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BIOLOGICAL ADAPTATION: DEPENDENCE OR INDEPENDENCE FROM ENVIRONMENT

Opublikowano w: ***FORUM PHILOSOPHICUM***
Facultas Philosophica Ignatianum, Kraków, T. 2: 1997, pp. 71-102.

Introduction

For more than a hundred years the attempts to explain the biological adaptations constitute the main current of the evolutionary thinking. In 1901 C. Ll. Morgan wrote: „The doctrine of evolution has rendered the study of adaptation of a scientific importance. Before that doctrine was formulated, natural adaptations formed part of the mystery of special creation and played a great role in natural theology through the use of the argument from 'design in nature”[1]. The modern doctrine of biology stresses the importance of the environment in „shaping” the inner properties of every living being[2]. This means an obvious although tacit refusal to assume or recognize any single, integrated agent in the origin of main functional biological traits and in the genesis of new kinds of life. The role ascribed to random mutations, and to „pressures of the environment” is just one aspect of the neo-Darwinian theory[3]. Another aspect of this doctri-

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[1] Morgan C. Ll. (1901) *Adaptation*. In: *Dictionary of Philosophy and Psychology*, ed. by M. J. Baldwin, Macmillan, New York. Later in the article Morgan mentions the formulation of the principle of natural selection, which – according to him – did eliminate the difficulties raised against the theory of evolution. „Now cases of lack of adaptation are cited as furnishing objection to the principle of natural selection.” Finally Morgan quotes a letter by Darwin who believes that the greatest difficulties roused by the adaptation phenomena have been surmounted.

[2] „The animal is fitted to the air it breathes, the water it drinks, the food it finds, the climate it endures, the region which it inhabits. All its organs are fitted to its functions; all its functions to its environment. Organs and functions are alike spoken of in a half-figurative way as concessions to environment. And all structures and powers are in this sense concessions, in another sense, adaptations. As the loaf is fitted to the pan, or the river to its bed, so is each species fitted to its surroundings. If it were not so fitted, it would not live.”... (D.S. Jordan and V.L. Kellogg quoted by Newman H. H., 1947/349).

[3] „Organisms appear to be generally more or less moulded, both internally and externally, by their environment” (Caullery M., 1933/2). For a more recent example see Alberts *et al*. (1994/780) on the role of random mutations in „training” the hypothetical „signalling networks” in the bacterial cell.

ne is the widespread conviction that all phenomena of life are a natural, both random and necessary result of interactions between constantly changing material objects[4].

To verify this thesis, a selected specific kind of biological dynamisms, namely the *protective adaptations*, will be analysed. A few obvious counter-examples will suffice to restrict any too comprehensive theory. The main question seems to be: „Can we rationally admit that the phenomena of the protective adaptation are a „coproduct" of biological and environmental influences, or should they rather be considered as a completely inner, immanent, autonomous dynamism of a living body?" This approach raises out of another question: „How to decide which is the right answer?" The solution may seem desperately difficult, but, on the other hand, we have no difficulty in assuming that the locomotory movements, DNA replication, or the metabolic chemical processes of an animal constitute a completely immanent type of activity. So, we do possess the sufficient cognitive means to solve such kind of a problem. The above questions may not be conclusively answered in this paper, but they show the direction and perspective of our investigations.

Ambiguity of the term „adaptation".

In biology the term „adaptation" is used in a descriptive or in a „genetic" sense. The descriptive sense refers to the actually observed phenomena of the living bodies. The „genetic" sense refers to the *origin* of those phenomena which are described as „adaptations". For instance, Mayr, quoting Sober, writes that „adaptation is that which has resulted from selection" (Mayr 1988/118; see also Lima de Faria 1988/9 quoting Dobzhansky). He also declares his firm belief in the traditional thesis of the Darwninian doctrine, namely that natural selection is sufficient to explain the origins of the adaptations. In this paper we will not analyze the validity of this belief. We will concentrate upon the *description* of the adaptive phenomena. A description, as such, may concern just a single specimen of a given kind of organisms, or larger units such as populations. We will limit ourselves to the analysis of the dynamism observed in the single specimens. The descriptive sense of the word „adaptation" can be split, in turn, into at least four different meanings:

(a) The „internal adaptations", e.g. the fit between the socket and the head in a joint between two bones, or a fit between the properties of retina and the vision center in the brain. The „fit" may be understood in a dynamic or static, strictly repetitive or statistic, passive or active sense[5].

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[4] The neo-Darwinian theories imply that „animals are what they are because they live where they live, [and] it is possible to explain the origination of all forms, past or present, on the assumption that either the environment changed or the animals changed their environment. Thus fishes acquired lungs through exposure to air, limbs as a consequence of living in the vicinity of shores, etc.; the phylogenetic literature abounds with further examples" (Loevtrup, 1977/4; see also Horn, 1978/16-18; Campbell, 1995/16).

[5] „Anatomical and physiological studies disclose internal adaptations which may concern the organism in its entirety or each of its organs without any relation to the external environment. ... internal adaptations are connected with the general plan of organization and function of a living organisms. Examples of this are the correlation of the circulatory system with the mechanism for the absorption of substances and for the elimination of waste;

One should add that the professional biologists use this term within some limits which seem to be quite evident to them but never explicitly stated. Without, however, these tacitly assumed limits the term „adaptation" might be applied even to the shape of a stone in connection to the shape of its bed in the ground. If the „fit" is to be recognized in respect to a nonarbitrary system of reference, one should ask how such a system is identified and defined.

(b) The „external adaptations," e. g. a set of structural and dynamic properties of a hawk which allows it to prey on small animals, or a set of the properties of a polar bear which enable it to survive in the Arctic[6].

The „external adaptations" refer to all properties of an organism which are decisive in its survival within a given environment (cfr Collier *et al*., 1978/30). „Adaptation ... can be judged only with respect to the external environment of the organism" (Bock, 1980/219).

(c) In physiology the term „adaptation" usually means any dynamism which minimizes the influence of changes of the environment upon the inner, biological processes.

This kind of phenomena can be illustrated by the constriction of the iris in bright light, the increase of sweating in a hot environment, the increase of the number of erythrocytes when the partial pressure of oxygene is diminished. In psychology the word „adaptation" is used in an identical or very similar way[7].

d) Many authors tend to equate *all forms of biological activity* with the meaning of the word „adaptation". „An adaptation is any genetically based characteristic – structural, behavioural or physiological – that aids an organism to survive and reproduce successfully" (Horn, 1978/16)[8].

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the connections of the nervous system with receptor and efector organs. Other adaptations are predominantly functional; for example, hormonal integration ..." (Colosi, 1961/11-12)

[6] „... external adaptation is the conformity of special parts, or the whole, to environmental conditions and habits of life" (Caullery, 1933; p. 2).

„The adaptation of a hawk for making a living by hunting small animals involves the combination of several features: soaring flight, telescopic vision, sharp grasping talons, strong body, and hooked tearing beak. ... The wings of birds in general are as much an adaptation for flying as the particular type of bill and clining feet of a woodpecker are an adaptation for a specialized method of food-getting." (Grant, 1963/115-116)

[7] „a form, a behavior is adaptative if it maintains the essential variables within physiological limits. For example, ... the retina works at a certain intensity of illumination. In bright light the nervous system contracts the pupil, and in dim relaxes it. Thus the amount of light entering the eye is maintained within limits. ... Some external disturbance tends to drive an essential variable outside its normal limits; but the commencing change itself activates a mechanism that opposes the external disturbance. By this mechanism the essential variable is maintained within limits much narrower than would occur if the external disturbance were unopposed. The narrowing is the objective manifestation of the mechanism's adaptation." (Ashby, 1960/58-62)

[8] „Adaptations are those details which result in suitable and convenient morphological and functional correlation between parts of an organ, between the organs of living organism, between individuals of the same species or of different species, and finally, between an orga-

The outline of the concept of the protective adaptation

In this paper we will concentrate upon the „physiological" sense of the term „adaptation" which can be suitably called „protective" adaptation. The protective adaptations are „self-regulating physiological processes [which] maintain the internal environment constant in spite of fluctuating external conditions" (Grant, 1963; p. 122). This definition consists of four different elements:

(1) the external, randomly fluctuating locale, milieu, surroundings, e.g. the atmosphere with its changing concentration of different gases, its changing temperature, pressure, humidity ... and so on;

(2) the immediate, closest part of environment which is to be kept (relatively) „constant", e.g. a concrete level of temperature, or humidity within the neighborhood of a biological body;

(3) a tacitly assumed „protected" biological dynamism which operates most adequately within this „constant" environment (2) (e.g. the process of embryological development of a given organism);

(4) the specific, *adaptive* dynamism which makes the internal environment „constant", e.g. the system which regulates the aperture of a pupilla of an eye, the constrictions and dilatations of blood vessels.

The adaptive dynamism (4) is clearly subordinated to an unmentioned, more fundamental, and manifestly different dynamism (3). The adaptive dynamism is also evidently correlated to both kinds of the „environment". It is obviously tuned to the proper level of parameters of the environment (2) and it becomes redundant if the external environment maintains a stability and happens to fit to the „environmental" requirements of dynamism (3).

The observational data.

