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Bionic - element for fixing the aim and finding the solution in the technical problem solving process

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Bionic - element for fixing the aim and finding the solution in the technical problem solving process

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Bionic - an approach for determining the aim, the method used and the solution to a problem or opportunity

Nature, with its great variety of efficient structures, is suitable as a source for the stimulation of possible ecologically sound and ergonomic solutions to problems and opportunities.

Examples in nature can become a creative element within the process of producing a solution to a problem. The rules of biological evolution can be used both for determining the aims and the principles of the functions of structures and organisations as well as providing a model for determining solutions. The Bionic approach, learning from nature, is being used in a number of subject areas in addition to technology. The approach is seen as reducing the gap between the man made world and nature. The bionic approach helps to link the mathematical approach of engineering with the aesthetic forms of nature. Examples are included which show how technological solutions were developed based on analogies, or models, of biological systems.

1 Learning through nature, bionic and technological education

Nature-orientated training and education has the aim of enabling students (female and male) to understand nature itself. Students find out that nature is interesting, beautiful and essential. Thus, nature can be revealed in such a way that students recognise nature as part of their world of experience, a sphere of life which can be a stimulus for solving problems.

Fascination, charm, gracefulness, beauty, smartness, wit and intelligence are points of orientation for conducts with nature (1,p. 11).

Countless examples show that nature has always been a major source for innovation. Nature has been and is an example for the solving of technical problems. Because of its fullness and variety of biological structures nature represents an inexhaustible reservoir of ideas.

Bionic - still a new branch of science - deals systematically with the technical realisation and application of construction processes and the principles of the development of biological systems (2, p. VIII)

Bionic, like 'technics', oriented towards nature, a kind of analogy to the technical problem solving process. Therefore, bionic is important for the pedagogical process, because bionic arouses interest for the beauty, functionality and efficiency of biological structures found in nature.[See Fig. 1]

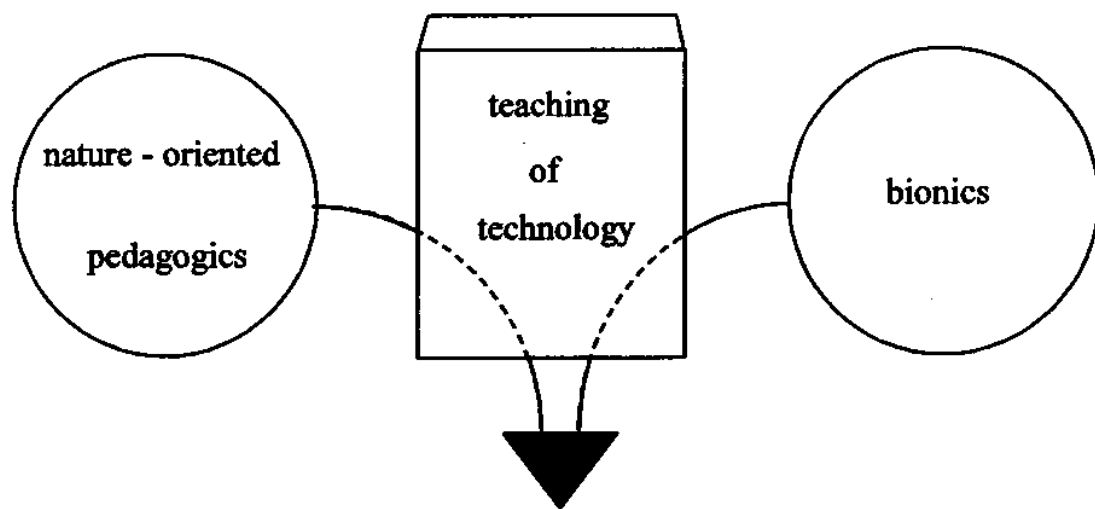
Students can bring creatively this wealth of experience into the technical solutions of problems. Technological education, which supports bionical thinking and acting, connects the calculated rationality of technics with the sensual-aesthetical shapes of nature.

Nature becomes an important source of inspiration in technology lessons. It is a source which provides material for thinking and learning.

2 Ways of thinking and acting which overcome the possible gap between nature and 'technics'.

Bionic uses analogies as a fundamental approach. Starting from a technical function to be realised, biological systems with similar functions are determined. The characteristics of the functions are compared and afterwards the possibilities of transferring the structural characteristics of the biological systems to the proposed technical system are checked.

