Chapter 4

Psychomatics (= The Science of Sensitivity)

The task of *psychomatics*

The main aim of the foregoing studies on the crystal psyche is the firm establishment of a unitary outlook on nature; the proof that in organic and inorganic nature, uniform, "eternal, ab initio, great laws", govern all that happens. The whole living world, inseparably joined with the so-called non-living world, is guided, as a "universe", uniformly by the same principle of evolution. As I sought in 1899, in my book "The Riddle of the Universe", to lay down the ground rules of this monistic philosophy in generally understandable form, I represented the solid basis, the concept of substance, still in the same way that Spinoza had done, and as after him Goethe had formulated it in the deathless phrase: "matter can never exist and act without spirit and spirit can never exist and act without matter". Although here one may interpret pantheistically oxr in the sense of modern physical "energetics", the concept of "spirit", in the sense of an omnipotent "God-Nature", in every case the inseparable unity of force and substance is asserted. Opposite the space-filling substance, the "*extensum*" or what-is-extended (= matter) there stands as the second attribute, the thinking, feeling, and willing substance (= psyche). First through continual comparative researches I later reached the conviction, that the two main properties of the psyche, movement and sensitivity, were better separated as two independent attributes of substance. Mechanics, which concerns itself with movement, and *psychomatics*, which concerns itself with the sensitivity of matter, require different methods of investigation.

Thus, in 1904, I reached the extended doctrine of the trinity of substance, the basis for which I had laid in chapter 19 of my "Lebenswunder". This new monistic theory of the general "Three-in-one unity of substance", which exists in all inorganic bodies as in all organic bodies, overcomes the difficulties of the older "philosophy of identity". I have provided a survey of its connections to the three unique directions of the doctrine of substance (I. Materialism, II. Energetics, III. Pan-psychism) made in the fourth table of my "God-Nature" (1914) and repeated here as an appendix.

***Psychomatics* and psychology**

Among all the different branches of human knowledge we now (as for 2000 years) assume psychology, as "the science of the soul", to have the most special place. On one hand there is the scientific researcher who concerns himself with all phenomena of nature, and in the monistic sense assumes the unity of nature in the whole cosmos, and claims the "psyche" as a natural phenomenon. On the other hand the scholastic philosopher takes the psyche-life as a supernatural appearance, he treats it in the dualistic sense as an action of the "spirit" which is independent of nature and overlies nature. This conspicuous and deep contradiction between the two world outlooks shows itself practically, in that academic instruction in psychology is generally divided between two different faculties. In the

medical faculty they teach, in physiology for the healthy organisms and in psychiatry for the sick organisms, that the whole psychic activity is a function of the brain, the sum of the mechanical actions which is directed by the neurones, the psyche-cells of the brain. On the other hand in the philosophical faculty they teach the official, metaphysical psychology, which is state-approved and tied to theology, that the "soul" is an independent, immaterial and undying "being", which lives in the mortal body only temporarily and leaves it on death. This violent and irreconcilable contradiction between the two main directions of psychology is usually so built-in, that it is simply assumed as a fact, without questioning its basis more deeply. The consequence of this is an unexampled entanglement in the literature of psychology, and an incessant struggle between the most respected representatives of the two directions, who for the most part do not understand each other and do not wish to understand each other.

Psychomatics and mathematics

Modern exact natural science seeks unanimously as its highest goal to refer back all natural phenomena to the laws of physics (in the widest sense, including chemistry) and to express its most general concepts, where possible, in mathematical formulae. Number and mass ought to express the laws of nature exactly and with incontrovertible certainty. In our outlook, this over-valuation of mathematical methods leads to dangerous fallacies. For mathematics as the doctrine of quantity can always only establish the absolute and relative amounts of these quantities and the quantity of objects. It cannot tell us anything about the quality itself, or the properties, the recognition of which is only possible through sensitivity. Here can only *psychomatics* in our sense, the recognition of the "en-souling" of all things—or the psychic "life" in the whole universe—provide a true insight into the being of "substance". Thus chemistry must establish numerically, above all with the help of the balance, the weights of atoms and the molecules, which the uncountable compounds form. But to the deep principles of these compounds, to the chemical "elective affinities" or affinities, we achieve access only through their *psychomatic* meaning. The feeling of pleasure or pain on stimulation, the "loves and hates of the elements" (Empedocles) is the true final cause, which the motions of the atoms and molecules directly supply.

Physics and metaphysics

Strictly exact scientific research will reproach our *psychomatics* that it may cross the secure domain of physics and enter the dangerous ground of metaphysics. Just this reproach meets, to the same extent, all comprehensive theories, all attempts of the thinking human spirit, to attain recognition of general laws covering the confusing plenitude of numberless single phenomena. So far, even in the domain of general physics (thus for example in the famous theory of relativity) confusion rules, which leads even the most famous physicists to the most obvious contradictions. This is especially so for the great problem of "matter", that is of extensive space-filling substance. According to the conception, which I have laid down in the "Riddle of the Universe" (chapter 13, 1899), there is no "vacuum". All space, which is not taken up by ponderable mass ("inert matter" in the narrower sense), is filled up by the imponderable ether. Even concerning the properties of this problematic "ether" (a real riddle of the universe!) the views of the most respected experts diverge widely (see below).

Comparative *psychomatics* (Comparative psychology of crystals and organisms)

In the second part of the "Riddle of the Universe" (1899, chapters 6–11) I tried to solve the difficult task of monistic psychology, in that I set up a continuous step-ladder for the evolution of the life of the soul, from the simplest unconscious cell-souls of the protists up to the highest self-conscious large-brain souls of human beings and the higher vertebrates of the same family. In this I supported myself with the basic biogenetic law, in which I sought to explain the empirically established facts of embryonic history (chapter 6) by its hypothetical, but based on the violent facts of paleontology, phyletic history (chapter 7). The method of the critical comparison of related psychic phenomena is of the highest value for reaching the conviction of the unity of the psyche life in the whole organic world. It leads us step by step from the simplest cell of the lowest protists (protophytes and Protozoa) up to the social cell psyches, the cell unions (coenobia); and from this to the organised tissue cells of the *histones*, which show a long series of evolutionary steps, on one side in the "plant psyches", the metaphytes (tissue plants) (usually called multi-cellular) and on the other side, in the animal psyches (tissue animals). The value of this comparative method has been long known in the region of animal morphology. Here, in the course of the 19th century, from Goethe and Cuvier to Johannes Müller and Karl Gegenbaur, the comparative anatomy of organs has been raised to a height and clarity of philosophical recognition, which places this branch of biology at the peak of modern natural philosophy. It is enough to recall an outstanding example, comparative craniology. This demonstrates to us, how the most secret and most complicated bony structure of our human skull has evolved gradually, in the course of many million years, from the simple cartilaginous capsule of the original animals with skulls (*Archicrania*). We have gained significant knowledge about the remains of the Cyclostomes, still living with us, the lampreys (petromyozonts) and the hag-fish (Myxinoidae). Further, as in the course of millions of years the typical mammalian cranium has evolved, first at the beginning of the secondary period (in the Triassic), from this primitive ancient skull of the Archicrania, the compound bony structure of the Silurian and Devonian fish and later to the Carbonaceous amphibia and the Permian reptiles. Now this vertebrate skull is most important in that it builds a protective capsule for the enclosed brain, the central psyche organ of the vertebrates. If we now apply the same method of critical comparison to the psychology of our phylum, then we will convince ourselves, how the historic course of evolution of our psyche (as a function of the brain, as the "action of its neurones") corresponds exactly with that of the central organs. In this respect the value as scientific knowledge of comparative psychology and its synthesis cannot be over-emphasised. This contrasts with the claims of the modern "physiological psychology", which wishes to penetrate into the being of the life of the psyche only through "the exact observation of single psyche phenomena" both through experiment and also through special analysis

Feeling (*aesthesis*)

The "world psyche" (*psychoma)* is, as a psycho-physical principle, one of the three "essential attributes" of all substance. It is inseparably tied in with the two other basic properties (energy and matter), both in organic (living) nature and in inorganic (non-living) nature. Feeling or unconscious "sensitivity" is the real "inner working" of substance, in contrast to energy which is the "manifestation". Feeling distinguishes the subject from the

surroundings of the external world (the object), while the energy as "force" acts on it (manifests itself). In *aesthesis* two alternating "original states" stand opposite each other, the positive pleasure feeling as inclination or attraction, the negative pain feeling as opposition or repulsion. The antagonism of the positive and negative feelings corresponds to the old doctrine of the "love and hate of the elements".

The unconscious sensitivity of all matter, the inorganic as well as the organic—in correspondence with their mobility—has been proposed recently from the standpoint of speculative physics by Gustave Le Bon in his work on "The Evolution of Matter"[1]. The change in the material equilibrium under the influences of the environment, as well as the variability of the chemical species, are here stimulatingly discussed, as are the important connections to evolutionary theory of molecular physics and especially of the modern theory of electricity. The different equilibrium forms of matter, which also appear formative in *statotaxis*, arise from the attractive and repulsive forces, which rule between isolated material molecules, but which are to be traced back to their *psyche*. The inner connections between "sensitivity and movement" (= feeling and willing) become clarified by our monistic psyche theory.

The conservation of feeling (Constancy of the *psyche)*

If my *psychomatic* theory is correct, if all substances, inorganic and organic, possess feeling or *aesthesis*, then the general "law of conservation" must be applicable with the same validity as for the other two attributes "energy and matter". The great law of the "conservation of matter" was proposed by Lavoisier in 1789 and the corresponding law of the "conservation of energy" by Robert Mayer in 1842. Although the connection between these two laws, which I had formulated in 1899 in chapter 12 of the "Riddle of the Universe"[2] under the concept of the law of substance, appears obvious for the monistic view of nature, it is still contentious today for dualistic philosophy. So we will have to wait a long time until the conservation of feeling is incorporated into the law of substance and the trinity of its attributes is thereby recognised. The unbiassed treatment of the continual exchange between the two original states: attraction and repulsion, the game played to and fro between positive and negative tropisms in all evolution, appears necessary, if we recognise the general connection between feeling and movement in the universal life of matter.

***Molethyn* (Molecular organising forces)**

The characteristic molecular forces which determine the characteristic inner structure of formed matter, especially geometrical symmetry, in the structure of a crystal, were designated by Lehmann as "molecular directing (organising) forces". Since a definite scientific term, distinguishing them from other molecular forces, is still lacking, we will call them briefly *molethyn*[3], in which we connect a definite *psychomatic* property with the material and physical. We base ourselves on the hypothesis of the space lattice, which is generally assumed in the newer crystallography. Fritz Rinne, who in his "Leptonic science" (1917) has duly validated the higher significance of this unique "organising force", adds the following characterisation of "crystalline matter"—"The three-dimensionally periodic linear ordering of equal particles, connected with the ability for arbitrarily extended repetition of the structure with the above-mentioned geometrical periodicity, through

growth without changing the chemical nature of the material", (Rinne, p. 54). Rinne further observes, also correctly, that the "liquid crystals" are of the greatest interest for this generally important question, since they directly mediate between liquids and rigid crystals.

Moletropism

If we understand by the concept of *moletropism* or *moletaxis* a special form of molecular motion in a determinate direction, then this elementary energy form must be treated as a primitive feeling and willing, as a special kind of molecular force, which is essentially distinct from cohesion and adhesion, and different from affinity and gravitation. For its correct estimation it appears to me that the comparison of *sterro*-crystals with the crystal skeletons of Radiolaria is of great value. For the feeling for equilibrium of these latter, the "feeling of pleasure in *statotaxis*", which for these single-cell protists determines the regular geometrical building of the *sterro*-crystalline skeleton, can also be adduced for the explanation of the regular formation of the quite analogous anisotropy of the mineral *sterro*-crystal. It hardly necessary to mention, that this unconscious soul activity, resting on the "feeling and willing" of the molecule, has nothing to do with the so-called "dominants" the goal-directed organising forces of vitalism and its "entelechy". It includes throughout no mystical or teleological principles but is a *psychomatic* phenomenon of a purely physical nature.

***Mneme* (Memory)**

As the most noted advances in our general knowledge of nature, for which we are indebted to the year 1904, we have, after the discovery of liquid crystals and the discovery of the non-nucleated cells which appeared at the same time, the work of Richard Semon (Munich) on "The *mneme*[4] as the preserving principle in the exchange of organic events". In this outstanding work Semon, supported by many years of profound research in evolutionary history, has found the remarkable proof, that the soul phenomena of memory, which everyone from his own internal life is fully confident of, in their deepest being are identical and closely connected with the ontogenetic phenomena of genetics, with the phenomena of the living plasma, which visibly confront us in the individual evolution of each organism. The similarity between the two series of phenomena is, in fact, so conspicuous that the usages of speech have applied the same concept of reproduction to both. Memory, or the "inner working[5]" repeats, in the spiritual action of our brains, the multiple impressions, which, in the course of the individual personal life, are taken in through experience, instruction, adaptation, etc. The history of the embryo, on the other hand, repeats in the development of the embryo from the fertilised egg and in its subsequent metamorphoses, the most important of the changes in the ancestral series, which have taken place in the course of millions of years and generations through heredity consequent on sexuality. These "ex-periences" were "reproduced"[6].

The significant idea of the essential identity of these two "phenomena of reproduction" was first determined and clearly expressed by the physiologist Ewald Hering (Leipzig) in his famous lecture delivered in 1870 before the Viennese Academy: "On memory as a general function of organic matter". I myself tried then to extend this important principle of organic evolution and to reach, through joining the ontogenetic and

morphological facts with the paleontological facts, a firm basis for my "Basic biogenetic law". In my treatise on "The *Perigenesis* of the *Plastidule*"[7] I laid emphasis on the psychic properties of the smallest particles of life and turned the mechanical principle of transferred movement to the "branched wave motion of these plastidules as the effective origin of the biogenetic process". "Heredity is the memory of the *plastidule*; variability is the power of understanding of the *plastidule*." The complex connections which exist in all organisms in the course of their phyletic history between heredity and adaptation, have been discussed in the greatest detail by Richard Semon in his *Mneme*. In a new presentation of this groundbreaking work (1909) there are treated most excellently the "*mnemetic* sensitivities in their relationship to the original sensitivities".

Hysteresis (inorganic memory)

In chapter 18 of my "Lebenswunder", which appeared at the same time as Semon's "*Mneme*", I had tried to represent the "*psychoma* as the general sensitivity of all substances". Here I laid special weight on the strength of habit; for it leads, as one of the most important forms of adaptation, on one hand through heredity up to the instincts of animals and plants, and on the other hand, through ethical strengthening of the social instincts to human fashion and custom, and finally to the conscious formulation of law and duty for rational civilised mankind. At the same time I had myself commented on this, that habit, that is, alteration in a material substance and its energy by the repetition of a certain activity, also occurs in the realm of inorganic nature. I related this especially to the expressions of Wilhelm Ostwald who, in his thoughtful lectures on natural philosophy in 1902, drew attention to the great significance of this inorganic habituation and its affinity with "unconscious memory". Ostwald correctly emphasised that "the most important performance of the organism is the transformation of different chemical energies one into another. Each cell is a chemical laboratory, in which the multiple reactions are carried out without ovens or retorts". The catalytic acceleration of a particular chemical process operates through habituation, like alterations which have remained behind, in the inorganic substance, as enzymes operate in organisms. Recently, Walter Hirt, in particular, in his "Life in the Inorganic World" (1914) has carried through this equating of the soul behaviour in organisms with that in inorganic substances and has emphasised the analogy of the *mneme* with hysteresis, the alterations which, for example, metals undergo on magnetic and electric stimulation. Iron, magnetised several times, "remembers" a foregoing magnetisation and reacts to a new stimulus differently from before[8].