A. *The photoadaptive dynamism in Mougeotia spp*.

Mougeotia is a green alga living in relatively shallow inland waters of Europe and North America – in rivers, permanent ponds and lakes, or temporary pools (Graham *et al*. 1996/253; Podbielkowski, Tomaszewicz, 1996/305).

A cylindrical cell of this alga uses its single, flat chloroplast to capture the energy of light and to drive photosynthetic processes with it. These processes provide the cell with reduced forms of the carbon atom and the high-energy chemical compounds.

In weak light (Fig. 1) a plate of chloroplast is oriented perpendicularly to the direction of light – and the surface of the illuminated organ is large („face" or „weak-light"

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nism and its organic environment. Those adaptations consist of conformations, of structures, and of functions, particularly well adjusted to the role played by the organ in question on which they confer a high level of efficiency, or which are at least very advantageous either to the maintenance of the individual or to the perpetuation of the species. ...". (Colosi, 1961/11).

„Adaptation. A particular part of the anatomy (such as color), a physiological process (such as respiration rate), or behavior pattern (such as a mating dance) that improves an organism's chances to survive and reproduce." (Wilson, 1992/375).

position). In bright illumination a plate of chloroplast is moved into a parallel position, so the illuminated surface is minimal („profile" or „strong-light" position). If just a part of a chloroplast is strongly illuminated, this part is moved into parallel position while the rest of the chloroplast remains in the perpendicular orientation (Fig. 2).

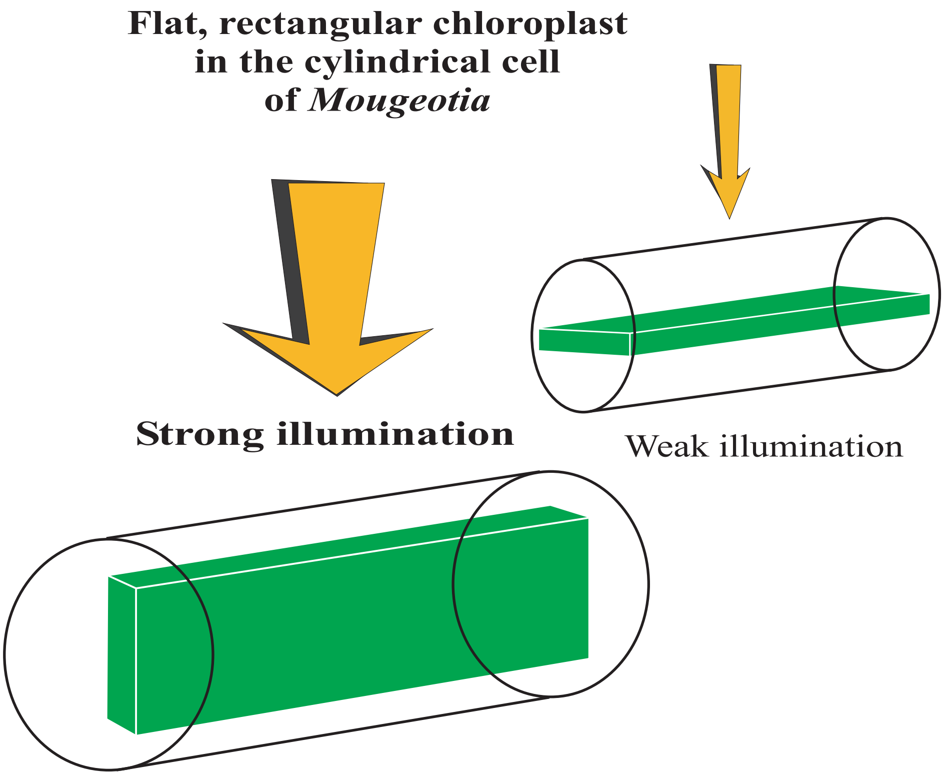

Fig. 1.Protective adaptation in *Mougeotia*.

The electron-microscope data revealed that the long edges of chloroplast are attached to an inner surface of a cell membrane with the aid of extremely delicate microfilaments (diameter of some 10 nm; Alberts *et al*., 1989/1171-2; Alberts *et al*., 1994/789; Britz, 1979/190; Kopcewicz *et al*., 1992/fig. 63). When a chloroplast is to be moved, these filaments behave like Russian haulers of a river boat upstream, „walking" in an ordely manner on an inner surface of a cell's membrane, and pulling the chloroplast into proper position (Fig. 3).

The essential connection between the movement of a chloroplast of *Mougeotia* and the intensity of light is beyond any doubt (cfr. Hoppe *et al*. '83; Hader, Tevini, 1987/272-274; Alberts *et al*., 1989/1172; Kopcewicz *et al*., 1992/183-184). It is clear that the movements help to maximize or minimize light absorption, and in this way to maintain an optimal level of intensity of light falling on a surface of a chloroplast, or to protect structures of a photosynthetic system against the excess of solar energy. An excessive illumination may bleach chlorophylls and thus damage these fragile but essential parts of a cell's photosynthetic apparatus (Britz, 1979/174-184; Zurzycki, Michniewicz, 1985/370-379).

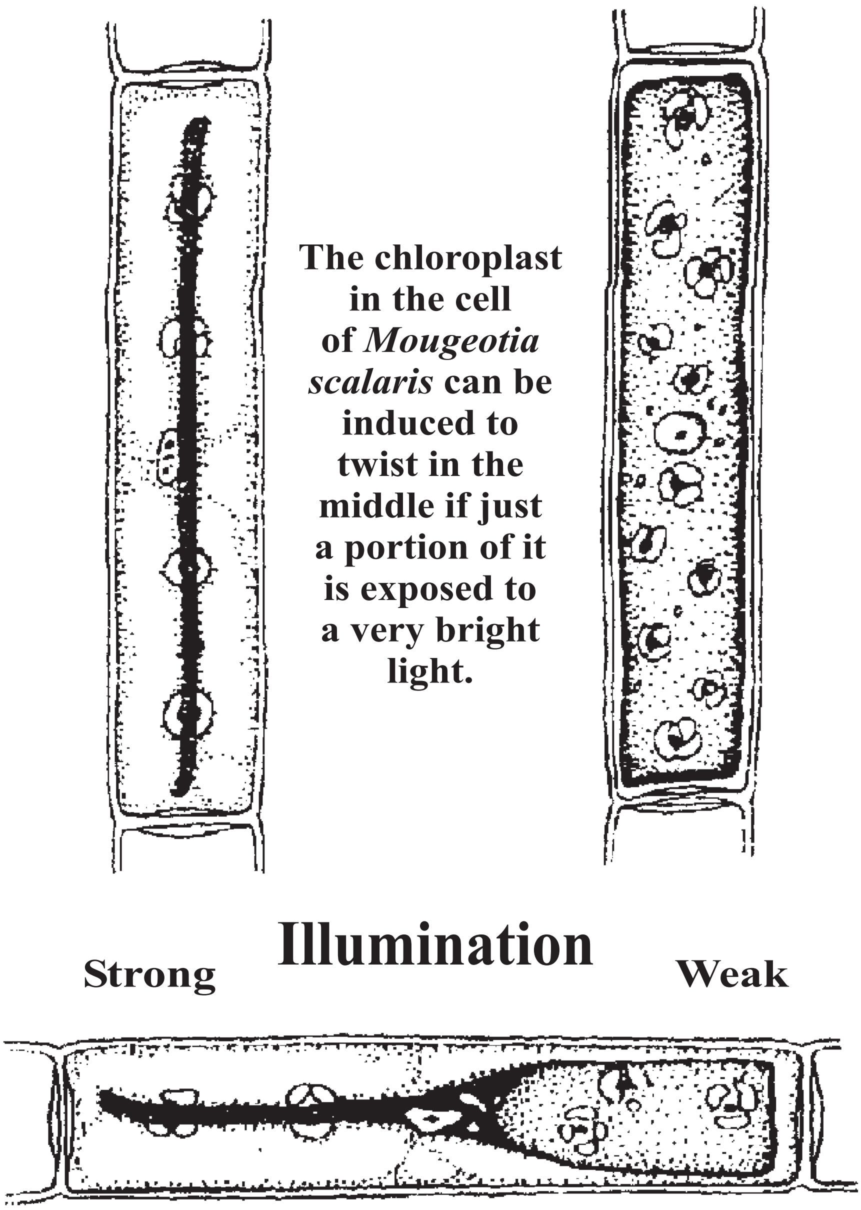

Fig. 2. Selectivity of the protective adaptation in *Mougeotia scalaris* (after Podbielkowski, Tomaszewicz, 1996 – modified)

