The Theory of Meaning*

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Introduction to the first edition

> The materialists pull everything down from the sky and out of the invisible world onto the earth as if they wanted to clench rocks and oak trees in their fists. They grasp them, and stubbornly maintain that the only objects that exist are those that are tangible and comprehensible. They believe that the physical existence of an object is existence itself, and look down smugly on other people — those who acknowledge another area of existence separate from the physical. But they are totally unwilling to listen to another point of view.
>
> (Plato, *Sophistes*)

An excellent researcher and director of an Institute for Biology who is correctly held in high regard has blamed me for misleading the public. His reproach should not be taken lightly. As far as I can understand his criticism, he states that my theory of the orderly arrangement of nature stirred up vain hopes among my many readers.

I have previously been accused of deception, but under different circumstances.

On the isle of Ischia, where I spent a few beautiful spring days, I met an old acquaintance who asked for directions. I told him to turn left at the flowering rose bush. Somewhat later, we met each other at said rose bush. My acquaintance accused me of having misled him because he said that the rose bush was not in bloom. I then discovered that he was color-blind, and could not see the red roses against the green of the leaves.

The reproach of misleading the public is the consequence of a similar constitutional deficiency as was the reproach of my acquaintance in

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Ischia. If my acquaintance was color-blind, the other accuser is 'meaning-blind'. He perceives nature's countenance like a chemist confronting the Sistine Madonna. Although he can see the colors, he cannot see the picture. The chemist can certainly learn much by chemically analyzing the colors, but such an analysis is irrelevant to the painting.

Although the aforesaid naturalist is an excellent chemist and cytologist, his work does not deal with biology defined as a theory of life. Only he who is a biologist investigates the planful processes of life and determines their changing meanings. This way of conceptualizing biology has almost vanished; for most investigators the lawfulness of *meaning relations is *terra incognita.*

I am, therefore, forced to start with the simplest examples, in order initially to convey to the reader some idea about how meaning is to be understood, and then to demonstrate to him that life can only be understood when one has acknowledged the importance of meaning.

I must also state that it is deceptive to: (1) commission a chemist, rather than an art historian, to judge a painting; (2) entrust the critique of a symphony to a physicist instead of to a musicologist; (3) concede to a mechanist, and not a biologist, the right to limit the study of the reality of the behaviors of all living organisms to the law of the Conservation of Energy.

Behaviors are not mere movements or tropisms, but they consist of **perception* (*Merken*) and **operation* (*Wirken*); they are not mechanically regulated, but meaningfully organized.

This concept naturally defies the 'Law of simple explanations' (*Denkökonomie*) that guides the mechanists and has made their investigations easy! But to push problems aside does not solve them. Progress in the life sciences in the last few decades is characterized by behaviorism and the study of conditioned reflexes; one can certainly concede that experiments have become more and more complex, but must declare that scientific thought has become easier and cheaper.

Cheap thought has the same effect as an infectious disease — it spreads, and suffocates all attempts at an independent *Weltanschauung*: 'God is Spirit and Spirit is Nothing' goes the common saying, which satisfies the simple-minded today.

This maxim is so cheap that it ranks as capital nonsense.

I ask each naturalist whether he wishes to steer the public to that goal.

The meaning-carrier

The sight of winged insects, such as bees, bumblebees, and dragonflies, flying about a flower-filled meadow reawakes in us the impression that the whole world lies open for these enviable creatures.

Even earth-bound animals, such as frogs, mice, snails, and worms, appear to move freely in nature.

This impression is deceptive. In truth, every free-moving animal is bound to a specific habitat and it remains the task of the ecologist to investigate its limits.

We do not doubt that a comprehensive world is at hand, spread out before our eyes, from which each animal can carve out its specific habitat. Observation teaches us that each animal moves within its habitat and confronts a number of *objects, with which it has a narrower or wider relationship. Because of this state of affairs, each experimental biologist seems to have the task of confronting various animals with the same object, in order to investigate the relationships between the animal and the *object. In this procedure, the same object represents a uniform standard measure in every experiment.

American researchers, for example, have attempted indefatigably, in thousands of experiments, starting with white rats, to investigate the relationship of a vast variety of animals to a labyrinth.

The unsatisfactory results of this work, despite the most exact techniques of measurement and their most refined mathematical treatment, could have been predicted, because it was based on the false assumption that an animal can at any time enter into a relationship with a *neutral object.

The proof of this seemingly surprising assertion is easy to demonstrate by means of a simple example: Let us suppose that an angry dog barks at me on a country road. In order to drive it off, I pick up a stone and frighten it off with an adept throw. Nobody who observes this process and afterwards picks up the stone would doubt that it was the same object, 'stone', which first lay on the road and then was thrown at the dog.

Neither the shape, nor the weight, nor the other physical and chemical properties of the stone have altered. Its color, its hardness, and its crystal formation have remained the same and yet, a fundamental transformation has taken place: It has changed its meaning.

As long as the stone was incorporated in the country road, it served as a support for the walker's feet. Its meaning in that context lay in its playing a part in the performance of the path, we might say that it had acquired a 'path-quality' (*Weg-Ton*).

This changed fundamentally when I picked up the stone to throw it at the dog. The stone became a missile — a new meaning became imprinted upon it. It had acquired a 'throw-quality' (*Wurf-Ton*).

The stone lies in the objective observer's hand as a neutral object, but it is transformed into a *meaning-carrier as soon as it enters into a relationship with a subject. Because no animal ever plays the role of an observer, one may assert that they never enter into relationships with neutral objects. Through every relationship the neutral object is transformed into a

meaning-carrier, the meaning of which is imprinted upon it by a *subject.

The influence that the transformation of meaning exercises on the properties of the object is clarified by two further examples. I take a domed glass dish, which can serve as a neutral object because it has not performed any previous function for human beings. I insert the glass dish into the outside wall of my house and transform it in this way into a window that lets in the sunlight; but, because it also reflects light, it screens out the glances of the passers-by. However, I can also place the glass dish on a table, fill it with water, and use it as a flower-vase.

The properties of this neutral object are not altered at all during these transformations. But as soon as the glass dish has been transformed into a meaning-carrier, 'window' or 'vase', its various properties acquire a rank-order of importance. The transparency of the glass is a 'key' property of the window, while its curvature represents a subsidiary property. In the case of the vase, the obverse is true: The curvature is the key property and the transparency the subsidiary property.

Through this example, we can understand why the scholastics divided the properties of objects into 'essentia' and 'accidentia'. In so doing they had only meaning-carriers in mind; because the properties of neutral objects are not meaning-carriers, they cannot be rank-ordered by importance. Only the tighter or the looser bond between the meaning-carrier and the subject makes possible the separation of the properties into key (essential = 'essentia') and subsidiary (inessential = 'accidentia') ones.

A neutral object consisting of two long poles and several short poles, which are connected to the two long poles at regular intervals, may serve as a third example. If I lean the long poles against a wall, the object acquires a 'ladder-quality' (*Leiter-Ton*). However, I can give it the performance-quality of a fence if I fix one of the long poles horizontally to the ground.

It soon becomes apparent that, in the case of the fence, the cross-poles play a subordinate role. In the case of the ladder, however, they must be distanced at regular intervals so as to make steps possible. A simple spatial construction-plan is, therefore, already apparent in the meaning-carrier, 'ladder', which makes the performance of step-climbing possible.

It is inaccurate to refer to all the uses to which objects are put (although they are, each and all, human meaning-carriers) as if they were neutral, devoid of quality (*Ton*). We even regard a house, with all the things contained in it, as if it existed 'objectively' as a neutral object, in that we totally disregard the people who occupy the house and use the things in it.

That this view is wrong is demonstrated immediately if we replace the human being with a dog as occupant of the house and envisage its relationships to the things in it.

We know from Sarris's[1] experiments that a dog trained to the

command 'chair' learns to sit on a chair, and will be on the look-out for other seating-accommodations if the chair is removed; indeed, he searches for canine sitting-accommodations, which need in no way be suitable for human use.

The various sitting-accommodations all have the same 'sitting-quality' (*Sitz-Ton*); they are meaning-carriers for sitting because they can be exchanged with each other at will, and the dog will make use of them indiscriminately upon hearing the command 'chair'.

Therefore, if we make the dog a house-occupant, we will be able to establish that many things will have a 'sitting-quality' for the dog. A great number of things will also exist that will have an 'eating-quality' (*Fress-Ton*) or a 'drinking-quality' (*Trink-Ton*) for the dog. The staircase certainly has a 'climbing-quality' (*Kletter-Ton*). The majority of the furniture, however, only has an 'obstacle-quality' (*Hindernis-Ton*) for the dog — especially the doors and cupboards, which may contain books or washing. All of the small household effects, such as spoons, forks, matches, etc. do not exist for the dog because they are not meaning-carriers.

Without doubt, a description of the house and its contents in terms of the qualities imparted to them by the dog is an insufficient one for the human inhabitant.

Are we not taught by this example that the forest, for instance, which the poets praise as the most beautiful place of sojourn for human beings, is in no way grasped in its full meaning if we relate it only to ourselves?

Before we follow this thought further, a sentence from the Umwelt chapter of Sombart's[2] book *About the Human* may be cited:

> No 'forest' exists as an objectively prescribed environment. There exists only a forester–, hunter–, botanist–, walker–, nature-enthusiast–, wood gatherer–, berry-picker– and a fairytale-forest in which Hansel and Gretel lose their way.

The meaning of the forest is multiplied a thousandfold if its relationships are extended to animals, and not only limited to human beings:

There is, however, no point in becoming intoxicated with the enormous number of *Umwelts (subjective universes) that exist in the forest. It is much more instructive to pick out a typical case in order to take a look into the relationship-network of the Umwelts.

Let us consider, for example, the stem of a blooming meadow-flower and ask ourselves which roles are assigned to it in the following four Umwelts:

(1) In the Umwelt of a girl picking flowers, who gathers herself a bunch of colorful flowers that she uses to adorn her bodice;

(2) In the Umwelt of an ant, which uses the regular design of the stem-

surface as the ideal path in order to reach its food-area in the flower-petals;
(3) In the Umwelt of a cicada-larva, which bores into the sap-paths of the stem and uses it to extract the sap in order to construct the liquid walls of its airy house;
(4) In the Umwelt of a cow, which grasps the stems and the flowers in order to push them into its wide mouth and utilizes them as fodder.
According to the Umwelt-stage on which it appears, the identical flower stem at times plays the role of an ornament, sometimes the role of a path, sometimes the role of an extraction-point, and finally the role of a morsel of food.

This is very astonishing. The stem itself, as part of a living plant, consists of well-planned interwoven components that represent a better-developed mechanism than any human machine.

The same components that are subjected to a certain building-plan (*Bauplan*) in the flower stem are torn asunder into four different Umwelts and are integrated, with the same certainty, into various new building-plans (*Baupläne*). Each component of an organic or inorganic object, on appearing in the role of a meaning-carrier on the life-stage of an animal subject, has been brought into contact with a 'complement', so to speak, in the body of the subject that becomes the *meaning-utilizer.

This conclusion draws our attention to an apparent contradiction in the fundamental features of living nature. The fact that the body structure is ordered according to a plan (*Planmässigkeit*) seems to contradict the idea that the Umwelt structure is also ordered according to a plan (*Planmässigkeit*).

One must not be under the illusion that the plan to which the Umwelt structure accords is less systematically complete than the plan according to which the body structure is ordered.

Each Umwelt forms a closed unit in itself, which is governed, in all its parts, by the meaning it has for the subject. According to its meaning for the animal, the stage on which it plays its life-roles (*Lebensbühne*) embraces a wider or narrower space. This space is built up by the animal's sense organs, upon whose powers of resolution will depend the size and number of its *localities (*Orte*). The girl's field of vision resembles ours, the cow's field of vision extends away over its grazing-area, while the diameter of the ant's field of vision does not exceed 50 centimeters and the cicada's only a few centimeters.

The localities are distributed differently in each space: The fine pavement the ant feels while crawling up the flower stem does not exist for the girl's hands and certainly not for the cow's mouth.

The structure of the flower stem and its chemistry do not play any part

on the stages upon which the girl or the ant play their life-roles. The digestibility of the stem is, however, essential to the cow. The cicada sucks out the sap it needs from the finely-structured sap-paths of the stem. It is even able, as Fabre[3] has shown, to obtain completely harmless sap for its foam-house from the poisonous spurgeplant.

Everything that falls under the spell of an Umwelt (subjective universe) is altered and reshaped until it has become a useful meaning-carrier; otherwise it is totally neglected. In this way the original components are torn apart without any regard to the building-plan that governed them until that moment.

The contents of the meaning-carriers are different in the various Umwelts, although they remain identical in their structures. Part of their properties serve the subject at all times as *perceptual cue-carriers, another part as *effector cue-carriers.

The color of the blossom serves as an optical perceptual cue in the girl's Umwelt, the ridged surface of the stem as a feeling perceptual cue in the Umwelt of the ant. The extraction-point presumably makes itself known to the cicada as a smell perceptual cue. And in the cow's Umwelt, the sap from the stem serves as a taste perceptual cue. The effector cues are mostly imprinted upon other properties of the meaning-carrier by the subject: The thinnest point of the stem is torn apart by the girl as she picks the flower. The unevenness of the stem's surface serves the ant both as a touch perceptual cue for its feelers and as an effector cue-carrier for its feet. The suitable extraction-point that is made known by its smell is pierced by the cicada, and the sap that flows out serves as building material for its house of air. The taste perceptual cue of the stem causes the grazing cow to take more and more stems into its chewing mouth.

Because the effector cue that is assigned to the meaning-carrier extinguishes in every case the perceptual cue that caused the operation, each *behavior is ended, no matter how varied it may be.