Catalysis

Just as for the physical phenomena of hysteresis, the chemical processes of catalysis are also only to be understood through *psychomatic* explanations. The important phenomena of catalysis, in the exact investigation of which the said Wilhelm Ostwald has acquired the greatest credit, already in 1810 aroused great attention. Certain bodies give rise, through their mere presence—not through chemical affinity!—to decompositions and to compositions of other bodies, without being changed themselves thereby. Moreover, this puzzling "contact action" (decomposition though contact), which plays an important role in the organic processes of fermentation (fermentation, enzymatic action), can only be explained through our *psychomatic* assumption, that all substances are endowed, not only with energy

but also with sensation. (I have reported this more exactly in chapter 2 of the "Lebenswunder".)

Basic biogenetic law (1866)

This mechanical "basic law of organic evolution"—the real "causal nexus between ontogeny and phylogeny"—has been for the half-century of its existence, so actively discussed from many viewpoints and has been validated so clearly and creatively in thousands of valuable works, that it would appear excessive to mention it further here. But it is important, on one hand because of its close connection with our *psychomatics* and especially with the "*mneme*" of Richard Semon, and on the other hand, because it is also still beset with numerous attacks and misunderstandings. The general basic law of the new bio-genesis based, mechanico-causally, as it can be, on the "reformed descent theory of Charles Darwin", has already been formulated by me in books V and VI of my "General Evolutionary History"[9]. Eight years later, I essayed its fruitful practical application in my "Anthropogenesis"[10]. Here it is proved, for each single organ and organ-system of our human organism, how one can win an understanding of its individual development in the brief course of its embryonic history, only through the close connection to its historic reconstruction in the long course of the phyletic history. Here also a sharp exposition of the basic biogenetic law is given in the following expression—"The embryonic history (*ontogenesis*) is a condensed and abbreviated repetition of phyletic history (*phylogenesis*); and this repetition is the more complete the more, through constant inheritance, that the original direction of the path of evolution (*palingenesis*) has been adhered to. On the other hand, the repetition is the more incomplete, the more through changing adaptation that later deviant evolution (*cenogenesis*) has been introduced."

Many opponents of the basic biogenetic law are thus led into error, in that they relate all phenomena of embryology to the primary *palingenesis* and do not understand the important deviations, which have been introduced in the course of many million years by secondary *cenogenesis*. Many other opponents, namely the so-called "exact embryologists", would especially like not to recognise phyletic history. They lack also the unavoidable preconditions: a basic knowledge of paleontology and comparative anatomy. Some of these embryological specialists, whose whole interests are absorbed in the smallest details of the fertilisation of the egg and of gastrulation, have recently wished to replace completely the basic biogenetic law by a strange "causal biogenetic law" and by a new theory of the "type-cell" based on it. "There are as many specifically distinguished cells, as the systematics of the world of organisms distinguishes species" (that is, as many different types as were originally created[11]). If this "species-cell" really contains the "specific properties of the organic species" in a nut-shell, and passes it on unaltered from generation to generation, then one must necessarily assume a "constancy of species" and reject their transmutation. The *descendance* theory then becomes invalid.

The *psychomatic* scale

The step ladder for the evolution of the psyche, which on the basis of comparative and genetic methods, I sought to present in 1899 in chapter 7 of "The Riddle of the Universe", concerned only the five "psychological groups of the organic world" and the corresponding morphological "five steps in the building of the organs of the psyche". However, now

through the discovery of living crystals (liquid crystals) and their "inorganic psychic life", the ladder of psychic evolutionary steps is extended, both to the realm of the whole inorganic world and to the *psychomatics* of substance. As I tried to show in my writings on "God-Nature" (1914), the attribute of unconscious feeling (*aesthesis*) must also be extended to all inorganic bodies of nature and in the same way an inner psychic activity must be ascribed to all substance. This "inner working", as Heinrich Schmidt in his philosophical dictionary calls it, is the subjective psychic state of substance, which possesses, in its various "manifestations", its objective physical correlate. The modern "physiological doctrine of the psyche", can also be designated "the psychology of manifestation", in contradiction to the uniquely pure psychology, designated as "the psychology of inner working". Both must eventually completely include and supplement themselves[12].

Psyche of the Ether (*psychom* of the world ether)

The real constitution of the imponderable ether and its relationship with ponderable mass is still today one of the most difficult and controversial questions of physics. Even the recent advances in theoretical and mathematical physics have brought no complete clarification. While one group of speculative physicists declare the "ether problem" to be the most important problem of all physics, a second group regards it as an uncertain hypothesis and a third group denies altogether the existence of an ether. The latter set in its stead the vacuum—empty space. All agree that the problematic "luminiferous-ether" is the carrier of light and electricity; they measure and calculate the length of the light-waves and the electric waves; but at the same time many "exact" physicists claim that the phenomena come, not from the ether, but from the vacuum. According to our logical thinking this proposal is incomprehensible; for "empty space" is a purely negative concept, the absolute "nothing". Thus we cannot at all dispense with the hypothetical ether if we cannot build a secure representation on its special physical properties, namely its "state of aggregation" and its own "structure". According to our own personal "dilettante outlook", the world ether (as space-filling) is really "matter", but differs from ponderable mass, through its characteristic (etheric) state of aggregation and the lack of a "granular structure". Some *psychomatic* relationship between the luminiferous world-ether as "tense matter" and the heavy mass as "densified matter" must be assumed in any case, in as much as one defines the concept of substance in a kinetic or in a *pyknotic* interpretation[13] (see Table 8 in the appendix).

The psyche of electrons

Progress in modern electricity (since Heinrich Hertz, 1888) has led us, at the beginning of the 20th century, to a significant extension of atomistics. The ruling and well-founded assumption of most physicists is now, that the ultimate elements or fundamental particles of matter are not the atoms but the electrons. The smallest "corpuscles" or "elementary quanta of electricity" are in themselves completely simple and structure-less, and are not composed of still smaller particles. According to Mie[14], they are "no more than singularities in the world ether, namely places where the electric lines of force in the ether run together; in brief, knots in the electric field in the ether". On the real "substance" of these problematic fundamental particles of matter and their energy, the hypothetical views of modern

physicists are very varied. While the "materialists" regard these smallest fundamental particles as really material—that is extended and space-filling—the pure "energeticists" wish, on the other hand, to attribute to them no mass, but to regard them simply as "excited force fields". In this there comes into consideration the antagonism between positive and negative electrons, between the two polar and yet coexisting opposite forces of each *singulate* electron. Their relationship is, in spite of all advances in the highly developed science of electricity, not yet satisfactorily explained. According to our monistic interpretation it is also necessary to assume, for electrons, just as for atoms and molecules, a *psychomatic* principle, an electric sensitivity, which induces for the fundamental particles, in the positive case, attraction (pleasure) and in the negative case, repulsion (pain). The different kinds of atoms are determined by the different proportions of positive and negative electrons. In 1825, Goethe said in his observations "On meteorology": "Electricity is the pervasive element, which accompanies all material existence and thus also the atmospheric existence. It could be thought of impartially as a world soul".

The psyche of atoms (*Psychomatic* chemistry)

Our modern chemistry is based at the first level on the law of simple and multiple proportions (Dalton, 1804). From this it appeared that the molecules of mass are put together from the smallest identical particles, and that these atoms enter with each other into chemical compounds in altogether determinate proportions of weight. These latter distinguishable elementary particles are the chemical *singulates* of ponderable matter. "Atomistics", the theory that the life of the whole world can be traced back to the motion of such atoms, was proposed 2300 years ago by the great Ionic philosopher Democritos (400 BC), and presented by Epicurus and Lucretius (44 BC). But the certain empirical foundation was recovered first through the mathematical determination of the various atomic weights. The endless combinations of the different atoms, for the laws of which modern chemistry has supplied definite mathematical formulae, are the mechanical reason for the complicated phenomena which have been combined into the concept of "elective affinities". Now the manifestations of the lives of the atoms are, as our advanced chemistry has recognised on a large scale, really purely mechanical, without a teleological background. All the internal workings of chemistry, which open to us a deeper understanding of it, are to be traced, only through psychomatic interpretation, through research, to the unconscious sensitivity of the atoms, which as chemical *aesthesis*, make up the real "atom psyches".

Elective affinities (Wahlverwandschaft)

The basic *psychomatic* thought of our monism, that every substance has a psyche, was already current in the 5th century BC among the ancient Greek natural philosophers. Empedocles of Agrigentum expressed it in his doctrine of the "loves and hates of the elements". Essentially, according to the monistic interpretation, this ancient "*psychomatician*" unified the parts into a whole; peace, love and friendship ruled. Then disturbances entered as a consequence of growing hate and strife. The parts divided and fought each other; splitting of the unity separated them from each other. Only if the equilibrium of the forces working against each other is re-established, does the matter return to the whole "*spheros*". In the discussion of chemical affinity, which I have given in chapter 12 of "The Riddle of the Universe", I commented on how perceptively Goethe

in his classic novel "Die Wahlverwandschaften" (elective affinities), had recognised the similarity of these relationships with the erotic passions of human beings and how our modern "psychology of the cell" had confirmed the same. "We base on this our conviction that there is resident, even in the atoms, the simplest form of sensitivity and will,—or expressed better, "feeling" (*aesthesis*) and striving (*tropesis*)—also a universal psyche of a primitive kind." I believe that this conception, which I have expressed more precisely in the fourth synoptic table of my "God-Nature" (p. 67), has achieved a further firm grounding through the foregoing *crystallotic* and *probiontic* discussions.

***Psychomatics* of the elements ("Elementary psychology"). Inorganics and biology**

The so-called chemical elements, the number of which is now about 80, behave very differently in their combining relationships, and also in their *psychomatic* characters which are the basis of this combination. Almost three-quarters of these (56–58) belong to the main group of the metals, divided according to their weights into light metals and heavy metals. In spite of their many differences they all belong together in many general characteristics, mechanical and thermal as well as optical and electrical. Thus the metals stand in striking contrast to the second main group, the "metalloids" or non-metals, some 20–22 in number. Since these metalloids differ greatly in relation to their physical and chemical properties, and especially with respect to their affinities, they are divided into four different groups according to their valencies or values; hydrogen, chlorine, bromine, iodine, fluorine are one-valued; oxygen, sulphur and selenium two-valued; nitrogen, phosphorus, arsenic, antimony, boron are three-valued; carbon, silicon, germanium are four-valued. As a fifth group, marked by their extraordinarily limited affinity, the recently discovered noble gases can be distinguished (helium, neon, argon, krypton, xenon). The extremely multiform and important relations which these 80 elements—and above all the 20 metalloids—show in their innumerable compounds, have been successfully investigated in their manifestations and determined mathematically by modern chemistry. Moreover they have been divided according to their group affiliations in the "periodic system of the elements" into 8–10 main groups, and within these groups arranged according to the magnitudes of their atomic weights, so that chemically related elements form family series. These chemical "affiliations" recall in many respects the groups of organic forms into which, in the natural phyletic system of animals and plants, species can be distinguished. Just as these "varieties" are produced through transmutation from common simple ancestral forms, in the same way as probably also the eighty elements, as various "species of mass", formed from the same ancestral material, result from the hypothetical *prothyl*. The unimaginable degree of heat, which our planet, like all other bodies in the universe, has undergone in an earlier stage of its evolution, as a molten sphere, and the dissociation of the elements associated with this, must have been determined by quite other relations, not only in the chemical and physical but also in *psychomatic* respects. There remains for monistic speculation still a wide field of fruitful speculation with regard to this "evolution of matter". But both the affinities of the present permanent and indivisible elements, the internal parts of the atoms, and their "elective affinities", will become much more intelligible when we pursue the movements of atoms and molecules in causal connection with their "sensitivity" and their "feeling" in each chemical process. The many levels of temperament and passion in our human emotional lives, the numerous levels of intensity of our personal affections (= feelings of

pleasure) and dislikes (= pains) let us guess from a distance at what important roles the eternal exchange of attraction and repulsion may play in the chemically combining lives of the elements.

Carbon souls (*Psychomatics* of carbon)

The wonderful element, which must be treated as the veritable "creator" of the whole organic world, is the four-valent carbon (*carboneum*). We must regard the chemical and physical nature of carbon, and above all its unique ability to enter into the most complex compounds with other elements, first and last, as the single origin of all those characteristics, which distinguish the so-called inorganic compounds from the organic"[15]. This "*carbogen* theory", which I proposed, first in 1866 in chapter 5 of the "General Morphology" and later developed in other writings, has often been disputed but never disproved. It has received the most valuable confirmation and enlargement through the works, also appearing in 1904, mentioned above. For the life-like phenomena of the rheo-crystals and the probionts are both determined as much through the feeling and willing of the carbon psyche as those of the protists and histones (multi-cellular organisms). The *psychomatic* scale (Table 5 in the appendix) leads us from the lower steps of the scale, again through a long series of intermediate steps, up to the complex psychic activity of the higher organisms. Also in the psychic cells of the human brain, the most developed "mind organ" that we know, we should seek the first and historically oldest source in the phylogeny of the carbon psyche. For more than a hundred million years it has been connected with other *organo-genic* elements in building the plasma, and much later in the composition of the *psycho-plasma*. The psyche of carbon is not merely distinguished only in the organic, but also in the inorganic, world by special properties among the other organic psyches but, for example, through the curved faces and the bent edges which the octahedral crystals of diamond show. Carus Sterne (Ernst Krause) and Wilhelm Bölsche have presented very stimulating treatments of this and other important relationships of carbon in their distinguished work "Becoming and Disappearing"[16].

The psyche of molecules (*Psychomatic* molecular physics)

The advances in physics and chemistry in the 19th century have led to the recognition that all mass, that is all ponderable matter, is built up of very small particles, of definite size and composition, which we call molecules. These uniform particles of mass, the physical *singulates* of ponderable matter, which can be divided still further into atoms by the operations of chemistry, fill up the whole of space, insofar as it is not occupied by the imponderable world ether. In this un-weighable ether, the molecules move, altering their positions and the distances between them. The forces or "energy forms", the expression of which thus comes to light, depend on a definite inner working, which can only be understood *psychomatically*, and interpreted as a "molecular psyche". The two antagonistic sensations, which everywhere operate against each other, and which can be designated as "original states" of the *psychom*, are the sensation of pleasure, fondness or attraction of the molecules (positive tropism) and pain, opposition or repulsion of the molecules (negative tropism). The changing from one original state to another is determined by changing temperature. Increasing temperature drives the molecules apart and expands the body. The accelerated molecular action effects then the change of state of the aggregate. The liquid

state in which the particles hold together, but are freely moveable, goes over into the gaseous state in which the particles collide with each other on all sides and wander freely in all directions irregularly. With decreasing temperature on the other hand, the fluid becomes rigid or crystallises. It goes over into the liquid and finally into the solid state. The degree of fluidity is determined by the inner friction of the molecules. The attractive force of the disturbed molecules, which holds together the similar particles, acts as a cohesive or connective force or, in the case of two different bodies, as an adhesive or as an attachment force. In both cases the "sensation of pleasure", as the positive tropism, holds together the particles attracted to each other. The force which operates in *moletaxis* or *moletropism* to produce crystallisation is different from this generally operating form of the actual energy or "living force".