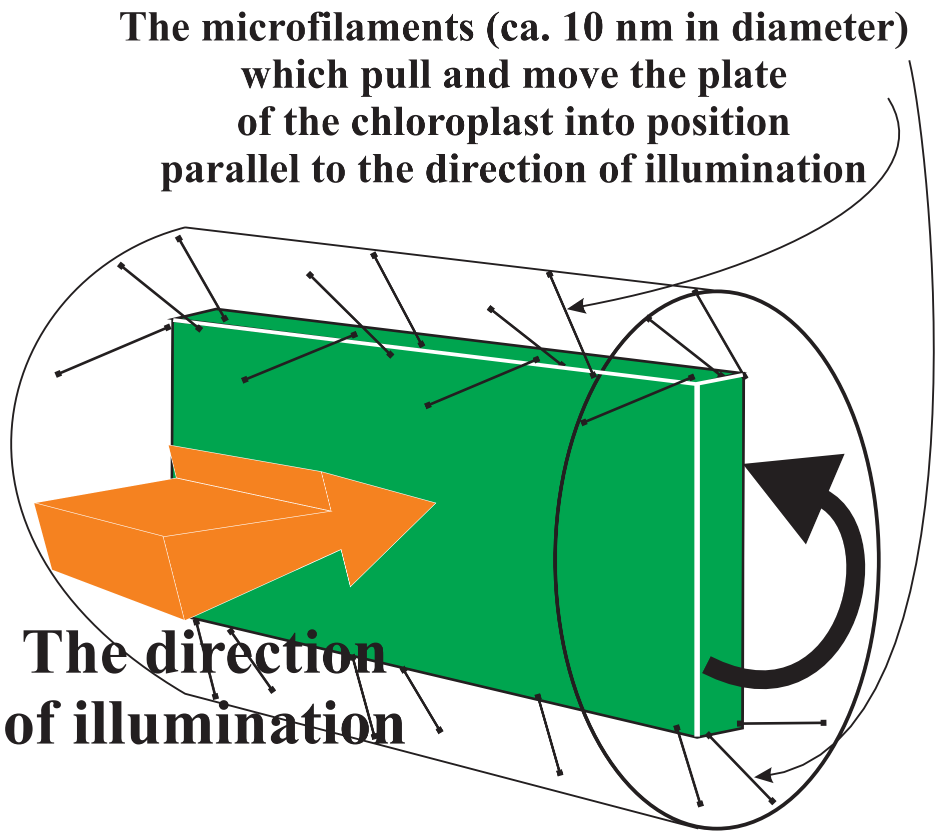

Fig. 3. Morphodynamic aspect of the protective adaptation in *Mougeotia*.

B. *The adaptive changes of the locomotory behavior in the bacterium Escherichia coli*.

Every single cell of the bacterium *Escherichia coli* (2-3 micrometers of length) is equipped with at least six spiral filaments (flagella) attached to six rotating devices (Fig. 4) which spin faster than a hundred times per second. Because of the flagellar movement the bacterium is able to swim up to 30 micrometers per second (15-20 µm/sec, in average). It is necessary to mention, that the flagellar „motor" can rotate either counterclockwise or clockwise (Macnab, 1979/318; Alberts *et al*., 1989/720). Three forms of the locomotory behavior of a bacterium were observed.

„Nowhere" locomotion (NL). In an environment rich in food particles (small organic compounds, such as aminoacids or sugar molecules) a bacterium constantly moves but *goes nowhere* (Fig. 5C). Every few seconds it turns its flagellar motors clockwise, just for a tenth of a second. A bacterium comes to a sudden stop, as all single flagellae stick apart, and the bacterium changes its direction about 60° („tumbling", see Fig. 5B). Next the counterclock spin of the motors is resumed for a short while and then again the bacterium stops and changes the direction of its movement.

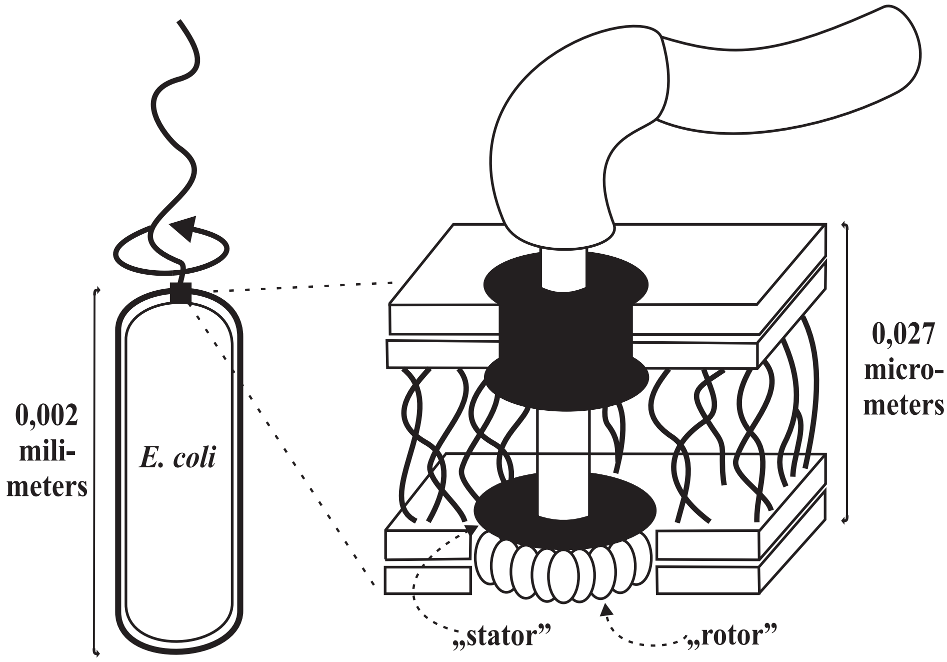

Fig. 4. Flagellar „motor” of *Escherichia coli* (after Alberts *et al*., 1994 - modified).

„Search” locomotion (SL). If, however, a bacterium detects that concentration of food particles grows in a certain direction, its frequent „tumbling” is suppressed and the motors propel the body of the bacterium in the direction of the richer source of food (Fig. 5A and D; see also Macnab 1979/310-311). The chaotic „grazing” was changed for an obviously purposeful way of movement.

„Escape” locomotion (EL). The third kind of the locomotory movement is observed whenever a bacterium detects the presence of a harmful substance in the environment[9]. In such a case the bacterium moves away from the greater concentration of this substance (Fig. 5A and D).

C. *The protective adaptation in the megapods (Megapodiidae).*

The hen-like Australian bird *Leipoa ocellata* incubates its eggs (5-33 in number, average 18) for 7-13 weeks in a big mound (Fig. 6) prepared during winter time from leaves and small branches (Lack, 1968/200-201). The mound can be „as much as 10.7

[9] In the reports on the locomotory behavior of the bacterial cells there is a custom to call the food particles „attractants”, and to call the harmful substances „repellants”. This is misleading, because it suggests an analogy to the chemical signals produced, for instance, by some female insects to attract a male, or the substances produced by skunks to discourage a predator. That kind of signaling requires much more complex biochemical and morphogenetic dynamism, and so it can be doubted if the above mentioned terminology is justified in the case of the bacterial locomotion.

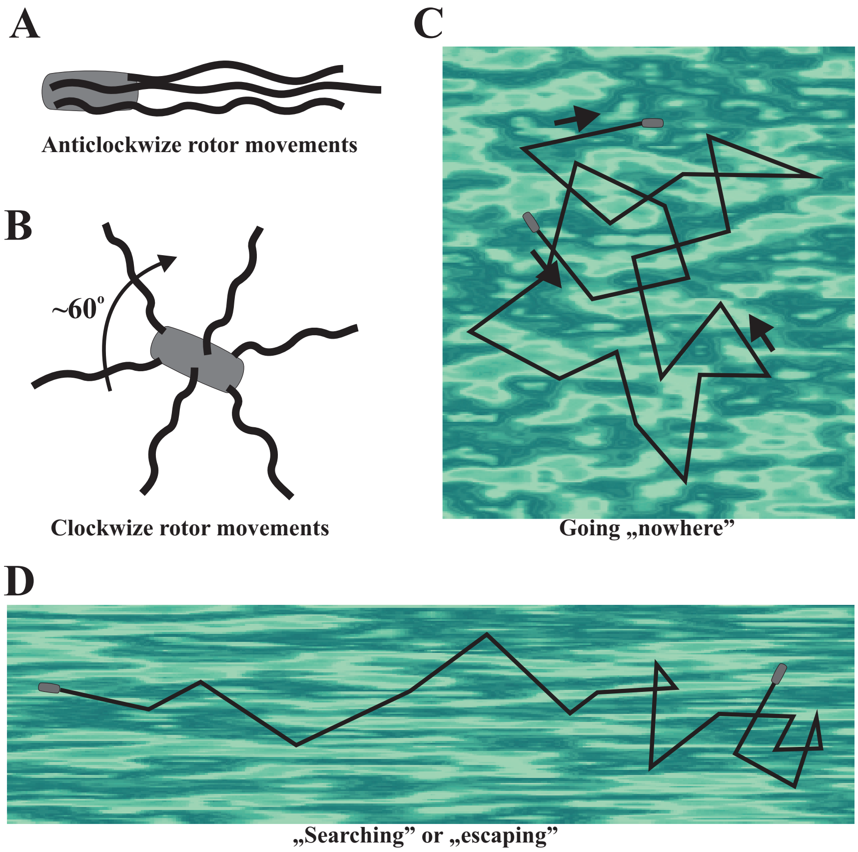

Fig. 5. Locomotion of *Escherichia coli* (after Alberts *et al*., 1994 - modified).

meters in diameter and 4.6 meters high, perhaps the largest structure made by birds.” (Collias, Collias, 1984/11)[10].

> „The rotting vegetable matter ferments very actively, causing a great deal of heat. The temperature of these piles of fermenting vegetable matter varies considerably. The fluctuations depend on the amount of moisture in the mound and the degree of aeration, thus the temperature may vary in different parts of the mound” (Hill, 1964/49).

