before biological evolution arrived. It occurs in ammonium bimalate and ammonium oleate crystals as well as in minerals. If they get broken regeneration ensues the addition of identical atoms which lead to the restoration of the identical pattern (Bonner 1952).

Research on atomic configuration, taking place during crystal formation, shows that disorder is transformed into order depending on temperature. In the mineral feldspar low temperatures lead to an ordered assembly of novel atoms (Wenk & Bulakh 2004).

In living organisms the appropriate genes are called to action, and the cells only develop a preprogrammed cellular order that does not deviate from the original configuration of the organism. This program is actually a memory which remembers the whole organization — without it no identical pattern could be recreated.

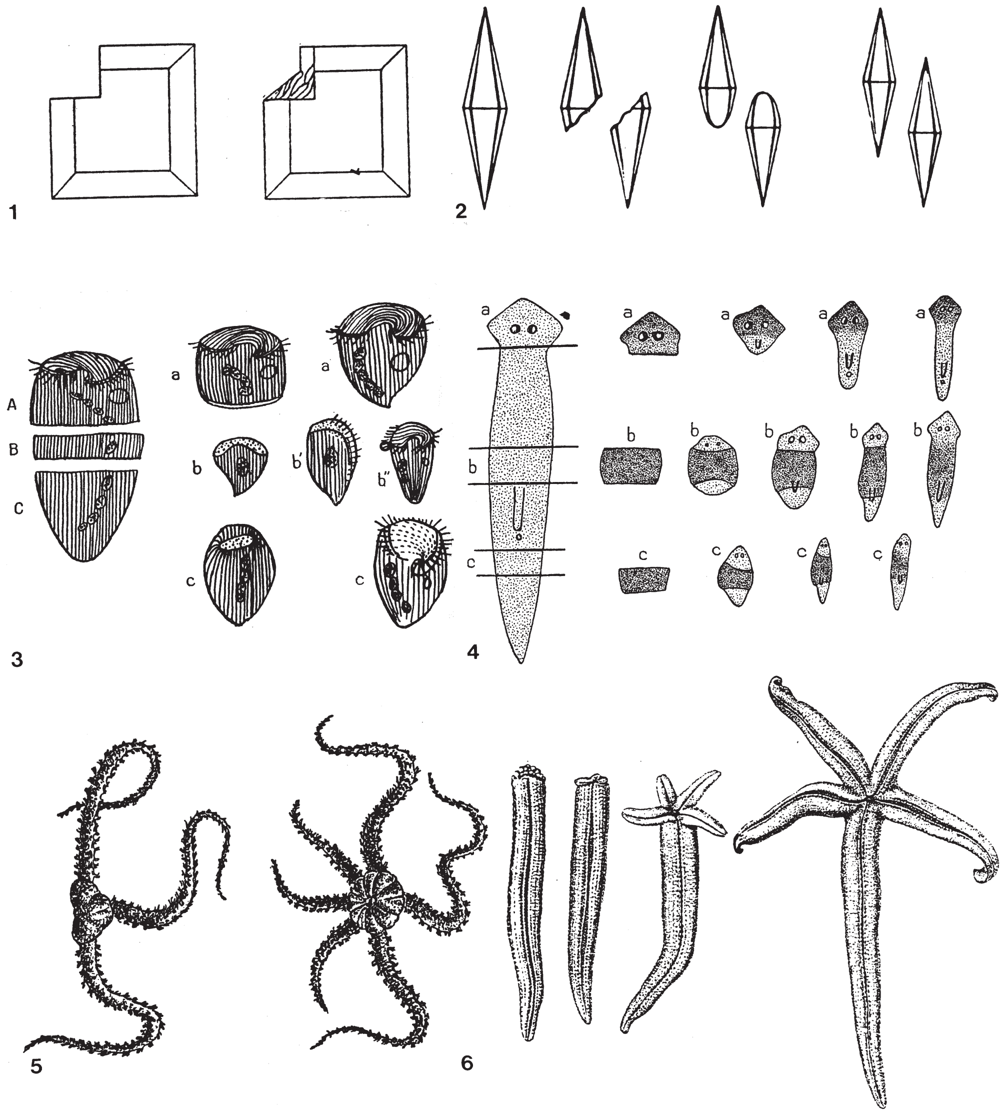


Figure 11: Regeneration in crystals, protozoa and invertebrates. (1) Crystals of ammonium bimalate. Crystal with its end broken (left) and under regeneration which leads to the restoration of the original pattern (right). (2) Liquid crystals of ammonium oleate. Following breakage the crystals regenerate building the original pattern. (3) Protozoa, *Stentor*, stages of regeneration from three separate fragments. (4) Flatworms, *Planaria*, regeneration of complete individuals from three separate fragments. (5) Echinoderm, an ophiuroid after being divided into two parts (left). Shortly after, one half regenerates building the original pattern (right). (6) Echinoderm, starfish, *Linckia*, three successive stages of the regeneration of the whole body from the end of a single arm.

Protozoa and algae rebuild their body from isolated fragments by releasing chemicals that determine the pattern. Hydras have body memory and the ability to sense structure size. These properties extend also to higher organisms (Figure 11).

The genes participating in regeneration have been identified in flatworms (Turbellaria). The *Wnt 3* genes induce a wave of proliferation in neighboring cells. As many as 694 genes decide ordered regrowth of organs in brittle stars when they regenerate the whole body from a single arm (Purushothaman *et al*. 2015).

As one reaches the vertebrates, fish rebuilt the: tail fin, kidney, heart and brain, when a battery of genes is activated.

The ability to reestablish the body pattern diminishes in vertebrates, becoming reduced to the mammalian heart, pancreas and other organs. Birds show an absence of regeneration, except for their feathers, that are replaced continuously. On the contrary mosses and ferns know their body plan and in flowering plants a single somatic cell can give rise to a whole plant (Haberlandt 1902) (Table 5).

Increasing grade of complexity	ABSENCE OF MEMORY	CRYSTAL AND CELL MEMORY	ORGAN MEMORY	WHOLE BODY MEMORY
1	CTENOPHORES MESOZOANS GNATHOSTO-MULIDS GASTROTRICHS	CRYSTALS MOSSES *Sphagnum* FERNS *Pteris* CONIFERS *Pinus*	RIBBON WORMS ECHIURANS Proboscis PRIAPULIDS Appendages ANNELIDS Lost parts INSECTS Antennae	PROTOZOA *Stentor* PLACOZOA *Trycholax* ALGAE *Acetabularia*
2	ROTIFERS KINORHYNCHS ACANTHOCE-PHALANS ENTOPROCTS	FISH Scales	CRUSTACEANS Limbs FISH Tail Teeth Brain Heart	SPONGES Ameboid cells
3	NEMATODES NEMATOMORPHA ECTOPROCTS PHORONIDS	AMPHIBIANS Skin	AMPHIBIANS Limbs	CNIDARIANS *Hydra*
4	BRACHIOPODS MOLLUSCS SIPUNCULANS TARDIGRADES	REPTILES Scales	REPTILES Tail	FLATWORMS *Planaria*
5	PENTASTOMA ONYCHOPHORANS POGONOPHORANS CHAETOGNATHS	BIRDS Feathers	BIRDS No indication of re-generation capacity	ECHINODERMS Starfish and others
6	BIRDS Absence of memory (except feathers)	MAMMALS Skin Hair Fibroblasts	MAMMALS Teeth Antlers Heart	FLOWERING PLANTS Many species

Table 5: PERIODIC TABLE OF REGENERATION. Biological memory is the capacity to copy preexisting patterns. Regeneration is a form of memory which started in the crystal world and expanded into cells, organs and whole bodies. The periodicity is shown by the absence of regeneration in many invertebrate phyla which is accompanied by a high ability of whole body memory in other species. This occurred in simple invertebrates and flowering plants. As organism complexity increased organ memory tended to decrease.