***Leptonics* (the science of *leptons*) (= the doctrine of the fine structure of materials)**

The mineralogist, Fritz Rinne (Leipzig) has briefly elevated this branch of physics to be a particular science, with the name "*leptonics*", dealing with "the properties and aggregation of the fine building elements of matter, the molecules, atoms and electrons"[17]. As Rinne aptly remarks, it is a discovery of the greatest importance for the advance of crystallography that X-rays are diffracted by crystals. With this, "at one stroke three great scientific results are achieved; the nature of X-rays, as being light waves of exceptionally short wavelength, is securely established; crystals are confirmed as being space lattices; and the two thousand year old question of the existence of atoms is answered experimentally in the affirmative". When Rinne states that chemistry, physics, crystallography and natural philosophy are all equally interested in the same theme, so I might add for completeness that this is also the case for the questions of biology and psychomatics sketched out here. Just those many interesting problems, about which my intensive studies of Radiolaria have been concerned with for sixty years, especially in their comparison with the rigid and now also with the liquid crystals, will be much promoted by comparative critical *leptonics*.

The psyche of albumen or protein

The "psychic activity of albuminoid bodies", that is, the energy and *aesthesis* of the albuminoid substances, is one of the most important chapters of our monistic *psychomatics*. For, since the reformed cell theory (1860) and especially the secure proof of *cytodes*, the nucleus-less cell in the probionts (1904) led us to the consideration that the plasma, the active "living substance", consists essentially of "albumen bodies", the comparative study of albumen molecules has become a fundamental problem of biology. I have already in chapter 6 of the "Lebenswunder" (1904) collected the most important general results of numerous valuable investigations which, in the course of the last half century, have been carried out by physicists, biologists and especially by physiologists, on the puzzling nature of the albuminoid bodies. For completeness and in connection with our *psychomatics*, a few generally important points will be raised briefly here. The infinite variety of the chemical constitutions of the albumen bodies (and especially those of the living plasma) is to be explained now through the extraordinary sizes of their molecules. Each is usually composed of more than one hundred and often of more than one thousand atoms, and thus they have high molecular weights. For the peptones a molecular weight of between 200 and 1000 is given on average by the breakdown products. The most complicated synthetic peptide has

a molecular weight of 1213, and serum albumen has a weight of 10,166[18]. Because of this gigantic size of the albumen molecule, and the unusually high number of its component atoms, its complicated structure is of especial significance. Modern stereo-chemistry expresses its multiform regularities graphically and by mathematical formulae. This complicated structure is, however, highly labile and alterable. A displacement or replacement of a single atom or of a small group of atoms is sufficient to give the whole albumen molecule a different chemical character. This high plasticity, in adaptation to the influences of the surrounding environment, is only to be explained through the feeling and willing of the albumen molecule having reached an especially high level.

The cell psyche (Cellular *psychomatics*)

The doctrine of the "cell psyche" as the elementary phenomenon of organic psychic life (1866) has, at the beginning of the 20th century, found recognition in wide circles, after it had been frequently ignored or directly opposed, on one hand by the interested empirical physiologists and on the other by the speculative psychologists. Since I had already discussed in generally understandable form my personal conception of this important problem in my "Concordia Lecture"[19] and in 1866 had broken new ground in my "Cellular psychology", and also in other writings had sought to develop it further, I can limit myself here to laying out shortly the main thoughts on "cell en-soulment". I should especially emphasise the reform which this has undergone since 1904 through Semon's foundation of the mneme and now through the connection with the "crystal psyche". The most conspicuous phenomenon of the psychic life, namely motion and will, as "manifestation", sensitivity and stimulability as "inner working"—especially also the "memory" mneme—relate quite generally to the living cell. This is the case also for the single cell protists, the protophytes and Protozoa living independently as "nuclear cells", as well as for the social tissue cells, which build the "organism" in the multi-cellular bodies of histones, the tissue-forming metaphytes and Metazoa.

The cell psyche of the protists, through which the single cell organism claims its independent *psychomatic* individuality, shows a long ladder of evolution from the nucleus-less probionts and the lowest steps of the nucleated "single-cell organisms" (protophytes, Sporozoa, Amoeba) up to the higher Protozoa. Among these we have the rhizopods (Radiolaria and thalamophores) in the course of morphological differentiation, and on the other hand the Infusoria (flagellates and cilliates) which achieve, in their physiological perfection, an astonishing degree of psychic efficiency. In his outstanding "Psycho-physiological studies of protists" in 1899 Max Vorworn had shown, on the basis of his significant experiments, that the "psychic events among protists build the bridge which connects the chemical processes in inorganic nature with the psychic lives of the highest animals"[20].

The tissue psyche of the *histones*, for which numerous socially connected cells build up the form of a tissue (*hista*) with higher individuality, offers a much greater variety of steps in cellular psychic life. The building of many different tissues and organs, as a consequence of the far-reaching division of the work among the cells, takes place here, on one hand in the realm of the tissue-plants (metaphytes), rich in shapes, and on the other hand in the realm of the tissue animals (Metazoa) rich in psychic behaviour (souls) where there is unlimited interesting *psychomatic* differentiation and perfecting.

Cell psyches of the protophytes (The psyche of the single-cell original plants)

The group of single cell Algae[21], rich in shapes, is of interest in many connections for our *psychomatics*, as well as for general morphology and physiology. In my "Systematic phylogeny of the protists" (1894) I have separated them from the true, multicellular, tissue-building Algae, with which they have hitherto been united[22]. "The protophytes are of the greatest significance for the exchange of material in the sea; for they supply the greater part of the original marine food-stock. The enormous masses of nourishment, which the unnumbered throngs of swimming sea creatures consume, originates directly or indirectly from the planktonic flora, and in this the single-cell protophytes are of much greater significance than the multi-cellular metaphytes[23]. In 1890 in my "Plankton studies" I have explained more exactly these remarkable ecological connections, only recently more valued, in which next to the physiology also the *psychomatics* of the protophytes plays a great role. The fantastic and rare forms of the Peridinea and diatoms, their comparative morphology and *psychomatics* present an especial number of interesting problems.

For our *crystallotics*, among the Algae, the silica shelled diatoms are of special interest (Figs. 44–49), on account of their remarkable relationships to the Radiolaria; on this account they have been treated above in chapter three and will appear again below in an appendix. With the other Paulosporatea can be included morphologically the Paulotomea, to which the Palmellacea, Murracytea and the Calcocytea belong. These last "single-cell" chalk Algae, which are spread in enormous masses in the plankton of the tropical ocean, are small simple spherical cells, which surround themselves with faceted protective chalk shells. The delicate shell consists of chalk plates firmly fixed together in a characteristic form. For the coccospheres the plates are like starch grains (Fig. 5), for the cyathospheres, like cufflinks. For the rhabdospheres, each plate carries a radial rod, and for the discospheres this is furnished at the end with a tangential disc. Thus the whole spherical shell of the latter two genera appears as a regular star with many rays like a Spheroidean (Fig. 1). Since now the living body of the swimming calcocyte is a quite simple plasma sphere, without different organelles (for the central core there is still some doubt), these skeleton structures of the "single-cell chalk Algae" can only be counted as bio-crystals.

Desmidieae (Cosmariae)

Another Family of the Algaria, included in the diatoms for the delicate and geometrically regular shaping of their single-cell bodies, are the fresh-water Desmidacea (Figs. 50–53). Here the protective shell is not formed of silica or chalk, but of the usual plant cell fabric, cellulose. Many kinds of these "ornaments" have the forms of flat four-cornered discs, from the edges of which arms protrude symmetrically or radially as in the discoidal Radiolaria. The propagation here proceeds sometimes by simple division, sometimes by pairing. In division (*hemitomy*) each cell splits into two equal halves after the nucleus has divided; each half then again completes itself (Fig. 53). In pairing (copulation) two cells lie crosswise one over another (Fig. 51). The two copulating cells then throw away their hard shells; their bare cell bodies melt together to a single cell (zygote) and these build a new differently shaped shell. This zygospore then multiplies itself by division.

Hydrodictea (Coenobiotic protophytes from the family of the "water-nets" (Figs. 54–56)

Social single-cell original plants from the genus Pediastrum. These delicate Algaria

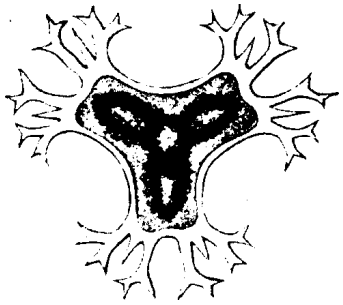

Fig. 50. Staurastrum furcatum. A regular three-fold cosmarie (ordered arrangement).

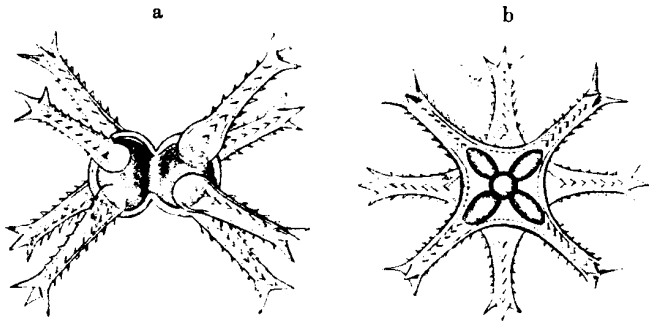

Fig. 51. Staurastrum paradoxum. Two cross-forming four-fold cosmaries as a pair. (a) cis- (b) trans-configurations.

massively populate our fresh-water and form on the surface green sheets of slime ("bloom"). They are distinguished from the closely related Cosmaridae or Desmidaea (Figs. 50–53) in that the green cell assemblies (coenobia), which multiply by repeated cell division, remain together. In the genus Pediastrum the coenobium builds a flattened round disc; all cells lie in the one plane. Each cell contains a rounded shining protein crystal (pyrenoid) and near it more cell nuclei. The Hydrodictynea are thus *psychomatically* interesting in that the cells in the small varieties (Fig. 54) remain similar sibling cells, while in the larger varieties (Figs. 55 and 56) the cells arrange themselves into differently formed edge cells and middle cells.

The cell psyche of the Protozoa (*psychom* of the single-cell original animals)

The soul activity of the single-cell protist-organism demonstrates in the plasmophage original animals (Protozoa) a great stock of remarkable phenomena, just as in the *plasmodome* original plants (protophytes); the former are derived phyletically from the latter, through reversal of the metabolism (*metasitism* or *metatrophy*)[24]. This significant exchange of nourishment—the "historic conversion of synthetic *phytoplasm* into analytic

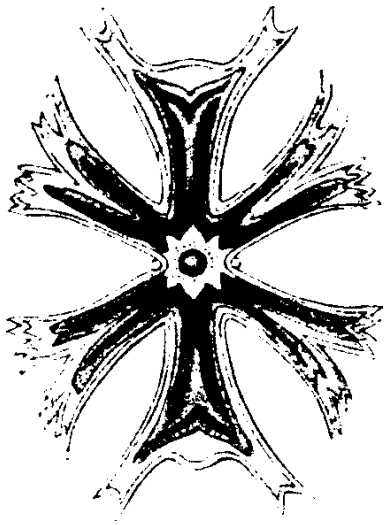

Fig. 52.

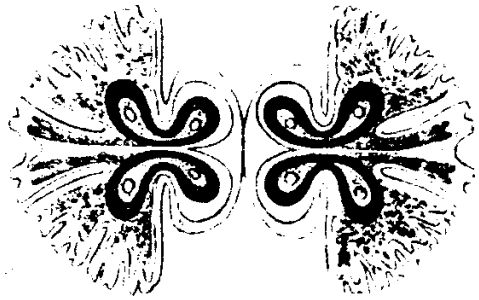

Fig. 53.

Fig. 52. Micrasterias melitensis. A six-fold cosmarie, with six divided arms.
Fig. 53. Micrasterias denticulata. A rounded lenticular cosmarie viewed in division. Each half is completing itself again. The nuclei begin hemitomy.

zooplasm"—is *polyphyletic* and has been repeated in various plant groups, independently of each other, at various times. In the class of flagellates, those which were named "original plants" by the botanists but pre-empted as "original animals" by the zoologists, the *metasitism* is again today even permanent. In different families of the flagellates (or "goats-beard"), which behave morphologically quite similarly, they nourish themselves, some as vegetables (by carbon assimilation), some others as animals and a third, neutral group, stands in the middle between these and uses both methods of metabolism. This important fact is not so much interesting because it shows directly (in physiological and systematic relationships) the connecting bridge between the two groups of protists, but because with this metabolism deep-reaching *psychomatic* metamorphoses are connected. Both the different forms of the movement (of the "will") and the feeling (the "sensitivity") in the young Protozoa reach a much higher level than in the other protophytes. Max Vorworn (loc. cit.) thirty years ago had already carried out very important and interesting experimental investigations on the psychic life of the Protozoa.

The two great main-groups of the Protozoa, the rhizopods ("root-feet") and the Infusoria ("infusion animalcules") are related closely—because of the ancient roots of their common origins—as much with each other as with the protophytes. But both families, with many forms, on going upwards (in the phyletic tree), diverge widely from each other; both evolved, in morphological as in physiological and in psychomatic connections, quite different properties. The rhizopods are particularly distinguished, in that their bare bodies

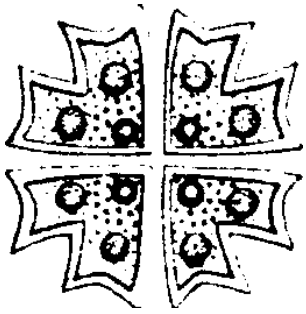

Fig. 54.

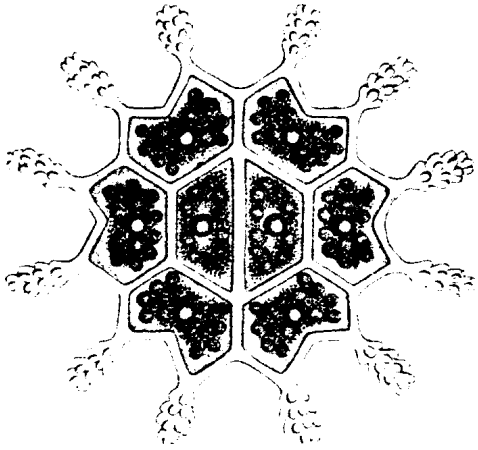

Fig. 55.

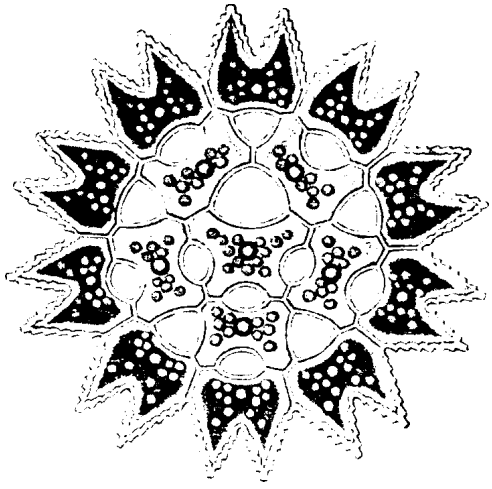

Fig. 56.