The picking of the flower transforms it into an ornamental object in the girl's world. Walking along the stem changes the stem into a path in the ant's world, and when the cicada-larva pierces the stem, it is transformed into a source for building material. By grazing, the cow transforms the flower stem into wholesome fodder.

Every action, therefore, that consists of perception and operation imprints its meaning on the meaningless object and thereby makes it into a subject-related meaning-carrier in the respective Umwelt (subjective universe).

Because every behavior begins by creating a perceptual cue and ends by printing an effector cue on the same meaning-carrier, one may speak of a *functional circle that connects the meaning-carrier with the subject (Figure 1).

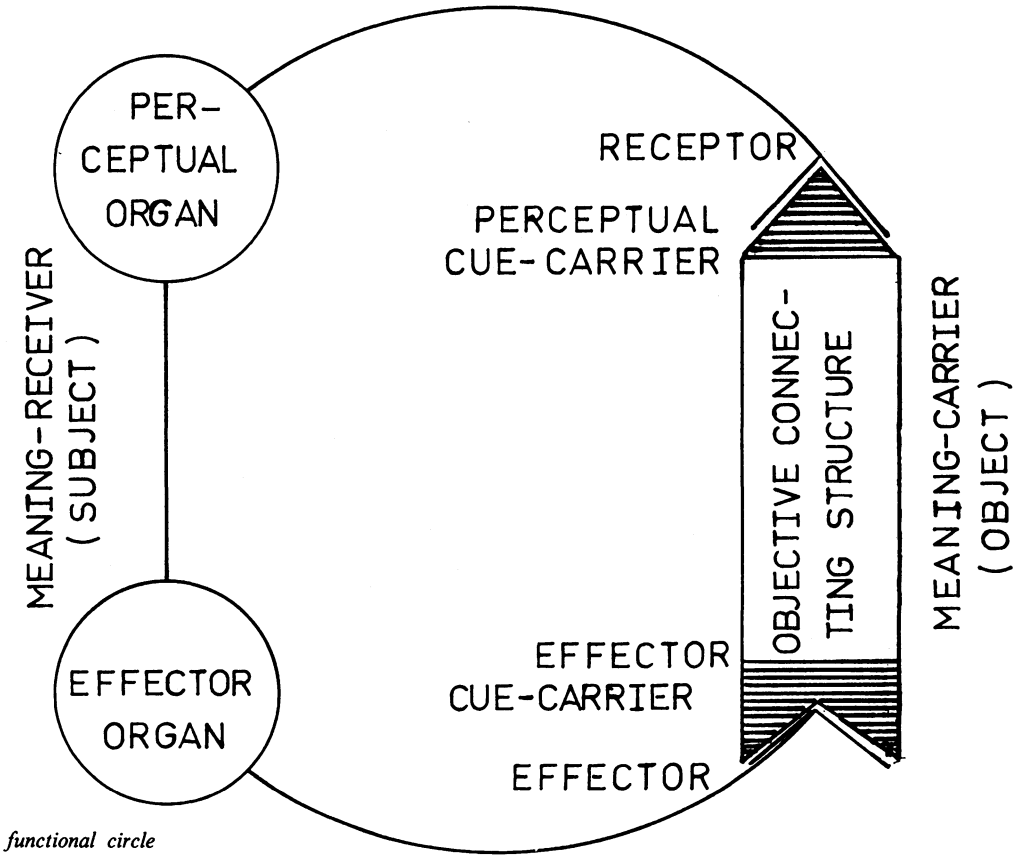

Figure 1. *The functional circle*

The most important functional circles found in most Umwelts are the circles of physical medium, food, enemy, and sex.

Due to its integration into a functional circle, every meaning-carrier becomes a complement of the animal subject. In the process, particular properties of the meaning-carrier play a leading role as perceptual cue-carriers or effector cue-carriers; and other properties, on the other hand, play only a subsidiary role. The biggest part of the body of a meaning-carrier frequently serves as an undifferentiated *objective connecting structure (*Gegengefüge*) whose function is only to connect the perpetual cue-carrying parts with the effector cue-carrying parts.

The Umwelt and the dwelling-integument

Both animals and plants build living houses for themselves, i.e., their bodies, with whose help they lead their existence.

Both types of houses are built throughout in a well-planned way but, nevertheless, they differ in essential respects. The dwelling-house of the animal is surrounded by a wider or narrower space, in which the meaning-carriers of the subject bustle about. However, they are all connected with their appropriate subject through the functional circles.

The nervous system is the segment of each functional circle that lies within the animal's body; beginning with the *receptors (sense organs) it transmits excitatory potentials to the central *perceptual and *effector organs and then to the effectors. The plant has no nervous system, receptors, or effectors; therefore, no meaning-carriers, functional circle, perceptual, or effector cues exist for the plant.

The houses of animals are mobile and can move and carry about their receptors everywhere, with the help of their muscles.

The houses of plants lack mobility. Because they possess neither receptor nor effector organs, plants are not able to construct and be in command of an Umwelt.

The plant possesses no special Umwelt organs, but is immersed directly in its habitat. The relationships of the plant with its habitat are altogether different from those of the animals with their Umwelts. The building-plans of animals and plants are the same in only one respect: Both select precisely from among the stimuli that impinge upon them from the environment.

Only a fraction of the outside world is picked up through the sense organs of animals and treated as stimuli, which are then transformed into nerve-impulses and conducted to the central perceptual organs. *Perceptual signs then arise in these perceptual organs and are projected as

perceptual cues to become properties of the meaning-carriers.

The perceptual signs in the perceptual organs induce, so to speak, corresponding impulses in the central effector organ that become the sources of the nerve impulses that are transmitted to the effectors.

If one speaks of the *'induction' of impulses by the perceptual signs, what is meant is not an electrical induction between two wires in parallel at all, but rather the induction that the melody creates in tones, how one tone follows another.

Essential stimuli also exist for plants; they emerge as *meaning-factors out of all of those that impinge upon them from all sides.

The plant encounters these stimuli, not with the help of receptor or effector organs, but because it has a living cell-layer — the dwelling-integument — that enables it to make its choice of stimuli.

Müller[4] taught us that the concept that life-processes consist of a mechanical sequence is wrong. Even the simple blink-reflex, caused by the eye being approached by a foreign body, does not consist of a mere sequence of physical causes and effects, but of a simplified functional circle, beginning with perception and ending with effect.

That the functional circle, in this case, does not pass through the cerebral cortex, but makes its way through lower centers, changes nothing. Depending upon its nature, the simplest reflex is a perception–effect operation, even if its arc only consists of a chain of individual nerve cells.

We can make this assertion with complete certainty since Müller showed that each living tissue differs from all machines in that it possesses a *'specific' life-energy in addition to physical energy. To clarify: if we compare a living muscle with a bell, one can elicit from the bell its performance — ringing — by letting it swing to and fro in a certain manner. Each attempt to get the bell to ring by any other method fails: neither warming or cooling it, nor treating it with acids or alkalis, nor influencing it with magnets or electric currents will make it perform in this manner — it remains silent. On the other hand, a living muscle whose performance is contraction may be induced by most of these outside influences. The bell behaves like a dead object that only receives effects. By contrast, the living muscle behaves like a subject, which transforms all outside effects into the same stimulus to induce its performance.

If we imagine that we had a number of *living* bells, each producing a different tone, we could make a chime. The bells could be operated either mechanically, electrically, or chemically, because each living bell would answer each kind of stimulus with its own *'ego-quality' (*Ich-Ton*).

The meaning of the living chime does not lie in the manner in which the bells are operated; the chemical or electrical operation of the bells is a

mere mechanism, producing useless ego-qualities. A chime composed of living bells must possess the capacity to let its tune resound, not only because it is driven by mechanical impulses, but also because it is governed by a melody. In this manner, each ego-quality would induce the next one, corresponding to the prescribed tone-sequence created by the melody.

This exact requirement is fulfilled in each living body. One can certainly prove experimentally that in many cases — especially in the case of the transmission of the impulse from nerve to muscle — the living interaction of ego-quality has been replaced by a physico-chemical connection. This connection is always only the result of a secondary development of specialization, leading to mechanization. Originally, all embryos of living organisms consisted of independent cells of protoplasm that obeyed only the melodious induction of their ego-qualities.

Arndt[5] has supplied convincing proof for this fact in his film, in which we see a slime mold (*Myxomyces*) grow before our very eyes. The spores of this fungus consist, in their initial state of development, of freely moving amoeba-like cells that busy themselves feeding on bacterial flora, without regard for each other. These single cells reproduce by division; the more food available to them the faster they reproduce, with the result that the store of food decreases simultaneously in their surroundings.

And now an astonishing event occurs: The amoeba-like cells gather together in separate areas of the same size, and then inside each area they make their way to a central point. Upon reaching this point, they crawl on top of each other, so that the first to arrive are transformed into firm supporting cells that serve the subsequent single cells as a ladder. As soon as the ultimate height of the waferthin stem is attained, the cells last to arrive are transformed into a pistil containing living spores. The spores are then blown away by the wind and disseminated over a new feeding area.

In this example, nobody will doubt that the finely-tuned mechanism of the fungus body is a product of free-living cells, which only follow a melody that governs their ego-qualities.

In addition, Arndt's exposition is especially important because it concerns itself with a living organism, which behaves in the initial phase of its existence as if it had the properties of an animal and in the subsequent one those of a plant.

We are forced to attribute an Umwelt, however limited, to the free-living fungus-cells, an Umwelt common to each of them, in which the bacteria contrast with their surroundings, as meaning-carriers, as food and, in doing so, are perceived and acted upon. On the other hand, the fungus, composed of many single cells, is a plant that possesses no animal

Umwelt — it is surrounded only by a dwelling-integument consisting of meaning-factors.

The governing meaning-factor of the fully grown slime mold is the wind, toward which the fungus grows with surprising certainty. Although not as ingeniously formed as the puff-ball of the dandelion, the fruit-capsules of the fungus are, nevertheless, a prey that the wind easily wafts and that is assured of a wide dispersion.

Utilization of meaning

The habitat of an animal, which spreads out around it, transforms itself before its eyes into its Umwelt (subjective universe), where the most varied meaning-carriers scurry about. The habitat of the plant, which is limited to the area around its location, transforms itself, from the plant's point of view, into a dwelling-integument consisting of various meaning-factors that are subject to regular change.

The life-task of the animal and the plant consists of utilizing the meaning-carriers and the meaning-factors, respectively, according to their particular building-plan.

We are familiar with the concept of food-utilization. But we look at this concept in too limited a way. Food-utilization does not merely consist of the chopping up of food by teeth, and its chemical processing in the stomach and intestines, but it also consists of the recognition that it is food by the eyes, nose, and palate.

That is the reason why, in the animal's Umwelt, every meaning-carrier has acquired meaning through perception and operation. The same perception–operation cycle is repeated in each functional circle. One may even speak of functional circles as meaning-circles, whose task lies in the utilization of the meaning-carriers.

In the case of a plant, one cannot speak of functional circles. However, the meaning of the plant's organs (which also consist of living cells) lies in the utilization of the meaning-factors of its dwelling-integument. It masters this task due to its shape, built according to a plan, and the exquisite organization of its components.

On watching the movement of clouds in the wind, we attribute an ever-changing meaning to their changing shapes. This process is mere phantasy, because the various shapes of the clouds are a product of the wind, and obey the law of cause and effect.

A completely different picture emerges when we follow the flight of the dandelion's graceful, puff-ball umbrellas in the wind, or observe the spinning descent of the maple tree seed or of the lime tree's delicate fruits.

In these examples, the wind in no way brings about the forms, as is the case with clouds; the shapes of the plants and trees are adapted to the meaning-factor, wind, which they use in various ways to disperse their seed.

There are people who, nevertheless, like to think of the wind as the cause of these shapes, because it has influenced the object (plant) for millions of years. The wind, however, has influenced the clouds for a much longer time without shaping them permanently.

The meaningful shape is constant; it is always the product of a subject, and never the product of random influences on an object.

What is valid for the wind is also true for all other meaning-factors of plants. The rain is caught in the gutters of the tree-leaves, and is guided to the delicate root-ends under the earth. The sunlight is caught by the chlorophyll-containing cells of the plant and is used for carrying out an intricate chemical process. The chlorophyll is not synthesized by the sun, nor is the gutter the product of the rain.

The meaning of all plant and animal organs as utilizers of the meaning-factors external to them determines their shape and the distribution of their constituent matter.

The question of meaning is, therefore, the crucial one to all living beings. Only when we have solved this question will there be any point in investigating causal connections, which are always extremely limited, because the activity of living cells is directed by their ego-qualities.

Thus one may speak of a growth-melody or a growth-command that governs the ego-qualities of the germ cells. This growth-command, as Arndt's film teaches us, demands that living forms be shaped. It divides up the areas in which the cells congregate, to whose center all the cells gravitate. The fate of the individual cells depends solely on where they find themselves in the developing structure of the fungus.

The equipotential of individual germ cells was first inferred by Driesch[6] from his famous experiments on sea urchin germs and was conclusively confirmed by Arndt.

The germ cells of most animals first form a mulberry shape, and then assume the shape of a hollow ball that invaginates at one pole and at the same time has three cell layers. The gastrula is formed in this manner, and its three layers constitute the original shape of most animals. Each higher form of animal life begins with this simple tone-sequence.

Other animals, such as the fresh-water polyps, master their primitive lives in the simple form of a gastrula. As with slime molds, one has the impression that polyps execute the command that a form be shaped, which in turn defines their meaning-relationships. Until now, we had no reason to infer a meaning-command separate from the form-shaping command.

Spemann's[7] and his students' experiments have taught us more. Spemann developed a method of grafting a small piece of the body wall of an embryo in the first gastrula stage onto the body wall of another embryo. The graft develops, not according to its site of origin, but according to its surroundings in the new host. The transplanted cells, when placed in the area destined to become brain, become neural tissue, although normally they would have become skin.