3.6. Luminescence — Is Found in Many Minerals and Has Become a Main Property in Bacteria, Insects and Fish, but Was Precluded in Later Evolution

Bioluminescence has been described as a "random and spasmodic phenomenon" and selection has also been evoked and denied. Luminescence occurs from minerals to fish, but like regeneration is a limited process. It is both an electronic event, resulting from changes in atomic energy states, and at the same time a genetic process.

Luminescence was widespread in minerals before it arose in living organisms. It was found even earlier in chemical elements, which are considered to be color activators in minerals, such as Europium and Uranium. No less than 21 minerals are luminescent and the colors emitted by living organisms are the same that are emitted by minerals (Figure 12).

All luminous bacteria have a common DNA sequence, they share the *lux operon*, that encodes for the biosynthesis of luciferase and its substrates (Dunlap *et al.* 2007) (Figure 13).

There are luminous and non-luminous algae and a large number of invertebrates were not allowed to develop luminosity. However, in some families of insects luminescence attained extreme intensity. Among the molluscs, the Cephalopods, are covered by hundreds of luminescent organs that glow in the ocean water. The number of photophores is as high as 687. Fishes, look also like Christmas trees with their long lines of luminous organs that "Are extraordinarily elaborate", but marine mammals are not luminous, yet they live at

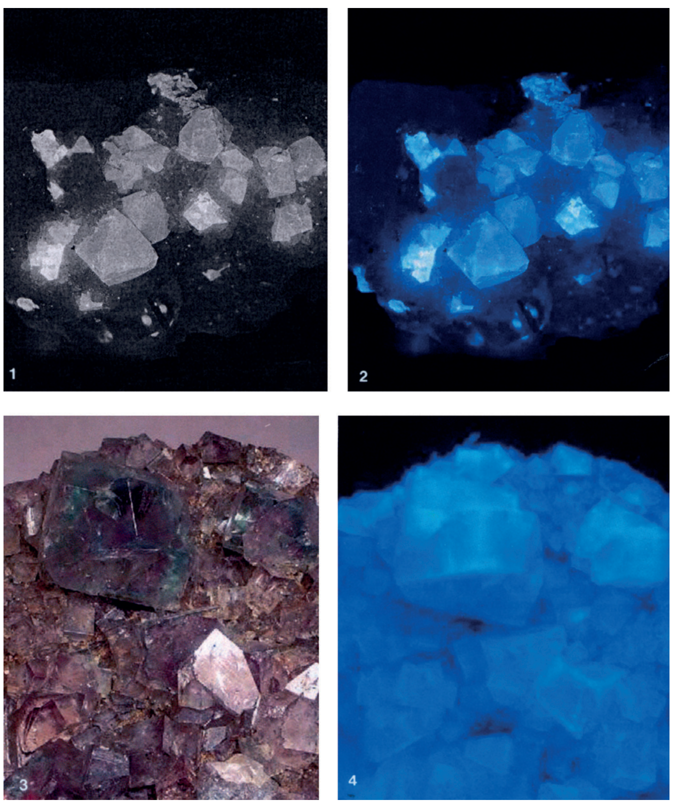


Figure 12: Luminescence in minerals. (1) Crystals of scheelite ($CaWO_4$) seen under daylight. (2) Luminescence in crystals of scheelite submitted to ultraviolet radiation. (3) Crystals of fluorite (CaF_2) seen under daylight. The large cubes have a blue-green color dispersion (natural fluorescence). (4) Luminescence in crystals of fluorite submitted to ultraviolet radiation.

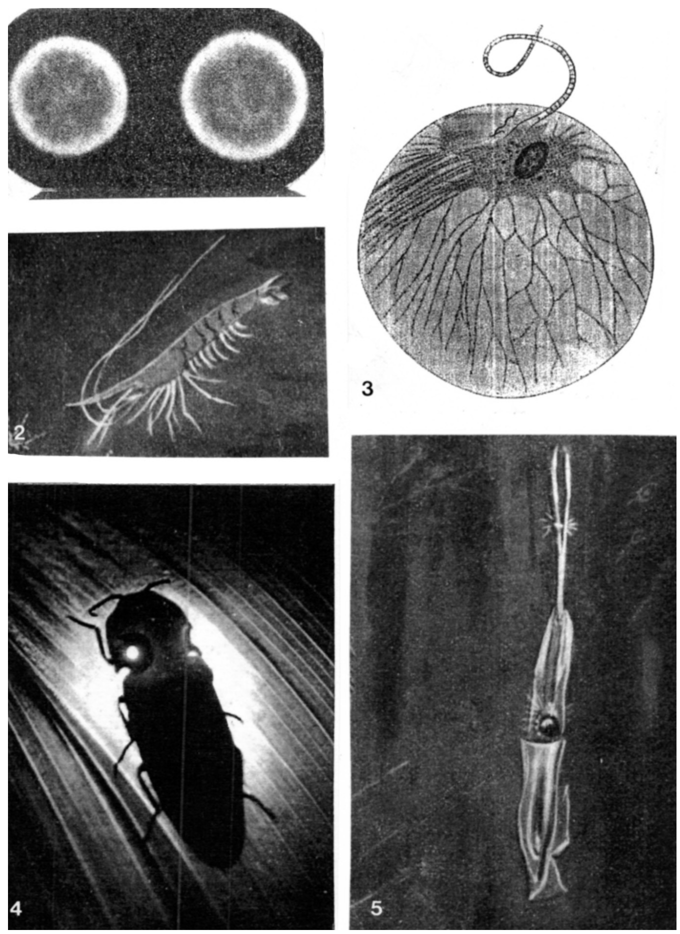


Figure 13: Bioluminescence. (1) Photobacteria, two colonies of *Photobacterium* photographed in obscurity. (2) Shrimp, a luminous crustacean species. (3) Noctiluca, adult stage of *Noctiluca* sp. (4) Insect, the strong light emitted by Pyrophorus. (5) Squid, mollusc, a luminous species.

Increasing grade of complexity	ABSENCE OF LUMINESCENCE	PRESENCE OF LUMINESCENCE	ORGANIZATION OF PHOTOEMITTERS
1	MINERALS Most non-luminous	MINERALS Over 20 are luminescent	CRYSTALS Fluorite Calcite
2	CYANOBACTERIA ALGAE Most non-luminous	EUBACTERIA *Photobacterium* *Vibrio* DINOFLAGELLATES Luminous	PHOTOCYTES Bacteria Hydrozoa Ctenophores
3	FUNGI (MYXOMYCOTA) Not luminous	FUNGI *Mycena* Luminous	LIGHT SECRETION Bivalvia Annelids Crustaceans
4	INVERTEBRATES Of 31 phyla 20 have no luminous species	INVERTEBRATES POLYCHAETA STARFISH JELLYFISH Weak luminosity	PHOTOPHORES Molluscs Insects Polychaeta
5	FLOWERING PLANTS Non-luminous FISH Most non-luminous AMPHIBIA Non-luminous	INVERTEBRATES MOLLUSCS INSECTS Extreme luminosity	GLANDS Cephalopods Fishes
6	REPTILES Non-luminous BIRDS Non-luminous MAMMALS Non-luminous	FISH Near-shore and abyssal Highly luminous	ELABORATE REFLECTORS LENSES SHUTTERS AND MIRRORS Molluscs Fishes

Table 6: PERIODIC TABLE OF LUMINESCENCE. Luminescence appeared with light intensity in simple organisms such as bacteria, insects and molluscs. It became maximal in fishes but was totally precluded in later evolution. Luminescence occurs in minerals, before the arrival of DNA and the cell, showing that this phenomenon is due to atomic and electronic processes. High light intensity emerges irrespective of the animal's phylogenetic location and it arose independently at least 40 times.

depths exceeding those of luminous fish. Non-luminous molluscs occur also at depths from 200 to 7,000 meters and the bats, which regularly live in darkness, did not become luminous.