In addition the temperature of the environment can drop by 16°C at night. In spite of it a male megapode keeps the temperature of eggs surprisingly constant. In a mound, in which continual recordings were taken, the temperature was regulated to 92°F (33°C), with slight variations immediately being counteracted by the vigilant bird (Hill, 1964/50). In an experiment with megapod *Alectura lathami,* an electric heater was plan-

[10] Early settlers of the australian continent thought that these massive piles of forest debirs and earth must be native burial mounds (Hill, 1967/48). It is interesting to note that „in places where dark tropical forests fringe the rivers, female crocodiles build mounds of leaves for their eggs, in close proximity to the leafy mounds of megapodes” (Collias and Collias, 1984/13).

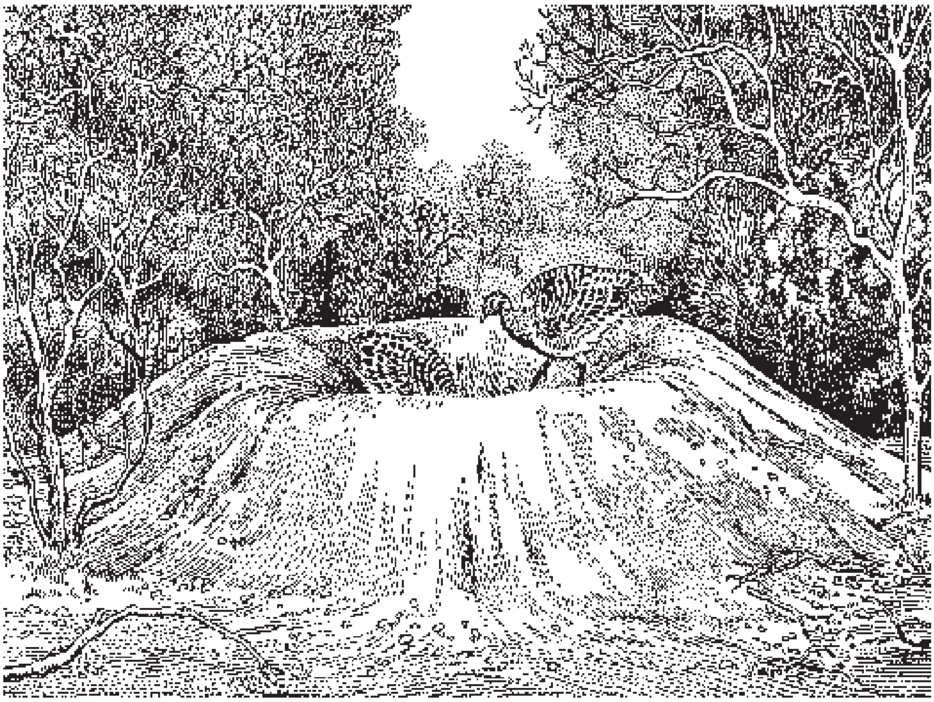

Fig. 6. *Leipoa ocellata* on the top of a fermentation mound (after Lack, 1968).

ted into its mound. When the temperature exceeded the level favorable for eggs the bird reacted immediately, opening the parts which were overheated and managed to keep the temperature close to 34°C (Veselovsky, 1975/108).

The protective activity of a male consists of measuring the temperature of each channel in which the individual eggs are incubating and either opening a top of a mound to let some heat escape or gathering more sand to prevent loss of heat (if fermentation is to be slowed down)[11]. This activity keeps the male bird busy for about ten months a year.

In a desert area, where vegetable material easily desiccates instead of fermentation and it is blown away by the wind or eaten by termites, a megapode bird digs a hole in the ground up to 1 m deep and up to 3 m in diameter and there it gathers the proper material, covering it with a layer of sand. The vegetable material rots there more easily and produces the desired amount of heat (Veselovsky, 1975/108).

Another bird, Jungle-fowl *(Megapodius freycinet)* lays its eggs in the hot sand of a sunny beach of the Dunk Island. On the Savo Island (Solomon Islands) there are two sandy areas through which volcanic steam filters. Jungle-fowls come there in a great number to lay their eggs. The same species is able, however, to build the fermentation mounds, probably the biggest ever recorded (see Hill, 1964/48).

[11] „The bird will even go to the length of spreading the sand in the hot sun so that it is all heated before being scraped back over the nesting chamber" (Hill, 1964/50).

Discussion

Problem of the proper observation and description. The way we observe and describe something, may seriously affect our awareness of its essential properties. Little knowledge can be gained by observing the behavior of an eagle squeezed in a small cage, a cat's locomotion in a microscope, or a bird's nesting behavior just within a split second. Which way of description is proper? What kind of a cognitive approach has to be applied to make the results of our observation objectively valid ? In modern biology an *analytical* tendency to observe the most subtle details on one hand, and a *statistical* tendency to trace the stable relations between the roughly identical members of big populations on the other, are quite well developed. But in biology there is an important sphere of phenomena which are inherently complex and dynamically indivisible. A locomotory system, for instance, must be observed and described in its intact, undivided state, regardless of its inner complexity. Its activity can be registered neither by the analytical cognitive approach, nor by the statistical methods, but has to be observed as a certain dynamic whole in the context of a single specimen. So, apart from the already mentioned analytic and statistical methods of description, a *reconstructive* approach has to be recognized[12]. It is rather clear that *the analytic, reconstructive and statistical descriptions are mutually irreducible and complementary* at the same time. The mental, conceptual reconstruction of the flagellar motor in *E. coli* is a good illustration of this point.

The concrete, empirical fact of the protective adaptation cannot be grasped without the reconstructive cognitive approach. One has to put together many different, separate observations before one realizes this fact. It is irrelevant whether this synthesis is made consciously, deliberately or just instinctively, subconsciously. The *genesis* of the discovered adaptive tendency, however, is treated in a totally different way. An analytical concept of mutation and a statistical concept of natural selection constitute a backbone of modern genetic explanation. The main difference between the reconstructive approach and the two other approaches can be reduced to the problem of an integration. In the reconstructive approach the awareness of a nonarbitrary, objective whole is crucial, fundamental.

Problem of the natural object. Do we observe a natural unit, an *objective* object, or can we observe only a *subjective* object, i.e. a fragment of our environment arbitrarily or subconsciously separated from all the rest of this surroundings? This problem is usually tacitly solved on the basis of common sense and the prescientific experience with our environment. The same applies to our case. We will not discuss for instance such a question: „Is bacterium a single unit, or is it rather an arbitrarily separated fragment of the heterogeneous material space ?" We presume, for example, that we observe the behavior of a megapode as a *whole* and that the muscle contractions in megapode eye sockets constitute a *part* of this behavior, not a separate kind of behavior on its own. We may mention however, that limits of a natural object are determined by temporal and spatial limits of a repetitive life cycle pattern. The dynamisms going on in a decaying corpse do not fit into the repetitive and integrative pattern of a living body.

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[12] Joseph Altman (1966) calls this kind of approach the *teleological or functional* method.

The right context of the observation. Turning back to the problem of proper description one has to know what is the right context of described phenomena. In case of a man-made machine (a car, for instance) the full and absolutely necessary context will embrace mines which supply the material, smelting works which process this material, a factory or a workshop where the material is shaped and parts of the machine are mounted, and last but not least man, who guides all these complex stages of production.

What is the right context of the protective adaptation ? This dynamism starts on the condition that the right biological machines, the biological tools and the right behavior are already formed. Fig. 7 represents the biological origin of the adaptive tendency.

Inner principles show up through more superficial activities. Another fundamental, common sense principle we accept is this. Every natural object of observation gradually reveals its own, inner principles which have to be respected by an observer, if one wishes to deepen the knowledge of this object. This principle does not apply to *any* object, but only to *integrated* objects. For instance, any part of a crystal is good enough to study its nature. But it is not the same with a body of a bacterium or a body of

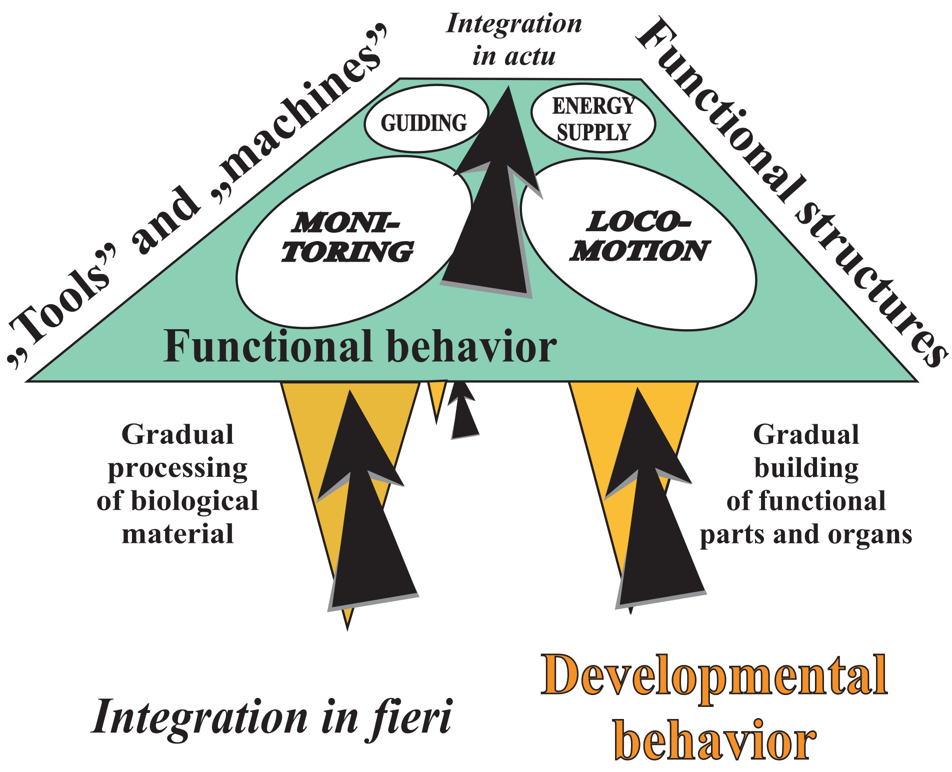

Fig. 7. The developmental context of the adaptive (functional) tendency.

a bird, which is obvious to any unprejudiced observer. It is a historical fact, that physicians made many sound observations observing butcher's activity, while butchers themselves, as far as I know, are not famous for any valid biological observation. A butcher is not concerned about the integration of a living body.