The form-shaping command conforms to the directive of a basic building-plan, already recognizable in the gastrula-stage. In this stage of the embryo it is possible to transplant pieces of tissue from embryos of different species. This remarkable experiment also succeeds when pieces of tissue of embryos of different kinds are exchanged.

For example, the exchange of grafts from the mouth areas of tadpoles and triton larvae are of especial interest.

Spemann writes: 'As is well known, the triton-larva has real teeth in its mouth that are of the same origin and structure as the teeth of all vertebrates; the tadpole's mouth, on the other hand, consists of horny jaws and short horny spikes which are constructed completely differently and have a completely different origin than real teeth have.' A graft of tadpole tissue was inserted into the mouth area of a triton larva.

'In one case', reports Spemann, 'where the implanted material covered the whole of the mouth area, a typical tadpole mouth with horny jaws surrounded by horny spikes had developed in exactly the right place. In another, perhaps more interesting case, half of the mouth had remained free of the transplanted tissue and had developed into a triton mouth with real teeth.'

Thus, Spemann concludes: 'A general statement can now be made with assurance: The inducing stimulus must be of a very special nature because it determines *what* will develop; but in what manner it develops is of a very general nature. Metaphorically speaking, the cue is "mouth armour", which is delivered by the ectoderm. The particular structure that will develop from the ectodermal layer is, however, species-specific.'

A spectator attending the theater would be very astonished if an actor playing 'William Tell' were suddenly replaced by an actor playing 'Hamlet', who on the cue 'Monologue' would not speak: 'Here through this hollow way, he must descend ... here will I do it — the Site is favorable ...', but would speak: 'To be or not to be, that is the question ...'.

Similarly, as big a surprise would be in store for a carnivore that depends on sinking its sharp teeth into its struggling prey, if it had the mouth of a vegetarian with a horny palate suitable only for peeling off the soft parts of plants.

How is such an exchange possible? We should not forget that the grafted cell-tissue represents a living chime, the ego-qualities of which have been prepared for the melody 'vegetarian mouth' from the very beginning, on receipt of the meaning-command 'mouth'.

From this example, we can see that the *meaning-command and the form-shaping command are not identical:*

During normal development, the original equipotential cell-material arranges itself into growth-buds that receive their meaning-commands in accordance with a prototypical building-plan — because the organism consists of meaning-utilizers. Only then does the specific bud-melody begin to resound and form the shape of the meaning-utilizers.

If one exchanges the growth-buds of various animal species, each bud receives a meaning-command in its new location, whose nature will depend on its role in the overall building-plan. As it were, the command is: 'Become a mouth, an eye, an ear, etc.'

The transplanted growth-bud obeys the meaning-command of the new host even if it has been taken from a different site on its donor's body that would have given it a different meaning-command. Nevertheless, it follows the donor's form-shaping melody: Indeed it becomes a mouth, but not a triton's mouth, rather a tadpole's mouth.

The end-product is a malformation, because a carnivore with a vegetarian mouth is an absurdity.

We are bewildered by this deformity that originates from a discrepancy between the general meaning-command and the special form-shaping command, because such a discrepancy is unknown in everyday life.

It would occur to no one to order an unspecified stool from a carpenter, because he would then run the risk of receiving a milking-stool for his drawing-room or an armchair for his cowshed.

Here, however, we are witnesses to a natural occurrence, during which the general command 'eating-equipment' is given to equipotential cells, the meaning of which are not yet specified, with the result that totally unsuitable eating-equipment develops.

That the meaning-command may not correspond with the form-shaping command may be seen in the case of two flat-fish, the ray and the plaice, whose living conditions are analogous, but who are formed according to totally different principles: The goal is the same but the method is different! Rays are compressed from back to belly, and their eyes remain on the top of their heads. Plaices are compressed from side to side, with the result that one side assumes the function of the back. Therefore, one eye must once have been on the underside, where it could see nothing. It has since wandered through the plaice's head to reach the upper side.

The principles that underlie the shaping of the many different structures that make it possible for various animals to climb up a smooth wall all lead to the same result: using the meaning-carrier — smooth wall — as a path.

Houseflies have adjoining seams on the soles of their feet. As the fly walks, the weight of its body forces these upward to form vacuum pads, which keep the fly on the windowpane.

Caterpillars and leeches move with the aid of two suction-pads. Snails crawl stickily forward regardless of how steep the ground is. The task is identical for all; however, its execution is completely different.

The principle is strikingly illustrated in the case of the short-quilled sea urchin. It has poisonous pincers that have the task of driving away the meaning-carrier: enemy. The enemy may be a sea snail or a starfish.

These enemies are recognized by the sea urchin because they first emit a chemical stimulus on approach, and then deliver a mechanical stimulus on contact. The poisonous pincers of all species of sea urchins open in response to the chemical stimulus. At the moment of contact they close and release their own poison.

All species of sea urchins except one solve this task with a reflex. A touch receptor is extended toward the enemy as the pincers open. As soon as the receptor is touched by the enemy, the pincers snap together by reflex action.

Only one species of sea urchins performs the task in a different way: As its pincers open, three prongs spring back so far as to become a streched cross-bow. They do not need a reflex mechanism to snap shut at the slightest touch.

Both methods lead to the same result: in both cases, the meaning-carrier — enemy — is attacked and poisoned through the meaning-utilization organ. The meaning-command is the same in each case, but the form-shaping command is completely different.

Spemann's lovely discovery is confirmed in every case, in that similar actions are carried out by various animals with various devices.

Spemann's discovery can also further our understanding of the principal difference between the construction of a mechanism and a living organism. Every machine, a pocket-watch for example, is always constructed centripetally. In other words, the individual parts of the watch, such as its hands, spring, wheels, and cogs, must always be produced first, so that they may be added to a common centerpiece.

In contrast, the construction of an animal, for example, a triton, always starts centrifugally from a single cell, which first develops into a gastrula, and then into more and more new organ buds.

In both cases, the transformation underlies a plan: the 'watch-plan'

proceeds centripetally and the 'triton-plan' centrifugally. Two completely opposite principles govern the joining of the parts of the two objects.

As we all know but only too easily forget, each living organism, in contrast to all mechanisms, consists of organs, not of parts. An organ always consists of living cells, all with their ego-qualities; it has its organ-quality, which is also a meaning-quality. From Spemann's explanations we may conclude that the organ-quality governs the ego-qualities of the organ cells. In a similar manner the meaning-plan of Arndt's slime mold compels the single cells to form the fungus. The meaning-quality begins suddenly and triggers the form-shaping command to the ego-qualities of the cells that have been equipotential until that time. These cells then differentiate themselves into various qualities that are attuned to each other, and allow the development of living forms to proceed according to a given melody.

We learn from Spemann's experiment that the organs of living beings have an innate meaning-quality, in contrast to the parts of a machine; therefore they can only develop centrifugally. The three stages of embryonic development first occur before bud formation begins. Each bud must first have received its organ-quality before its cells organize and transform themselves.

In the final analysis, the life-quality of the whole animal consists of organ-qualities. The living animal is more than its bodily mechanisms; it is built of organ-cells according to the form-shaping command.

When the life-quality is extinguished the animal is dead. The bodily mechanism may continue to function for a while because a few organs survive.

Thorough research will be needed in the future for a more complete understanding of nature, founded upon a theory of meaning. For example, we assume that a 'thought-quality' must exist, but our knowledge of the brain is rudimentary. Meaning must also bridge physical and nonphysical processes in the brain, in the same way as a musical score is connected to a melody.

The interpretation of the spider-web

When I want to order a new suit I go to the tailor. He takes my measurements in order to ascertain the most important dimensions of my body, in centimeters. Then he commits these measurements to paper, or, if he is quite sure of himself, he cuts out the cloth in accord with the measurements. He then sews together the pieces of cloth. First he fits me with the suit and then he delivers it. The suit is a more-or-less successful representation of the shape of my body.

I would be very astonished if a tailor made a suit that fit me without taking my measurements or first fitting me with it. I would assume that he had obtained my correct measurements from his own body, because all human bodies look alike on the whole. Because of this fact, ready-to-wear suits can fit one; they reproduce the normal proportions of the human body in various sizes. Every tailor's shop, therefore, is a gallery of hollow shapes of the human body.

In the case of the spider, however, these prerequisites do not occur — and yet, it is possible for the spider successfully to fit the web to the hollow shape of a fly. It uses this hollow shape not in the fly's interest, but to destroy it. In the spider's Umwelt the web represents a meaning-utilizer of the meaning-carrier 'prey'.

The meaning-utilizer is attuned exactly to the meaning-carrier, so that one can designate the spider's web as an image of the fly.

The spider as tailor reproduces the fly's image without the human tailor's tools. The spider cannot take measurements of its own body to build the web, because its shape differs completely from the fly's shape. Nevertheless, it spins the size of the mesh to accord with the size of the fly's body. It measures the strength of the web's threads to resist the force of the insect in flight. The radial threads of the web are spun tighter than its circular threads, which yield slightly, enclosing the fly and entangling it in their sticky droplets. The radial threads are not sticky; they serve the spider as the shortest route to the captured prey. The fly is then rendered powerless by a web the spider spins around it.

Spiders' webs are mostly to be found in 'runways' of flies.

A special miracle is that the threads of the web are so finely spun that the construction of the fly's eye is too crude to perceive them, and the fly plunges without warning to its own destruction. In an analogous manner and completely without warning, we drink water that contains invisible cholera germs.

The web is truly a refined work of art that the spider has painted of the fly.

But stop! That is not what the spider does at all. It weaves its web before it is ever confronted with an actual fly. The web, therefore, cannot represent the physical image of a fly, but rather it is a representation of the archetype of a fly, which does not exist in the physical world.

Hark! I hear the mechanists calling: They will say that by this example Umwelt-theory is revealed to be metaphysics; because he who seeks effective factors beyond the physical world is a metaphysician.

All right; then present-day physics is, next to theology, the purest metaphysics.

Eddington[8] describes simply that he owned two desks, one of which he

usually used, and which appeared in his perceptual world. In addition he owned a *physical* desk, whose substance amounted to only a billionth part of the first desk, because it was not made of wood, but of an immeasurably large number of smallest elements. One cannot be certain whether these elements represent particles or waves, which orbit around the nucleus of the atom at unimaginable speeds. These elements are not matter, but their effects simulate the existence of natural substances in the world of the sense organs. They scurry around in four-dimensional space-time, which is curved and is at the same time both infinite and limited.

Biology does not claim to be such extensive metaphysics. It only seeks to point to those factors present in the living subject that allow him to perceive a world around him, and serve to make this world of the senses coherent. Biology, however, does not seek to turn the world of the senses topsy-turvy, as modern physics aspires to do.[9]

Biology starts from the observation of a planful development of the embryo that begins with the triple beat of a simple melody. In the case of all multicelled animals this beat consists of a morula, blastula, and gastrula. Then begins the formation of the growth-buds of organs — a program that is laid down for every animal species from its very beginning.

This proves that the sequence in which form develops is 'scored' or programmed. Indeed, this program is not perceived by the senses, but it determines the material world. It also governs the spatial and temporal growth, as well as the properties, of cell-matter.

Therefore, an original program exists both for the fly and the spider. And I would maintain that the fly's original program (or 'archetype') influences the original program of the spider in such a way that the spider's web can be called 'fly-like' (*fliegenhaft*).

Behind a curtain of natural events, the various programs or archetypes are linked by a comprehensive *meaning-plan.*

In individual instances, it is enough to trace out the articulation between specific meaning-utilizers and specific meaning-carriers so as to gain an insight into the web of the Umwelts (*Umweltgewebe*).

Meaning is the guiding star that biology must follow. The rule of causality is a poor guide: causal relationships deal only with antecedents and consequences, thereby completely concealing from us broad biological interrelationships and interactions.

Whoever invites scientists to follow a new guiding principle must first convince them that it opens up new vistas that advance our knowledge more than the previous ones did. He must also be able to direct attention to hitherto unsolved problems, whose solution can only come about with the help of this new guiding principle.

Jules Fabre, the great master of insect biology, pointed out such a problem. The female pea-beetle lays its eggs on young peapods. The larvae hatch, bore through the pod, and penetrate into the still soft peas. The larva that has settled closest to the pea's center grows the quickest. The other larvae, also settled in the pea, soon give up the race, stop feeding, and die. The one remaining larva first hollows out the pea's center and then tunnels a path toward the pea's surface. It builds a door at the end of this tunnel, by cutting out a circular flap in the pea's surface. Then the larva withdraws into its cave of food, and continues to grow until the pea is attaining its ultimate size and hardens. The hardening process should actually kill the young beetle that has now developed from the larva. Although the hard pea forms a protective covering around the beetle, it would have become its coffin were it not for the fact that the larva had built an exit — the tunnel and door — for the beetle.

The behavior of the larva and beetle cannot be explained on the basis of inherited experience, gained by trial and error. Any attempt to get out of the hardened pea would prove to be an error. The building of the tunnel and door must be contained from the outset in the program for the shaping of the form of each developing pea-beetle larva. Meaning must, therefore, have been transferred from the archetype of the pea to the archetype of the pea-beetle, so as to achieve harmony between them.

Although the building of the tunnel and the door by the larva is essential to the beetle, it may also lead to the animal's destruction, because a small ichneumon wasp unerringly finds the door and tunnel and by means of its delicate egglaying tube lays its own eggs into the defenseless pea-beetle larva. The egg develops into a small wasp larva and devours its fat host from the inside. The larva then metamorphoses into an ichneumon wasp, which finds its way into the open through the path prepared by its prey.

This further example allows one to speak of a trio of meanings connecting these original programs.