The luciferase gene produces the sole enzyme responsible for luminescence. The complete DNA sequencing of luciferase genes demonstrates that they have been highly conserved (Choi *et al.* 2003). Following genetic manipulation flowering plants and rabbits have become luminous

The periodicity of luminescence is evidenced by the fact that "Bioluminescence is estimated to have evolved independently at least 40 times" (Hastings 2011) and all authors agree that luminescence has had independent origins throughout its evolution (Table 6).

3.7. Carnivory in Plants — Their Trapping Organs Contain: Doors, that Open and Close, Sensorial Hairs that Recognize Prey and Digestive Glands, but Have no Nervous System

Plants have no brains and no nervous system, yet they perform activities comparable to the brain functions of animals as shown by the analysis of their carnivorous behavior.

Carnivory in plants is not a "Paradoxical Event" but is due to the expression of specific genes and chemical modifications of DNA.

Mammals have not inhabited the planet for a long time, the animals of the order carnivores arose 10 million years ago (Wilson & Mittermeier 2009–2019). Equally, the carnivorous plants are not old. Flowering plants had their major radiation 125 million years ago, but all extant carnivorous plants are found in recently derived groups. McPherson (2010) states that carnivory is a "relatively young evolutionary invention" among flowering plants.

Its periodicity is evident. The 20 extant genera of carnivorous plants have turned out not to be closely related. Carnivory evolved at least on ten separate occasions and may have evolved independently 12 times (Williams *et al.* 1994, McPherson 2010).

The fusion of leaves is a primary event in the building of traps. This is determined by a battery of genes that have been isolated, cloned and sequenced (Glover 2007, Eilenberg *et al.* 2006).

Movements of tendrils, which are also part of carnivory, are decided by touch-inducible genes. Carnivory is also an epigenetic phenomenon; within the same individual plant, the leaf morphology changes during development resulting in the production, side by side, of non-carnivorous and carnivorous leaves.

DNA evolution has not allowed flowers to become carnivorous, which is a phenomenon limited to leaves. These have been successively modified resulting in highly advanced trapping organs such as: spiral branches, funnels, pitchers and bladders.

The origin of periodicity in carnivorous plants is elucidated by the finding that the basic structures and functions participating in carnivory, existed separately in multiple plant families, without having anything to do with flesh digestion. It is only when they were suddenly combined coherently that carnivory emerged (Table 7).

Traps take various forms from rosettes to trumpet-like tubes covered with hoods and in some species are closed by lids and in others by doors that open and close.

Hairs and bristles have sensorial functions. The trapping mechanism is so specialized that it can distinguish between living prey, and pebbles or sticks, that touch the leaf.

The inner part of the trap is covered by more than 6,000/cm^2 microscopic glands in Nepenthes. The glands not only secrete the digestive fluid but also absorb the products of the digestion (Figure 14).

The digestive enzymes in plants are the same that participate in animal digestion and also have the same active sites — another example of plant — animal similarity.

Carnivorous plants may use traps without or with active movements. In *Dionaea* the trap closes within 0.5 seconds, in *Aldrovanda* within 0.01 seconds and in *Utricularia* the door opens within 30 milliseconds following prey detection. This is a speed of reaction comparable to that found in the nervous system of higher mammals.

3.8. High Mental Ability — is Evident from Ants to Humans Reappearing Suddenly

The concepts of instinct, intelligence and selection were terms that belong to the 1800s when research on animal behavior and evolution were based mainly on an ignorance of genetics, biochemistry and biophysics. These were scientific disciplines that did not yet exist.

Increasing grade of complexity	LEAF TRANS-FORMATIONS	GLAND SECRETION	SENSITIVE HAIRS	DIGESTIVE ENZYMES	DIRECTED MOVEMENTS
1	*Drosophyllum Pinguicula Drosera* Leaves slightly curved	*Dionaea Genlisia* Microscopic and small glands	*Drosophyllum Drosera* No hairs	*Darlingtonia* No enzymes	*Drosophyllum Heliamphora Sarracenia* No movements
2	*Heliamphora Sarracenia Darlingtonia Cephalotus* Leaves forming tube with a lid	*Cephalotus Nepenthes* Nectar and digestive sessile glands	*Nepenthes Cephalotus* Hairs outside pitcher	*Utricularia* Some proteases plus phosphatases	*Darlingtonia Nepenthes Cephalotous Genlisia* No movements
3	*Nepenthes* Leaves forming two types of pitchers	*Pinguicula Drosophyllum* Mucous and sessile digestive glands	*Polypompholyx Utricularia* Hairs at entrance of bladder	*Aldrovanda* Proteases	*Pinguicula* Leaf rolls over prey *Drosera* Tentacles move
4	*Aldrovanda Dionaea* Leaves bilobed building trap	*Drosera* Mucous tentacles and digestive glands	*Dionaea Aldrovanda* Spines and trigger hairs	*Drosera Drosophyllum Dionaea* Proteases plus phosphatases	*Polypompholyx* Trap door opens and closes
5	*Genlisia* Leaves as spiralled branches	*Polypompholyx* Two-armed and four-armed glands	*Darlingtonia Sarracenia* Downward pointing hairs	*Sarracenia* Proteases nucleases and phosphatases	*Dionaea* Trap closes within 0.5 seconds *Aldrovanda* Trap closes within 0.01 seconds
6	*Polypompholyx Utricularia* Leaves building traps as a bladder	*Utricularia* Three types of large glands	*Genlisia* Complex system of hairs forming valves	*Pinguicula Nepenthes* Proteases lipases chitinases and others	*Utricularia* Trap door closes in 30 milliseconds

Table 7: PERIODIC TABLE OF PLANT CARNIVORY. Carnivory occurs solely in flowering plants. These arrived late in evolution and most species have about the same degree of organization. The periodicity is evidenced, among other features, by the same trait re-emerging in unrelated families. Besides each trait starts with a simple structure or function that becomes successively more complex in species with similar body complexity (since all are flowering plants). This property is divided into 5 main traits that result in the ability that plants have to trap and digest animal prey. Most traits start with simple structures and successively the complexity increases leading to extreme refinements, which due to their efficiency and speed, are comparable to the nervous system of animals. These traits are decided by specific genes. Carnivory re-emerges at least 10 times.