Functional and developmental integration. The sense of the biological integration we refer to, was described earlier (Lenartowicz, 1975/122-129; 1985/216-281; 1993). Functional integration is recognized whenever the transmission or transformation of energy is achieved with the minimal increase of entropy of the system. Man-made machines and many biological organs reveal such a quality. Developmental integration is recognized whenever functionally integrated structures are built with the minimal increase of entropy of the system and the minimal waste of the material. This idea can be illustrated by the technology of machine construction and the epigenesis of biological organs during the biosynthesis and morphogenesis. A growing volcanic cone never achieves any structural functionality and its gradual formation should not be included in the same concept as the gradual formation of a head or a nest.

„Machines", „tools" and „behavior". An adequate description of biological phenomena requires formation of proper concepts and proper terminology. Our current vocabulary has to be either enriched or made more precise to convey the results of a more detailed analysis of phenomena. Therefore we propose to use the words „machine" and „tool" in a slightly modified, limited meaning to make more evident the inner properties of the dynamisms under consideration.

(a) **The „machine"** (according to our new, restricted definition) means such a structure which is able to transmit or transform a specific form of energy along a precisely determined path with the minimal increase of entropy. Consequently the result of this transformation is just one. In other words a machine can be switched on or off, but it cannot be used to perform more than one function. A „machine" is *mono-functional.*

Switching it on or off does not enter into this narrow definition of the „machine". A separate, properly structured system is necessary to break the link between a machine and its source of energy. An attempt to stop a machine-like dynamism without switching off the energy input, leads to destruction.

Examples. An enzyme, for instance, is *monofunctional*. It does not need any guiding influence. Similarly the locomotive moving along the rails is a machine if we ignore changes of velocity. Its structure and nature of the energy transformed, fully determines its function. In the above described, restricted sense, a typewriter is not a „machine", because its structure does not select the result of its activity, i.e. it does not select any particular sequence of characters. A computer also should not be considered as a „machine" in that sense, except such relatively short moments when it makes a printout, or performs a calculation.

(b) **The „tool"** (according to the new, restricted definition) means such a structure which can transmit or transform a specific kind of energy but the results of this transformation may be different. The differences in the resulting changes come from the behavior, which determines both the amount and the direction of the transmitted energy.

Examples. The legs of *Megapodiidae* may illustrate our concept of a „tool". They are not *monofunctional.* The legs can be used to dig, to gather, to search, to escape. The locomotory system of *E. coli* is also a „tool" not a machine. It manifests at least two different activities: a propelling one, be it a search or an escape, and the second one, a „tumbling". A separate selective system has to be postulated to explain why, in a particular environment, this or another dynamism is selected. The morphodynamic system in *Mougeotia* may be used to move a chloroplast either into „weak light" position or „strong light" position. The system itself does not decide which way to behave.

(c) **The „behavior"** (in the new, restricted definition) means this element of the biological activity which determines the utilization of biological „tools".

The behavior cannot be deduced from a structure of a tool. On the other hand the behavior is a capacity to make a tool from almost „anything". A common swimming beatle *Dytiscus marginalis* uses only the rear pair of his legs to navigate. If this pair is removed, it swims efficiently with the remaining middle pair and if this pair is also destroyed, it moves in the desired direction with the help of the front pair. Even an unsymmetrical mutilation cannot destroy the beattle's capacity to move in the „right" direction. Such observations are commonplace in physiology and pathology. The phenomenon of regeneration, which we are going to mention later, adds a new dimension to the problem of behavior.

Examples. The structure of a bird's leg, or its beak is not sufficient to guess the complex behavior of such expert nest constructors as weaver birds or tailor birds. A beaver's body, or a body of a termite gives us no hint about their architectural talents.

The problem of the behavior of man-made machines. Is there any reason to talk about the „behavior" of a machine? The Turing's turtle in its search for the source of energy seems to manifest the behavior. In the similar way a thermostat will „behave" in different ways, if the temperature in its vicinity changes. According to the prevailing linguistic usage the behavior means such a dynamism which depends upon the environmental influences[13]. The most essential difference, we think, between the „machine-like" and the „behavioral" dynamisms consists in their relation to environment. In the case of the behavior there is an obvious dependence of the dynamism upon the state of environment. A thermostat somehow „feels" the level of temperature, and the outcome of that „feeling" decides about switching on or off the heating element. A thermostat consists of a bimetal plate (the sensor), a heater within a container, and a switch, which, depending on the position of the „sensor", switches the energy source on or off. So the „behavior", in our restricted sense, implies not just „feeling", but also „guiding" activity in respect of a tool, i. e. a heating element.

[13] The Random House *College Dictionary* (1973) gives two *psychological* meanings of the word *behavior*: (a) an aggregate of observable responses to the internal and external stimuli, and (b) any activity of an organism taken as a subject matter of psychology. The second definition is obviously too equivocal, even nebulous. But the first one seems to fit quite well to the dynamism of a thermostat. The Encyclopedia Britannica (1968) enumerates the following, essential traits of a behavior: the *movement* of the *whole* body as a *reaction* to the *external* or *internal stimuli.* This definition also does not suffice to distinguish between the dynamism of a living body and the dynamism of a thermostat.

The above definition of the behavior may seems too general and too simplistic. We think it is necessary to distinguish between the *secondary behavior* and the fundamental, *primary behavior.*

(1) The *secondary behavior* we define as a *limited dynamism* in which *„machine-like”* structures do not change and limits are linked with the registration of environmental parameters.

Examples. Pupillar reflex, reflexive constriction of the vessels in skin touched by an icelet, „reflexes” of a thermostat, flight of the rocket „Cruise”[14].

(2) The *primary behavior* we define as a process of building the „machine-like” and „tool-like” structures, or using „tools” without structural constraints. A „tool” may be a part of a body, or an external object.

Examples. The most important examples of the primary behavior come from embryology and man's technical achievements. Biosynthesis, organellogenesis (construction of the „proton motor” of the *Escherichia coli,* for instance), embryogenesis in general, the metabolic turn-over, the processes of metamorphosis and regeneration. The „tool-making” primary behavior may be illustrated by morphogenesis of a beak or talons of birds, or fins of fish (see table I).

Seed	***Life cycle – the development***
1. Dynamic Genome Indivisible, immanently active, integrating entity, of a specific kind	
2. Dowry **a)** minimal set of the cell enzymes **b)** minimal set of the cell organelle, **c)** fragmentary, encoded, passive DNA genetic messages – (**Static Genome**), **d)** a magazine of the material	**3. Building of the *tools* and the *machines* to:** **a)** *exploit* the environment, and to **b)** *protect* the organism against the detrimental influences of the environment **4. The origin of the specific behavior**
Table I.	***Reproduction***

[14] In this sense the inventor's and technician's achievements are in a more fundamental sense *human* than an artistic *opus.*, a portrait or a sculpture.

„Dynamism", „activity", „tendency" We think that it is necessary to distinguish between, at least, three different „levels" of the observed changes, which we will call the *dynamisms,* the *activities* and the *tendencies*[15]. The word *dynamism* will denote any distinguishable change of a given structure, be it functional or not. The hydrolysis of an ATP molecule, or a single muscle contraction is the dynamism. The word *activity* will denote a functional, complex and integrated dynamism which reveals no specific limit. The running, or heartbeating or eating is the activity. The word *tendency* will denote the activity which operates within an observed limit.

As an example of the *tendency* we may take a nesting behavior which ends when a structure of a nest is completed, or a movement of *Mougeotia* chloroplast which ends, when a new, proper orientation towards light is achieved. Similarly a „search" or „escape" behavior of *E. coli* also fits to the idea of *tendency*.

According to this terminology the monitoring will fall into the category of *activities* rather than *tendencies.*

After these terminological considerations we may now turn back to our subject of the protective adaptation.

A reflection on the data

The inner complexity of the adaptive dynamism

Protective adaptation and monitoring. It is clear, that the light-induced chloroplast movements in *Mougeotia* suggest the existence of a „monitoring" or photodetective system, capable to measure the intensity of illumination. Similarly a „search" or „escape" locomotory dynamism in *E. coli* indicates a subtle chemoreceptive capacity of the bacterium. Finally one has to admit, that megapods have means to monitor the actual temperature in the vicinity of their eggs.