The rule of form-shaping and the rule of meaning

To make the foregoing presentation of metaphysical ideas palatable to today's biologists will be no easy task.

Loeb's[10] theory of tropism[11] has exercised the largest influence on recent biology.

Loeb was a confirmed physicist. He only recognized the interaction between objects, discounting the subject's influence on natural events. In his opinion, only an *operational world (*Wirkwelt*) existed, in which all

physical and chemical processes took place. One object acts upon the other like a hammer on an anvil, or a spark on a powderkeg. The counter-action is due to the kinetic energy conveyed by an agent and the potential energy stored in the affected object.

The counter-action of plants resides in the shape and arrangement of the substances in their organs. We need only think about the gutters in the leaves of a tree and about the grains of starch in wheat-seed that may be understood as potential energy. In doing so, one naturally disregards the complete form of the plant, whose structure results from the planned action of impulses of living cell subjects.

Certainly, plants do not possess sense organs or nerves — and, therefore, their whole existence seems to take place in an operational world.

Loeb's theory only acknowledged that an operational world exists for animals as well; he refused to recognize a perceptual world by means of a very simple trick.

No matter how complicated an animal's performance may be, it will in the end always approach or distance itself from an affecting object. Loeb equated this simple, spatial component of each animal's performance with the performance itself, and thus classified all performances into 'turning toward' actions or 'turning away' actions.

Instead of performances, he named these actions tropisms, with the result that he transformed all living animal subjects into nonliving machines that arrange themselves separately in space. Even the simple magnet, by attracting iron, acts as a positive ferrotrop, and the magnetic needle as a negative polotrop.

Loeb's theory became decisive for the way a whole generation of biologists viewed the world.

If we stand before a meadow covered with flowers, full of buzzing bees, fluttering butterflies, darting dragonflies, grasshoppers jumping over blades of grass, mice scurrying, and snails crawling about, we would be inclined to ask ourselves the unintended question: Does the meadow present the same view to the eyes of so many various animals as it does to ours?

A naive person will answer this question, without further thought: 'Definitely — it is still the same meadow to every eye.'

A follower of Loeb, however, would give a completely different answer. Because all animals are mere mechanisms, steered here and there by physical and chemical agents, the meadow consists of a confusion of light waves and air vibrations, finely-dispersed clouds of chemical substances, and contacts, which operate the various objects in it.

The Umwelt theory contradicts both of these interpretations of the

meadow, because — to cite but one example — the honey-gathering bee does not see the meadow with human eyes, nor is it insensible like a machine.

Colors are light waves that have become sensations: This means that they are not electrical stimuli to the cells of our cerebral cortex, but the ego-qualities of these cells.

Sensory physiology proves this point. Since the time of Goethe and Hering,[12] we have known that colors obey their own laws, which differ from the physical laws of light waves.

Light waves forced through a prism arrange themselves according to their wavelengths, and in doing so form a kind of ladder whose rungs decrease in length. The shortest rungs are at one end and the longest rungs at the other end of the ladder.

Our eye cuts a short section out of this ladder, and our cerebral cortical cells transform this section into a band of color perceptions that are then projected onto the outside world. The primary colors (red, yellow, green, blue) follow each other in this band and the secondary colors lie between them.

The light-wave scale has a linear shape: In contrast, the color-band forms a complete circle, because the secondary color between red and blue — namely violet — connects its one end to the other.

In addition to this, the color-band also shows curious, lawful properties that the light-wave ladder does not have. The colors that lie opposite each other in the color circle do not mix, but produce white.

These opposite colors reciprocally call each other forth — a not unusual event when opposites are perceived.

No physical experience acts in this manner. As stated previously, colors are not perceived because of the physical interactions of living cerebral cortical cells with each other, but because of the relationships of their ego-qualities, which also follow basic laws.

The colors are the specific energies (ego-qualities) of cerebral cortical cells that are influenced by the eye. The eye sorts out the light waves and, after transforming them into nerve impulses, transmits them to the cerebral cortex. Similarly, sound-tones are the specific energies of those brain cells that are connected with the ear. The ear records certain vibrations in the air.

The laws of tones are contained in the theory of music. Consonants, dissonants, octaves, fourths, fifths, and so on owe their existence to tone perception and have no separate physical existence. Anyone is invited to explain the tone-sequence of a melody using the law of causality that is valid for all physical processes.

Our sense organs — the eye, ear, nose, palate, and skin — are built

according to the principles of a safety-match box. Safety matches only react to selected outside influences. Stimuli also selectively excite sense organs to produce nerve impulses, which are then transmitted to the cerebrum. These mechanical events accord with the law of causality. At this point we arrive at the inner boundary of the sense organs, which takes the form of a living chime whose individual bells are the cells that sound the various ego-qualities.

Is this structural model of the sense organs also found in animals? No doubt the mechanical part of the sense organs in animals is constructed in an analogous manner: They may therefore be regarded as receptor organs. But what about their inner boundary?

Although we cannot know the sense perceptions of our fellow men, their eyes undoubtedly receive visual signs that we call colors. No doubt their ears also receive auditory signs that we call tones. Their noses have the capacity to detect olfactory signs, their palates, taste signs, and their skin, tactile signs. All these signs consist exclusively of ego-qualities.

We classify all these qualitatively different sensory signs as 'perceptual signs', which are then projected onto external objects as perceptual cues.

Now we may ask ourselves: When the receptor organs of animals are stimulated, do perceptual signs also occur that correspond to the specific sensory-energies of their brain cells? And are these also projected outward to be used as perceptual cues from which the attributes of all things of the animal's life-stage (*Lebensbühne*) stem?

The pure mechanists deny this scheme. They assert that the receptor organs of animals possess no inner boundary at all but serve only to collect various kinds of external stimuli and put them through to the corresponding parts of the brain.

Are the sense organs the expression of various sensory circles, or, functioning as receptor organs, do they merely express various physico-chemical kinds of effects of the outside world?

Has the eye been shaped by light waves or by colors? Has the ear been shaped by air waves or by tones? Is the nose a product of an air saturated with gases and aroma-particles, or of the olfactory signs of the animal subject? Do tastebuds owe their origin to chemical substances dissolved in water or to the subject's taste signs?

Are the receptor organs of animals the product of an outer physical boundary or of an internal nonphysical perceptual boundary?

Because the sense organs of human beings are organs that connect the outer boundary with the inner boundary, it is likely that they perform the same function in animals as well; therefore their construction is due both to the outer and the inner boundary. We cannot consider the receptor organs of animals as merely the product of the outer boundary — proof

for this statement is found in the case of fish, which only come in contact with substances dissolved in water; nevertheless, they possess a taste organ as well as a distinct organ of smell. Yet birds, which have the best chance of developing both organs, do not have an organ of smell.

Only when we have clearly understood the problem of the sense organs will the manner in which the whole organism is built become clear. At the outer boundary, they serve as a gutter for the physico-chemical effects of the outside world. Only such effects as hold meaning for the animal subject are transformed into nerve impulses. In turn, the nerve impulses evoke the perceptual signs at the inner boundary of the brain. In this manner the outer boundary also affects the inner boundary and determines the number of visual, auditory, olfactory, tactile, and taste signs that can appear in the perceptual circles of the respective animal subject.

In this way the structure of the Umwelts is built up, because each subject is only able to transform the available perceptual signs into perceptual cues in its Umwelt.

After looking at a large number of pictures painted by the same artist, one may speak of his 'palette' — that is, the number of colors at his disposal during the painting of his pictures.

Perhaps these relationships become even clearer if one imagines that the ego-quality of each perceptual cell in the brain makes one specific perceptual sign resound. Each of these living bells is then connected to the outer boundary by a nervous bell-rope, and determines which external stimuli are allowed to ring and which are not.

The ego-qualities of these living bells made of nerve cells communicate with each other by means of rhythms and melodies: It is these melodies and rhythms that are made to resound in the Umwelt.

The results of Mathilde Hertz's (1937, 1939) experiments on bees allow us to assume that their perceptual sign for color is shifted one step to the violet end of the human light-wave spectrum ladder, so that the outer boundary of the bee's eye does not correspond to the outer boundary of the human eye, while their respective inner boundaries appear to correspond with each other. One can only speculate about the meaning of this shift of the perceptual sign for color in bees.

On the other hand, the meaning of the perceptual sign 'palette' of night moths is definitely established. Eggers (1919, 1924) has shown that they only have two stretched resonators in their ears, which respond to air waves of a frequency that is at the upper limits of the human ear's capacity to detect. Yet this is the frequency of the bat's squeak; the bat is the principal enemy of the moth. The moths only perceive the sound emitted by their specific enemy. The rest of the world is silent for them.

In the bat's Umwelt, the squeak serves as a recognition-sign during darkness.

Sometimes the same sound reaches another bat's ear and sometimes a moth's ear. In both instances the squeaking bat is a meaning-carrier — in the former a friend, in the latter an enemy, depending upon which meaning-utilizer is confronted with it.

Because the perceptual sign 'palette' of the bat is large, the perceived high tone is but one among many. However, the night moth's perceptual sign 'palette' is very limited; only one sound is heard in its Umwelt — the sound of its enemy.

The bat's squeaking sound is a simple product, while the spider's web is a very artistic product. However, they have one thing in common: the squeak and the web are not intended for only one specific, physically-present subject, but for all animals of a similar structure.

In building the moth, how does an apparatus for hearing the bat-tone come about? From the start, the program for shaping the form of moths contains the instructions to develop a hearing organ adapted to the bat's squeak. In this case, there can be no doubt that the meaning-program acts upon the form-shaping program so that the meaning-utilizer faces the meaning-carrier, and vice versa.

As we have seen, the program for form-shaping creates a horn-jawed mouth in the vegetarian tadpole, and a mouth with real teeth in the carnivorous triton. Everywhere the meaning rule intervenes decisively from the beginning of the development of the embryo to lay down in the right place an organ for food utilization that grows toward the appropriate meaning-carrier — the diet of plants or meat. If, however, the program for the form rule is diverted along the wrong track by grafting, the meaning rule cannot bring it back onto the right one.

Therefore, it is not the active shaping of form that is influenced by meaning, but rather the whole program for form-shaping depends upon the meaning-program.

The rule of meaning for the bridging of two elementary rules

While walking through a forest, we pick up an acorn that has fallen from a mighty oak tree and may have been displaced by a squirrel. We know that a variety of tissue cells will develop from this tree-seed, to form the underground root-structure; and above the ground it will shape the trunk with its roof of leaves, according to one of the programs for the shaping of form characteristics for the oak tree.

We know that the *Anlage* of the oak's organs resides in the acorn that

will enable the oak tree to take up its struggle for life against the hundredfold effects of the outside world. In our imagination we can picture the future oak tree struggling with future rain, storms, and sunshine. We can see it enduring future summers and winters.

In order to be a match for the effects of the outside world, the rapidly growing tissue cells will have to differentiate into organs — root, trunk, and foliage. The foliage will absorb the rays of the sun and the leaves will flutter like lightweight flags in the wind to which the gnarled branches will offer resistance. At the same time, the foliage serves as an umbrella that directs the precious moisture from the sky to the delicate root-ends under the earth. The leaves contain the wonder substance, chlorophyll, which uses light beams to transform power into substance.

The foliage disappears in the winter when the frozen ground prevents the roots from sending a stream of liquid filled with minerals from the earth up to the leaves.

All these future effects on the future oak tree cannot causally influence the shaping of the form of the oak tree, nor can they do so because of their influence on the mother oak tree, because the acorn did not then exist.

When we look at the acorn the same puzzle confronts us as in the case of each plant-seed or animal-egg. In none of these cases may we speak about a causal connection between outside effects and an object either before or after it was alive. Only when cause and effect coincide in time and place can one speak of a causal connection.

It is hopeless to try to find a solution to this problem if one looks for it in the distant past. The development of an acorn a million years ago is as difficult to understand as it will be a hundred thousand years hence.

From this it follows that we have lost our way in a dead end with our questions when we thought it was possible, with the help of artificial constructions, to produce a causal link between the acorn seed and physico-chemical outer effects on it. The problem cannot be mechanically solved, nor can evolution offer us the key to its solution.

We therefore have to tackle the problem from a different angle.

If we, as human observers, contemplate the effects of the outside world upon the oak from its perspective, we will soon discover that it is subject to a common rule of nature.

The sun, moon, and stars travel across the sky in fixed orbits over the oak tree. The seasons change under their influence. Calm weather, storms, rain, and snow change in the wake of the seasons. At one time the air is filled with the fragrance of spring, and at another with the harsh scent of autumn. Every spring the forest is full of the songs of birds. Both in summer and winter the oak's foliage and bark offer hundreds of feathered and unfeathered guests a rich variety of shelter.

The oak tree is also bound by this law of nature, already known to Noah, although many of the facts of nature familiar to us do not affect the oak tree's dwelling-integument. Neither the moon, the stars, nor the sun are meaning-factors that build the dwelling-integument of the oak. On the other hand, certain chemically efficacious light rays penetrate to the chlorophyll in the leaves, and manifold heat rays stimulate the growth of the young shoots. The rainfall is deflected for optimal use and the strongest resistance is offered against storms. Neither smells nor sound-waves, however, affect the oak tree.

Just as it did millions of years ago, the same meaning rule has selected various elements of nature and brought them to play the particular melody of the living chime of the cells of the acorn, eventually to create the organs of the oak tree from the seed's cells of protoplasm.

Thanks to Arndt's film, we do not have to rely upon mere suppositions. We can observe how numerous independent cells develop through cell division from the first germ cell. Like their free-living sisters, they are independent, acquiring their own nourishment when it is available.