Fig. 1 Nature - orientated teaching of technology



- Developing a creative attitude towards nature
- Using nature as an approach and source of knowledge (creatures as partners to talk to)
- Encouraging close connections with nature - a closer observation by enabling encounters with nature
- Developing ways of thinking and acting which overcome the gap between models in nature and the technological solution

In order to make the formation of analogues more effective there exists the possibility of using catalogues of structures of biological systems. By using such catalogues as sources of inspiration, problem recognition and, or, data bases problem solving can be made easier or speeded up.

By considering examples from nature and the technical function to be realised, possible analogies can be found systematically. By the use of analogies the main point is not the exactness of transformation but the resulting inspiration achieved. Biological systems can become the starting point of the problem solving process. Because an example for nature cannot usually be transferred directly to a technical problem many cognitive skills are required.

The use of analogies of nature are important for the following reasons:

1. Nature had a period of development of millions of years in order to produce an immense variety of functional structures (principle of the optimum construction)

2. Closed cycles exist in nature which are examples of control systems (principle of self-regulation)
3. The existing systems in nature:
 - are produced and maintained with a minimal use of material and energy (principle of economical effectiveness)
 - have the possibility of renewing or changing their components without changing the basic structure (principle of self-regeneration)
 - consist of a minimum of basic elements which are combined in such a way that they produce a maximum of living functions (minimum-maximum-principle).

Taking these aspects into consideration in problem solving processes, it is possible to shape technical systems:

- more perfectly
- more efficiently and
- more ecologically.

The creative transformation produced by this orienteering strategy into technical systems makes it possible to adjust 'technics' so that

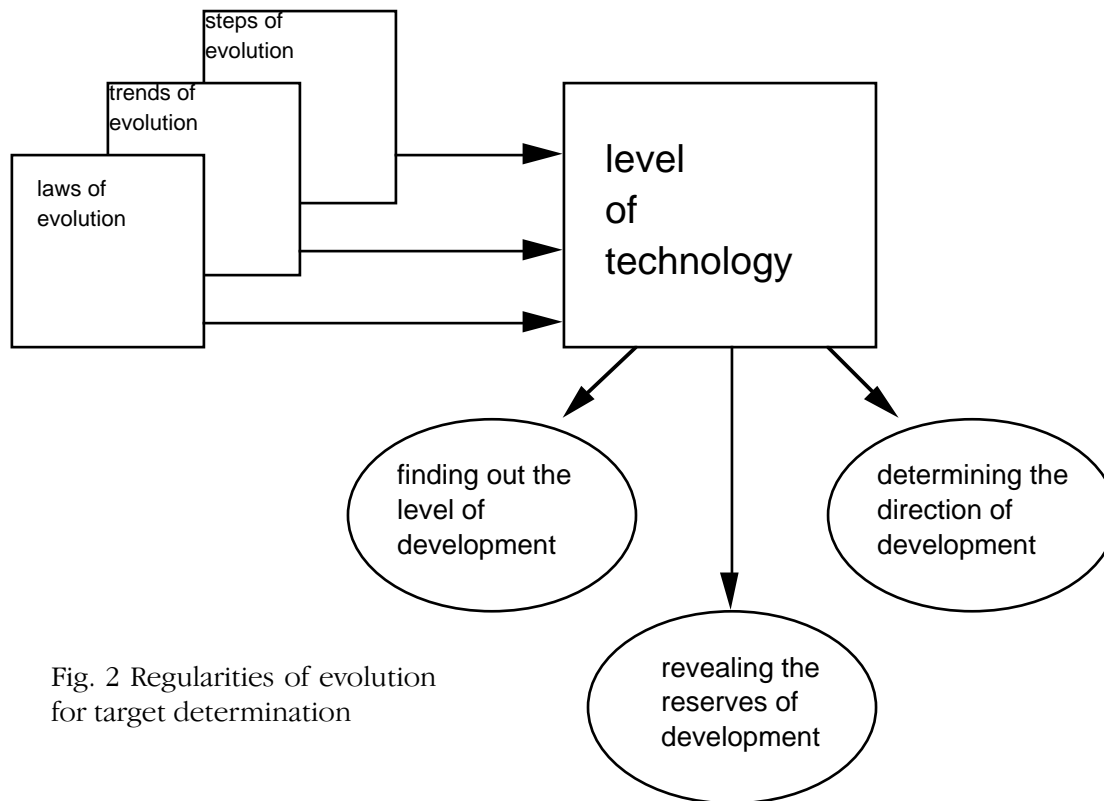


Fig. 2 Regularities of evolution for target determination

development can take place according to the biological rules and principles of evolution. In this way, a harmony can be obtained between 'technics' and the biosphere.