Sensitivity of the monitoring systems. The monitoring system is activated by the amounts of energy absolutely insufficient to harm the organism[16]. Photodetection starts with the illumination at least 10^7 times weaker than the illumination needed to drive the photosynthesis (Kopcewicz *et al*. 1992/26-27). The harmful level of illumination must, of course, exceed the level necessary to drive photosynthesis. Photodetection is activa-

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[15] This distinction is analogous to the previously proposed distinction between the *elements, parts and wholes* (Lenartowicz, 1986/242-243, 1993). E. g. a carbon atom, or even an aminoacid molecule is an *element* of a bacterial locomotory system. A „stator", or a „rotor", on the other hand, is a *part* of this system. The „functional fit" exists between parts, not between elements. The „functional fit" is recognized where a transfer or a transformation of energy is achieved within the *minimum level of the dissipation of energy (synergy)*. In a bacterial proton engine a chemiosmotic proton gradient is „synergically" (i.e. economically) converted into a spin of a flagellum and this spin is further converted in the propelling force which moves the body of the bacterium in the liquid medium. A single part, of course, is not sufficient to do this, a *whole* system of fitting parts is necessary.

[16] In *Mougeotia* the „photosynthetic" pigments building the photon traps (chlorophylls of the light harvesting system), are both structurally and functionally different from the pigments engaged in the photodetection (phytochromes and cryptochromes).

ted by the amounts of light energy which are absolutely insufficient to drive photosynthesis. So, a tremendous gap exists between the intensity of photodetected light and the intensity of the light which could provoke any harm.

We do not have, unfortunately, any data concerning the maximal sensitivity of photodetection in *Mougeotia.* We know, however, that this organism detects both the intensity and the direction of falling light. The switch from weak light to strong light position of a chloroplast of *Mougeotia* is observed on the boundary dividing dusk illumination and moderate daylight illumination (cfr. Britz. 1979/178 ss)[17].

The sensitivity of the bacterial chemodetective system is also exceedingly specific. First, *E. coli* is able to recognize rather minute differences between the isomeric forms of hexose sugar molecules and the equally subtle differences between aminoacid and non-aminoacid forms of simple organic molecules (Macnab, 1979/315-316). A bacteria reacts to the 100 times more dilute solution of aspartate molecules than to its methylated form (Mesibov and Adler, 1972). It reacts to 1000 times more dilute solution of galactose than to its analog, 2-deoxy-D-galactose (Adler *et al*. 1973). It is a well known fact that the surface of the bacteria *E. coli* is covered with about 25.000 receptor molecules. They are remarkably sensitive to changes in the concentration of different forms of chemical substances over the range which in some cases extends from M^{-3} to M^{-10} (cfr Alberts *et al*., 1994/775-778 and Alan Ward, 1996 <http://monera.ncl.ac.uk/energy/chemotaxis.html>).

In the case of harmful substances, a bacterium is less sensitive, although it can, for instance, detect their presence far below toxic levels, and in the case of the indole it reacts with „escape" behavior to its 10^{-6} molar concentration.

The rather obvious sensitivity of thermodetection in the Megapodiidae does not need any additional comments.

Protective adaptation and photosynthesis. The first stage of photosynthesis consists in capturing the solar energy, the main and sometimes even the only source of biological energy. The chloroplast movements in *Mougeotia* evidently tend to protect this fundamental process.

Protective adaptation and the morphodynamic system. It is obvious that the photosynthetic system of a chloroplast is both structurally and dynamically different from the „morphodynamic"system which moves a chloroplast into the proper position in respect to the direction of illumination (see Fig. 3). Both are different from the photodetective system which monitors the direction and the intensity of illumination and from the „guiding" system which, on the basis of the detected information selects the proper locomotory activity[18]. Summing up[19] we may state that:

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[17] The growth inhibition of etiolated oats mesocotile may start on the influence of an even 10^{11} times weaker signal than the compensation point of photosynthetic system Kopcewicz *et al*., 1992/27.

[18] In all three examples we analyze the „morphodynamic" means, in fact, „locomotory", i.e. denotes the transport or reorientation of a material object in space.

[19] We limited ourselves to the *Mougeotia* case and skipped the analogous analysis of the protective adaptation in *E. coli* and in Megapodiidae. The results of such analyses may be easily and reliably predicted on the basis of the data we already mentioned.

The protective adaptation is an inherently complex set of monitoring, locomotory, guiding and energy supplying activities.

There is nothing revolutionary in this statement. This evident truth was expressed by Britz (1979/170):

„The mechanism [of the light-induced chloroplast movements] is considered in terms of a photoreceptor-effector system assumed to comprise a means of sensing light direction ... and intensity, an actual movement system to change chloroplast distribution, and a transducing mechanism capable of regulating the movement system."

In the above quotation Britz mentions photodetective, morphodynamic (we call it locomotory) and transducing systems (which we prefer to call the „guiding" system).

The „durability" and the „vulnerability" of the adaptive tendency

Now we may ask how the empirical data we described reflect on the outcome of our inquiry. Do these data reflect the dependence or, to the contrary, the independence of the organism from its surroundings ? The abstract essence of these data is presented in the table II.

	Escherichia coli	***Mougeotia***	***Megapodidae***
Surrounding	concentration of the chemical compounds	illumination intensity	temperature range
Monitoring divices	chemoreceptors	photoreceptors	thermoreceptors
Activity I. biologically essential parameters of the surrounding are *below* the adequate range	monitoring „serch" type of locomotion	monitoring chloroplast turned to the „weak light" position	monitoring heating of the eggs
Activity II. parameters of the surrounding are *within* the adequate range	monitoring	monitoring	monitoring

Table II

Monitoring. The least controversial element of this presentation is the item „monitoring”. The empirical data unquestionably demonstrate that:

The monitoring system is resistant to the enormous changes in the intensity of the specific environmental parameters.

This *mutatis mutandis* is also true in respect to locomotory (morphodynamic), the energy supply and the guiding systems. Their unimpaired dynamism is observed within a very broad range of intensity of the environmental physico-chemical causality.

Let us turn to another item of the table II.

Activity II. In each of the analyzed examples it is relatively easy to see, that in a certain, relatively narrow range of the environmental conditions an organism remains rather „passive”. The protective activity is null, apart from the constant monitoring. This „narrow” range of circumstances we will call the „adequate surroundings”.

Adequate surrounding. As we have seen the locomotory, monitoring, guiding and the energy supplying systems can operate efficiently and properly far beyond the limits of the „adequate surroundings”. On the other hand it is well known that excessive illumination may bleach photopigments and thus damage these fragile but essential elements of a cell's photosynthetic apparatus. It is also clear that the excessive or too low temperature may stop, damage or completely destroy the process of embryogenesis in an egg, and that toxic substances may kill a bacterial organism. So, one may ask, what trait distinguishes the biological activities which are relatively resistant from the ones which are most vulnerable.

To answer this question let us look at the Fig. 7. It represents two sets of activities. One – depicted on the horizontal plane – is composed of „functional structures”, i. e. „tools and machines” which form a functionally integrated complex. The second kind of activity, depicted along the vertical plane, consists in building this complex from the raw material and the raw energy of the surroundings. (An organism never incorporates a ready-made machine – it digests food, that means it destroys any functional organization of the material before it starts building the functional structures needed).

Now it seems that the developmental, integrative, biochemical and morphogenetic activities of an organism are vulnerable to fluctuations of the surroundings, and that the protective adaptation tends to create the optimal conditions of this fundamental biological activity. The most important conclusion is:

The developmental activities do not „fit” to the environment – that is why they are so vulnerable.

Activity I and III („search and escape” behavior). These two kinds of activity are complementary. The same „tools” are used in both of them. What distinguishes them is the direction of activity. But the tendency is manifest. It is the tendency either to create (megapods) or to find (bacteria) the environmental conditions which are optimal to developmental processes. So:

The developmental activities are carried in an „artificial” surrounding, created or selected by the organism itself.

An organism tends to oscillate within the narrow range of those environmental conditions which are optimal for the processes of development.

Conclusions

How to answer the main question of the present paper ? Is biological adaptation a manifestation of dependence, or rather independence of an organism from surroundings?

There is no simple answer to such question, mainly because the word „dependence" is highly equivocal.

Certain *dependence* between the monitoring, locomotory, guiding and the energy supplying activities, is unquestionable. This kind of dependence we may call the *functional dependence.* It appears between the coexisting, fully shaped structures, which are shaped in such a way, and arranged in space in such an order, that the flow of energy between them occurs with an exceedingly small increase of entropy (see Fig. 7).

Considering the relation between a „proton motor" and the complex dynamism which led to the proper shaping and proper mounting of its structures, it is clear that the motor is *dependent* on the specific biosynthetic and morphogenetic pathways. This relation is much more difficult to describe. First of all, we do not have *coexisting* structures. The structures in question are *in statu nascendi*. This kind of dependence we may call the *developmental dependence.* In the similar sense any car is dependent on the factory which produced it.

Finally we must consider raw material and raw energy, which are absolutely necessary to produce both the car and the „proton motor" of a bacterium. This sort of dependence we will call *material dependence.* But in this point another important distinction must be introduced.