A new subject is formed only after the nutriment has been consumed. The amoebae rush together to form a new homogenous subject; they no longer direct themselves to the meaning-carrier, nourishment, but to the meaning-factor, wind, toward which all of them grow. The chime of the single-cell stage, which consisted of a disorderly ringing of single-cell bells, suddenly rings according to a uniform melody. A new meaning rule then connects the elementary rule of the wind and independent cell-formation to create a new subjective unit.

The pressure of the wind, no matter how finely regulated, will never directly create a slime mold from freely-moving single cells.

In contrast to the acorn, the slime mold unites its mobile cells of protoplasm into a single bud. After the bud's shape has been formed, it represents an individual consisting of a single organ-subject. The acorn, however, develops many buds, each forming an organ-subject that is directed to one or more meaning-factors. The oak leaf, for example, serves both as a rain-gutter and as a receptor of light rays by virtue of its chlorophyll-containing cells.

All these organ-subjects are united with their organ-melodies into a symphony, named 'oak-organism', that can be designated as the archetype of the oak.

The process by which the subject is progressively differentiated from cell-quality, through the melody of an organ to the symphony of the organism, stands in direct contrast to all mechanical processes, which consist of the action of one object upon another.

The former process is on the same plane as every musical composition.

The effect of the meaning-factors of plants and of the meaning-carriers of animals on their meaning-utilizers demonstrates this point very clearly. As the two parts of a duet must be composed in harmony — note for note, point for point — so in nature the meaning-factors are related contrapuntally to the meaning-utilizers. The shaping of the form of living beings will be more understandable only when we have succeeded in deriving a *theory of the composition of nature* from it.

The theory of the composition of nature

Nature offers us no theories, so the expression 'a theory of the composition of nature' may be misleading. By such a theory is only meant a generalization of the rules that we believe we have discovered in the study of the composition of nature.

Therefore, it is appropriate to begin with single examples and to set out their rules so as to arrive at a theory of the composition of nature.

The theory of composition of music can serve as a model; it starts from the fact that at least two tones are needed to make harmony. In composing a duet, the two parts that are to blend into harmony must be written note for note and point for point for each other. On this principle the theory of *counterpoint in music is based.

We must also look for two factors that form a unit in the examples taken from nature. Therefore we always begin with a subject that finds itself in its Umwelt (subjective universe) and we examine its harmonious relationships with individual objects that have appeared as meaning-carriers to the subject.

The organized body (*Organismus*) of the subject represents the meaning-utilizer or, at least, the meaning-receiver. If these two factors are joined by the same meaning, then they have been jointly composed by nature. The content of the theory of the composition of nature consists of the rules that govern such pairings.

When two living organisms enter a harmonious meaning relationship with each other, we must first decide which one of the two is to be designated as the subject and meaning-utilizer, and which is to be assigned the role of the meaning-carrier. Next we will have to look for their mutual properties that are related in the manner that point and counterpoint are. If, in a given case, we know enough about the functional circles (meaning-circles) that join a subject to its meaning-carrier, then we can look for the counterpoint on the perceptual side as well as on the side of the effector. This search will enable us to determine the special meaning rule that the composition has followed.

To continue with the example of the acorn: I would first like to present a table concerning the composition of the oak tree and one of its meaning-factors, the rain (Table 1).

Table 1.

Foliage of the oak tree:	*Rain*:
Meaning-receiver	Meaning-factor
Points:	*Counterpoints*:
Roof-tile shaped arrangement of the leaves with gutter	Raindrops that run down
Rule of the form-development of the oak tree	Physical rule of raindrop formation

Common meaning rule:
Collection and distribution of the fluid to the tips of the roots

The foliage of the oak tree mechanically affects the distribution of the raindrops. The rule of the formation of raindrops influences the composition of the melody of the living chime of the acorn cells.

We now turn our attention to animals and try to examine the individual meaning-circles: In the circle of the medium we will find relationships that are similar to those that occur between the oak tree and the rain.

Let us take, as the first example, the *octopus*, designated *as the subject* in its relationship to *sea-water as the meaning-carrier*. We will immediately perceive a contrapuntal relationship. The fact that water cannot be compressed is the precondition for the construction of the octopus muscular swim-bag. The pumping movements of the swim-bag have a mechanical effect on the noncompressible water that propels the animal backwards. The rule that governs the properties of sea-water acts upon the composition of the living chime of the cells of protoplasm of the octopus embryo. It shapes the melody of the development of the octopus form to express the properties of sea-water in a counterpoint; first and foremost, an organ is produced whose muscular walls force the water in and out. The rule of meaning that joins point and counterpoint is expressed in the action of swimming.

The same meaning rule in numerous variations governs the development of the living forms of all marine animals: Sometimes they swim forwards, sometimes backwards, sometimes sideways; sometimes they propel themselves with wave-like movements of the tail, sometimes by fins, and sometimes by legs through the water; but the characteristics of the organism bear the same relationship to the properties of the water as point to counterpoint. In each case, the composition that has a common meaning can be proven.

The same applies to all the various circles of the physical medium, whether the animal lives in water, on the land, or in the air. In every case the effector organs for running, jumping, climbing, fluttering, flying, or soaring are formed contrapuntally to the properties of the respective medium. In the case of many insects that live in the water when they are young and in the air when they are older, one can ascertain in the second larval stage how easily the constitution-rule of the new medium causes the initial organs to disappear and new ones to emerge.

Inspection of the relationship between the subject's receptors and the medium teaches the same lesson. A sensory organ formed as a counterpoint is always present when a subject meets an obstacle: In the case of light it is the eye, and of darkness, tactile organs or the ear.

From the very beginning the bat, like the swallow, is equipped with different means to perceive obstacles in its path of flight.

These, you will reply, are nothing but banalities. Certainly they are everyday experiences that can everywhere be seen. But why has one neglected to draw the only possible conclusion from these experiences? Nothing is left to chance in nature. In every instance a very intimate meaning rule joins the animal and its medium; they are united in a duet, in which the two partners' properties are contrapuntally made for each other.

Only extreme disbelievers of meaning as a factor in nature would want to deny that in the functional circle of sex, males and females are made for each other in accordance with meaning. They assert that the love-duet, which is heard throughout the whole living world in thousands of variations, has emerged totally unplanned.

In the case of the love-duet of animals and humans, two equal partners face each other, each of whom exists in its Umwelt as a subject and appears as a meaning-receiver, while the role of the meaning-carrier is assigned to the other.

Both the perceptual and the effector organs of both partners are allied to each other contrapuntally.

The first requirement necessary for a successful composition of nature is that the meaning-carrier stand out distinctly in the Umwelt of the meaning-receiver. The most diverse perceptual cues can be used to attain this goal.

Fabre reports that the female emperor moth makes pumping movements with its hindquarters in order to press its scent glands to the ground. The scent that rises up from the ground is so potent in the male moth's Umwelt that they are attracted to the scented spot from all sides, and are not distracted by any other smells, all of which sink beneath their perceptual threshold. The attraction of this smell is so strong that when a

female is placed in a glass case in the path of the males to make her visible but odorless, they are not distracted from their efforts to reach the scented ground: the meaning-carrier.

Unfortunately, the same experiment has not been tried with a bitch in heat. Possibly male dogs behave exactly like male moths.

In a very interesting case reported by Wunder,[13] the sexual partner does not necessarily serve as the primary meaning-carrier: A second meaning-carrier may be interposed in a sex-circle.

The male bitterling, a small fresh-water fish, puts on a luminous wedding dress at mating time. The sight of a pond-mussel, not the sight of the female fish, causes this to occur; specifically, the male feels the water with which the mussel breathes streaming into and out of the mollusk.

The female also reacts to this stimulus by extending its long ovipositor outwards. While the male discharges its sperm into the water, the female attaches the impregnated egg to the mussel's gills. The young larva can grow there protected from all dangers, in the middle of the stream created by the mussel, which provides the larva with all the requisite nourishment. The meaning of the male's 'wedding dress' is not, of course, related to the mussel, but rather it serves to frighten off other male bitterlings.

These examples serve to illustrate that the meaning-carrier does not alter at all, but nevertheless is treated differently: Its perception by the subject has changed meaning. Meaning is the key by which the compositions of sex in nature are unlocked so that they can be understood.

Fabre tells us in his report on the brown ground-beetle that the males and females pair off after first hunting together. After mating, the male's behavior toward the female does not change at all. The female, on the other hand, throws herself upon her mate and ravenously tears him apart with hardly a struggle. In the Umwelt of the female the meaning-carrier 'friend' has changed into the meaning-carrier 'food' although the structure of the meaning-carrier has not changed in the slightest. In the same way, the paving-stone, without altering its structure, gives up its meaning as an element of a path when it is transformed into a projectile as the mood of the human subject changes. Thereupon the human imprints a different meaning on the stone.

The imprinting of meaning also explains the puzzling behavior of the young gray-geese that Lorenz[14] reports on. According to him, the gray-goose chick identifies and follows constantly the first living being that it sees after hatching; this becomes its mother-companion.

Even a human being can acquire the meaning of 'mother' for the gray-goose. 'What does the human being who becomes identified as the mother-companion look like in the eyes of the gray-goose?' is the question that preoccupied Lorenz.

We should not forget that in the Umwelt of our puppy we do not appear as a 'mother' but as the meaning-carrier 'milk-bringer'; we are sucked at by the puppy without our having assumed the form of a dog.

Von Korff (1938) reports that an eagle-owl had hatched two duck eggs. It treated the ducklings as young eagle-owls, tried unsuccessfully to feed them raw meat, and watched over them during the day while perched on a branch above the duckpond. In the evenings, it returned to its cage with them. When other young ducklings tried to join them, the eagle-owl immediately killed and ate them, although they only differed from the young foster-ducklings by virtue of the meaning conferred upon them by the eagle-owl. While all the other ducklings appeared in the eagle-owl's Umwelt as the meaning-carrier 'prey', the two ducklings hatched by the eagle-owl played the role of eagle-owl chicks.

Because individuals of the same species are usually involved in the sex- and child-circles, the range of the meaning rule, which spans the distance between meaning-carrier and meaning-receiver, is small. However, inspection of the functional circles of enemy and food shows us that their range knows no limits, and that the properties of the remotest objects can be contrapuntally connected.

I have already discussed the bridging of the constitution rule of the bat and the constitution rule of the night moth by the meaning rule.

On one side stands the bat as meaning-carrier, producing only one tone, and on the other side stands the night moth, which can receive only one tone because of its very specialized hearing organ. In both animals this tone is identical. The meaning rule that has created this coordination consists of the relationship between the enemy's attack and its being warded off by the prey.

The tone exists as a sign by which bats recognize each other, while it also serves as a signal for the night moth to escape. In the bat's Umwelt it is a 'friend-tone' and in the night moth's Umwelt, an 'enemy-tone'. According to its different meanings, the same tone creates two completely different hearing organs. Because the bat is able to hear many tones, its ear is adapted to resonate broadly. However, it can only emit this one tone.

It would be equally interesting to trace the bridge formed between the tick and the mammal by the use of the meaning rule (as shown in Table 2). The tick sits motionless on the tip of a branch until a mammal passes below it. The smell of the butyric acid awakens it and it lets itself fall. It lands on the coat of its prey, through which it burrows to reach and pierce the warm skin with its sting. It then pumps the liquid blood into itself; it does not possess an organ of taste.

The pursuit of this simple meaning rule constitutes almost the whole of the tick's life.

Table 2.

Tick:	*Any mammal*:
Meaning-receiver	Meaning-carrier
Points:	*Counterpoints*:
1. The organ of smell is adapted for one smell, namely, butyric acid.	1. The only smell common to all mammals is the butyric acid found in their sweat.
2. A tactile organ is present, ensuring that the tick can exit from the hairs of its prey.	2. All mammals have hair.
3. A thermal organ senses a perceptual sign for warmth.	3. All mammals possess a warm skin.
4. The tick's stinger is suitable for boring into the skin of each mammal, and at the same time serves as a fluid pump.	4. All mammals possess soft skin well-supplied with blood.

Common meaning rule:
Recognition and attack of the prey and extraction of blood on the part of the tick.

The deaf and blind tick is solely constituted to make every mammal in its Umwelt appear as the same meaning-carrier. This meaning-carrier can be described as an extremely simple mammal without the visible or audible properties that usually differentiate the various species of mammals. For the tick, the meaning-carrier has only one smell, which comes from the sweat common to all mammals. That meaning-carrier is also tangible and warm, and allows itself to be bored into and to have blood extracted from it. In this way it is possible to reduce all mammals — no matter how greatly they differ in shape, color, sound, and smell in our Umwelt — to a common denominator. On approach, the properties of any mammal — be it a human, a dog, a deer, or a mouse — contrapuntally activate the life-rule of the tick.

In our human Umwelt a mammal does not in itself appear as a vivid object, but as a mental abstraction, a concept to be used to classify, not as an object we ever encounter.

The case of the tick is quite different. A vivid mammal exists in the tick's Umwelt that has a few properties capable of serving as counterpoints and exactly meeting the tick's needs.

If one only searches for mechanical explanations, the fit of the hermit crab in the snail shell must rank as a special enigma. This fitting-in cannot be interpreted as a gradual adaption through any modifications in anatomy.

However, as soon as one gives up such fruitless endeavors and merely ascertains that the hermit crab has developed a tail as a prehensile organ to grasp snail shells, not as a swimming organ, as other long-tailed crabs have, the hermit crab's tail is no more enigmatic than is the rudder-tail of the crayfish.

The prehensile tail is composed as a counterpoint to the snail shell, just as the rudder-tail of the crayfish is to the water.

Hertz (1937, 1939) made the interesting discovery that honey-collecting bees are only able to differentiate between two shapes: open and closed ones. Beam-shapes and polygons of every kind attract the bees, while closed shapes, like circles and squares, repel them. The gestalt-theorists claim that the reason for this is that the open shapes possess a greater stimulus-value. This point can be conceded to them. But what does this idea mean? The answer becomes immediately apparent the moment we say the following: All inaccessible buds, which the bees shun, have closed shapes. Blossoms that offer them their honey have open shapes.