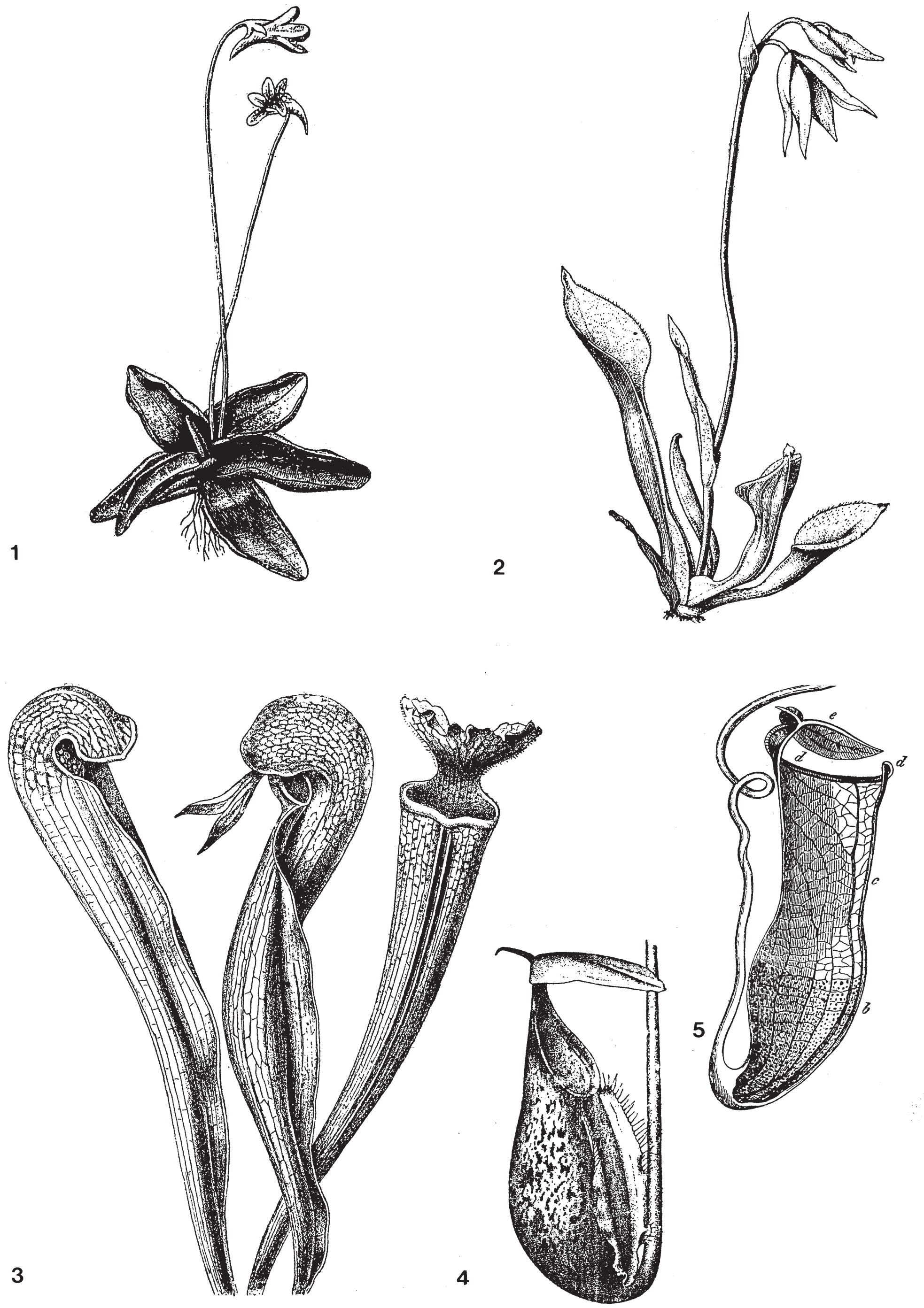


Figure 14: Plant carnivory. Evolution from simple to complex leaves. (1) *Pinguicula vulgaris*, flowering plant with a rosette of leaves slightly curved at the borders. (2) *Heliamphora nutans* with leaves building an amphora. (3) Leaves of *Sarracenia variolaris* (left), *Darlingtonia californica* (middle) and *Sarracenia liciniata* (right) building an open tube curved at the end. (4) *Nepenthes Dominii*, modified leaf as a pitcher with large lock. (5) *Nepenthes laevis*, transformed leaf (partly sectioned) showing numerous glands (as black specks) in the lower part (b) and accompanied by a spiralized tendril and a lid (e) at the top.

At present these concepts are being superseded. Instinct and intelligence were coupled to the assumption of human biological supremacy that now is shown to be less pre-eminent. Selection has turned out to be of little significance as molecular processes explain the pathways.

Periodicity at the mental level seems unexpected but mental processes are equally directed by the evolution of DNA sequences. The brain develops under the control of well defined Hox genes which decide the formation of part of the brain in vertebrates.

High mental ability has resurged without previous announcement. The formation of societies occurs in bees, ants, termites and humans. In insects it is accompanied by agriculture (raising of fungi in termites), animal husbandry (use of sugary products of other insects in ants), language (with dialects in bees), weaving (of leaves in ants) and other activities