Fig. 54. Pediastrum tetras. The coenobium forms a regular cross from four like cells put together.

Fig. 55. Pediastrum granulatum. The disc consists of eight cells. The two middle cells are four-cornered (trapezoidal) without protuberances; the six edge cells are doubled, each armoured with two thorny radial bulges. Each cell contains a rounded protein crystal (pyrenoid).

Fig. 56. Pediastrum pertusum. The disc is put together from 16 cells; the ten edge cells are doubled; the six middle cells have ordered themselves so that a central cell is surrounded by five others as a wreath.

extrude on the surface many variable extensions, the liquid "apparent feet" or pseudopodia. These serve as sense and gripping organs, as much for feeling and motion as for taking up food; there is no permanent mouth. On the other hand the Infusoria possess permanent organs of movement in the form of flagellae or cillia, and usually also a permanent mouth-opening; many develop also differentiated sense organs. Both the inner workings of the cell psyche (feeling, stimulability, sensitivities to many kinds of different stimuli) and their external workings (energies of the various kinds of movement, differentiation of special receiving organelles—evolve in the Infusoria, (especially in the cilliates) to a much higher level than in the Rhizopoda. This is particularly so for their sexual propagation. On the other hand the psyche of the rhizopods is much more fruitful in the invention of protective organelles, of hard shells and skeletons which surround the soft cell-body protectively. The coarser and larger Thalamophores (with chalk shells, Monothalamia and Polythalamia) evolve here a multiformity similar to the finer and smaller Radiolaria, whose psyche we have already discussed in the third chapter.

Plant psyches (botanical *psychomatics*)

That plants in a certain sense are just as endowed with psyches as animals are, that they in a way similar to the latter are sensitive to stimulation, has been remarked on by observant and thoughtful observers. Every gardener and landowner knows, that the growth and flourishing of plants are dependent more or less on light and warmth and on moisture and nourishment. Also the movements, which especially the climbing and twining plants show, and also the sexual events on fruiting, are so obviously dependent on their tastes, that many older research workers have ascribed a "psyche" to plants. This natural interpretation was first abandoned in the middle of the 19th century, when the progress of plant physiology emphasised, all too one-sidedly, the mechanisms of their life activities. In fact more exact research on the animal psyche and its organs, the system of nerves and the tools of the senses, led to the firm conclusion that also these highest "animal" functions of the animal organism, are just as much determined through physical and chemical laws as the lower "vegetal" activities—metabolism and propagation. Since even the higher plants lack, as do the lower plants, a nervous system, it was concluded also that they possess no psyche. In spite of this, the spiritual natural scientist Theodor Fechner (Leipzig) in 1848 in his book: "Nanna, or the soul life of the plants", explained that these are not significantly different from the animals. In the next half century, botanists were so outweighed with the build-up of the cell doctrine, compared with the claims of the morphological and experimental physiological works, and the mechanical nature of the life processes and their reactions to stimuli was so one-sidedly emphasised that, with this concern with externals, interest in the corresponding internal workings was much retarded. Only at the beginning of the 20th century did the *psychomatics* of plants again receive its proper recognition. Especially in the epoch-making year 1904 through the work of Haberlandt, Nemec, Francé and others[25], simultaneously the sense activity of the tissue plants and the fine structure of their sense organs was so intensively investigated, that now a real psyche could be ascribed to the metaphytes, just as to the lower Metazoa. The step on the ladders of the historic evolution of the former and of the latter are also related (compare the fifth table—the *psychomatic* scale—in the appendix).

The instincts of plants

An unbiassed and critical comparison of the psychic life (both sensitivity and movement)—for the higher plants and the lower animals—leads us to the secure conclusion that the stepwise evolution of the psyche in the two kingdoms of histones followed closely related paths. This is the case both for the lower instincts, the unconscious habits established by inheritance and for the higher soul activities, which for animals are designated as intellect or intelligence. Especially instructive, in the light of this, is the highly sensitive Mimosa, the flesh eating plants (Dionaea, Drosera) and the parasites (Cuscuta, Orobanche). For these coromorphytes (higher flowering plants) special sense organs evolve, which are mostly lacking in the lower thallophytes (non-flowering) plants. The so-called tropisms, or movements on stimulation, in the former are on a far higher *psychomatic* level than for the latter.

Animal psyches (Zoological *psychomatics*)

The comparative psychology of animals is in its basis so generally known, and in its comprehensive literature so exhaustively dealt with that, for the task in hand it is enough to lay out the most important steps in the phyletic evolution of the animal *psychom*. Already in chapter 7 of "The Riddle of the Universe" I have given a brief "Survey of the main steps in the evolution of psychic life" and have pointed out the predominant differences, which exist in the many steps in the evolution of the soul between the lower animals and through the higher animals to human beings[26]. The lowest tissue-animals (Metazoa), the so-called "plant-animals" (zoophytes)—especially the sponges and polyps—do not rise above the psychic lives of most plants in their excitability and reflex movements; they lack both nerves and the machinery of the senses. First with the step-wise evolution of the true "soul organ" its higher faculties are also gradually perfected. The more the single sense organs differentiate, and the more also the nervous systems becomes centralised, so much more perfected become the ideas and their numerous interconnections, and so much more does the consciousness develop step by step. Out of the unconscious "instincts" (transmitted by inheritance and acquired adaptations) gradually those higher representations predominate which lead, in the higher tissue animals, to the astonishing formation of understanding or "intelligence". Here the two most developed families, the arthropods and vertebrates, reach the highest levels of perfection. Both families have emerged, independently of each other, from the lower families of the worm-animals (Vermalia). In each the formation of the higher sense organs (eyes, organs of hearing and smelling) and of the central nervous system have chosen completely different routes. The arthropods (Articulata) have built below the gut an articulated spinal cord, which is connected, through a pharynx-ring (enclosing the pharynx) with the brain situated above. The vertebrates (Vertebrata) on the other hand have evolved on top a dorsal (situated over the gut) spinal cord, the forward end of which itself has become the brain. In both families the older classes living in the Silurian and Devonian times were water dwellers of lower intelligence (Crustacea among the Articulata and fishes among the vertebrates). First the younger classes, which adapted to life on land in the Carbonaceous period (spiders and insects among the arthropods, amphibia and reptiles among the vertebrates) have evolved, in the "struggle for existence", more intellect and finer senses. Only in the higher levels of both families, insects among the Articulata, birds and mammals among the vertebrates, has eventually, (since the

Triassic) intellect and thought reached such a high perfection, that it could be placed on the level of human reason. The culture of the civilised "culture man" has advanced his organ of thought (phronema) to the "science" and the "world-consciousness" which the raw "natural man" still lacks.

The psyche of sponges

The remarkable class of the swimming animalculae (Spongiae or Porifera) assumes a quite unique position in the realm of organisms. A hundred years ago the organisation of these widely distributed sea creatures (of which only very few, the Spongillidae, have adapted themselves to fresh water life) was almost unknown. Our ordinary bath sponge, with which every "civilised person" daily washes his face is, without doubt, the creature with which human beings most frequently come in contact; and yet most people do not know what this porous, elastic body really is: namely, the horny skeleton of an animal mass which is built of millions of tiny metazoans. Earlier, most zoologists took the "sponges" for plants and put them next to the Fungi. The botanists hitherto treated them as animals, but neither investigated them intensively. Only in the middle of the 19th century was their real nature recognised by careful microscopic studies. On the basis of many years extended comparative research, I published in 1872 my monograph on chalk sponges[28]. In this I furnished the proof that the real individual creature of the sponges is a very small (at most only measuring a few millimetres) elongated round bubble, a "flagellar chamber", the thin walls of which consist of two sheets of cells. These two epithelial sheets are equivalent to the two primary embryonic sheets of the Metazoa, to the two cell sheets, out of which the embryo of all the tissue-animals, up to human beings, develop. In all sponges, the inner cell sheet (which corresponds to the endoderm or inner embryo leaf) is formed from vibrating flagellar cells packed close together, which serve for gathering nourishment (Figs. 57 and 58). Then the cells in the outer sheet (which corresponds to the ectoderm or outer sheet of the embryo) fuse together to form a synctium, or a binding substance in which the biocrystals disperse themselves. For the chalk sponges (Figs. 57 and 58), these consist mainly of regular needles of calcium carbonate, some simple, some with three-fold or four-fold symmetry (corresponding to the cubic or the tetragonal crystal systems)[29]. For the silica sponges the crystalline silica needles have joined up in the same basic form (*triaxonia*) or they may be six-fold (Hexactinellidae, Figs. 59–61) and remodelled in numerous ways. Not only the single bio-crystals, corresponding to the three coordinate axes of the cubic system, are highly regular and delicately formed (Fig. 61), but so also is the lattice work, out of which the whole skeletal system of the sponge aggregates (Figs. 59 and 60). The ectodermal wall of the water canals, which run through the sponge aggregate, is formed from radially, closely packed flagellar chambers in regular rings (Fig. 59). Our ordinary bath sponge (Euspongia) has no such a crystalline mineral skeleton, but instead has an elastic horn-fibre scaffolding which on account of the porosity of its tissues is so good for sucking up liquids.

***Histopsyche* of sponges**

As for the *gastraea* theory and the fundamental biogenetic law, so the comparative study of the sponges has also proved most fruitful for our "theory of the tissue-psyche" (*histopsyche*)[30]. The organisation of sponges remains at the lowest level for all the

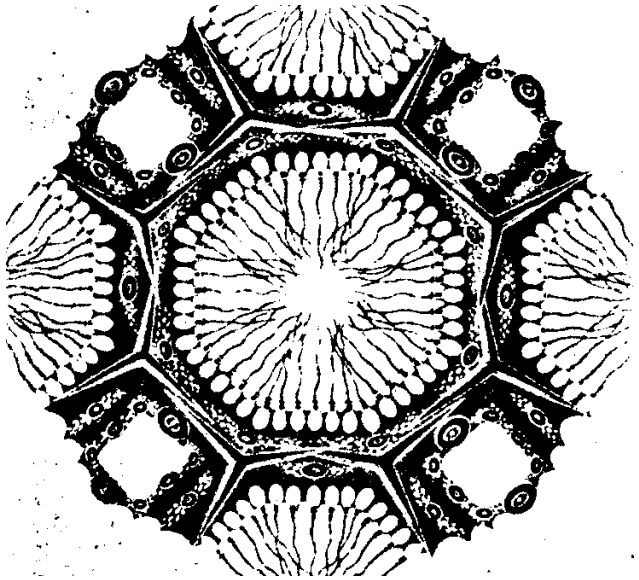

Fig. 57. Sycarium elegans (Chalk sponge, Sycon). Section through the octagonal flagellar chamber. Its wall is supported by eight three-fold chalk needles.

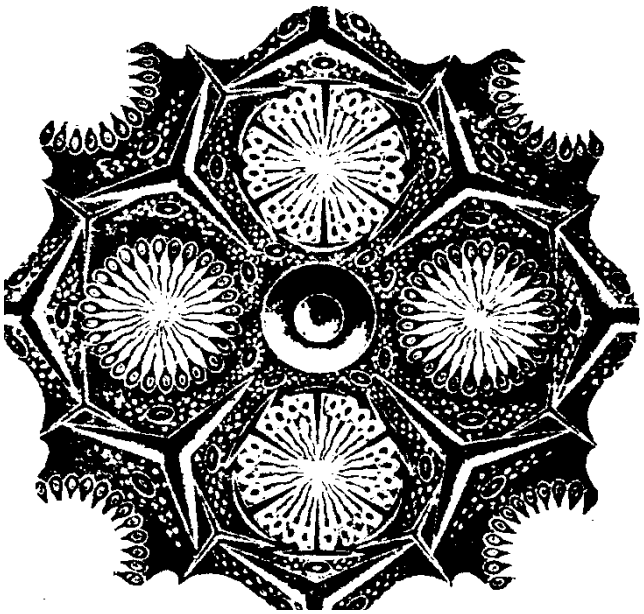

Fig. 58. Sycaltis perforata (Chalk sponge, Sycon). Section through four neighbouring flagellar chambers. Their walls are supported by three-fold chalk needles.

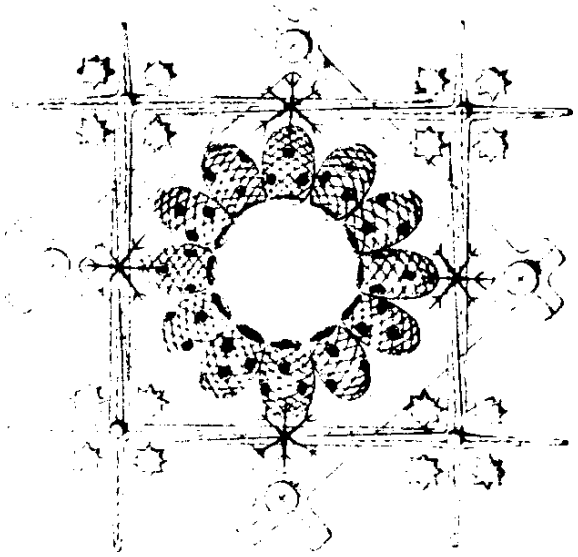

Fig. 59. Farrea haeckeli (Hexactinellar silica sponge). The *crystalars*[27] (four-edged silica rods) hold a regular lattice-work of square meshes together and support in the middle a six-fold *crystallar*. At the four corners of the square lie sphero-crystals. Inside the circular cross-section of a channel is visible, wreathed by twelve flagellar chambers.

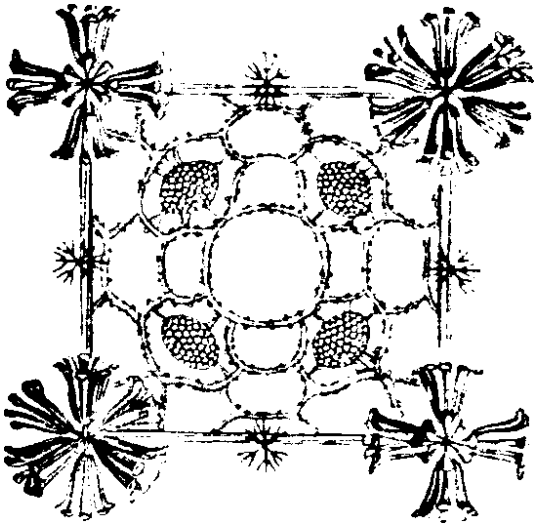

Fig. 60. Euplectella aspergillum (Hexactinellar silica sponge). A part of the outer skin which is divided regularly into square fields; these are supported by four silica rods, which in the middle carry small six-fold silica stars. Four larger six-fold stars lie at the four corners of the square; each carries at its end a bell-shaped paintbrush of bent silica needles.