Two spatial-perceptual schemata for blossoms and buds are incorporated into the shape-forming rule of bees because the collection of honey follows the meaning rule. In this manner, the two schemata are firmly joined in counterpoint with the two principal shapes of flowers.

But how does nature manage when an animal subject depends on differentiating between shapes but possesses a very primitive central nervous system incapable of forming shape-schemata?

The earthworm pulls linden or cherry tree leaves into its narrow hole. The leaves simultaneously serve as food and protection. It grasps the leaves by their tips in order to roll them up easily. If the earthworm were to try to grasp the leaves at their base, they would resist being pulled and rolled. However, the earthworm's structure does not permit the formation of shape-schemata; to compensate for this deficit it possesses a particularly fine sense organ for taste.

We owe to Mangold[15] the discovery that the earthworm can nevertheless distinguish between the pieces that belong to the bases and those that belong to the tips of finely-chopped leaves. The tips of the leaves do not taste the same to the earthworm as do their bases: This distinction allows the worms to treat them separately. Taste perceptual cues, acting as counterpoints, take the place of shape-schemata to make it possible for the earthworms to pull in the leaves, an action that is essential for the survival of the earthworms.

In this example one can speak of nature's refined composition.

Experience has taught human anglers that, when angling for fish of prey, they do not need to affix an exact likeness of the prey to the hook. Rather it is enough to offer the pike as bait a simple little silver plate that is a very general facsimile of a whitebait.

Nature, however, does not need to be taught this lesson. *Lophius piscatorius*, the angler-fish, is a wide-mouthed fish, next to whose upper lip is a long movable bone that causes a silver band to flutter.

This band attracts smaller fish of prey that, on snapping at this bait, are sucked into the wide mouth that suddenly produces a whirlpool.

The range of the meaning rule is further extended by this example, because it does not connect the form-shaping rule of *Lophius* with its prey's form-shaping rule. The victims are themselves predators who respond to a very simplified image (presented by *Lophius*) of their own prey in their Umwelt and are caught.

A similar example occurs in the case of those butterflies that are decorated with spots resembling eyes. By opening their wings they chase away the small birds that pursue them: These birds automatically fly away at the sight of the eyes of other small predators that may suddenly appear.

In the same way *Lophius* is unaware how the prey it catches looks in the Umwelt of the fish of prey, the butterfly does not know that the sparrow flees at the sight of a cat's eyes. However, the composer of these Umwelt-compositions must be aware of this fact.

This is no human knowledge that can be obtained through experience. The tunnel-boring actions of pea-beetle larvae prove to us that they are conditioned by a transsensual knowledge that is timeless. Thanks to this knowledge, the composer can shape the future life-requirements of an unborn beetle and program the actions of the beetle larva.

The tolerance of meaning

We are already familiar with the example of the flower stem and its transformation in the four Umwelts of the girl, the ant, the cicada larva, and the cow. The flower stem, acting as a meaning-carrier, was in each instance confronted with a new meaning-receiver that could also be described as a meaning-utilizer. The meaning-utilizer used the flower stem as decoration, as path, as supplier of material for the building of a house, and as food, respectively.

However, this example has another aspect to it that becomes apparent when we substitute the whole plant for the flower stem. The whole plant then becomes a subject of the flower stem and can be added to the previous four subjects, which become meaning-factors for the flower-stem.

The plant cannot then be spoken about as a meaning-utilizer. The reception of meaning can only be equated with a *tolerance of meaning. This tolerance has various gradations. The transformation of the stem

into an ant-path is easy to tolerate. The extraction of the sap for building the cicada larva's house also causes only slight damage to the plant. However, the picking of the flower by the girl and the grazing of the cow can be fatal for the plant.

In none of these four examples can a meaning rule that is in the plant's interest be discovered.

The meaningful role of the spider's web in the life of the fly is in no way in the fly's interest — in fact, it contradicts it. The fly, entangled in the web, cannot use this meaning-carrier in its Umwelt at all: it can only tolerate it.

The pea-beetle larva, having bored its tunnel through the pea in order to prepare in good time for its future before the pea hardens, is confronted with the meaning-carrier 'ichneumon fly', and can only tolerate its assassin without being able to defend itself.

The significance of these apparent contradictions of meaning is immediately clarified when we disregard the particular individual and consider only the species as a whole.

The basis of all life is the submergence of the ephemeral individuals for the sake of the long-lived species. The individuals of every generation mate in pairs to produce a new generation. The number of offspring always exceeds that of the parents. In order to maintain the members of a species at the same number, the supernumerary ones must perish. Consequently, the same number of parents of the next generation provides for the further propagation of the species. The elimination of the excessive members occurs in many different ways. In the case of most species, the duration of life of the individuals is determined by the change in seasons. Each year all one-year-old individuals make way for the individuals of the next generation.

Wasp colonies consisting of thousands upon thousands of individuals die out completely every autumn. Only a few females hibernate and establish the same number of new colonies the next year.

Our houseflies perish in the autumn; one would think they had all died, and yet in the following spring, they appear in the same numbers. The number of flies that meet a premature end in the web of their enemy — the spider — plays a minute role in the regulation of their population.

Migration is a great strain on birds; year after year it eliminates supernumerary individuals not equal to the journey.

The number of individuals is not the only important factor for a species; their powers of resistance also play a role. Therefore we can recognize that injury is tolerated because it eliminates weaker individuals so that they do not produce weak offspring.

Hawks and foxes benefit the species upon which they prey; they catch

the weak members of the species. When foxes are exterminated, rabbits perish in an epidemic because those infected have not been eradicated in time.

Sick animals are impeded in their movements; therefore they have a particular attraction for their enemies. Some birds take advantage of this fact. When the lapwing's eggs are threatened by the approach of an enemy, it does not simply fly away, but pretends to be lame. Its apparent inability to fly attracts its enemies and diverts them far enough away from the nest, until it flies away to complete safety.

The ichneumon fly pursues the pea-beetle larva, thereby protecting the peas, which would otherwise be sacrificed by a supernumerary number of the larvae.

Australia is a remarkable example of the importance of specific enemies for the fauna and flora of a country.

A hundred years ago a South American woman brought a cutting of a Barberry fig cactus to Australia. It thrived in its new homeland. It soon became apparent how useful the prickly plant was for fencing in gardens and farms. The cactus was, therefore, planted everywhere.

But it transformed itself into a public menace. It spread over gardens and farms, although it was supposed to be protecting them. It encroached upon forests and strangled all plant life.

The authorities intervened when wide areas of land were completely devastated. With hoes and fire they fought the new enemy. When these measures had no effect, they scattered poison from aircraft on the forests overrun by the cactus. The only result of this measure was that all the other plants totally perished but the cactus continued to thrive.

In their desperation, the authorities consulted the botanical institutes of universities, who in turn dispatched a number of able researchers to the cactus's original homeland. These experienced observers succeeded in discovering a small caterpillar, belonging to a species of moth, that feeds exclusively on the cactus's flesh.

After several years of experiments, millions of eggs of this enemy of the cactus were bred. They were then scattered over the cactus deserts. Lo and behold, within a few years, the cactus jungles were successfully destroyed and the land was reclaimed for cultivation.

It is highly attractive to study the compositions of nature, and to determine the meaning attributable to the tolerance of meaning. Two aspects of this problem must be considered; first, the tolerance of meaning lies behind the elimination of individuals in the interest of the species. In this way all unhealthy and less resistant individuals are gotten rid of. Second, the removal of surplus individuals occurs in the interest of the balance of nature.

Von Baer[16] believes that supernumerary gnat-larvae and tadpoles serve fish as food. Spencer[17] made a basic error when he interpreted the destruction of supernumerary offspring as supporting the notion of the 'survival of the fittest', in order to support the theory of progress in the evolution of living beings. The question is not the survival of the fittest, but the survival of the normal so as to further the existence of the species.

The technics of nature

It was, as far as I can recall, a Mahler symphony that Mengelberg ravishingly conducted in the Amsterdam Konzertgebouw. The great orchestra, reinforced by a male and female choir, rang out in overwhelming splendor and fullness.

Next to me sat a young man who was totally immersed in the score and who, with a sigh of satisfaction, closed his copy of the music as the last chord died away.

My lack of musical knowledge made me ask him what pleasure he derived from following the written notes with his eyes when his ear could perceive the musical tones directly. He answered me with ardent zeal that only he who follows the score can obtain the full conception of a musical work of art. He went on to explain that each voice, whether human or instrumental, is a separate being that through point and counterpoint melds with the other voices into a higher form. In its turn, this new form continues to increase and grow in richness and beauty to form an entity that conveys the mind of the composer to us.

By reading the score, one may follow the growth and distribution of the individual voices, which carry the score like pillars of a cathedral support its all-embracing dome. Only in this way can an insight into the form of a performed work of art be gained; its form is composed of many parts.

The young man's answer was very convincing, and raised the question in me whether it is not the task of biology to write a score of nature.

I was already familiar with the contrapuntal relationships of Umwelt to Umwelt at that time. I began to pursue further the example of the flower stem and its relationships with the four other Umwelts.

The girl presented a bunch of flowers to decorate her beloved, so the flower stem entered into a love-duet. The ant used the stem as a path and ran along it to the flower pistils, there to milk its 'dairy cows', the aphids, while the cow transformed the fodder that contained the stem into milk. The cicada larva, having developed in its foam-house made from the sap of the stem, soon filled the meadow with its soft love-chirp.

Other Umwelts supervened. The bees, joined in a counterpoint with the

scent, color, and shape of the blossoms, flew by. Having saturated themselves with honey, they informed their hive-companions of the new sources by way of impressive dances (described in detail by von Frisch[18]).

The color of the flower, although not the same to the bees as it is to us, serves them, nevertheless, as a positive perceptual cue because the flower and the bees are composed in counterpoint to each other.

Although this is a modest start, it is nonetheless a start in solving the problem that the score of nature confronts us with.

All musical instruments can be reduced to the same denominator if the tones they produce are arranged as in a chime. Then the violin produces a very rich chime consisting exclusively of violin tones; a simpler chime will be rung by harp tones; and the tones of the triangle will make an even simpler chime.

For each musical composition, one must pick out from among the chime of one instrument's tones those tones that form a melodic sequence; at the same time, they must be joined in harmony with the tones of the chimes of other instruments.

In accordance with counterpoint theory, rules are laid down for merging together the tones of various parts or voices in a score. The composer is, however, free to combine the tones of each instrument in counterpoint with the tones of every other instrument.

In order to denominate animals in the same way as musical instruments, it suffices to consider their central nervous system as a chime and to call the perceptual signs of the chime's living cells perceptual 'tones' that are projected as perceptual cues. In this scheme, the impulses that induce the execution of movements become the effector 'tones'. Every animal, like every instrument, harbors a certain number of tones that enter into contrapuntal relationships with the tones of other animals.

It is not enough to consider that musical instruments merely produce air-waves, as the mechanists do. One cannot create a melody or a harmony with air-waves; neither can one compose a score with them. Only the relationship between the air-waves and the human ear that transforms air-waves into tones makes it possible to produce melodies and harmonies and to write scores.

The task of animals and plants in the meadow is not only to display their colors, sounds, and scents. These displays must first appear in the Umwelts of other animals and then be transformed into perceptual signs.

The relationships of living things can then be translated into a musical idiom; and we may speak about perceptual and effector tones of the various animal subjects that are joined to each other in counterpoint. Only then can one arrive at nature's score.

In nature the perceptual tones of various animals can be used as

counterpoint: The tone that attracts bats in the bat-Umwelt is at the same time a warning-tone in the Umwelt of the night moth.

The shell worn by the snail has a dwelling-quality for the snail. After the death of the snail its empty shell remains behind to acquire a corresponding dwelling-quality for the hermit crab. This unison of qualities is fully exploited in the snail–hermit crab composition.

The composer of a symphony is not limited in the choice of instruments he may use in his composition, nor is nature: she is completely free in her choice of animals to join in counterpoint. The fishing-tackle of *Lophius* is designed as a counterpoint to the catching-quality of the schema that attracts its prey. The terms catching-quality and dwelling-quality show that in using a musical analogy with animals, we have left pure music theory behind. In this theory one can indeed speak of the tone of a violin or a harp as a violin's or a harp's quality, but never of the catching-quality of prey or the dwelling-quality of a house — just as we cannot speak of the cup's drinking-quality or the chair's sitting-quality. The way a comparison to music can be made in the field of biology is by expanding the meaning of the word 'tone' or quality: Mere hearing-qualities become meaning-qualities of the objects, so that they appear as meaning-carriers in the Umwelt of a subject.

In its role as a counterpoint, the shell's dwelling-quality in the snail's Umwelt and its dwelling-quality in the hermit crab's Umwelt are mutually interchangeable, the implication being that each one of the two qualities, although not identical with the other, can nevertheless be adapted by one of nature's compositions to become the other, because they share the same meaning.

Meaning in nature's score serves as a connecting link, or rather as a bridge, and takes the place of harmony in a musical score; it joins two of nature's factors.

Every bridge has a support on each bank of a river; they are joined as point and counterpoint to each other by the bridge. Point and counterpoint in music are joined by the harmony, and in nature by the same meaning.

With numerous examples, enough to weary the reader, I have proved that real factors, not merely logical constructs, exist in nature.

We have now reached the point where we may indicate that the meaning-score is a description of nature, just as the score written in notes may be equated with description of music.