3 Structures of the bionical processes of thinking and acting

The bionical process of thinking and acting is directed by the determination that the aim to be realised is successful ideas for solutions. The determination of the aim is based on the rules of evolution. The determination of the aim can be performed using the following steps:

1. determine the level of 'technics'
2. transfer the rules of evolution to the level of 'technics'
3. derive conclusions in order to formulate solutions for the technical system to be developed. [See Fig. 2]

The biological system represents the starting point for finding a solution. This will be found by analogy forming by comparing the technical function to be realised with examples in catalogues of the structure of biological systems (compare fig. 2). There is also the possibility of carrying out investigations in nature in order to analyse biological systems.

In both cases relevant structures have to be revealed and the active principle has to be determined. [See Fig. 3]

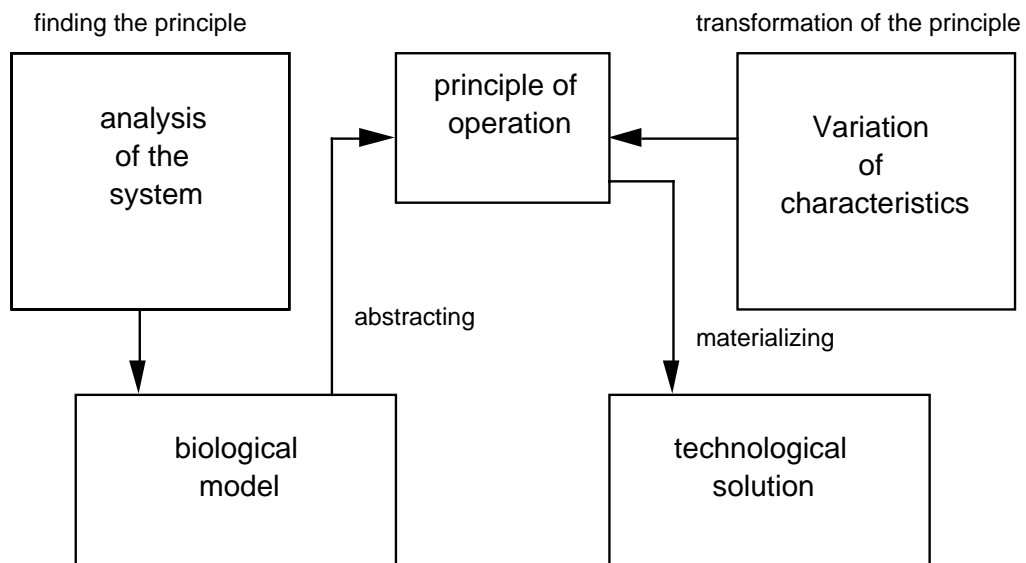
The obtained principle can be put into a technical solution by the variation of and/or the combination of elements of structure on the basis of the demands, conditions, and need required. As far as that goes, this procedure is based on the understanding of biological systems on one side and on the other side the understanding which leads to the application of the principle into the technical solution.

The solution finding is characterised by the following steps:

1. defining the required technical function
2. finding the biological example, which fulfil this function
3. transferring the knowledge gained to the problem to be solved.

The ability of students to use analogies is acquired by applying orienteering functions to the finding of solutions. Using this approach an interest is consolidated that the variety in nature is something worth protecting.