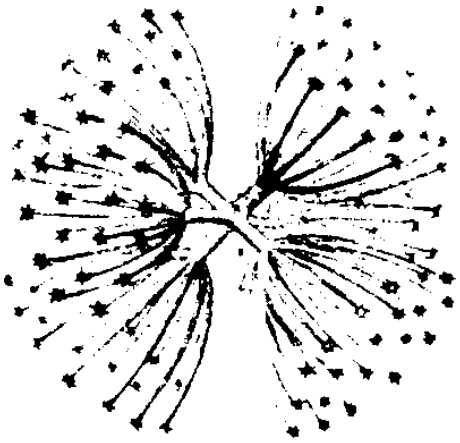

Fig. 61. Crateromorpha meyeri. A six-fold biocrystals of the skeleton. Each ray carries at the end a delicate paintbrush of silica hairs (hexaster).

metazoans. These possess neither nerves nor sense-organs, nor muscles. They also lack all those important organs and tissues, which in the majority of the other Metazoa, mediate the characteristic "psychic life" of the animal senses. From this also the manifestations of life—movement and sensitivity—are the most modest, and it is conceivable that these creatures, with vestigial senses, sitting motionless at the bottom of the sea, were earlier generally taken to be "plants" related to Fungi or sponge-plants, so much the more since the external form of the large aggregates, which are made up of millions of small flagellar chambers put together, is highly irregular and without meaning. Nevertheless, not only does each individual flagellar chamber (each Olynthus) have its individual psyche, but also does the whole corm, which is propagated though continued budding from a single Olynthus[31]. Also the whole aggregate is a social individual and has its psychomatic and morphological individuality. But the lower level of this "*histopsyche*" make it the more probable that in the biocrystallisation of its skeleton the *molethyn* of the calcium carbonate and the silica is more involved than are the ectoderm cells, which determine the whole conformation of the sponge aggregate.

Psyches of the Nesselaria (Psyche of the Cnidaria)

The Nesselaria family with many forms which were earlier combined with the sponges under the heading of zoophytes, is of special interest for comparative and genetic psychomatics. The Cnidaria (mostly living in the sea) appear in two very different forms; as lower static polyps and as higher free-swimming medusae. Both forms are not only different in their external appearances, but in their inner organisation are so far from each other that earlier they were put into separate classes as quite different creatures. The static polyp has no centralised nervous system and no differentiated sense organs. Its primitive psyche raises itself only a little above the tissue soul of the sponges (*histopsyche*). On the other hand the free-swimming medusa, through adaptation to the free range of situations

and modes of living, has acquired a higher sense apparatus, in the form of eyes, organs for sensing equilibrium (or "hearing bubbles") and organs for smelling; and these are connected through a nerve centre. Now these two classes are closely connected through the alternation of generations. The medusae grow out of the polyps as buds, and out of the eggs of the medusae polyps appear again. This permits one to follow directly by observation, the historic formation of nerve cells (*neuropsyche*), as a higher form of the psyche, from the lower tissue cells (*histopsyche*); for this ontogenetic process can, following the basic biogenetic law, be interpreted only as the hereditary repetition, determined by *mnemes*, of a corresponding phylogenetic event. I have given detailed evidence for this, and especially for the phylogenetic production of the neuropsyche from the histopsyche, in my monograph on the medusae[32].

Psychomatics of the siphonophores (The doubled soul life of jellyfish colonies)

Very many Nesselaria (especially polyps and corals) build though repeated budding, aggregates or corms, which are composed of many socially connected individuals or units. Through the division of labour among the latter there result "animal states (colonies)" in which the psychomatics of the personal soul of the individual citizen is more or less dependent on the corm soul of the whole aggregate. The most remarkable phenomena in this connection are provided by the wonderful swimming colonies of the siphonophores or "state" jellyfish. Since I have already, in "Cell souls" (1878) and "The division of labour" (1868), treated these in the popular literature, I can deal with them here briefly. My monograph on the siphonophores[33] (with 50 tables, 1888) contains detailed expositions. Many serious errors of the out-dated, although still dominating, dualistic "scholastic psychology" would have been avoided if the official academic representatives had made themselves familiar with the facts of the soul lives of the siphonophores.

Human psyches (Anthropological *psychomatics*)

All psychology, no matter which direction it adopts, must start from the recognition of the human psychic life. For only through our own feeling and consciousness do we comprehend directly the inner working and only through our own will do we comprehend the external manifestations of the psyche. It is now 43 years since a decisive turning point between the two main directions of psychology, the monistic and the dualistic, in favour of the former, was reached, that the *anthropogeny* (1874) of the descent of man from the vertebrates has been palaeontologically established and that the most important steps in their animal ancestry have been proved[34]. Our whole soul activity is mediated by the same physical and chemical processes as in the other vertebrates. The organs, brain and spinal cord, peripheral nerves and sense organs are the same in both cases. Just as the soul organs have evolved slowly and step by step from the lower states of the vertebrate ancestors, the same is the case naturally for their functions. Although now this history of the descent of the human psyche is undoubtedly certain, it still now runs up against the most obstinate resistance of scholastic psychology, which recognises in the higher spirit of human beings special properties beyond those of animals, and ascribes to human beings the "personal immortality" of their souls[35]. Since in chapter 11 of "The Riddle of the Universe" I have already explained in detail how this myth is invalid, I will confine myself here to the repeated advice that comparative and genetic psychology can furnish full certainty[36]. The

unbiassed comparison of the psychic lives in the higher and the lower human races teaches us that the higher spirit is a product only of many thousand years of culture, since it is lacking in the lower peoples of nature as in the apes and the other mammals. One of the greatest faults of the ruling dualistic school of psychology is that it treats the most developed spiritual activity of the educated people of culture, of which the wild people of nature show hardly a dark trace, without a second thought, as generally distinguishing the human psyche from the animal psyche. Comparative evolutionary history clear shows that the historical evolution of the psyche from lower states in every case follows the same path. For all creatures the elementary organs are the "psychic cells" of the nervous system, the neurons in the brain and especially in the grey matter of the cerebrum.

Psyche of the family cell (*cytula* psyche)

Comparative anthropology teaches us in the first part, the history of the embryo, that every single human being takes his origin from a single spherical family cell, that this *cytula*, as a consequence of the basic biogenetic law, is the hereditary recapitulation of the corresponding protozoic ancestor cell. Like all others, for animals built up of single cell tissues (Metazoa), the human being develops also from the *cytula*—or the "fertilised egg"—through the path of gastrulation[37]. Through repeated division of the embryo cell embryonic sheets arise, which differentiate into the various tissues and organs. For our *psychomatics*, the nature and emergence of the spherical family cell is now of outstanding significance. Through the exhaustive researches of the last forty years on fertilisation and inheritance we now know the fundamental process in all details. At the moment of fertilisation or "conception" in sexual generation, two different cells meet and fuse together, the female egg cell of the mother and the male sperm cell of the father. The nuclei of the two cells, the material carriers of hereditary properties, fuse together. Thus a new spherical cell results, which contains the most essential characteristics of both parents (and at the same time those of the four grandparents) mixed together.

Amphimixis

The mixing of the substance of both "parent cells" into the newly resulting "family cell" concerns all three attributes of the substances, their matter (plasma), their energy (life) and their psyche (soul). Just as the psyche of the mother in the egg cell, so also the psyche of the father in the sperm cell partially lives on. The mixing of the two determines the whole character of the child which develops from the *cytula*. This ontogenetic fact is of the highest importance. For it proves that each human being, as each other multicellular animal, and like each plant, has a secular beginning for its personal existence. This point of time is exactly determined through the moment of conception. Since now the normal development of the human embryo in the womb usually lasts nine months (about 270 days) so each human being, strictly speaking, is nine months older than given by his official date of birth. From this it follows, immediately, that this individual essence (a transitory plasma-*singulate*!) can make impossible the claim to "immortality". Since now further the cytula (sometimes called "the fertilised egg", sometimes "the first cleavage sphere") not only in the material, but also in energetic and *psychomatic* respects, exhibits the hereditary, historically transformed, memory picture of a single-celled ancestral form, so it is well to heed in the sense of the *mneme*, that its *idioplasma* (either just the *caryoplasma* of the cell

nucleus or also the cytoplasm of the cell body) is in chemical composition a highly complex composite substance. In the molecules of this structure-less embryonic plasma there are in play milliards of inheritance processes left behind as fall-out by a hundred million years of family history.

***Statotaxis* (Sensitivity to equilibrium)**

The whole world order, the mighty wondrous structure of the cosmos, keeps itself stable. In spite of the eternal and continual movement of all parts, overall a striving for equilibrium rules. The attraction and repulsion of the parts are the secret original states of the "world psyche", which constantly act against each other and through their equalisation the equilibrium striven for is reached. The modern "kinetic theory of matter" teaches that, overall at all times in the universe movement rules; "universum perpetuum mobile". Our "psychomatic theory of substance" completes this cosmic universal principle, in that it joins inseparably *Aesthesis* to *Kinesis*: "Universum ubique sensibile". The whole "life" of the cosmos, in which the two basic states of the "world force", the "living force" (actual energy) and the "resting force" (potential energy) are constantly exchanging with each other, are only rendered intelligible if the positive tropism is joined with pleasure and the negative tropism is joined with pain. We have seen in the *psychomatics* of the Radiolaria how the feeling for equilibrium of the peacefully swimming body and connected with this the pleasure feeling of the plastidule drives the fluid plasma of the sensitive cell to the production of the most various and complicated forms of biocrystals. But we can assume just the same *statotaxis* as the reason for the working of the *molethyn* in the *sterro*-crystals. For the definite three-dimensional order of the molecules in the symmetry classes of the solid crystal (Table 1 in the Appendix) can be attributed to this same *statotaxis* as leads to the same geometrical construction of the crystalline skeleton of the Radiolaria—especially of the Acantharia (Figs. 27 and 28). Thirty years ago I pointed out the remarkable "plastic feeling for distance" of this single-cell rhizopod and the crystalline regularity of its *dictyosis* (network formation). This distinctive feeling for symmetry obviously goes together with its *stereotaxis* and this is again on one hand determined by the physical laws of equilibrium and on the other by the psychomatic laws of their attraction and repulsion.

***Symmetrism* (feeling for symmetry)**

I have laid out in detail in my "Doctrine of basic form" (1866)[38] the important role which the feeling for symmetry of the living substance plays in the construction of complicated organic forms. In (my book) "Art Forms in Nature"[39] they are illustrated in a hundred plates by numerous illustrations[40]. In the eleventh (supplementary) folio of this work (1904) the aesthetic and artistic problems of this little-cultivated *promorphology* are discussed. In chapter 8 of the "Lebenswunder" (1904) I have emphasised the general symmetry law especially in connection with the *promorphology* of crystals and *bionts*, and have distinguished six classes and nine orders of these in the review of basic geometrical forms (p. 215). This table is reproduced here as an appendix. In that I concern myself with these extensive, hitherto little noticed investigations, I refrain here from further discussion. I only emphasise again especially that the monistic mechanics, which determines the regular structure formation through definite directed movements of the components ordering themselves symmetrically, is intelligible only if, on the basis of our monistic

psychomatics, the feelings connected with it are suitably taken into consideration. This is the case both for crystals and for organisms.

Diffusional *crystallars*

Of especial interest for our *psychomatic* judgment of the crystal life and the *statotaxis* connected with it, especially for the feeling for symmetry of the molecules and for *leptonics*, is the formation of regular *crystallars* in diffusing liquids. If one takes two different, mutually miscible liquids (a lighter, e.g. alcohol and a heavier, e.g. water) arranged in layers one over another with the lighter on top, then after a time they diffuse completely one into the other. That is, the two different molecules divide themselves equally, independently of gravity and of chemical affinity, and without the action of any external force (e.g. shaking) on their movement. This diffusion is explained by the *psychomatic* assumption that the molecules possess both feeling (*aesthesis*) and directional forces (*moletropism*)—or, in other words: "elementary sensitivity and elementary will". If the diffusion proceeds slowly in complete quiet, then "diffusional *crystallars*" result, which are as regularly formed as the geometric forms of *sterro*-crystals (Fig. 11). Stephan Leduc[41] (Nantes) has shown, with numerous interesting experiments, that the products of this mixing, in which cohesion, adhesion, diffusion and crystallisation act together, equal the complete regularity of structures and the basic geometrical forms of the most compound products of organic life, which we wonder at in the radial figures of the diatoms, the radiolarians and the corals. Larger and smaller molecular groups order themselves in definite distances and directions so regularly that we can determine mathematically and quite sharply rays[42] of first second and third orders (*per-radii*, *inter-radii* and *ad-radii*).

Figures 62, 63 and 64 show with photographs three different *crystallars* of silver nitrate, which result from putting a drop into a solution of gelatine, in which the salt is dissolved; the drops are equally divided. Figure 62, a regular eight-rayed star, resulting from the diffusion of silver nitrate with ammonium bromide, shows the structure of a regular eight-rayed flower (e.g. Erica), in which eight *per-radii* petals alternate with eight inter-radial sepals and stamens. The six-rayed star of Figs. 63 and 64 is like a hexa-radial hexacoral, in the gastral space of which six per-radial stomach pockets alternate with six inter-radial septa; Fig. 63 results from the diffusion of six drops of silver nitrate with sodium carbonate; Fig. 64 by diffusion of six drops of silver nitrate with a solution of potassium citrate. Figure 65 shows the action of the diffusion of potassium ferrocyanide and gelatine. The hexagonal *crystallars* are so regularly arranged that a deceptive similarity with organic cell tissues results. Naturally, however, these products of *moletropism* are not "artificial cells".

Number symmetry

The survey of the six crystal systems, which is given in the first synoptic table and the general system of the basic geometrical forms, in the second table in the appendix show us, that in the real incorporation of the stereometric basic form proportionately few numbers determine the symmetrical or regular structures. Among the prime numbers only 2, 3 and 5[43] are generally common; on the other hand 7, 11, 13, 17, 19 etc. never enter the form world of crystals, and only very rarely the world of organic forms (e.g. radiolarians, Nessellaria, flowers). Of the assembled numbers, which are multiples of a prime number, by far the

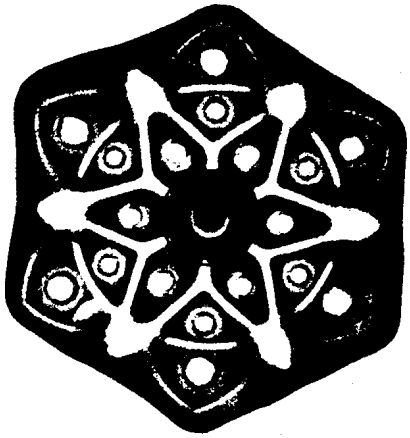

Fig. 62.

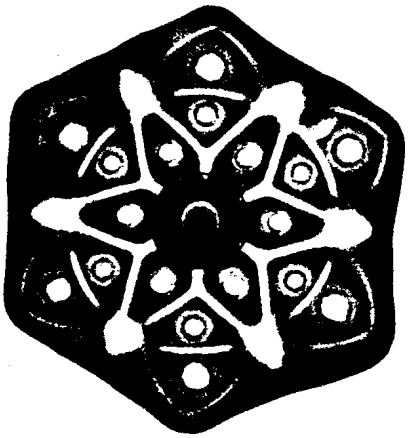

Fig. 63.

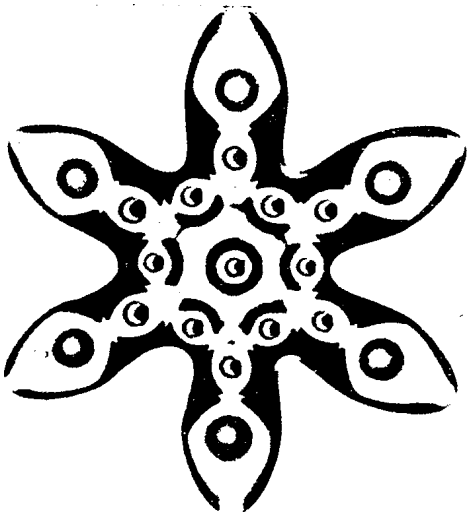

Fig. 64.