If we look at an orchestra, we can see that each individual instrument has a music stand, upon which are found the written notes it will play. The complete score of the work rests on the conductor's desk. We can, however, also see the instruments themselves, and we ask ourselves

whether these instruments are possibly attuned to each other by virtue not only of the respective tones they emit, but also of the manner of their entire construction: that is, do they form not merely a musical but also a technical unit?

Because most of the instruments to be found in an orchestra are also able by themselves to produce performances of musical compositions, this question cannot immediately be answered in the affirmative.

Anyone who has listened to clowns play music with instruments that otherwise are only used for making noise — such as combs, cowbells, and the like — will be convinced that they can indeed produce a cacophony but not a symphony with such an orchestra.

If one inspects the instruments of a real orchestra closely, one sees that even their structures are related to each other as counterpoints.

This point is even more evident in the orchestra of nature as seen in a meadow: We need merely to think of the flower in the four Umwelts. The relationship between the structures of the flower and of the bee is most striking; in fact, one could say that:

> If the flower were not bee-like
> And the bee were not flower-like
> The unison could never be successful.

Thereby, the fundamental theme of all the technics of nature is expressed. In this statement we can recognize Goethe's wisdom once again:

> If the eye were not sun-like,
> It could never behold the sun.

But now we can also complete the quotation from Goethe and say:

> If the sun were not eye-like,
> It could not shine in any sky.

The sun is a celestial light. However, the sky is a product of the eye; it establishes its own furthest plane that embraces the dimensions of the Umwelt. Eyeless living beings know neither sky nor sun.

The counterpoint as the motive for the shaping of form

We can now apply the technical basic rule (expressed in the bee's 'flower-likeness' and in the 'bee-likeness' of the flower) to other previously mentioned examples.

The spider's web is certainly formed in a 'fly-like' manner, because the spider itself is 'fly-like'. To be 'fly-like' means that the body structure of the spider has taken on certain of the fly's characteristics — not from a specific fly, but rather from the fly's archetype. To express it more accurately, the spider's 'fly-likeness' comes about when its body structure has adopted certain themes from the fly's melody.

The tick's body plan also expresses certain distinctive mammalian themes. The influence of the bat's theme in forming the night moth's ear is the clearest example of the rule.

In each case, the counterpoint represents the theme in the structure. We should be familiar with this point after considering the construction of the utensils we use.

The handle of a coffee-cup demonstrates without doubt the contrapuntal relationship of the coffee and the human hand. These counterpoints are the main influences on the themes for making the cup: They are indeed more important than the material of which the cup is made.

It sounds banal and self-evident to say that the coffee-cup is 'coffee-like'. However, this statement implies more than is initially apparent: It implies that the cup performs its function by accommodating coffee, but also that this performance was the theme for producing the cup.

The theory of meaning culminates in explicating this connection. The meaning to us of our household utensils lies in their performance. Their performance can always be traced back to the bridge that is built between our and the utensils' counterpoints. At the same time, the performance expresses the theme of this joining together.

The chair is a seating accommodation that rises from the floor, whose meaning lies in its being a number of bridges to various counterpoints. Its seating surface, back and armrests find their counterpoint in the human body, to which they form bridges, while the legs of the chair form distinct bridges to the counterpoint, ground. All these counterpoints are simultaneous themes for the cabinet-maker in building the chair.

Time does not permit me to cite even more obvious examples. It should suffice to point out that with all our utensils we have built bridges between ourselves and nature. In so doing, we have come no closer to nature; in fact, we have removed ourselves from her. We have begun with ever-increasing speed to build these bridges to other bridges by constructing simple machines, which cannot be disregarded by man, if he wishes to remain close to nature. In the city we are exclusively surrounded by artifacts. The trees and flowers in our parks and gardens are removed and transplanted at will; we have torn them *in toto* from nature, and converted them into utensils.

The much-lauded human technology has lost all feeling for nature:

Indeed, it presumes to solve the most profound questions of life — such as the relationship between man and god-like nature — with totally inadequate mathematics.

All this is incidental. It is much more important to gain an idea about the methods nature uses to evoke her creatures (which she does not make from individual parts in the way we construct objects) from undifferentiated germ-plasma.

Arndt's film about the origin of the slime mold showed us that in its first phase of life an ever-increasing number of free-living cells are formed, built in counterpoint to their bacterial food. After the food has been consumed, a new counterpoint steps in immediately as a new theme, to transform the single cells by pushing them on top of each other into tissue cells of a plant that is situated in the wind.

If we look at the very limited habitat of the slime mold, we find that it lives in a filamentous form on a ball of old horse dung and as a seed-carrier in the wind that scatters its seeds and is its sole effective factor in nature.

The seed-carrier and the seed-disperser play a duet together. The free cells first play a living chime with their identical-sounding ego-qualities.

Nature then plays with the single cells together and transforms them by means of a new theme into tissue cells in order to construct a seed-carrying form that presents itself to the wind.

We find this process just as mysterious as the change of themes in a Beethoven sonata. However, our task is not to compose a nature sonata but rather it is to write down its score.

We are still in the very early stages of asking such technical questions about the vertebrates. The 'bud-like' origin of the organ is bound to an elementary building-plan, and the meaning of each bud is determined by its position in the whole organism, so that its meaning is not lost, and it does not form structures in duplicate.

This determination is so certain that, as Spemann has shown, a graft of tadpole epidermis becomes a tadpole mouth after being implanted into the location of the triton's future mouth in the triton embryo: the score for the development for the frog's mouth was simultaneously transferred with the frog's cells.

A similar discrepancy would ensue if one tore a sheet out of the music score containing the first violin's part and put it into the corresponding place in the cello's part.

The tunnel-boring activity of the pea-beetle larva tells us a great deal about the scores for the shaping of form. In this example, the counterpoint that becomes the theme for the boring of the tunnel is the shape of the fully-developed beetle, which only develops somewhat later. The adult

beetle would surely perish if it were not for the tunnel exit built by the larva. The future form can, therefore, play the role of a theme in the development of shape.

This fact opens up further possibilities. If the future shape that is the goal of development can itself become a theme, then von Baer is correct when he speaks of goal-directedness in the origin of living creatures. However, he does not grasp all the implications of his statement.

When the spider weaves its web, the various stages of the formation of the web, such as the radial construction of its frame, can be described as the goal of and the theme for forming the frame. The web itself can certainly be designated as the goal of its forming that can in no way be attributed to the fly. However, the fly certainly serves as the counterpoint and as the theme for forming the web.

The accomplishment of the boll-weevil is a striking example of the many puzzles with which the technics of nature will continue to face us. Two partners confront each other in counterpoint: the small weevil with a fret-saw as proboscis and the large birch leaf whose fate it is to be sawn up. The saw must take such a direction that the weevil can later easily roll the lower part of the leaf into a bag in which to lay its eggs. The path of the saw has a characteristic curvature and remains the same for all weevils, although its outline is not traced on the birch leaf. Is 'the constancy of the path' the theme that lies behind its trace?

The answer to this riddle is one of the secrets of nature's composition, which we encounter everywhere in our research on the technics of nature.

The first investigator to busy himself with the problems of the technics of nature appears to have been Lamarck.[19] In any event, his experiment, in which he attempted to reconcile the origin of the giraffe's long neck with the tall trunks of palm trees, contains the first reference to a contrapuntal relationship.

Interest in the technics of nature later disappeared completely and was replaced, mainly because of Haeckel,[20] with speculations about the influence of ancestors on later generations. No one will be able to acknowledge a technical achievement in the assertion that amphibians have resulted from fish. The wishful thinking that so-called 'rudimentary' organs exist has been responsible for diverting attention from the truly technical problems that face living creatures.

Only the proof furnished by Driesch that two complete half-sized sea urchins, and not two halves of a sea urchin, develop when a whole sea urchin embryo is cut in two cleared the path for a deeper understanding of the technics of nature. Everything that is physical — but not a melody — can be cut in two by a knife. The melody of a song played by the free chime of living bells remains unchanged, even if it directs only half the number of bells.

Progress

This time as I listened to St. Matthew's Passion in beautiful St. Michael's church in Hamburg the biological parallels to music forced themselves upon me once again. This supreme work interwoven with the most beautiful hymns proceeds in the gravest, most fateful manner. However, this was certainly not the progression that investigators in their phantasies attributed to the temporal progression of all that occurs in nature.

Why should the mighty drama of nature have unfolded on earth since life first appeared in a manner different from Bach's Passion, which is composed of high and low tones?

Was the highly valued advance that is said to have led living creatures from imperfect beginnings to increasingly higher perfection perhaps nothing but a bourgeois speculation on the pragmatics of the market place?

In any event, no trace of their imperfection had ever occurred to me — even in the case of the simplest animals. As far as I could judge, the material available for building their structure has always been exploited in the best possible way. Each animal has filled its own stage of life with all the objects and fellow actors meaningful to its life.

The properties of the animal and the properties of its fellow actors harmonize in every case like point and counterpoint of a polyphonic choir.

It was as if the same master's hand had from time immemorial been gliding over the keys of life. One composition followed the next without end — some of them difficult, some easy, some splendid, some dreadful.

Simple, but fully-developed crabs are to be found scurrying about in the ocean tides that once completely covered the earth. After a long period of time had elapsed, the rule of the cephalopodes came to an end when they were wiped out by the sharks. The Saurians emerged from the warm marshes of the mainland, their gigantic bodies grotesque caricatures of life. The master's hand, however, continued to glide. New forms of untold varieties developed from the tree of life into new melodies without ever showing an improvement from the imperfect to the more perfect.

The Umwelts were certainly less complicated at the outset of the world drama than later. However, each meaning-carrier was always confronted with a meaning-receiver, even in those earlier Umwelts. Meaning ruled them all. Meaning tied changing organs to a changing medium. Meaning connected food and the destroyer of food, enemy and prey, and above all, male and female in astonishing variations. In every case an advance occurred, but never progress in the sense of the survival of the fittest; never selection of the superior one, through an unplanned, furious

struggle for existence. Instead a melody prevailed, embracing both life and death.

I decided to present the following question to our greatest historian: 'Has any progress occurred in the history of human beings?'

Leopold von Ranke writes in his *Epochs of Modern History*:

> If one wanted ... to presume that progress consisted in the fact that the life of mankind develops in each epoch to a higher level — that each generation, therefore, surpasses the previous one in every way — the latest generation would as a result of progress always be the favored one. The previous generations would, however, only be the load-carriers of the succeeding generations — and that would be an injustice done by God. A mediatized (dismissed) generation of this kind would have no meaning in its own right: it would only have meaning insofar as it would be a step upon which the succeeding generation raises itself in a manner that bears no direct relation to the Divine. I assert, however: *each epoch is close to God*; its value does not reside in what emerges from it, but rather lies in its own existence, in its own self.

Ranke rejects the idea of progress in the history of mankind, because all epochs can directly be traced back to God, and none, therefore, can be more perfect than the previous one.

What can we understand by an 'epoch', in Ranke's sense of the word, other than a homogenous group of human Umwelts within a limited period of time?

One may conclude, therefore, that each group's Umwelts can directly be traced back to God, because all Umwelts belong to the same work of composition, whose composer Ranke designates as God.

To every materialist the word 'God' is like waving a red flag in front of a bull. He would recognize a work of composition that has developed by chance over vast periods of time, if one conceded to him that force and matter have remained unaltered since the beginning of the world, and that the law of the conservation of energy is eternally and generally valid.

At the beginning of my discussion, I showed that research on the Umwelts mainly proves the changing nature of objects; in every Umwelt they change their form when their meaning changes. The identical flower stem becomes four different objects in four different Umwelts.

What remains is to show by means of previously cited examples that the constancy of matter is also illusory. The properties of an object's material depend on the subject's sensory scales, whose Umwelt we wish to investigate.

Suppose we examine the yellow color of a flower on which a bee has landed. We can state with certainty that the flower does not appear to be yellow (but probably red) in the Umwelt of the bee, because the color scale of the bee's eye does not correspond to the same light-wave scale as

our color scale. We also know that the night moth's auditory scale, the tick's smell scale, the earthworm's taste scale, and the form scale of most invertebrates are totally different from these human scales. Even the 'hardness' scale of ichneumon flies, which pierce the hardest wood of fir trees as if it were butter, must differ completely from ours.

Not one single property of matter remains constant when we examine the full range of Umwelts. Each object we observe not only changes its meaning-quality from one Umwelt to another, but the structure of all its material and formal properties also changes. Matter in the human Umwelt is the 'basic rock' on which the Universe rests; and it is precisely this material world that vanishes from one Umwelt to the next.

No! The constancy of matter, about which the materialists boast, is not a solid base for a comprehensive view of the world.

The constancy of subjects is substantiated far better than the constancy of objects. The materialists will, however, interject that subjects also consist of matter. That is correct — but body-matter that subjects have must be built up anew from one generation to the next.

A particular individual obtains a very small amount of matter from his parents in the form of a germ-cell, itself capable of division, and a keyboard composed of genes. With each cell division these genes are distributed in the same number to the daughter cells. This keyboard is played upon by the form-shaping melodies like the keys of a piano, in order to produce the development of form. Each gene that is set into action acts as a differential stimulus to the protoplasm of its cells to build structures.

The form-shaping melodies that produce structure in this manner derive their themes from the form-shaping melodies of other subjects, which they encounter on their stage of life.

> If the flower were not bee-like,
> And the bee were not flower-like,
> The unison would never be successful.

These themes at times derive from the food circle, at other times from the enemy circle, and at still other times from the sex circle. The form-shaping melody draws most of its themes from the medium circle, e.g., the structure of our eye is sun-like and the construction of the maple leaf's gutters rain-like.

Thanks to the fact that extraneous themes are taken over, each subject's body assumes the form of a meaning-receiver for those meaning-carriers whose melodies are the themes that determine its shape.