Functional structures of living body are shaped from a material, but it is *not* a raw material. It is necessary to distinguish between the *raw, inorganic material* (e. g. carbon dioxide, water, mineral salts, random „rain" of photons) and the *transformed, biological material* (e. g. glucose, aminoacids, fatty acids, cellulose, chitin, bone, cartilage). It is also necessary to distinguish between *inorganic structures* (e. g. crystals, sediments, volcanic cones, river beds) and the *biological structures* (joints, sense organs, cell organelle, nests, spider nets and mussels). There is a clear difference between biological structures and the inorganic structures. Biological structures are accurately shaped by an organism and functionally integrated.

There is also an obvious, objective difference between the inorganic material and biological material. Actually, it is extremely difficult to change biological material back into raw, inorganic material. Even digestive, pathological and *post-mortem* processes can rarely degrade biological material back to a raw, inorganic form.

The raw material and raw energy are not, *sensu stricto* „provided" by surroundings. They are actively gained by specific, selective activities of the living body. A necessity of new raw material and energy arises from the spontaneous and permanent tendency of a living being to develop – i. e. to build new biological structures. During developmental processes the raw material is transformed into functional structures of the living body. The development is a step-by-step process. Even the first stage of developmental transformation can be recognized as biologically transformed material.

We may now ask if an organism is positively *influenced* by the surroundings. The word „influence" is also equivocal. There are *lethal* influences of the surroundings, e.g. by an excess of heat or toxic material. There are also mutilating influences. Finally the surroundings' energy may release a protective activity of the organism, and in this way to „influence" its dynamism.

This is the problem of the environmental „stimuli". Are they influencing the organism and if so, in which sense might this be understood?

We have seen that an organism

(1) is *dependent* on the raw matter and the raw energy and

(2) incessantly *monitors* the level intensity of environmental energy (be it chemical or physical).

In both cases it is an organism itself which produces tools and machines capable to detect minute changes in the environmental parameters. So, it does not seem proper to suggest that the environment „produces stimuli". The essential property of an organism is to determine which kind of raw material and raw energy will be utilized in its developmental tendencies. It is also an organism itself that decides which environmental parameter will be monitored.

We may conclude that the biological protective adaptation does not confirm the general thesis which claims that the surroundings positively determines essential biological phenomena, or that an organism may be considered as a co-product of the genetic program and the environmental influences. The above thesis seems to be founded on a lack of proper analysis of the empirical data and on the confusion of the ideas provoked by linguistic ambiguity. Modern biology claims that surroundings shape the developmental messages, enciphered in the specific sequence of the DNA monomer units present in all living cells. This, supposedly, is the result of random mutations and the sieve-like „activity" of the surroundings („natural selection"). Mutations and natural selection therefore, constitute the main creative dynamism which yields new developmental possibilities and new dynamic faculties of a living being.

This theory, however, seems absolutely unacceptable. It suggests that inner properties of an adult body are the consequence of the random influences of surroundings. The modern reconstruction of molecular dynamism gives no support to such a thesis. To the contrary, the study of molecular dynamism of living cell reveals a surprisingly high level of order and an unexpected capacity to counteract any possible damage. The *explanans,* therefore, simply does not fit the *explanandum.* The deceptive power of the above mentioned thesis is hidden on the level of words, rather, than data. The „impossible" is called „improbable", the „improbable" is called „almost impossible", the „almost impossible" is called „infinitesimally possible", the „infinitesimally possible" is called „the best possible explanation" of phenomena of life. What is „the best" in the above verbal game? The „best" means agreement with the thesis:

the dead matter is the only existing reality.

In this way, an arbitrary, metaphysical thesis becomes a leading criterion of biological research. From the biological point of view such a restrictive criterion can hardly be accepted as the best solution.

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ADAPTACJA BIOLOGICZNA: ZALEŻNOŚĆ CZY NIEZALEŻNOŚĆ OD ŚRODOWISKA?

Streszczenie

Pytanie zawarte w tytule artykułu może się wydawać trywialne, czy wręcz zbędne. Wszak większość współczesnych biologów już dawno rozstrzygnęła ten „dylemat” – organizm żywy, mimo niekwestionowalnej autonomii strukturalnej i funkcjonalnej jest zdecydowanie *zależny* od otoczenia. Szczególnie wyraźnie przejawia się to jakoby w tzw. *adaptacjach biologicznych*.

„Możemy zatem stwierdzić, że znaczna część przystosowania organizmu do środowiska polega na tym, że rozwój każdego osobnika jest kształtowany przez środowisko, aby do niego pasować. W ten sposób rozwiewa się przynajmniej część tajemnicy jaka spowijała zjawisko adaptacji” (Newman, 1947349).

Ho (1984) dochodzi do przekonania, że zmienność organizmów obserwowana w przyrodzie – traktowana przez neodarwinistów jako przykład adaptacji – może być wywołana chemicznymi (woda, proste substancje pokarmowe) lub fizycznymi (np. temperatura) czynnikami obecnymi w otoczeniu. W konkluzji autorka stwierdza, że zewnętrzne środowisko odgrywa centralną rolę w tworzeniu i w ewolucji adaptacji.

Takie poglądy, w naszym przekonaniu, są wyrazem nieporozumienia i opierają się przede wszystkim na błędnym opisie zjawisk. W dużym stopniu wynikają też ze stosowania bardzo dwuznacznej terminologii. Celem obecnego opracowania jest z jednej strony dokładne przeanalizowanie danych empirycznych a z drugiej strony próba ukształtowania bardziej precyzyjnych pojęć i bardziej jednoznacznej terminologii.

Jako przykłady niekwestionowalnych zjawisk adaptacyjnych wybraliśmy: różne formy zachowania lokomocyjnego u bakterii *Escherichia coli*, tzw. *fototropizm* u zielenicy z rodzaju *Mougeotia*, oraz złożoną, instynktowną działalność samców nogali *(Megapodiidae)* opiekujących się jajami.

Bakteria *E. coli* wykazuje trzy formy lokomocji: (1) tendencję bezkierunkową, umożliwiającą efektywną eksploatację zasobów pokarmowych najbliższego otoczenia, (2) tendencję poszukiwawczą, dzięki której bakteria znajduje nowe rejony bogatsze w cząstki pokarmowe, oraz (3) tendencję ucieczki, gdy bakteria wykrywa obecność czynników szkodliwych.

U zielenicy, wykorzystującej energię świetlną środowiska, obserwujemy trzy analogiczne tendencje jej wewnętrznych struktur lokomocyjnych. Gdy do aparatu fotosyntetycznego dociera optymalna ilość fotonów, układ lokomocyjny nie przejawia aktywności. Nazwijmy to tendencją spoczynkową. Tendencja poszukiwawcza (ustawianie chloroplastu prostopadle do światła) pojawia się, gdy poziom energii docierającej do chloroplastu opada. Natomiast tendencja unikania (ustawianie chloroplastu krawędzią w kierunku padającego światła) pojawia się, gdy poziom tej energii zbytnio wzrasta.

Te trzy formy tendencji równie wyraźnie pojawiają się u nogali. Gdy poziom temperatury w bezpośrednim otoczeniu jaj jest optymalny dla rozwoju zarodkowego, samiec nie wykazuje tendencji do zmiany tej sytuacji. Gdy temperatura wokół jaja opada, samiec szuka sposobów by temperatura powróciła do poziomu optimum. Przeciwnie, gdy poziom temperatury zbytnio wzrasta, nogal stosuje różnorodne zabiegi obniżające temperaturę do optimum.

We wszystkich trzech wypadkach stwierdzono, że organizm posiada bardzo subtelne, selektywne narzędzia pomiaru (monitorowania) parametrów takich jak stężenie substancji chemicznych, intensywności oświetlenia lub poziomu temperatury. Te narzędzia pomiaru są z jednej strony bardzo precyzyjne, a z drugiej bardzo odporne na stosunkowo ogromne wahania poziomu rejestrowanego parametru.

Samo istnienie narzędzi monitoringu nie wystarcza do wyjaśnienia opisywanych zjawisk adaptacji osłonowych. Równie niezbędny jest odpowiednio ukształtowany *system lokomocji* zewnętrznej (jak u nogali lub u *E. coli*), bądź wewnętrznej (jak u zielenic), *system dostarczający odpowiedniej formy energii* oraz *system „sterujący”*.

Wszystkie te systemy są nie tylko czysto logicznym postulatem teoretycznym, ale zostały zaobserwowane i opisane w swojej strukturze cytofizjologicznej. Są one maszyno-podobne, lub narzędzio-podobne. Struktury maszyno-podobne są tak zdeterminowane swoją wewnętrzną budową, że ich dynamika nie poddaje się sterowaniu i jest absolutnie *monofunkcjonalna*. Przykładem mogą być tu receptory systemu monitorującego, pewne elementy struktur lokomocyjnych, np. silniczek protonowy, pompy protonowe i ogólnie pojedyncze cząsteczki enzymów. Sterowanie tego typu maszynopodobnymi strukturami może się odbywać jedynie poprzez system zaopatrujący w energię.

Czym innym są struktury narzędzio-podobne. Ich przykładem mogą być kończyny lub dziób nogala. Takie struktury nie są monofuncjonalne. Bywają zaangażowane w bardzo różnorodnych formach aktywności (grzebanie, kopanie, nagarnianie, poszukiwanie lub ucieczka). Ich wewnętrzna struktura nie determinuje wyboru takiej lub innej formy aktywności. O tym decyduje element behawioralny. Ten element jest jak dotąd mało poznany. Jego dynamikę u wyższych zwierząt wiąże się ze strukturami centralnego układu nerwowego, ale i tu natura tej dynamiki pozostaje zagadkowa.