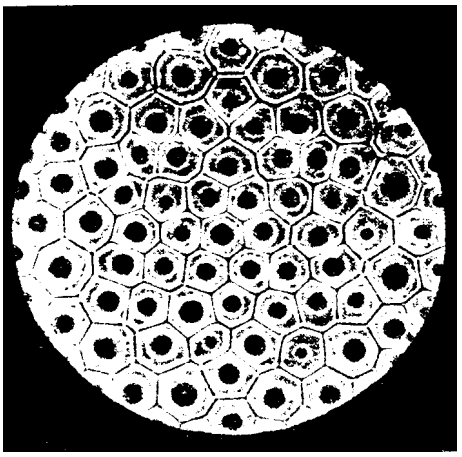

Fig. 65.

Fig. 62. Diffusion *crystallar* of silver nitrate and ammonium, bromide (Photogram after Leduc, 1910, p. 77). Eight-fold star like an octagonal coral.

Fig. 63. Diffusion *crystallar* of silver nitrate and ammonium, bromide (Photogram after Leduc, 1910, p. 78). Six-fold star like a hexagonal coral.

Fig. 64. Diffusion *crystallar* of silver nitrate and potassium citrate (After Leduc, 1910, p. 79). Six-fold star like a lily flower.

Fig. 65. Diffusion *crystallar* of potassium ferro-cyanide and gelatine (After Leduc, 1910, p. 80). "Artificial cell formation".

commonest are 4, 6 and 8, as well as multiples of these three numbers; more rarely 10 and 12, etc. The same proportion that rules here in natural forms, we find again in the symmetrical art forms which people apply for decoration, in architecture, sculpture, etc. Thus, for example, the rosettes and flowers, which are generally applied as decoration in the middles of room ceilings, are painted predominantly four-fold or six-fold; the prime numbers 2, 3 and 5 rarely occur. The higher prime numbers 7, 11, 13, etc. almost never occur. Obviously the artistic feeling for symmetry or the "taste" of the art-appreciating person, is most pleased by simple equivalent proportions. That the numbers 4 and 8 predominate also in the natural forms of the medusae, is due to the fact that in the symmetrical division of a circle into quadrants and octants the cross form is the simplest; also in the protists, which propagate by repeated division, this four-fold basic form is very common (see Figs. 50–56). (The spherical *rheo*-crystals show the same cross in polarised light between crossed polarisers[44], Title plate, Fig. 11.) For *sterro*-crystals, fourfold symmetry is determined by the square plane in the cubic and in the tetragonal systems and the six-fold in the hexagonal system. Since the cause of the numerical symmetry in crystallisation is still quite unknown, one could perhaps think that here the feeling of pleasure in balance determines that the molecule should choose this form. For polymorphic crystals, where the same chemical composition crystallises on two or more different crystal systems, a change in the feeling for equilibrium is to be assumed; thus, for example, for carbon it might be hexagonal in graphite and cubic in diamond according to the action of the *molethyn* (orienting forces); for calcium carbonate, when it crystallises as calcite in the hexagonal system and when as aragonite in the orthorhombic system[45].

The reasons for symmetry

The real operative causes of symmetrical shape (causas efficientes) can be traced back in general to the *statotaxis* and to the positive "feeling of pleasure" which is associated with the achievement of equilibrium; but individually these may be attributed to very different and often multiple physical circumstances. For the sphere, as the simplest of all basic forms, it has already been mentioned above, that it has the widest occurrence as the product of surface tension. Thus *sphero*-crystals and hanging drops in stable equilibrium and cells assume the spherical form. The uniaxial (*monaxonform*) (spheroidal or conoidal) basic form is mostly determined by gravity (*geotropism*). The crossed axis form (*stauraxonform*) of free-swimming animals (for example the medusae) appears here to be the best and most useful, because the equal distribution of the organs along determined radii or ray-axes (for the medusae mostly 4, 6 or 8) facilitates the free swimming in all directions of the delicate animal. On the other hand the *triaxonform* of the Amphipleurea and the Zygopleurea is conditioned by the circumstance that free motion from place to place in a determined direction would be especially promoted by the formation of a median plane. The three mutually perpendicular axes (*euthynen*), of which two are polar, the third non-polar, fix for this bilateral form (or "dorso-ventral form") the difference between left and right and between back and belly. As most higher free-moving animals (namely arthropods and vertebrates) so also our artificial vehicles (cars and ships) are built on this practical bilateral principle; here selection has chosen the most useful out of all possible cases. An important consideration is the equal distribution of load on both *antimers* or halves of the body.

In many other cases we cannot recognise the true mechanical reasons for the

symmetry, as for example, in the many variants of the snow-crystal (Plate B). Especially for us the feelings of the molecules in the crystal, which determine their arrangement with six-fold symmetry, and especially the polymorphism of those elements which crystallise in several different crystal systems (e.g. calcite and aragonite) remain quite unknown. This is also the case for the symmetrical forms of many crystallites (for example margarites, belonites), and for the special *crystallars*, those crystalloid structures discussed above, which are formed through osmosis on the mixing of two liquids (Figs. 62–65). From the operation of two different streams (*exosmosis* and *endosmosis*) there result here "diffusion *crystallars*" which, for completely regularity of structure, compete with the radial medusae and the actinomorphic flowers. Stephan Leduc (Nantes) has also synthetically created related regular ray-formations, by letting some drops of Indian ink diffuse into a drop of salt water (Figs. 66–69)[46].

Spherology **(doctrine of spheres)**

For this concept the laws are discussed in writings on physics, among which our Earth, like the majority of other heavenly bodies, has taken the shape of a sphere or of a rotating sphere-like spheroid. For these, this part of spherical geometry has a far wider extension and application, insofar as the sphere—as the unique absolutely regular form—in the forming of mass in the most various conditions, plays an important role. Overall, where liquid matter is under the influence of complete equivalence, and with the exclusion of external formative forces such as directed forces (*moletropism*), it takes up a spherical shape, since the surface tension energy is less for the sphere than for any other shape. Only for the sphere is the cohesion pressure at all parts of the surface the same. If one puts an oil drop into a mixture of water and alcohol of the same specific gravity, and thus eliminates the effect of gravity, it assumes a spherical shape. Two or more separate drops flow together when disturbed and form a larger sphere the surface area of which is naturally smaller. We have seen in our third chapter the important role which the spherical shape plays in the realm of the protists, both for the free-hanging single cells and also for the spherical coenobia (Halosphera, Volvox, etc.). But also the egg cell of human beings, as for many other animals, is a regular sphere.

The *singulation* of substance (= Individuation of natural bodies)

All bodies formed from single cells, which take up a definite space, consist as single bodies (individuals or *singulae*) through a physical process which we will designate briefly as singulation, in order to avoid the nine-syllable expression of "individualisation". This process of formation consists in a formless mass of fluid, liquid or solid substance breaking up into individual spatially bounded parts, which can be firmly defined in shape, weight and measure. Such individual *singulae* are drops (water drops, oil drops), air-filled bubbles (soap bubbles, foam bubbles, vacuoles), grains (amorphous sand grains, chlorophyll grains), crystals (liquid and solid crystals), monerans (non-nucleated cytodes) and the organic cells. The appearance of celestial bodies rests also on the *singulation* of disturbed matter; also these cosmic individuals result either from the break-up of larger rotating masses or from the condensation of cosmic dust. The physical laws of this singulation are, on one hand, determined by chemical constitution and the inner workings of the mass connected with it and, on the other hand, through the external working of the environment.

Fig. 66.

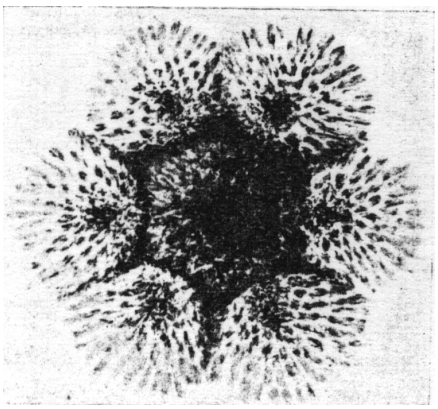

Fig. 67.

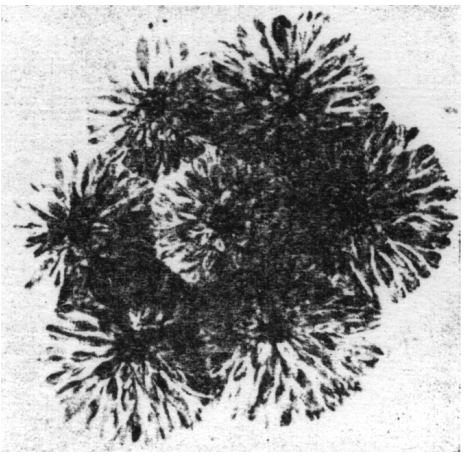

Fig. 68.

Figs. 66–68. Radial sensitivity of the carbon molecules (Radial *monotropism*). Seven drops of Indian ink, diffused into a drop of salt water. The soot molecules order themselves into a regualar hexagonal star about the centre; Fig. 66 after 2 minutes; Fig. 67 after 15 minutes and Fig. 68 after 30 minutes (After Leduc, 1910, pp. 97–99).

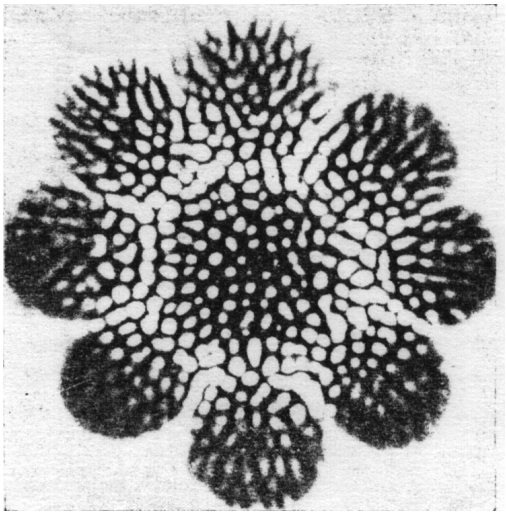

Fig. 69. Radial sensitivity of carbon molecules (*Moletropism*). Eight drops of Indian ink diffused into a drop of salt water; after 30 minutes ordered so that a regular octagonal star results with symmetrical net formation (dictyosis) (After Leduc, 1910, p. 100).

Especially there comes into consideration the inner friction of the molecules in competition with the surface tension, the cohesion and adhesion, and the directional forces, etc.

The integration of substance

In conflict with the *singulation* of matter stands its integration, the unification of separated individuals into greater units. In this way molecules result from the association of atom groups, and crystals from the association of ordered molecules. Next comes into consideration the cohesion of similar molecules and the adhesion of different kind of molecules. Gravitation as attracting mass produces the growth of celestial bodies; from the uncountable masses of meteorites and cosmic dust, which hangs between the Sun and the planets, part constantly falls down. When many rheo-crystals grow next to each other in solution, the bigger individuals consume the smaller. Also in the social and political life of the culture-people, the greater unions and states absorb the smaller through their attractive forces and grow at their expense. Eternal "becoming and passing away" rules both the greatest and the smallest aggregates. From the eternal game of exchange between integration and disintegration emerges the drama of both cosmic and organic life, crystallisation and weather as well as biogenesis.

***Archigony* (original generation)**

The question of the first origin of organic life on our planet stands in the widest circles as the hardest "riddle of the universe". I have dealt with this controversial problem, about which even now the strangest hypotheses contradict each other in many earlier writings, in so much detail, that I can here mention it only briefly. In chapter 15 of the "Lebenswunder"

(1904) I have collected in brief the grounds which support my personal views on this difficult problem (these had been already laid out in 1866 in volume 2 of my General Morphology, chapter 6). They agree essentially with the perceptive physical discussion on this which Karl Naegli (1884) has given in his "Mechanico-physiological basis of the descent doctrine". Then the "liquid crystals", which twenty years later afforded him such important support, were not known. Today the difficulties of this contentious question for us are essentially removed. It depends on whether we interpret the concept of "life" in the wider (physical) or in the narrower (physiological) sense. If we follow the world outlook of the modern monistic physics, then we must assume the kinetic theory of matter and ascribe the "life force" to the "actual energy" of all natural bodies, as long as they are in a state of motion (molecular motions, chemical and mechanical energies, etc.). With this life is "eternal"; an uninterrupted exchange of motion (actual energy) and rest (latent energy). If, on the other hand, with the present day cellular physiology (Max Verworn), we limit the concept of organic life to the metabolism of the plasma molecules (as complexes of proteins), then we must assume that this organic life on our planet has had a beginning in time; it could first arise after the glowing planet had cooled on the outside and liquid water had been precipitated in drops, for this is indispensable for the metabolism of the liquid plasma. We must now assume, however, that the oldest organisms were not cells (nucleated plastids) but cytodes (non-nucleated "creators"). The problem of archigony is then solved through the following simple hypotheses:

I. Plasma appears through chemical processes (catalysis of colloidal substances) as the material "life stuff".

II. Through *singulation* this structure-less plasma broke up into identical individual parts: plasma spheres like Chroococcus.

III. These spherical cytodes (non-nucleated plastids) form inside themselves nuclei and transform themselves in this way into true cells (through differentiation of the inner caryoplasma and the outer cytoplasma).

IV. The characteristic phenomena of "organisation", the cooperation of various "organs", has first gradually evolved over a long period through the division of labour among the organelles**.**

Vitalism (dogma of the life force)

Up to the middle of the 19th century the old outlook remained dominant, that a special life force (vis vitalis) governed organic life, in contradistinction to the inorganic phenomena, which were determined solely by physical and chemical laws. Only in the years 1850–1860 was this vitalist metaphysics driven back and vanquished by modern evolutionary theory. This held that all the phenomena of life are to be referred back to the same laws of physics and chemistry which govern inorganic nature. Recently, however, a mystical "neo-vitalism" has again awoken; this seeks by means of a supernatural "entelechy" to make valid an artificial dualism. Through metaphysically obscure concepts, like, for example, "harmonic equipotential systems", apparently supported by experiments of a very complicated nature, this new modern vitalism has called up considerable confusion. This comes from the circumstance that many biologists have lost a perspective over the whole domain of the life sciences and ignore especially its historic component. In fact the teleology of this modern vitalism is more weakly based and is easier to refute, than the old

paleo-vitalism of 50 years ago. In chapter 2 of the "Lebenswunder" I have carefully made this distinction.

Through the discovery in 1904 of the life-like phenomena in "liquid crystals", and through the simultaneous proof of the non-nucleated cells in the sex-less "probionts", the "concept of life" in all natural bodies is extended; and with this, the foundations of every kind of vitalism are removed—for the old as for the new. "Everything lives" as long as it possesses sensitivity and motion. The old concept of "the life force", which has recently been substituted by "actual energy", is now again corrected. As long as the atoms and the molecules built out of their combination perform actions, they are "living". When this action stops and the substance goes over to the resting state, the actual energy is exchanged into "potential energy" and the driving force into tensional force. The "ability to do work", however, also remains conserved as this "resting" or latent force and is designated as energy of position. The universal law of substance—the conservation of matter, energy and psyche—teaches us that the whole exchange game of life rests only on this "exchange of force". In the universal psychic life there exchange continually the two psychomatic original states: attraction (positive tropism) and repulsion (negative tropism)—the loves and hates of Empedocles.

