Darwin – and what's next?

The successes of the theory of natural and artificial selection are overwhelming – however, we are still far away from a universal explanation of life events and a real understanding of societal developments.

I would like to briefly outline what a more general view of evolutionary processes could look like, and what advantages would result from this.

The law of entropy governing the inanimate world seems to hold good for the animated world as well. Life events cannot violate basic physical interrelationships – and they don't do it, either. Life events are processes establishing order; they resemble resistance against the omnipresent effects of increase in entropy.

This particular function of bringing order into a system can only be implemented when there is energy available which will maintain the structures brought into order. Resistance against increase in entropy is always locally confined; the entropy of the overall system is then increasing that much stronger.

The inception of life, the buildup of structures assimilating and converting energy, procreating and then evolving further, is obviously a process of building up a certain form of order and assimilating information.

How does this information enter into the evolving structures? Where does it come from, and where does it lead to?

If we take a closer look at the selection process, it corresponds with what is generally known as “optimization”. System properties are altered for as long as is needed for them to correspond to local (extreme) values of a target function. This target function is located in a multidimensional space, the so-called state space. Each dimension of the space represents a system property. The selection process, an optimization process in itself, thus transports the structure of the target function into the system.

An information transport takes place from the source, in the following referred to as “evolutionary criterion”, to the “drain”, the evolving system. Obviously, this information transport only comes into being via the optimization process which is searching for more beneficial system conditions.

The question to be asked is: how could this information transport have become more effective over time?

The process of natural selection features two supports: first, the variation of the system, and second, the selection criterion providing the information.

Let us first take a look at the variation of systems to be selected. The variation results in slight system deviations which are assessed and selected by the selection criterion. If there should be a transition from passive to active adaption now, like the evolution of organisms as an information-assimilation process suggests, then the support pillar "variation" would be a point of contact. If a system itself could take over the procedure of generating variations, then the threshold from passive to active adaption would have been passed – the system would be able to actively intervene into its adaption process.

The question that poses itself in the classic view of evolutionary theory is the question about the evolutionary advantage. This question can be answered with a referral to faster adaption. Whoever is capable of generating their variants themselves can determine when variants are being generated and how pronounced the generated deviations are. Looking at the Internet links below, it turns out that there is an evolutionary advantage in taking over the variation and actively interfering into the own adaption process.

This takeover of the variation sounds a little bit too theoretical. The biologists Patricia Foster and Jill Layton found such a mechanism in E. coli bacteria. E. coli bacteria copy their own DNA with the RNA polymerases I, II and III nearly fault-free. In reserve, there are the polymerases IV and V which are copying with a higher fault rate, thus increasing the range of variation. In case of stress, the stress protein sigma-38 switches from standard replication via the polymerases I, II and III to polymerase IV.

Under stress, the range of variation increases, and the chances of survival for that particular species increase as well. Thus, a mechanism exists which can switch back and forth between narrow and wide ranges of variation, according to the individual living conditions. As the switchback without stress to nearly fault-free copying, system stability at its optimum, is sensible as well, the acquisition of this particular switch translates to an evolutionary advantage. A demand of the system, heretofore conveyed to it selectively, is now actively carried out by it.
E. Coli: http://newsinfo.iu.edu/news/page/normal/1160.html

Flagellates and yeast cultures also switch from asexual to sexual reproduction whenever certain living conditions necessitate this. Yeast cultures:
http://www.welt.de/data/2003/03/17/53299.html

Also see: http://www.heise.de/tp/r4/artikel/21/21407/1.html

What about the second support pillar of optimization via selection, the selection of suitable system states?

If a living organism can exert an active influence upon its living conditions, its chances of survival and those of its offspring are increasing. One of the first major achievements in evolution is the ability to move from one location to another. From the view of cybernetics, motivity is also a shift in the state space, as is the alteration of the system structure. In this state space, it is important for the system to find the local optimum. The individual depends upon the structure it has inherited. The ability to actively move in this state space includes the ability to change locations and to adapt one's own structure accordingly.

Those who want to actively move in the state space must be able to orient themselves within it. The attack on the second support pillar of optimization is inseparably connected to this essential fact. There won't be any precise target-oriented motion if the direction is not known. The location of the optimum, target of the motion which started out passively at first, must be known. What remains to be explained is from where the system will receive information about the location of the optimum.