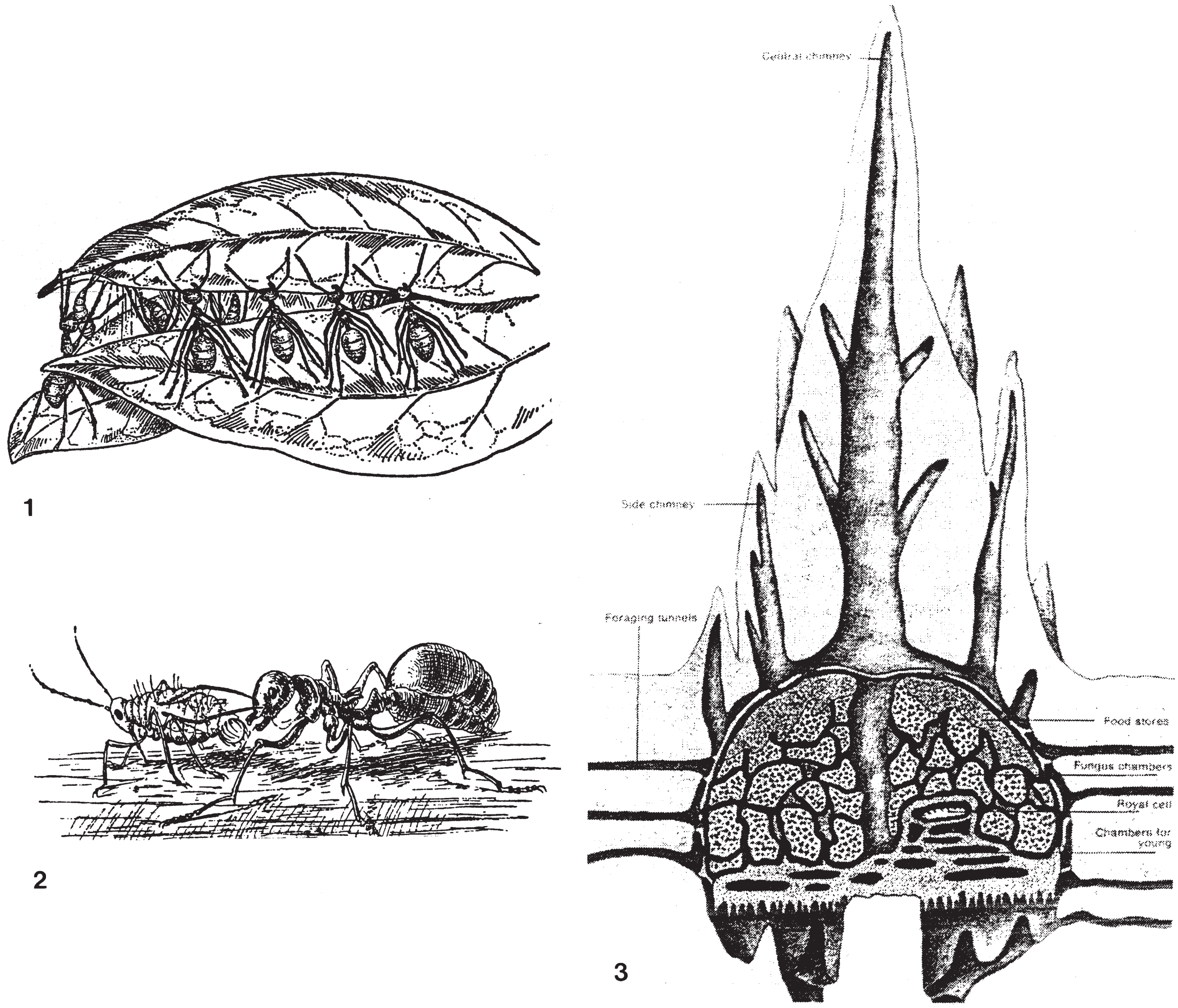


Figure 15: Mental ability in insects. (1) African weaver ant *Oecophylla longinoda*. Ant weavers use their feet and mandibles to combine the borders of leaves. Simultaneously, other ants carry larvae, which have in their mouth a liquid, that seals the leaves together. (2) Ant farming. *Formica* sp. Ants use aphids (insects), which excrete a sugary substance, as a source of nutrition. They even move them to appropriate sites where the aphids can better feed on the sap of plants. (3) Nest architecture in termites, *Hodotermes meriodinalis*. The central chimney keeps the temperature constant. Different compartments function as: foraging tunnels, food stores, the royal cell, and chambers for the young termites. There are also chambers where fungi are cultivated as a source of food.

previously considered to be limited to humans. Octopuses display the highest mental ability, among invertebrates, which is linked to the recruitment of novel genes (Figure 15).

The periodicity of mental ability is based on the following evidence (Table 8).

Insects are distributed into 29 orders. In only two of them: Hymenoptera (ants, bees and wasps) and Isoptera (termites) did social behavior lead to the formation of highly complex and dynamic societies. Hence, 27 orders did not acquire this behavior although they had millions of years of evolution at their disposal. Biologists were led to the conclusion that in insects: "social organization has evolved independently eleven times in the Hymenoptera, but only once in the Isoptera" (McFarland 1981).

Insects, birds and primates came to different solutions depending on the species. This diverse mental ability is dependent on genes. The gene *Fox P2* is responsible for singing in both birds and hu-

Increasing grade of complexity	PROBLEM SOLVING	NEST BUILDING	MIGRATION	TOOL MAKING
1	INSECTS ANTS Farming ARACHNIDS SPIDERS Web-repair MOLLUSCS OCTOPUSES 29 shapes	INSECTS AFRICAN ANT *Dorylus* INSECTS TERMITES *Macrotermes*	INSECTS MONARCH BUTTERFLIES LOCUSTS North-South CRUSTACEANS SPINY LOBSTERS Winter and summer residences	INSECTS WEAVER ANTS Leaves sealed ARACHNIDS SPIDERS Webs as traps MOLLUSCS OCTOPUSES Shelters
2	FISH ARCHERFISH Captures insects by projecting water	FISH SEA HORSES Nest building by male	FISH SALMONS EELS Migration from sea to fresh water	FISH No detailed information
3	AMPHIBIANS Maze learning	AMPHIBIANS Nest building by leaf folding	AMPHIBIANS FROGS TOADS Short distance (1 mile) between feeding and breeding sites	AMPHIBIANS No detailed information
4	REPTILES Parental care Counting-like skills	REPTILES PYTHON *Antaresia* Nest building	REPTILES MARINE TURTLES Long distance migration	REPTILES MONITOR LIZARDS Use forelimbs to extract prey
5	BIRDS HERONS Compensation for refraction	BIRDS MOST SPECIES WEAVERS BOWER BIRDS Complex nests with decorations	BIRDS MOST SPECIES From North to South and back	BIRDS RAVENS Insertion of twigs in crevasses
6	MAMMALS CHIMPANZEES Choose different squares	MAMMALS DORMICE CHIMPANZEES Build nests to overnight	MAMMALS ZEBRAS From forests to plains WHALES Between tropical and polar waters	MAMMALS CHIMPANZEES Putting sticks together

Table 8: PERIODIC TABLE OF MENTAL ABILITY. Problem solving, nest building, migration and tool making, attain remarkable development in simple invertebrates as well as in complex mammals. The genes involved in some of these processes are known: singing in birds and humans (*FoxP2* gene) and web building in spiders (proteins *MiSp*, Flag and *MaSp2*). Only two of the 29 orders of insects formed high complex and dynamic societies. Social organization evolved independently 11 times in one of these orders but only once in the other. Another feature of periodicity is that closely related species do not exhibit the same specific trait.

mans, and the silk of the spirals built by spiders, is the product of genes that have been isolated. Spirals are also drawn by humans and drugs lead in both cases to the drawing of irregular geometric figures. Moreover, the same brain chemicals are present in spiders and humans.

There is among animals a common form of abstract thinking: bees, birds and chimpanzees can count (Dacke & Srinivasan 2008).

The similarity between plants, invertebrates and vertebrates (including humans) is becoming more comprehensive as molecular biology expands.

Increasing grade of complexity →

MARSUPIAL SERIES

POUCHED MOLE	MULGARA MOUSE	PHASCOG-ALE	OPOSSUM	ANTEATER NUMBAT	GREATER GLIDER	SUGAR GLIDER	WATER OPOSSUM	POUCHED HYENA	TASMANIAN WOLF	MARSUPIAL LION	SABRE-TOOTH TIGER
Notoryctes	*Darcycercus*	*Phascogale*	*Caluromysiops*	*Myrmecobius*	*Petauroides*	*Petaurus*	*Chironectes*	*Borhyaena* Fossil	*Thylacinus*	*Thylacoleo* Fossil	*Thylacosmylus* Fossil

PLACENTAL SERIES

MOLE	MOUSE	SHREW	TARSIER	ANTEATER	SQUIRREL	COLUGO	OTTER	SPOTTED HYENA	WOLF	LION	SABRE-TOOTH TIGER
Talpa	*Mus*	*Sorex*	*Tarsius*	*Tamandua*	*Anomalurus*	*Cynocephalus*	*Lutra*	*Crocuta*	*Canis*	*Panthera*	*Smilodon* Fossil

Table 9: PERIODIC TABLE OF EQUIVALENCE BETWEEN MARSUPIALS AND PLACENTALS. The similarity between these two series of animal species has been repeatedly described as an "intriguing case of convergence" and as a "curiosity". Their similarities were considered the product of random events and these animals, arising on distant continents, could hardly have the same genes. Again, molecular evidence revealed another scenario. There has been an extreme permanence. The protein coding genes of the monotremes (the early ancestors of these two groups) were compared with those of marsupials and placentals. The number of these genes in the monotreme platypus is 18,527, in humans 18,600 (placental) and 20,800 for opossum (marsupial). Besides 82% of the monotreme genes have homologues in these other species (Warren et al. 2008). The animals that emerged are members of the most different families: moles, mice, anteaters, gliders, wolves, lions and sabre-tooth tigers. There are impressive similarities species by species, this is why they have been called, by different authors, as "carbon copies".