Purpose and chance (or Chance and necessity[47])

Through the combination of the epoch-making discoveries of the year 1904, the essentials and connections of which I have tried to exhibit in the foregoing writings on "Crystal Souls", are not only significant steps forward achieved in the various specialised sciences concerned with them, but also great general questions of our overall world outlook have been clarified and advanced. Our naturalistic monism, the principles of which I first formulated in 1866 in the "General Morphology", and advanced in many later writings has, through the empirical recognition of the last thirty years, acquired such a firm foundation, that its strongest opponent, metaphysical dualism, can in principle be reckoned as defeated. The mystical teleology of this (dualism) and the vitalism connected with it, are proved wrong. At the same time the ancient question of philosophical speculation, as to whether "chance or purpose (necessity)" rules the world, is settled[48]. When recently attempts are made to disprove the selection theory of Charles Darwin as a "theory of chance", this error needs no contradiction. For every single occurrence in the universe is determined by natural laws, and is no accident. It is true, however, that chance plays the greatest role though the temporal or spatial coincidence or two or more events, which earlier had no causal connection, but each of which has it own sufficient reason. The many misunderstandings related to this problem are for the most part caused by teleological, mystical and religious illusions, especially in that some people seek to explain the organisation of living things though the conscious, intentional goal of a personal creator. The comparison of the crystal souls with the cell souls, and the extension of psychomatics to the whole universe, have convinced us that in organic nature the same unconscious forces, sensations and movements prevail as in inorganic nature. The law of substance is as valid for organisms as it is for crystals.

Appendices

Table 1. Symmetry systems of the sterro-crystals*.

	Six systems	Basic form	Axes	Symmetry planes
I.	Cubic (regular)	Regular octahedron Cube	3 mutually perpendicular	9 symmetry planes (3 principal + 6 others)
II.	Hexagonal	Hexagonal dipyramid Hexagonal dodecahedron	1 vertical principal axis perpendicular to two others at 120° to each other	4 symmetry planes 1 principal, 3 other equal
III.	Tetragonal	Quadratic dipyramid Quadratic prism	1 vertical principal axis perpendicular to 2 others at 90° to each other	3 symmetry planes 1 principal, 2 others equal
IV.	(Ortho) hombic	Orthorhombic octahedron Orthorhombic prism	3 unequal, mutually perpendicular axes	3 symmetry planes intersecting at right angles
V.	Monoclinic	Clino-rhombic prism Inclined prism on rhombic base	3 unequal axes, 1 perpendicular to the other two which intersect obliquely	1 symmetry plane
VI.	Triclinic	Clino-rhomboidal prism Inclined prism with 3 unequal pairs of faces	3 unequal axes at arbitrary angles to each other	No symmetry planes

*Modern crystallography recognizes seven crystal systems, dividing the hexagonal system here into hexagonal and rhombohedral.

Table 2. **The promorphological system.** Classes of basic geometrical forms.

Four classes of basic form according to the properties of the main body	Six classes of basic form according to the properties of the axes of the body	Nine orders of basic form according to the properties of the axial pole	Character of the most important basic forms
A. First class **Centrostigma** The geometrical centre is a point. No main axis	**I. Homaxonia** Equiaxed baisic form **II. Polyaxonia** Multiaxed basic form	**1. Flattened sphere** (Holosphaera) **2. Platy sphere** (Platnosphera)	1.Geometrically exact sphere; all possible axes identical 2. Polyhedral forms, the edges of which lie on a sphere
B. Second class **Centraxonia** The geometrical centre is a straight line—(the vertical principal axis, Axon centralis)	**III. Monaxonia** Uniaxial basic form. No determinate intersecting axes. (Cross-section circular) **IV. Stauraxonia** Cross axes basic form. Defined cross axes (Cross-section polygonal)	**3. Spheroidal basic form** (Monaxonia isopola) **4. Conoidal basic form** (Monaxonia allopola) **5. Dipyramidal basic form** (Stauraxonia isopola) **6. Pyramidal basic form** (Stauraxonia isopola)	3. Spindle, ellipsoid, sphere, lens, cylinder 4. Ball, egg, hemisphere, half-lens 5a. Regular double pyramids 5b. Doubly truncated double pyramids 6a. Regular pyramids 6b. Doubly truncated pyramids
C. Third class **Centroplana** The geometrical centre is a plane (the sagittal median plane, planum centrale)	**V. Triaxonia** Triaxial basic form Three mutually perpendicular axes (euthyni) define right and left and back and front	**7. Amphipleura** Bilateral radial basic form (apparent basic form) 4 or more opposed parts (Antimers) **8. Zygopleura** Bilaterally symmetrical basic form. Yoked pair. Only 2 antimers	7a. Paired (paramphipleura) 7b. Unpaired (dysamphipleura) 8a. Persymmetrical (left and right the same) 8b. Asymmetrical (right and left unequal)
D. Fourth class **Centraporia** Geometrical centre absent	**VI. Anaxonia** Basic form without axes	**9. Irregular basic forms** Quite irregular	9. Definite axes and poles indistinguishable

Table 3. **Radiotics and crystallotics.** Morphological and psychomatic relationships between crystals and radiolaria.

First sub-class of Radiolaria (Spumellaria and Acantharia) Porulosa (= holotrypasta)	**Second sub-class of Radiolaria** (Nasselaria and Phaeodaria) Osculosa (= Merotrypasta)
Central capsule originally round, without main opening or osculum, with membrane with fine pores	Central capsule originally egg-shaped or spheroidal, with an osculum at the basal pole of the main axis
I. Legion: Spumellaria (Foam rays or peripylea) **Cell** with central, late cleft nucleus. Pores distributed uniformly over the membrane **Skeleton** of silica, originally a lattice sphere, often with regularly distributed radial spicules, according to the basic form of the tetragonal system **Dictyosis** crystalline, mostly regular **Psychoma** with labile equilibrium **Character**: sphero-crystal with combination of radial and tangential growth	**III. Legion: Nassellaria** (Basket radiant or monopylea) **Cell** with eccentric, late cleaved nucleus, with a basal porochora, a field of pores, out of wich a bundle of pseudopodia emerges **Skeleton** of silica, originally a vertical ring or as biocrystal in various systems. Very variable **Dictyosis** crystalline, mostly irregular **Psychoma** with stable equilibrium **Character**: unbiaxial biocrystal; usually with a combination of sagittal ring and basal tripodium
II. Legion: Acantharia (Star radiant or Actipylea) **Cell** with eccentric, early cleaved nucleus. Pores in the membrane ordered in radial bunches and rows **Skeleton** of celestine or acanthin, originally a star with many rays radiating from the central capsule. Usually a biocrystal from the tetragonal system with 20 radial spicules, divided according to Müller's law into 5 zones each of 4 spicules **Dictyosis** crystalline, symmetrical **Psychoma** primary with labile equilibrium, secondary with stable equilibrium **Character**: sphero-crystal with dominant radial axes—growth usually with isoacanth symmetry	**IV. Legion: Phaeodaria** (Tube radiant or cannopylea) **Cell** with an eccentric strongly differentiated nucleus, with a basal rayed cover (astropyle) from the mouth tube of which emerges a stronger plasmastream **Skeleton** of a carbonaceous silicate, sometimes very simple, sometimes highly compressed and differentiated **Dictyosis** polymorphic, very variable, often hexagonal. **Psychoma** very variable, originally with labile, but often later with stable equilibrium **Character** very various development (polyphyletic); sometimes crystalline, sometimes amorphous, often with very complex symmetry properties

Table 4. **The four main forms of hemitomy** determined by the operation of *molethyn* in the three directions of space (corresponding to the three coordinate axes of the crystal).

	Hemitomy of cytodes	**Chromaceea**	**Bacteria**	**Crystals**
I	**Polythyn hemitomy** Division of nucleus-less plastids freely and undefined in all directions **Coenobia amorphous or rounded**	**Chroococcus aphanocapsa** (Like this also many protists and tissue cells)	**Archicoccus, Micrococcus** (Many *molythyn*—sphereical bacteria)	Basic form of sphero-crystals: the sphere
II	***Cubothyn* hemitomy** Division of nucleus-less plastids in one plane, in two mutually perpendicular directions in space	**Gloeocapsa, Gloeocystis** (many other protists) cleavage cells in regular egg division	**Sarcina, Plakosarcina** Ordering in three directions. Cubic bacteria	Basic form of the cubic crystal system (cubes or octahedra)
III	***Plakothyn* hemitomy** Division of nucleus-less plastids in one plane into two mutually perpendicular directions **Flat, tabular coenobia** (often square or polygonal plates)	**Merismpedia Tetrapedia coelosphaerium tetraspora.** (also pediastrum and many protists. Discoidal egg division, growth of many epithelia)	**Micrococcus, tetracoccus** Ordering in two directions. Tabular bacteria	Basic form of the tetragonal system (tetragonal plates)
IV	***Hormothyn* hemitomy** Division of nucleus-less plastids in a single direction **Coenobia catenal** (chains or fibres)	**Oscillatoria, nostocaceae** (also thread like thallus of many protophytes. Hairs and fibres of many tissues of histones)	**Streptococcus bacillus** One-directional order (Thread bacteria)	Basic form of uniaxial crytals: spindle, daisy-chain (Catenal cylinder)

Table 5. Ladder of soul-life (*psychomatic* scale).

	Expressions of psychic activity (Psychomatic functions)	Material basis of psyche-endowed substance
Step 12 **Spirit of the civilised people**	Development of reason and world consciousness, sciences, philosophy and art	Organ of thought (phronema) in the cerebral cortex. Phronetal cells
Step 11 **Psyche of natural people and the higher animals**	Development of understanding and self-consciousness and higher mental activities	Brain and spinal column of the vertebrates
Step 10 **Psyche of the lower animals**	Development of sense and nerve activities in many levels. Higher instincts	Nervous system centralised: Sense organs mostly at a lower level
Step 9 **Psyche of the sponges and polyps**	Unconscious psychic life (dull) as in the lower plants. Instincts of a lower kind	Nervous system not yet centralised; higher sense organs still lacking
Step 8 **Psyche of the higher plants (Cormophytes)**	Highly developed sensitivity for sense-plants and higher cormophytes with sense organs	Psychoplasma of the social plant cells very sensitive, with special sense organs
Step 7 **Psyche of the lower plants (thallophytes)**	Many levels of instincts Less developed sensitivity for the lower cormophytes without sense-organs and for the thallophytes	Psychoplasma of the social plant cells, less sensitive without special sense organs
Step 6 **Psyche of cell associations (coenobia)**	Development of social instincts through lasting unification of many similar kinds of cells	Plasma nets of socially united cells in cell-colonies (plasmodesmes)
Step 5 **Psyche of single cell protists**	Solitary cell psyche of the protozoa (radiolaria, infusoria) and of the protophytes (diatoms, algae)	Beginning of sexual differentiation with copulation of the cell nuclei (egg and sperm)
Step 4 **Psyche of the probionts**	Cytode psyche of the non-nucleated plastids (monera, bacteria, chromacaea; without erotics, fully sex-less)	Archiplasma of non-nucleated cytodes without sexuality. (Propagation by hemitomy)
Step 3 **Psyche of crystals**	Crystallisation. Three-dimensionally pedriodic parallel ordering of socially connected molecules	Substance of crystals, assembled from homogeneous molecules
Step 2 **Psyche of molecules**	Physical energy of cohesion, adhesion, moletropy, etc.	Substance of molecules, assembled from atoms
Step 1 **Psyche of atoms**	Chemical energy, elective affinitiy, catalysis, contact activity, etc.	Substance of chemical elements, assembled from electrons
Levels 1–3 **Elementary psyche** (leptopsyche) Levels 4–6 **Plastic psyche** (plasmopsyche)	Levels 7–8 **Plant psyche** (phytopsyche) Levels 9–12 **Animal psyche** (zoopsyche)	

Table 6. The biogenetic scale. The parallel step-ladder of organisation.

Levels	In the plant kingdom **Vegetal scale**	In the animal kingdom **Animal scale**	Levels
IV. Level Stick-plants **Cormophyta** Metaphytes with corms (stalk with leaves)	Angiospermae Gymnospermae Pteridosphyta **Bryophyta**	Vertebrata Articulata Echinoderma Mollusca **Vermalia**	IV. Level Higher animals **Coelomaria** Metazoa with gut (bilaterata).
III. Level Bedding-plants **Thallophytes** Metaphytes with thalli (Bed of cells without leaves)	Fucoidea Lichenes Fungi Floridae Conferveae **Algae**	Platodes Cnidaria Spongiae **Gastraeades**	III. Level Lower animals **Coelenteria** Metazoa without gut (coelenterata)
II. Level Original plants **Protophytes** Single-cell plasmodome protists with nuclei	Diatomea Ascalgetta Paulotomea **Algaria** **Flagellata**	Radiolaria Ciliata Heliozoa Rhizopoda Amoebina **Infusoria** **Flagellata**	II. Level Original animals **Protozoa** Single-cell plasmophage protists (nucleated)
I. Level. Pre-plants **Archephyta** Nucleus-less plasmodome probionts	**Chromacea** (plasmodom) Rivulariaceae Nostocaceae Oscillariaceae Hormogonea Coccogonea **Chroococcus**	**Bacteria** (plasmophage) Eubacteria Thiobacteria Nitrobacteria Rhabdobacteria Sphaerobacteria **Chroococcus**	I. Level Pre-animals **Archezoa** Non-nucleated plasmophage probionts

Table 7. **Biotic geo-genesis.** The main periods of psychic life in the Earth's history.

Four periods of the evolution of life on the Earth	**Morphological processes** in the oldest stage of our planet	**Psychomatic progress** in the oldest psychic life of Gaia
I. Period: **Inorganic earth life** Physical and chemical processes without plasma	**Singulation of the planet Gaia** The body of the Earth separates itself as an individual body from its mother Sun. Formation of the solid skin and later the liquid water	**Mineral psyche** The physical and chemical processes in the molten mineral body of the planet do not permit the formation of plasma
II. Period: **Probiontic earth life** Chromacea Bacteria Monera	**Archigony of cytodes** Formation of the first plasma (of the oldest "living substance") through the catalysis of colloidal carbon compounds. Singulation of cytodes. Monogony. Still no sexual differentiation	**Carbon psyche** Beginning of organic life. Carbon combines with other organo-genic elements to give giant plasma molecules of arbitrary composition
III. Period: **Protist life on earth** Single celled, nucleated organisms **A. Protophytea** (plasmodome) **B. Protozoa** (plasmophage) (B from A through metasitism) Sexual differentiation	**Karyogenesis of cells** Formation of the first true cells from nucleus-less cytodes. (By differentiation of the inner karyoplasma of the inner cytoplasm the cell nucleus separates from the cell body (cytosome). The cell nucleus becomes the organelle of heredity; the cell body facilitates adaptation	**Cell psyche** The beginning of real organisation; by the inner division of work between the inner nuclear substance and the outer cell substance the "nucleated cell" results, as an "elementary organism" and with this sexuality evolves (*eros*)
IV. Period: **Histonic earth life** Multicellular organisms **A. Metaphytes** (tissue plants) **B. Metazoa** (tissue animals)	**Histogenesis of tissues** Formation of the first tissues: coenobia with physiological division of function and morphological differentiation (from loose cell associations, coenobia, firm sheets of cells develop with associated polymorphism	**Histone psyche** The close association of numerous cells into tissues and their progressive ergonomy leads to the formation of many kinds of organs and organ systems

Table 8. **The monist doctrine of substance.** (The three attributes of substance or "energy material".)