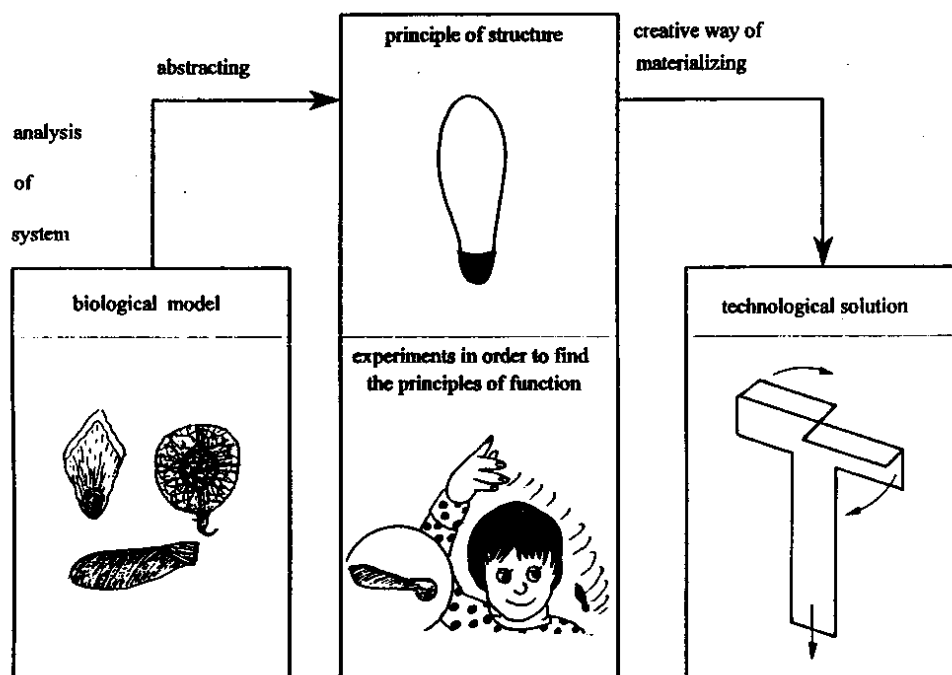
Fig. 3 Process of bionic thinking and acting