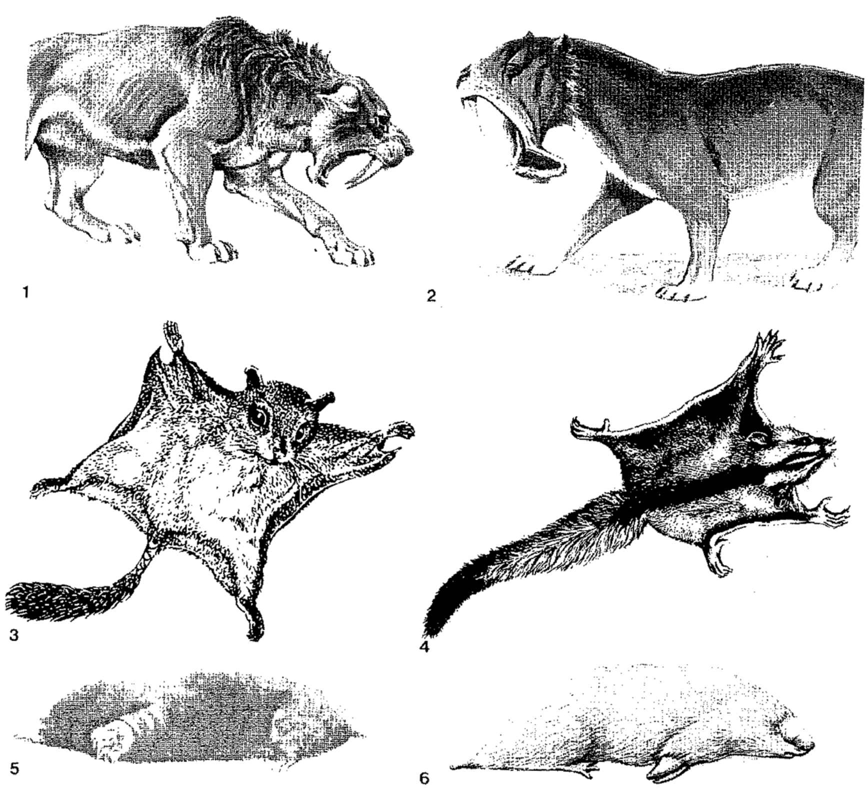


Figure 16: Some of the species that are "carbon copies" of one another in placental and marsupial mammals. (1) The sabretooth tiger *Smilodon* (placental) and (2) the sabretooth tiger *Thylacosmylus* (marsupial). Both are fossils. (3) Gliding squirrel *Anomalurus peli* (placental) and (4) the greater glider *Petauroides volans* (marsupial). (5) The common mole *Talpa europaea* (placental) and (6) the pouched mole *Notoryctes typhlops* (marsupial).

3.9. The Placental Mammals are "Carbon Copies" of the Marsupials

It has been repeatedly pointed out, by many authors, that the two groups are very much alike. However, this finding has not been examined in terms of periodicity. It was considered of marginal significance since it could not be explained by selection.

The first marsupials (that carry their young in pouches) arose 75 million years ago. The placentals (that retain the young inside the mother's body) appeared later 50 million years ago (Macdonald 1984). The "carbon copy" versions that emerged include species, genera, families and orders. Equivalents are found for members of carnivora, primates, rodentia, dermoptera, insectivora, edentata, perissodactyla and artiodactyla (Table 9). For instance, the fossil sabretooth tiger *Smilodon* (a placental) had a most similar species in the marsupial fossil *Thylacosmylus*. The European otter (placental) and the water opossum (marsupial) have the same body features and behavior. The same is the case of the common mole and the pouched mole (Figure 16). The genes in these two groups were also found to be most similar (Warren *et al*. 2008).

Periodicity is stressed by the finding that gliding species were produced, again and again, in marsupials and placentals.

3.10. Biological Periodicity is Characterized by the Following Features

The following text is a description of the main characteristics of biological periodicity and the enunciation of the Law of Periodicity. After four years, since they were written, it does not seem necessary to add or subtract any material to the statements made, which supports their validity (Lima-de-Faria 2017):

1. Biological periodicity is an event anchored in the mineral world where only simple atomic interactions decide the properties. These do not start at the biological level, as previously assumed, but existed before DNA and the cell arrived in evolution. Regeneration is evident in crystals of ammonium oleate, luminescence is pronounced in the minerals fluorite and scheelite as well as in 19 others. Also in vision the ability to deviate light rays (present in lens proteins) was already exhibited by calcite crystals with their double refraction.

2. The main feature of biological periodicity is its punctuated emergence. It seems to arise from nowhere coming and going without previous announcement. The organisms that exhibit flight, vision, plant carnivory, or any other of the described properties, do not show a relationship to their immediate predecessors. The pterosaurs were not directly related to the flying insects that preceded them, and carnivorous plants appear in plant families that are not closely related.

3. Periodicity emerges with few intermediate forms or abruptly in most cases. High mental ability is present in the building of elaborated societies by ants whereas many other insect species are solitary.

4. It is independent of organism complexity. Vision is present in bacteria in a way that it already resembles that of humans. The placenta emerges independently in plants, invertebrates and mammals.

5. It appears in a well defined organ or on a restricted species group. Plant carnivory is confined only to leaves and only to flowering plants. Luminescence became localized to specific organs and could not extend beyond the fishes.

6. The types of structures and functions that are an obligatory component of a given property (e.g. flight, mental ability, placenta formation) are essentially the same in all the different taxonomic groups that exhibit it. Flight in bats, birds and insects uses a wing whereas a quite different structural solution could have been created (such as jet propulsion in squids).

7. Periodicity occurs at regular intervals but of variable length. This is to be expected since we are dealing with living organisms which are more complex than simple atoms. High mental ability has re-emerged after millions of years but in plant carnivory the interval may have extended to only thousands of years.

8. It is independent of the organism's taxonomic location. The penis is as developed in invertebrates as it is in higher mammals.

9. It is also independent of the environment. Gliding has arisen in animal species living in the tropics as well as in Nordic climates. The marsupials that evolved in Australia (in a different en-

CHARTS OF CHEMICAL AND

PERIODIC TABLE OF CHEMICAL ELEMENTS

Increasing grade of complexity	ALKALI METALS	ALKALINE EARTHS	NONMETALS				HALOGENS	NOBLE GASES
								HELIUM 2 4.0
1	LITHIUM 3 6.9	BERYLLIUM 4 9.0	BORON 5 10.8	CARBON 6 12.0	NITROGEN 7 14.0	OXYGEN 8 15.9	FLUORINE 9 18.9	NEON 10 20.1
2	SODIUM 11 22.9	MAGNESIUM 12 24,3	ALUMINUM 13 26.9	SILICON 14 28.0	PHOSPHORUS 15 30.9	SULFUR 16 32.0	CHLORINE 17 35.4	ARGON 18 39.9
3	POTASSIUM 19 39.1	CALCIUM 20 40.0	GALLIUM 31 69.7	GERMANIUM 32 72.5	ARSENIC 33 74.9	SELENIUM 34 78.9	BROMINE 35 79.9	KRYPTON 36 83.8
4	RUBIDIUM 37 85.4	STRONTIUM 38 87.6	INDIUM 49 114.8	TIN 50 118.6	ANTIMONY 51 121.7	TELLURIUM 52 127.6	IODINE 53 126.9	XENON 54 131.3
5	CESIUM 55 132.9	BARIUM 56 137.3	THALLIUM 81 204.3	LEAD 82 207.1	BISMUTH 83 208.2	POLONIUM 84 (210)	ASTATINE 85 210	RADON 86 (222)
6	FRANCIUM 87 (223)	RADIUM 88 226.0	113	114	115	116	117	118

Increasing grade of complexity →

LANTHANIDE SERIES

LANTHANUM	CERIUM	PRAESEODYMIUM	NEODYMIUM	PROMETHIUM	SAMARIUM	EUROPIUM	GADOLINIUM	TERBIUM	DYSPROSIUM	HOLMIUM	ERBIUM	THULIUM	YTTERBIUM
57	58	59	60	61	62	63	64	65	66	67	68	69	70
138.9	140.1	140.9	144.2	(145)	150.4	151.9	157.2	158.9	162.5	164.9	167.2	168.9	173.0

ACTINIDE SERIES

ACTINIUM	THORIUM	PROTACTINIUM	URANIUM	NEPTUNIUM	PLUTONIUM	AMERICIUM	CURIUM	BERKELIUM	CALIFORNIUM	EINSTEINIUM	FERMIUM	MENDELEVIUM	NOBELIUM
89	90	91	92	93	94	95	96	97	98	99	100	101	102
(227)	232.0	231.0	238.0	237.0	(244)	(243)	(247)	(247)	(251)	(254)	(257)	(256)	(254)

Lima-de-Faria, A. 2017. Periodic Tables Unifying Living Organisms at the Molecular Level. The Predictive Power of the Law of Periodicity. World Scientific.