The flower is a collection of counterpoints that act upon the bee; its

form-shaping melody is rich in themes and has contributed to the shaping of the bee, and vice versa.

The sun, as the most important of nature's components for us, beams down on me from my sky only because it has been the main theme in the building of my eye's structure.

The sun's influence in forming the structure of an animal's eye is just as great as the sun appears to be to it. It may be large and radiant or small and insignificant in the Umwelt-sky of the eye in whose formation it has taken great or little part (little, e.g., in the case of the mole's eye).

Let us now consider the moon instead of the sun: if its meaning is relevant to an animal's eye, then it will be a theme in the development of that eye's form.

The meaning of mammals reaches into the tick's Umwelt: the melody of the development of mammalian shapes is the theme that also influences the development of the tick's shape. These themes are the smell of butyric acid, the resistance of hair, and the warmth of and ease with which the skin is pierced.

That mammals have thousands of other characteristics is of no concern to the tick. Only those characteristics that are common to all mammals appear as themes in the building of the tick; they influence the structure of its perceptual and also its effector organs.

We are always on the wrong track when we try to judge the world of animals by the standards of our own world. I could, of course, claim that the whole of nature has taken part in and has been the theme for the development of my personality, body, and mind: if this were not so, I would lack the organs needed to recognize nature. I can also express this point more modestly and state: I am a part of nature to the extent that she has integrated me into one of her compositions. I am not a product of all of nature, but only a product of human nature, beyond which I have not been granted the powers to perceive. Just as the tick is only a product of tick nature, the human being is tied to his human nature, from which every individual human being begins anew.

The advantage we have over animals lies in the fact that we are able to extend the range of our inborn human nature. Of course we cannot create new organs, but we can assist the functions of our organs. We have developed perceptual aids and effector tools that make us able — providing we know how to use them — to broaden and deepen our Umwelt. But we cannot go beyond the perimeter of our Umwelt.

Only when we recognize that everything in nature is created by its meaning, and that all the Umwelts are but voices that take part in a universal score, will the way be open to lead us out of the narrow confines of our own Umwelt.

Extending the range of our Umwelt over a period of millions of light-years will not carry us beyond ourselves. Only when we can recognize that the existence of the Umwelts of our fellow human beings and animals, and not only our personal Umwelts, are part of an all-embracing master plan, will we be uplifted.

Summary and conclusion

The body of an animal can be compared to and studied like a house: the anatomists have so far studied in great detail how it is built; and the physiologists have studied the mechanical appliances in the house. The ecologists have also plotted out and studied the garden in which the house stands.

However, the garden has been depicted as it presents itself to the human eye, resulting in the neglect of the picture it presents to the house's occupant.

This second picture may be quite surprising. The garden is not, as it appears to us, bounded by a comprehensive world of which it is only a small segment. Rather it is bounded by a horizon, whose central point is the house. Each house is covered by its own arc of the sky, across which the sun, moon, and stars, all belonging to the house, travel.

Each house has a number of windows that look over the garden: a light-, a tone-, a scent-, and a taste-window, and a large number of touch-windows.

The garden, as viewed from the house, changes according to the windows' structure and design: in no way is it a part of a bigger world; it is the only world that belongs to the house — its Umwelt.

The garden appears entirely different to the house's occupants than it does to our eyes — particularly with regard to the appearance of the things that fill it.

While we find thousands of various stones, plants, and animals in the garden, the house occupant's eye perceives only a very limited number of objects in his garden: indeed, only those that have meaning for him. This number of objects can be reduced to a minimum as in the tick's Umwelt, in which the same mammal has a very limited number of characteristics that appear to the tick on every occasion. The objects we find in the tick's surroundings — the colored and scented flowers, the rustling leaves, and the singing birds — never enter into the tick's Umwelt.

I have shown how the same object, when placed in four different Umwelts, assumes four different meanings and in each instance fundamentally changes its properties.

The only explanation is that all the properties of objects are actually nothing more than perceptual cues that are imprinted on them by the subject with which they enter into a relationship.

To understand this, one should remember that the body of each living being is made of living cells, which together form a living chime. The living cell contains a specific energy that enables it to answer every external effect with which it comes into contact with an ego-quality. The qualities can be joined with each other through melodies; they can influence each other despite the fact that they may not be in mechanical contact.

The bodies of most animals are basically similar in that they have organs needed for the metabolism of food; energy obtained from food makes the animal's life-tasks possible. Perception and action are the life-tasks of the animal subject acting as a meaning-receiver.

Perception depends on the sense organs, which serve to sort out the stimuli that impinge on them from all sides. They screen out the unnecessary stimuli, and transform those that are of use to the body into nerve impulses. When these impulses have reached the brain, the living chime of the brain cells resounds. The ego-qualities of the chime serve as perceptual signs for outer events. They are imprinted upon the respective sources of the stimuli as corresponding perceptual cues, no matter whether they are sound, visual, smell, or other signs.

At the same time, the cell 'bells' resound in the organ of perception and in the central effector organ, which in turn translates its own ego-qualities into impulses that activate and direct the movements of the effector muscles. Therefore, a kind of musical process is set in motion by the properties of the meaning-carrier, to which it is led back. And one can conceive of the receptor and the effector organs of the meaning-receiver as counterpoints that correspond to the meaning-carrier's properties.

One is persuaded anew that most animal subjects possess an intricate anatomy — the prerequisite for smoothly bridging the gap between them and the meaning-carrier.

The structure of the animal's body is never preformed. The body begins its development as a single cell — a bell — that divides, and whose ontogenetic chime is attuned to a developmental melody. How does it come to pass that two objects such as a bumble-bee and the flower of a snapdragon, whose origins are so different, are constructed in such a way that they harmonize perfectly in every detail? Apparently, their developmental melodies mutually influence each other; the snapdragon's melody appears as a theme in the bumble-bee's developmental melody, and vice versa. What holds true for the bee is also true for the bumble-bee; its development would be unsuccessful if its body were not 'flower-like'.

Once this cardinal principle of nature's technique is understood, we can state that no progression occurs from the less to the more perfect. Because if a variety of themes of meaning extraneous to the animal influence its development, it is impossible to see how successive generations could alter this situation.

Having eschewed speculations about the ancestry (of living things), we are on firmer ground in studying nature's techniques. Yet a major disappointment awaits us. The triumphs of nature's techniques are readily apparent, but the manner in which its melodies are created cannot be investigated.

Nature's techniques share common features with the creation of a work of art. We can, of course, see the painter's hand apply one color after the other to the canvas until he has completed the painting, but the creative melody that moves his hand is wholly hidden from us.

We can certainly understand how a musical clock produces its melodies, but we can never understand how a melody constructs such a clock.

That is exactly the question that the creation of every living being poses. Every germ cell contains the requisite material, and the keyboard is represented by the genes. Only the melody that brings about the organisms's construction is missing: From whence does it come?

Every musical clock contains a cylinder, from which spikes protrude. As the cylinder turns, these spikes strike strips of metal of different lengths to set the air vibrating; our ears perceive these vibrations as tones.

By observing the position of the spikes on the cylinder, a musician will easily be able to recognize the score of the melody the clock plays. Let us for a moment forget that the clock was made by human hands, and let us assume that it is a product of nature. We could then state that we are presented with the physical embodiment in three dimensions of a score that has crystallized out of the melody: The melody represents the clock's 'germ of meaning' (*Bedeutungskeim*), provided that enough adaptive material is at hand.

A small painting by Ivar Arosenius, entitled 'Jul' (Christmas), hangs in the National Museum in Stockholm; it portrays a tender young mother with a child in her lap. A faint halo encircles the mother's head. The small and moving Madonna is portrayed seated in a simple room in an attic. All the objects around her — the articles before her on the table, the lamp, the curtains, the crockery on a dresser — are quite commonplace; yet they are impressive themes that enhance the saintliness of the scene.

This picture is such a harmonious composition that its viewer forgets the painter and believes that he sees before him a small miracle of nature. Its germ of meaning can be called 'Madonna'. Everything else ensues from this, as from the melodious shape of a crystal. At the same time, one

has the impression that one perceives a pure Umwelt that contains no foreign elements. Point and counterpoint blend.

A small amount of malleable matter — a small piece of canvas and a few subdued colors — was all that was needed to crystallize out a small work of art. The quantities of available matter would have been incidental: the artist could have achieved the same result without regard to the amount of matter he used. A different artist using the same materials and guided by the same germ of meaning, 'Madonna', would have painted a completely different picture of the Madonna.

We will now use the example of the creation of a work of art in order to demonstrate that creation of a living organism occurs in the same way.

Undoubtedly, we can designate the acorn as a 'germ of meaning' of the oak, and the egg, of the chicken. In both cases, nature possesses the most malleable of matter — namely, living protoplasm; it complies with the shaping of structure that stems from ego-qualities, and once formed, preserves its shape.

The oak crystallizes out of the acorn's 'germ of meaning', as surely as the hen from the egg: But how does this come about?

As I have already explained, new organ buds repeatedly appear during ontogenesis and have an independent development. In each organ bud there is a germ of meaning that utilizes the available matter (protoplasm) to crystallize out as a fully formed organ. If a piece of this matter is removed, an organ will still develop; it will be smaller in size then, but otherwise an exact replica in every detail of the normal one. Braus[21] demonstrated that the ball will not fit into the socket of the shoulder joint if, during development, not enough matter is available for the latter to attain its normal size.

As we have also seen, Spemann demonstrated that an organ bud from one species of animal, transplanted into the equivalent part of another animal's body, develops into an organ that expresses the germ of meaning of its new location. Yet the developed organ is quite different in structure from the host's; it would serve the donor, but not the host, because each carries out the same function in a different manner. In both animals, the germ of meaning is the function of feeding; but the frog feeds on different food than the triton does.

Similarly, two paintings of the Madonna painted by two different artists will contain the same germ of meaning but will not look alike.

Deformities that, as Braus established, stem from a lack of building material no longer occur once the organs are joined to carry out a common bodily function. The German ophthalmologist Wessely (1920) established that the regenerating crystalline lenses of young rabbits may be larger or smaller than they were originally; as a result all the structures

of the visual system become larger or smaller to the same degree, so that vision may continue to function undisturbed. This example again illustrates that meaning guides this structural readjustment.

That meaning really governs tissue regeneration is illustrated by Nissl's[22] experiment. The meaning of the mammals' cranium is undoubtedly to protect the underlying cerebral cortex. The cranium of a young rabbit will regenerate automatically as long as its cerebral cortex is not damaged. If, on the other hand, one cerebral hemisphere is also removed, the cranium will not regenerate on that side. It has lost its meaning. In this instance just scarring will suffice.

Meaning is a decisive factor in nature; it appears always, often in novel and surprising guises.

Let us allow the Umwelts to pass in review before our mind's eye. We will observe wondrous forms in the gardens that surround the bodies that house the subject; these forms are the meaning-carriers, whose meaning is often very difficult to divine. We will therefore have the impression that the meaning-carriers represent a secret sign or symbol that members of the same species can understand, but that those of another species cannot comprehend. The silhouette of, and the water currents produced by, the fresh-water mussel are the love symbols of the bitterling. The earthworm uses the difference in the taste of the tips and stalks of leaves as a symbol of their shapes. The same tone symbolizes 'friend' to a bat but 'foe' to a night moth. And so on ... and on.

Once we are finally convinced by an overwhelming number of examples that each Umwelt is at base filled only with meaningful symbols, then a second, even more astonishing fact forces itself upon us: Each subject's symbol is at the same time a meaningful theme for the structure of the subject's body.

The body that houses the subject on the one hand produces the symbols that populate the surrounding garden and is, on the other hand, the product of these very same symbols that are the meaningful themes in constructing it.

The sun owes its shine and its form high up in the sky that extends over the garden to the eye, as the window of the body that houses ourself. At the same time, the sun is the theme guiding the construction of the window.

This principle applies to both animal and man; the same factor of nature manifests itself in both cases.

Let us assume that some natural phenomenon has caused all the night moths to die out. With the help of nature's techniques, we are now faced with the task of correcting this gap in nature's keyboard. How would we proceed?

We would probably retrain a day moth to search out flowers that are open during the night; it would also have to develop its sense of smell at the expense of its sense of vision.

The newly-trained moth would, however, be defenseless against flying bats. We would have to devise a sign that would identify the predator, so that the majority of moths could evade it in good time.

We would use the squeak of the bat, which is a friendly signal to other bats, as an inimical sign for the moth.

The moth would have to be rebuilt and provided with a hearing device to enable it to perceive the bat's squeak. This sign would then enter as a theme in the construction of the bat.

> If the night moth were not 'bat-like',
> Its life would soon end.

One can imagine that the tick came about to close a gap in nature's keyboard. If so, the meaning-carrier that has general mammalian characteristics would at the same time symbolize 'prey' and be a theme in the plan for constructing the tick.

Finally, we will attempt to take a look from outside at our own body, which is like a house with its surrounding garden. We now know that our sun in our sky and our garden, full of flowers, animals, and people, are but symbols of an all-encompassing symphony or composition of nature, which ranks all things according to their significance and meaning.

This overview defines the boundaries of our world. The development of progressively more refined machines and equipment, with which to investigate objects, will not enable us to develop new sense organs. The properties of objects, even when analyzed into their constituent atoms and electrons, will continue to remain sensory and perceptual cues.

When we die, our sun, sky, and earth will vanish; but they will continue to exist in a similar form in the Umwelts of succeeding generations.

There are not only the two varieties of space and time, in which objects are distributed. There is also the variety of Umwelts, in which objects assume a multiplicity of ever new and different forms.

At this third level, the countless Umwelts represent the keyboard upon which nature plays its symphony of meaning, which is not constrained by space and time. In our lifetime and in our Umwelt we are given the task of constructing a key in nature's keyboard, over which an invisible hand glides.