4 Examples of technology lessons

4.1 Development of the helicopter principle based of the maple- seed (Elementary school)

Fig. 4 Process of bionic thinking and acting



4.2 Development of a space - saving solar sails for space stations (Secondary school)

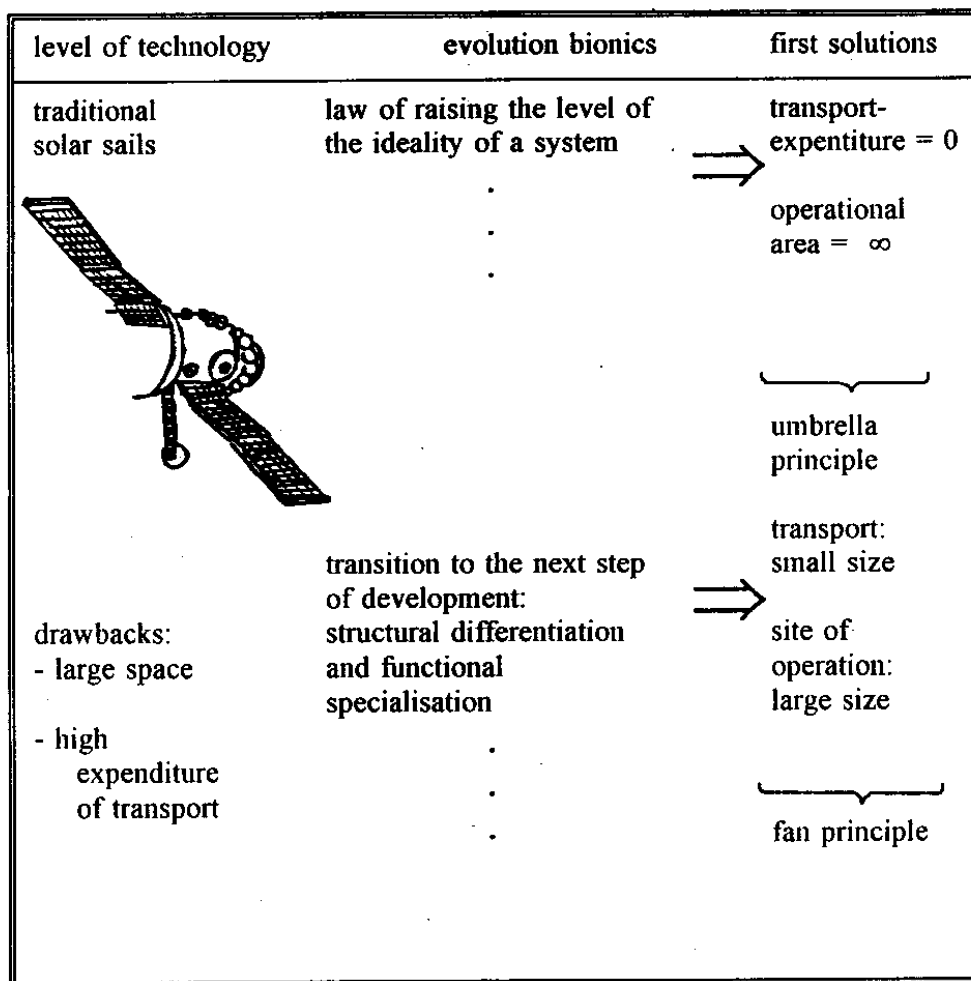
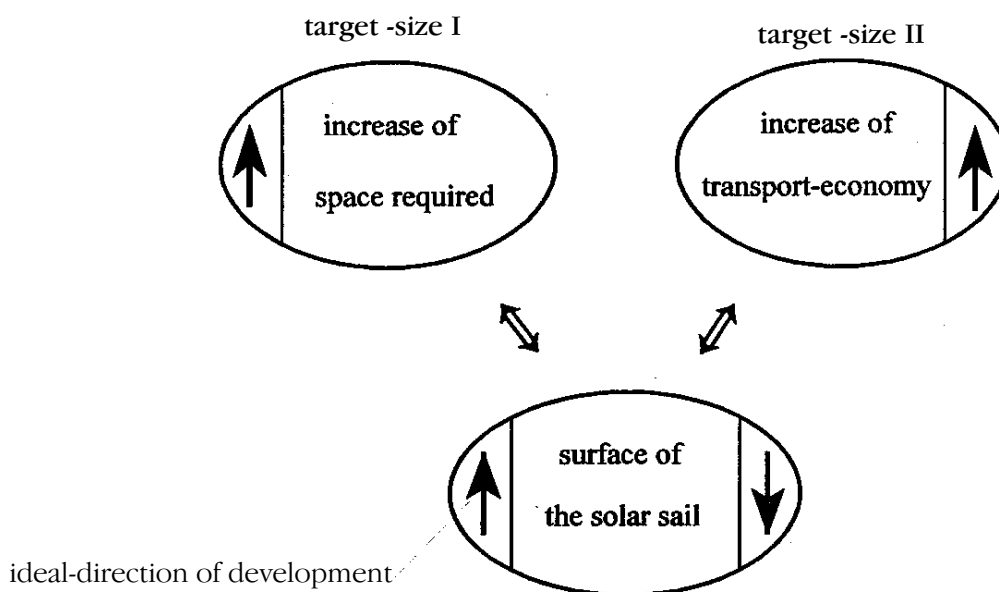


Fig. 5 Development of space-saving solar sails for space stations



constructive - paradoxical requirement:
 dimension - reducing surface enlargement

Fig. 6 Analysis of a contradiction in development



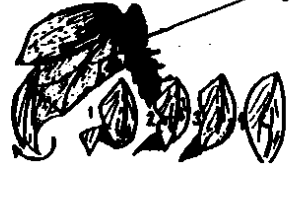
structure - catalogue: Shaping of matter			
magnifying and reducing size			
No.	name of objekt	structure of object	characteristics of function
1	Wings of cockroach (<i>Blatta orientalis</i>)		Between the foldet and the open wings one part of the structure is forced into concavity and the other part into convexity by the bent folds.
2	Wings of haylo eust (<i>Pachitilus migratorius</i>)		Hindwings fold into zig zag stripes running up and down.
3	Wings of may-cockchafer (<i>Melolontha vulgaris</i>)		Hindwing opens after phases 1 - 4 caused by muscles and folds in the same way.

Fig.7 Structure - catalogue : shaping of matter

Solutions of Contradictions


formation by analogy in order to produce of associations		
biological structure	associations	
1. wings of the cockroach →	transversally and longitudinally folded solar sail	
2. wings of the earwing →	fan - shaped solar sail	
3. rostrum of the cabbage butterfly →	unrolling solar sail	
4. patagium of the bat →	spreading solar sail	
5. folding petals →	blossom - shaped solar sail	

Fig. 8 Solutions of Contradictions