BIOLOGICAL PERIODICITY

PERIODIC TABLE OF LIVING ORGANISMS

Increasing grade of complexity	LUMINESCENCE	VISION	REGENERATION (WHOLE BODY)	PLACENTA	PENIS (SINGLE)	FLIGHT (IN AIR)	PLANT CARNIVORY (TRAP)	MENTAL ABILITY
1	MINERALS EUBACTERIA	MINERAL REFRACTION CYANOBACTERIA	CRYSTALS PROTOZOA	ONYCHOPHORANS BRYOZOANS	FLUKES	INSECTS	*Drosophyllum* Leaves slightly curved at top	ANTS TERMITES BEES
2	DINOFLAGELLATES	PLANT CELLS CNIDARIANS	ALGAE SPONGES	SPONGES WORMS FLIES	GNATHOSTOMULIDS GASTROTRICHA	SQUIDS	*Sarracenia* Tube with a lid	SPIDERS OCTOPUSES
3	FUNGI	CRUSTACEANS MOLLUSCS INSECTS	CNIDARIANS	ASCIDIANS FERNS	MOLLUSCS INSECTS	FISH	*Nepenthes* Pitchers of two types	ARCHERFISH
4	STARFISH JELLYFISH	FISHES AMPHIBIANS	FLATWORMS	SHARKS TOADS LIZARDS	CAECILIANS LIZARDS	PTEROSAURS	*Dionaea* Leaves bilobed and movable	MONITOR LIZARDS
5	MOLLUSCS INSECTS	REPTILES BIRDS	ECHINODERMS	FLOWERING PLANTS BANDICOOTS	OSTRICHES DUCKS	BIRDS	*Genlisia* Spirally twisted branches with claws	WEAVERBIRDS
6	NEARSHORE AND ABYSSAL FISH	MARSUPIALS PLACENTALS	FLOWERING PLANTS	EARLY PLACENTALS LATE PLACENTALS	MARSUPIALS PLACENTALS	BATS	*Utricularia* Bladder with movable door	CHIMPANZEES

Increasing grade of complexity →

MARSUPIAL SERIES

POUCHED MOLE	MULGARA MOUSE	PHASCOGALE	OPOSSUM	ANTEATER NUMBAT	GREATER GLIDER	SUGAR GLIDER	WATER OPOSSUM	POUCHED HYENA FOSSIL	TASMANIAN WOLF	MARSUPIAL LION FOSSIL	SABRE-TOOTH TIGER FOSSIL

PLACENTAL SERIES

MOLE	MOUSE	SHREW	TARSIER	ANTEATER	SQUIRREL	COLUGO	OTTER	SPOTTED HYENA	WOLF	LION	SABRE-TOOTH TIGER FOSSIL

Table 10 (previous pages): CHARTS OF CHEMICAL AND BIOLOGICAL PERIODICITY — PERIODIC TABLE OF CHEMICAL ELEMENTS COMPARED WITH PERIODIC TABLE OF LIVING ORGANISMS.

(1) PERIODIC TABLE OF CHEMICAL ELEMENTS. Mendeleev's original Table contained only 61 chemical elements but at present the Table extends to 118. Over 700 different representations of the Periodic System have been published putting in evidence particular properties of the atoms (Mazurs 1974). In the present table are included the groups of atoms that exhibit the highest degree of regularity. Hydrogen (with its variable location) and the transition metals were not included. The eight vertical columns consist of elements which have the same basic property. This property resurfaces independently of whether the atoms are simple or most complex. The intervals are not all of the same length. The Periodic System contains many irregularities, which are usually not mentioned, since the Table is one of the icons of science. The two horizontal series comprise the Lanthanide Series and the Actinide Series which are compared with each other due to the following common atomic features: (1) The lanthanides are especially notorious for being chemically similar to each other. (2) The actinides are also similar to each other by being all radioactive. (3) The properties found in the elements of lanthanides parallel those of the actinides (Gray 2009) The comparison, of the marsupial series and the placental series, with that of the lanthanide series and the actinide series, may seem farfetched, but this is because it is still difficult to think of DNA's gene sequences in simple atomic and electronic terms.

(2) PERIODIC TABLE OF LIVING ORGANISMS. Like in the Table of the chemical elements there are eight columns in which the properties were grouped according to basic common features: (1) Luminescence, vision and regeneration start all three at the mineral and crystal level. (2) Placenta, penis and wings (flight) are organs that appear from nowhere. (3) Plant carnivory and mental ability are processes that lead primarily to the acquisition of nutrients followed by digestion and assimilation.

Periodicity is characterized by: (1) The same property re-emerging as much as 10 times (plant carnivory), and 40 times (luminescence). Simple eyespots have evolved also independently at least 40 times and probably as many as 65 times (Land & Fernald 1992). In sharks the placenta emerged independently on over 11 occasions and the placenta of reptiles "has evolved on more than 100 separate occasions". (2) A property suddenly appears in the simplest as well as the most complex organisms. This sudden recurrence takes place in organisms that are not phylogenetically closely related. (3) The properties arise without previous announcement. (4) The novel structures appear "ready made" being functional and coherent from the start. (5) Some properties arise at the mineral level, before DNA arrived in evolution, supporting the notion that biological periodicity has an atomic ancestry. The emergence of two independent series, in the lower part of the two charts, reinforces the connection between the two types of periodicity the chemical and the biological. Only future investigation, at the atomic level will elucidate properly this surprising similarity, that at present, may appear fortuitous.

vironment and having a different plant diet) became carbon copies of their European placentals. Flight occurs in air but also in water and in the water-air interface.

10. The degree of complexity of a given structure or function does not necessarily follow the general increase in complexity taking place during evolution. Flight in birds is not more complex than that of flies. Four wings occur in fishes and butterflies but birds have only two. The eye of a fish is not more advanced than that of an invertebrate cephalopod (Table 10).

3.11. The Molecular Mechanism Responsible for the Emergence of Biological Periodicity

1. Biological periodicity could not occur if the genes of most living organisms were not essentially similar. The sequenced genomes of algae (Chlamydomonas), flowering plants (Arabidopsis) and humans were compared revealing that their gene numbers are 15,143, 26,341 and circa 23,000 respectively. Besides many gene families can be easily recognized in these 3 types of organisms (Merchant *et al.* 2007).

2. Before the sudden re-emergence of a given property was considered a "paradoxical event". Biological periodicity could not even be contemplated because the genes directly responsible for a given structure and function were not known. Now a single gene, isolated in the test tube, such as Pax6, decides vision in nearly all animals (Gehring & Ikeo 1999).

3. Plants were considered to be genetically far away from animals and as a consequence could not be included in the same periodicity. The placenta which is a general feature of a whole group of mammals, could not be compared to that of

plants, but its emergence in these totally unrelated groups is now known to be decided by common genes (Spielman *et al.* 2001).