W adaptacji osłonowej mamy do czynienia z zachowaniem się (behawiorem) organizmu jako całości*.

Wszystkie wspomniane wyżej systemy i ich specyficznie ukształtowane struktury powstają w procesach biosyntezy, cytogenezy i ewentualnie embriogenezy. Ten rozwój dotyczy też, w jakiś sposób, dynamiki behawioralnej.

Tu dochodzimy do pewnego paradoksu. Okazuje się, że procesy biosyntezy, cytogenezy i embriogenezy, czyli procesy rozwojowe są niezwykle wrażliwe na wpływy otoczenia. Otoczenie ma na te procesy działanie destruktywne, a w najlepszym wypadku pozostaje obojętne. Gdyby nie zjawiska typu adaptacji osłonowej, organizm dawno uległby zniszczeniu, lub przynajmniej uszkodzeniu i to we wczesnym etapie swego istnienia. Tak więc w trakcie rozwoju budowane są struktury, które niejako automatycznie będą chronić sam proces rozwoju. Nie ma tu zatem śladu „zależności" dynamiki biologicznej od środowiska. Wprost przeciwnie, można tu dostrzec wyraźne elementy *opozycji* pomiędzy dynamiką środowiska a dynamiką organizmu. Tendencja organizmu do uniezależnienia się jest tu oczywista.

Mimo to, wiemy, że organizm „potrzebuje" środowiska. Na czym to polega? Organizm budując swoje struktury musi czerpać z otoczenia surowy materiał i surowe formy energii. Organizm działa w otoczeniu, porusza się we wodzie, w powietrzu, we wnętrzu ziemi jak rosówka. Oba te działania, budowanie i poruszanie się, są aktywnością zupełnie immanentną, autonomiczną, mimo, że materiał otoczenia stanowi dla obu warunek konieczny. Jest to warunek całkowicie bierny, i nieporozumieniem byłoby uznanie go za dynamikę *współkształtującą* struktury organizmu.

Rozważmy to bardziej dokładnie. Struktury organizmu są zbudowane z *materiału biologicznego.* Materiał biologiczny powstaje wskutek przekształceń surowego materiału, selektywnie pobranego przez organizm z zewnątrz. Podobnie ma się rzecz z energią. Nie jest prawdą, że to środowisko „dostarcza" organizmowi materiału i energii.

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* „Zachowanie jako pewien typ stosunków ze środowiskiem może mieć miejsce tylko w całym organizmie. Nie zachodzi ono w poszczególnych segmentach czuciowych i ruchowych, izolowanych i niezależnych od siebie" (Tolman, 1995/37). Zjawiska adaptacji osłonowej są wyrazem tendencji behawioralnych i stosuje się do nich, bez żadnych istotnych ograniczeń, pojęcie *celu* i pojęcie *poznania,* tak, jak ono bywa stosowane przez zoopsychologów.

Organizm autotrofów przekształca tylko ten materiał mineralny który sam, swoimi strukturami, selektywnie wchłonął z otoczenia. Heterotrofy, natomiast, są *absolutnie* uzależnione od prostych materiałów biologicznych wyprodukowanych z surowca mineralnego przez autotrofy. Przekształcanie surowego materiału jest wieloetapowe. Jego przykładem może być budowanie cząsteczki glukozy w procesie fotosyntezy (np. cykl Calvina), budowanie cząsteczki ATP, cząsteczek aminokwasów i innych „cegiełek” stanowiących materiał do dalszej biosyntezy. Jeśli z zewnątrz, do organizmu, trafi złożony materiał biologiczny, zostanie on „strawiony”. Znaczy to, że organizm degraduje bardziej złożone struktury biologiczne i używa jako materiału budulcowego tylko prostych form chemicznych. Jedynie w wyjątkowych wypadkach (witaminy) organizm korzysta z gotowego, bardziej złożonego materiału biologicznego, ale i tu mamy do czynienia ze związkami chemicznymi o stosunkowo prostej budowie. Takie związki są zresztą selektywnie wchłaniane i selektywnie wkomponowywane w struktury ciała.

Istnieje ogromna różnica pomiędzy surowcem mineralnym a materiałem biologicznym. W materiale biologicznym jego pochodzenie z organizmu żywego jest prawie niemożliwe do zatarcia. Nawet popiół ze spalenia organizmu wyraźnie różni się od popiołów nieorganicznych, np. wulkanicznych. W przyrodzie martwej nie występują procesy, które mogłyby produkować substancje podobne do materiału biologicznego. Gdyby sonda marsjańska Viking odnalazła na Marsie materiał podobny do biologicznego, byłby to mocny dowód istnienia tam kiedyś procesów biologicznych.

Porzućmy teraz proces wchłaniania surowca i przejdźmy do dynamiki jaką organizm wykazuje w ramach środowiska. Ta dynamika w niczym istotnym nie przypomina dynamiki samego środowiska. Lot ptaka nie da się racjonalnie porównywać z „lotem” obłoków, lub z „lotem” trąby powietrznej. Pływanie ryby lub bakterii *E. coli* w płynie, nie da się rozsądnie porównywać z pływaniem kry w rzece, lub przemieszczaniem drobin mułu w prądzie wody. Lot ptaka nie da się też porównać z podmuchem wiatru, podobnie jak pływanie pstrąga nie da się porównać z prądem strumienia.

Obłok unosi się w powietrzu, bo jego gęstość jest mniejsza niż gęstość powietrza. Gęstość ciała ptaka jest zdecydowanie większa niż powietrza. Obłok jest biernie przenoszony przez prądy powietrzne, natomiast ptak aktywnie przeciwstawia się tym prądom lub aktywnie je wykorzystuje.

Jak organizm „wykorzystuje” dynamikę prądów powietrza, lub dynamikę prądów wody? Czyni to przy pomocy precyzyjnie ukształtowanych, funkcjonalnych struktur, przy pomocy informacji dostarczanych przez system monitoringu, czyni to selektywnie, w sposób wyraźnie podporządkowany podstawowym tendencjom biologicznym, takim jak poszukiwanie pokarmu, ucieczka przed niebezpieczeństwem, aktywność rozrodcza.

Powtórzmy, struktury lokomocyjne ptaka, zmysłowe struktury ptaka, behawior ptaka są rezultatem procesu rozwojowego, który środowisku zawdzięcza jedynie surowy materiał i surową energię. Jeżeli organy lokomocyjne ptaka okazują się idealnie sprawne w środowisku powietrza, to nie jest prawdą, że powstały one w skutek dynamiki powietrza. Dynamika kształtująca skrzydła ptaka nie posiada żadnego odpowiednika w dynamizmach materii martwej. To samo *mutatis mutandis* można powiedzieć o dowolnym organie dowolnej formy żywej. W każdym bez wyjątku wypadku środowisko jest zaledwie biernym magazynem surowego materiału i surowej energii.

Nowoczesna biologia głosi, że otoczenie kształtuje zapis instrukcji rozwojowych, zaszyfrowanych w nieprzypadkowej sekwencji monomerów cząsteczki DNA, występującej w każdej żywej komórce. Te chaotyczne wpływy, zwane mutacjami, są następnie, jak głosi teoria, odcedzane przez dynamikę otoczenia i to nazywane jest selekcją naturalną. Mutacje i selekcja naturalna są więc uznane, dzięki owej teorii, za decydujący, kreatywny mechanizm, produkujący nowe możliwości rozwojowe i nowe zdolności dynamiczne powstających w ten sposób gatunków.

Ta teoria, w świetle nowoczesnych danych biologicznych, wydaje się absolutnie nie do przyjęcia. Sugeruje ona, że wewnętrzne właściwości dojrzałego organizmu są, w ostatecznym rozrachunku, skutkiem chaotycznej dynamiki otoczenia. Nowoczesna rekonstrukcja dynamiki molekularnej, cytofizjologii, w najmniejszym stopniu nie daje oparcia dla takiej hipotezy. Przeciwnie, badania w zakresie biologii molekularnej najprostszych nawet komórek żywych wykazują zaskakująco wysoki poziom porządku i zadziwiającą zdolność do przeciwdziałania ewentualnym uszkodzeniom, oraz zdolność do naprawiania rozległych okaleczeń nawet okaleczeń samej cząsteczki DNA. Tak więc *explanans* po prostu nie pasuje do *explanandum.*

Złudna moc owej teorii wynika raczej z gry słów, niż z manipulacji na poziomie samych danych empirycznych. Jeśli to, co „niemożliwe" nazwiemy tym, co „nieprawdopodobne", a to co „nieprawdopodobne" utożsamimy z tym co „nieskończenie mało prawdopodobne", wtedy pojawia się fikcyjna „możliwość", że to, co „nieskończenie mało prawdopodobne" jest jednak „najlepszym z możliwych wyjaśnień" zagadki. Termin „najlepsze" oznacza tu zgodność z tezą, że jedyną, istniejącą substancją jest materia martwa. W ten sposób arbitralna, aprioryczna teza materializmu staje się kryterium poprawności badań i rozwiązań w dziedzinie biologii. Z punktu widzenia biologii nie jest to rozwiązanie poprawne.