I. Matter (= material = *hyle*) **World material**	**II. Energy** (= force = work) **World force**	**III. Psyche** (= original soul = feeling) **World psyche**
Materialist principle (*Prakrit, sankhya*) **Materialism** (= hylism) (Extension)	Dynamic principle (*Karma*, Buddhism) **Energetics** (= doctrine of energy) (will)	Psychic principle (*Atman* in the Vedas) ***Psychomatics*** (= panpsychism) (sensitivity)
Space-filling substratum of all substance (*hyperkymenon*) (Dependence of all being and becoming on matter or material)	Operative work, the functioning of all substance (energy) (Dependence of all being and becoming on energy or force)	Discriminating feeling of all substance (*aesthesis*) (Dependence of all being and becoming on psyche or soul)
Two original states **I. A. Ether** (World ether = lumeniferous ether. "Tense matter" Structure continuous (not atomic) Imponderable substance	Two original states **II. A. Tension** Potential energy "ability to do work. Resting force. Energy of position	Two original states **III. A. Attraction** "Loves of the elements" Pleasure feeling Positive tropism
I. B. Mass "Densified matter" Atomistic structure, discrete particles Ponderable substance	**II. B. Driving force** Actual energy. Rate of doing work. Living force Active energy of motion	**III. B. Repulsion** Pushing away. Counteraction. "Hates of the elements" Pain feeling. Negative tropism
All substance possesses extension (*extensio*) and fills space	All substance possesses force or energy and acts on its surroundings	All substance possesses feeling or sensitivity towards its environment
Constancy of matter Universal law of "conservation of matter"	**Constancy of energy** Universal law of "conservation of energy"	**Constancy of psyche** Universal law of the "conservation of feeling"

Notes

1. *Haeckel's note*: Gustave Le Bon, "Die Entwicklung der Materie" (Paris, German translation of the 12th edn. by Max Iklé, Leipzig, 1909). In the 5th book of this work the important problem of leptonics or "molecular physics" is treated from new standpoints, which can here be only fleetingly underlined: "The properties of the transitional substance between mass and ether"; "Electricity as one of the substances arising from the dematerialisation of matter", etc. Although many speculations of Le Bon seem very problematic and appear daring, his introduction to the sensitivity of all substances is well worth notice.
2. Much of this section is repeated from the "Riddle of the Universe".
3. *Haeckel's note*: *Molethynos* = composed of "moles" (Greek *molos*) = mass and "*thynos*" (Greek) = rapid motion, derived from "*thyno*" (Greek) = to hurry. (Hence the name "*tynnos*" for tunny-fish or tuna.)
4. This concept demands comparison with the *memes* of Richard Dawkins "The Selfish Gene" (1976) as discussed further by Daniel C. Dennett, "Darwin's Dangerous Idea" (1995).
5. pun
6. continuation of the pun.
7. *Haeckel's note*: On the wave generation of the particles of life or the perigenesis of the plastidule. Lecture given on 18 November 1875 to the Natural Science Society of Jena. II volume of my collected popular lectures and publications. 2nd. Ed., Bonn, 1902.
8. Haeckel has not properly understood the process of hysteresis.
9. *Haeckel's note*: "Allgemeine Entwicklungsgeschichte der Organismen" (1866); Vol. II, of "Generelle Morphologie"; Book V: "Generelle Ontogenie (Embryologie und Metamorphologie); Book VI, "Generelle Phylogenie (Genealogie und Paläontologie)" compare especially the ontogenetic and phylogenetic theses in chapters 20 and 26, printed also in the "Prinzipien der Generelle Morphologie" (Berlin, 1906), pp. 243 and 405. "Thesen von dem Kausal-Nexus der biontischen und phyletischen Entwicklung".
10. *Haeckel's note*: "Anthropogenie oder Entwicklungsgeschichte des Menschen", Leipzig, 1874; 6th revised edition 1910, with 500 text figures, 30 tables and 60 genetic tables.
11. *Haeckel's note*: "*Tot sunt diversae species, quot ab initio creavit infinitum ens*", (Linnaeus).
12. *Haeckel's note*: Heinrich Schmidt (Jena), "Philosophisches Wörterbuch", (3rd. Ed., 1918) Kröner, Leipzig.
13. *Haeckel's note*: I (as a dilettante in higher physics!) have only briefly hinted at the contradiction between the kinetic concept of substance (an original principle of oscillation or vibration) and the pyknotic concept of substance (an original principle of compaction or pyknosis) in chapter 12 of the "Riddle of the Universe". J. G. Vogt (Leipzig) who, in 1897 explained from new viewpoints "The essence of electricity and magnetism based on a unitary concept of substance", in 1912 gave a closer foundation of his original theory in the work: "Absolute monism, a mechanical world outlook based on a pyknotic concept of substance" (Hildburghausen).
14. *Haeckel's note*: Mie, "Moleküle, Atome, Weltäether", Leipzig, 3rd. Ed., 1911.
15. *Haeckel's note*: "General morphology" 1866, Vol. 1, pp. 120–122. The basic idea of the carbogen theory was just the biological consequence of the path-finding advances in theoretical chemistry which Kekulé (Bonn) made in 1858 through his theory of the four-valence of carbon and his new theory of benzene (1865). Kekulé strikingly names the whole field of research on the so-called "organic compounds" as "the chemistry of carbon compounds".
16. *Haeckel's note*: Carus Sterne, "Werden und Vergehen, Eine Entwicklungsgeschichte des Naturganzen in gemeinverständlicher Fassung", Berlin, 1876. Sixth revised edition by Wilhelm Bölsche, Berlin, 1905. This thoughtful and attractively written work is particularly to be recommended not only to educated laymen, but also to thoughtful research scientists. The third chapter, "The world of crystals and precious stones", includes many generally interesting thoughts.
17. *Haeckel's note*: In the journal "Die Naturwissenschaften", Berlin, (4), 49–56 (Jan. 1917).
18. *Haeckel's note*: The chemical formula of serum albumen (MW = 10,166) is, according to Hofmeister; C 450, H 720, N 116, S 6, O 140. The formula of haemoglobin (MW = 16,669, is C 758, H 1203, N 195,) 218, Fe S 3.
19. *Haeckel's note*: "Zellseelen und Seelenzellen", Lecture given on 22 March 1878 in the "Concordia" in Vienna (Leipzig, Kröner). Also printed in my collected general lectures, Bonn, 1902.
20. *Haeckel's note*: Further guidance will be found in the important larger work of Max Vorworn: "Allgemeine Physiologie, ein Grundriß der Lehre vom Leben", 6th. Ed., Jena, 1915.

21. *Haeckel's note*: The single cell protphytes (as vegetal or "original plants") are as different from the multi-cellular and tissue-building metaphytes ("tissue plants") in morphological and psychomatic respects as the single-celled Protozoa (as animal protists or "original animals") are from the multi-cellular and tissue-building Metazoa ("tissue animals"). Since also many protophytes build unions of cells (coenobia), so their bodies should not be designated as thallus. The true thallus of the real "thallophytes" (multi-cellular Algae and Fungi) has reached a higher level of plant *singulation* (corresponding to the gastrea-form of the animal gastraeadea.
22. *Haeckel's note*: All the "single-cell Algae" can be unified into the Family of Algaria and these can be divided into the main Classes of the Paulosporatea (without swarm spores) and the Zoosporatea (with moving swarm spores). To the first belong Paulotomea, diatoms and conjugates; to the latter, Volvocinea, Peridinea and Siphonea.
23. *Haeckel's note*: "Planktonstudien. Vergleichende Untersuchungen über die Bedeutung und Zusammensetzung der pelagischen Fauna und Flora", 1890 (Protophytten des Plankton, pp. 26–35). Peridinea , table 14 and diatoms, table 4, 84, in my "Art forms in nature" (Leipzig, 1904).
24. *Haeckel's note*: Metasitism = exhange of food. "Systematische Phylogenie der Protisten", Berlin, 1894. Para. 38, p. 44.
25. *Haeckel's note*: G. Haberlandt, "Die Sinnesorgane der Pflanzen", Leipzig, 1904—B. Nemec, "Die Reizleitung und die reizleitenden Strukturen bei den Pflanzen", Jena, 1904—R. Francé, "Das Sinnesleben der Pflanzen", Stuttgart, 1904. Detailed reports on this modern "Psychology of plants" and its history is contained in the second volume of R. Francé: "Das Leben der Pflanzen", Stuttgart, 1907.
26. *Haeckel's note*: "Stufenleiter des Seelenlebens". The survey of this most important stage, which I have given in 1899 at the end of chapter 7 of the "Riddle of the Universe", is now significantly extended with the "Kristallseelen". See Table 5 in the appendix: the psychomatic scale.
27. Haeckel's term for something which looks like a crystal but which may be amorphous internally.
28. *Haeckel's note*: "Die Kalkschwämme (*calcispongidae*)", Berlin, 1872. The first volume, general biology, contains the basis of the gastraea-theory; the second volume, "Systeme der *Calcispongien*", is an attempt at the analytic solution of the problem of the origin of species; the third volume, "Atlas von 60 Tafeln", contains numerous illustrations of bio-crystals.
29. *Haeckel's note*: Figure 57 shows an enlarged section through an eight-cornered flagellar chamber of a chalk sponge (*sycon*), which corresponds to an individual *olynthus*. The fine flagellar hairs, which are actively moving, and which direct the nourishing stream of water into the central belly, are radially directed with respect to the centre. The thicker external wall of the eight-cornered *olynthus*, in which the grains of the ectoderm cells fused together are visible, is supported by regular three-rayed bio-crystals. The four small four-cornered cavities, which lie at the four corners of the square, are the cross-sections of four inter-channels, which separate four juxtaposed neighbouring flagellar chambers one from another.
30. *Haeckel's note*: *Histopsyche*. The tissue-soul of the sponges and their duplicity (like that of the usual plant-soul of the metaphytes) is emphasised in chapter 9 of the "Riddle of the Universe", 1899.
31. *Haeckel's note*: *Olynthus*, the simplest and most primitive form of all sponges, which must be treated as the common family form of the whole multifarious family, consists of a single flagellar chamber, cylindrical or with the form of an elongated egg, a few millimetres in length. This original form of sponge is on this account of great interest, because it is essentially built in the same way as our ordinary fresh-water polyp (*Hydra*), which serves as the general form of all *Nesselaria*, and is also homologous with the gastrula, the general embryonic form of all tissue animals (Metazoa). In my gastraea-theory, the basis of which was published first in 1872 in the monograph on the chalk sponges (vol. 1, p. 464), I tried to show that this gastrula is the hereditary *gastraea*, the repetition of the hypothetical common family form of all Metazoa, determined through the *mneme*.
32. *Haeckel's note*: "Monographie der Medusen" (1865 *Geryoniden*, with 6 tables; 1869 the fossil medusae of the Jurassic, with 8 tables; 1879 *Craspedotae*, with 20 tables; 1880 *Acraspedae*, with 20 tables; 1881 *metagenesis* and *hypogenesis* of *Aurelia aurita*, with 2 tables; 1882 deep-sea medusae, with 32 tables), Jena, G. Fischer.
33. *Haeckel's note*: "Monographie der Siphonophoren". "Report on the Siphonophorea collected by H. M. S. Challenger", London, Longmans, with 50 tables, Quarto, 1888.—"Über Arbeitsteilung in Natur und Menschenleben" (Lecture in Berlin, 1868), 2nd. Ed., 1910, Leipzig (in vol.1 of collected speeches and publications, Bonn, Strauss, 1902).

34. *Haeckel's note*: "Unsere Ahnenreihe (*Progonotaxis* hominis) Kritische Studien über phyletische Anthropologie, Festschrift zur 350-jährigen Jubelfeier der Thüringer Universität Jena", Mit 6 Tafeln, Jena, 1900.
35. Since here Haeckel is dealing with the theological concept of the *soul*, we will use that word where appropriate rather than the word *psyche* with which we have usually translated Haeckel's word *soul*. The consideration is one of modernising obsolete verbal usage.
36. *Haeckel's note*: "Phylogenie der Menshenseele", in chapter 8 of my book "Systematischen Phylogenie der Wirbeltiere" (p. 626, Berlin, 1895). I have briefly collected the empirical arguments from the domains of anatomy and ontogeny, physiology and pathology which, for every unbiassed and honourable thinker appear incontrovertible, on the historical evolution of the human soul from the simian soul. With this the old fairy tale of the personal immortality of the soul definitely collapses.
37. *Haeckel's note*: "Anthropogenie oder Entwicklungsgeschichte des Menschen" (mit 30 Tafeln und 500 Textfiguren). I Teil: Keimesgeschichte (Ontogenie), II Teil: Stammesgeschichte (Phylogenie). Leipzig, Engelmann, 1874—6 Auflage 1910.
38. *Haeckel's note*: "Generelle Promorphologie oder Allgemeine Grundformlehre (Stereometrie der Organismen)." Fourth book of the Generelle Morphologie, vol. 1, pp. 375–574, Berlin, 1866 (in the partial offprint, which appeared 40 years later under the title "Prinzipien der Generelle Morphologie" only a small part of this fourth book is reprinted).
39. In 1974 Dover Publications Inc. of New York produced a reprint of these 100 plates with the title "Art Forms in Nature", omitting the text and giving only brief captions.
40. *Haeckel's note*: "Kunstformed der Natur". 10 folios with 100 plates. Leipzig, Bibliographic Institute, 1899–1904. The numerous figures for this "coffee-table book (!)", especially the beautiful forms of the micoscopic protists, as well as the lower plants and animals, little known to wide circles of people, are very suitable for the pictorial expostion of many questions of the "crystal souls". In the eleventh (supplementary) folio (1904) I have discussed their theoretical and aesthetic significance and added explanatory synoptic tables.
41. *Haeckel's note*: Stephan Leduc (Nantes), "Theorie physico-chimique de la Vie et Generations spontanées", Paris, 1910.
42. Haeckel tends to say, for example, *three-rayed* for a structure where we might say *with three-fold symmetry*.
43. Haeckel considers both crystals and non-crystals!
44. But for quite different reasons!
45. *Haeckel's note*: The relations between the physical properties of crystals and their chemical composition, (morphotropy, polymorphism, etc.) which Gottlob Linnek in the fourth chapter of his "Grundriss der Kristallographie" (Jena, 1913) has excellently discussed, could perhaps in the light of psychomatic treatment have still further elucidation.
46. Stephan Leduc (Nantes): "La biologie synthetique", Paris, 1912. Compare also Gustave Le Bon, The Evolution of Matter (German Ed. Leipzig, 1909).
47. "Everything existing in the Universe is the fruit of chance and necessity", Democritos of Abdera.
48. *Haeckel's note*: "Ewigkeit, Weltkriegsgedanken über Leben und Tod, Religion und Entwicklungslehre", Berlin, 1915.