4. The ordered evolution of an organ, such as the eye, has been guided by self-assembly, a pure atomic event, independent of external intervention.

5. Coherence of structures and functions building a harmonious organ with high efficiency are most evident in plant carnivory, flight, mental ability and vision.

6. The novel organs appear as "ready made". Extra pairs of wings in flies, and extra pairs of wings in birds, obtained in the laboratory, are formed, from the onset, with the correct skeleton, articulations, muscles and blood vessels. The extra legs of insects, produced in the same way, are also organized consisting of the identical segments and articulations (Bender *et al.* 1983, Lawrence 1992, Gehring 1998).

7. The sudden absence of a property, as well as its equally sudden reappearance, is due to the repression and the expression of a gene or gene cluster. Gene repression and expression are decided by changes within the DNA of chromosomes but also by the intervention of small RNAs.

8. The same genetic constitution which is present within the same animal or within the same plant, allows or blocks the occurrence of a given property. The same individual plant produces side by side carnivorous and non-carnivorous leaves. Among annelids, brachiopods and bryozoans the adults have no eyes whereas the larvae have eyes.

9. The resurfacing of the same property may occur again and again. Bioluminescence is estimated to have evolved independently at least 40 times and plant carnivory also independently on 10 occasions. The placenta in reptiles has evolved on more than 100 separate occasions.

3.12. The Law of Biological Periodicity

Scerri (2007) who treated extensively the periodicity of the chemical elements in his work *The Periodic Table — Its Story and Its Significance* formulated the Law of Periodicity at the chemical level as follows: "The periodic law states that after certain regular and varying intervals the chemical elements show an approximate repetition in their properties". To be noted is that the intervals are regular but "varying" and that the repetition is "approximate". And he adds "periodicity among the elements is neither constant nor exact". However, he emphasizes that there is a fundamental relationship among the elements.

The evidence gathered at the molecular level that unifies living organisms independent of their complexity or phylogenetic location, exposes a periodicity that can also be concretized in the form of a law.

The law of biological periodicity states that after certain regular and varying intervals the living organisms show an approximate repetition in their properties.

The similarity between the periodicity at the atom level and that of living organisms is so striking that the law of biological periodicity is a paraphrase of the law of the chemical elements. This is astonishing and could hardly be expected since we tend to think about biological phenomena following antiquated ways of reasoning far removed from the laws of physics and chemistry.

Now, when the evidence is so compelling, one thinks that it could not be otherwise.

3.13. Predictions

Predictions can now be better formulated, and treated more extensively, because in the last four years more data have become available. A comparison with these results allows a clearer overview.

1. **Chemical ignorance limited prediction**

When Mendeleev produced his Table it contained only 61 elements, and as a consequence there were empty spaces in the columns. He realized that these were not faults, but were a sign that there existed chemical elements that had not yet been discovered, which occupied the empty squares. These elements were later found corroborating his predictions. But since then many others were discovered (total 118) that could not be predicted.

2. **Biological ignorance limits prediction**

The same situation is faced at present. The Biological Tables contain empty spaces. This is not surprising. The number of species in eukaryotes (organisms with a cell nucleus) is 8.7 million + - 1.3 million and comprise mainly: protozoa, fungi, plants and animals. Microbial species (without a cell nucleus) are 1 trillion (Mora *et al.* 2011, Locey & Lennon 2016). Most of them have never been studied in detail as regards structure, function or behavior. The ignorance is monumental. Treatises describing in detail each species were published only recently. *The Handbook of the Birds of the World* (del Hoyo *et al*. 1992–2011), comprises 16 volumes covering 9,600 species and the *Handbook of the Mammals of the World* (Wilson & Mittermeier 2009–2019) has just been published covering 9 volumes (5,339 species). No comparable works exist for fishes (24,500 species), amphibians (5,000 species) and reptiles (7,984 species). Novel properties are being added continuously allowing animals and plants to be located with precision in the empty squares. An example is the number of animals that can count, or recognize signs, which will successively fill the table of mental ability. Also, the number of fish and invertebrate species, that display luminosity, will increase in the boxes of this table. Regeneration is being actively investigated and new organs are being added. Besides, new properties, which so far have not been studied from the point of view of periodicity, will create new columns or Tables. The nearest candidate is dentition.

3. **The inclusion of novel properties in the main Table**

Teeth are eliminated and replaced at specific intervals, but it has not been realized before that this is a programmed event, decided by internal genetic processes, which are independent of the environment. In humans the upper and lower teeth (central incisors) erupt by 6 to 12 months of age and are shed when children are 6 to 7 years old. Other teeth follow exact programs such as wisdom teeth (eruption at 17-21 years). Fossil birds had teeth, but they were eliminated in living species and turtles also lack teeth. However in many fishes, amphibians and reptiles tooth replacement continues throughout life. As Romer and Parsons (1978) point out the replacement is in waves, and what at first sight "seemed madness" and a "jumble" is the result of "an underlying principle of order" It is this order that now makes dentition a perfect example of periodicity.

4. **The length of the periods**

The length of periods is already highly variable in the Periodic Table of Chemical Elements. This is recognized as "the really crucial property of the periodic Table", yet the lengths of the periods are still not explained at present. At the biological level this phenomenon will be still more difficult to unravel, but should not be out of reach. In flight the interval is of the order of millions of years (e.g. insects to pterosaurs and birds to bats) but it may be of the order of hundreds of years between the plant carnivory exhibited by different families, or by days in the formation of the placenta in reptiles.

5. **The creation of novel organisms**

Using genetic engineering it will become possible to obtain the resurgence of a given property and consequently to create organisms with a specific structure and function that did not exist before. These will occupy empty spaces at most unexpected sites.

6. **The acceleration of evolution**

It will become possible to accelerate or to retard evolution by interfering with the own evolution of the macromolecules that direct the cell processes.

7. **The present interpretation of evolution is antiquated. Novel structures and functions arise as coherent combinations**

Contrary to the present dominating view of evolution, genetic engineering and biotechnology are disclosing that novel structures and functions arise, from the start as coherent combinations of parts and organs. They are the product of new rearrangements of DNA sequences that lead to molecular cascades which determine a new development and establish a novel final pattern.

8. **Novel organs appear "ready made"**

Equally, the emergence of novel traits is not considered to be the result of numerous random mutations accompanied by long periods of selection. Instead novel organs (which have been obtained experimentally) appear "ready made". They arise again and again, irrespective of whether they have a positive or negative effect on the organism. The own evolution of DNA, RNA and the proteins follows only the laws of physics and chemistry.

9. **Canalization of events**

The electron is a prisoner of its energy states. It can jump from one orbital to another but cannot fall between orbitals. The energy alternatives are, from the beginning not of all kinds. The canalization of evolution, is present at the very dawn of matter and life, since elementary particles and atoms have not changed their properties when the cell emerged.

10. **Biological Periodicity a key to novel alleys in physics**

Just as the law of periodicity, resulting from Mendeleev's work, became the key to modern chemistry, the law of biological periodicity is expected to lead physics into new alleys of research, obliging molecular biology to become Atomic biology.

11. **Prediction is always a difficult process**

As Scerri emphasized "Almost nobody, including Mendeleev, had predicted or even suspected the existence of an entire family of new elements", the inert or noble gases.

12. **A mathematical equation defining the law of periodicity**

As knowledge enlarges, and mathematicians will start collaborating with atomic biologists, it is expected that, in a distant future, the law of periodicity will become crystallized into a simple mathematical equation.

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