As was shown above, in the first phase of transition from passive to active adaption, the variation of system conditions can take place. With respect to an individual, this would mean that it tries to optimize its condition via trial and error. At this point, the individual´s own survival is more important than that of the species. Consequently, a feedback with regard to the chances of survival is ruled out for the individual. It has to rely upon a different way of feedback. Sensors now provide the individual with feedback about environmental influences. The individual can evaluate the success of its structural or locational changes and has now itself taken over the reaction to optimization feedback which used to carry out the natural selection. As such, the first phase is a trial-and-error stage with sensor feedback.

In the further course of events, practical experiences are accumulating. Trial and error with sensor feedback is replaced by learning. Favorable system conditions are memorized. The result is an image, a model of the environment. Once these interrelationships are learned and understood, the active search for favorable system conditions can take place in a targeted way. For instance, a strategy of searching for food using the trial-and-error approach with sensor feedback would resemble a random choice of the direction of motion with a reverse motion in case of food scarcity.

Different search strategies are possible, depending upon the quality of sensory feedback. Highly developed feedback mechanisms allow the living organism to directly follow the gradient decline and to thus find the shortest path to optimum conditions.

The environmental model coming into existence as sum total of all adaptive functions will determine the behavior of the system. This model stores advantageous patterns of behavior and makes them available for information retrieval. In the further course of building up this model, the stored interrelationships are subject to abstraction. Abstraction offers the advantage of more effective memory storage and the possibility to extrapolate conditions for which no experiential data exist up to that point.

For this prediction, it is advantageous when one's own existence is reflected in the model. In the course of perfecting itself, the model will therefore mirror the own position of the system in the world – conscious awareness begins to evolve.

A highly developed environmental model and an idea of favorable living conditions will result in the system going into action, function by function. The system starts to adapt the environment to its requirements. The original flow of information from inanimate nature to the animated system starts to run in reverse. The system designs the environment according to its own needs and wants.

The environment is not inanimate exclusively. Prey, partners, and competitors are also part of the scene. Certain living environments only exist due to the presence of other living organisms in that environment, as we can see in the examples of treetops, coral reefs, symbiotic relationships, or parasites. In this way, a wide complex of interaction opens up.

The evolving biological systems going into action lead to the exertion of an influence upon the environment and thus upon other systems, as was shown above. The interaction between systems creates an additional increase in evolutionary speed and efficiency. When systems are interdependent upon one another they set parts of their evolutionary criteria on a mutual basis.

As such, it is reported that a parallel evolution of the dentition of herbivores and the storage of wood material in plants has taken place. The plants were subject to selection, the criterion being resistance to herbivores. They developed thorns, poison, and wood material. The dentitions of herbivores developed stronger molars. Mutual influences of this nature are the typical avenues of evolution. A system adapts to certain conditions, it slowly moves towards the optimum. The other system does the same thing, thereby moving the optimum farther away. This mutual encouragement to engage in even higher performances will not subside for quite some time. The systems set a part of their evolutionary criterion on a mutual basis.

The contest between systems is subject to evolution even though these systems do not consciously fight each other. In the case of optimization processes considered up to now, the potential, the evolutionary pressure, ceased upon approximating the optimum. In this case however, pressure is maintained due to the reaction of the other system. If the evolutionary speed is dependent upon potential reduction – something which can reasonably be assumed – then it will not decelerate in the latter case.

In general, we can observe certain trends in evolution. Systems utilizing the energy at their disposal more efficiently have advantages over other systems. Systems capable of actively moving towards the optimum in the state space have advantages over other systems because they are also able to adapt faster to new conditions at hand. Systems having actively gained a certain motivity in several dimensions of the state space have several advantages, and their chances of survival are higher. Systems featuring a hierarchical structure and capable of quickly executing essential functions at a lower level, as well as complex functions at a higher one, also have advantages over other systems. Systems capable of abstracting information assimilated and thus capable of utilizing their memory storage more effectively, and being able to predict environmental conditions and reactions, also have advantages over other systems, and are preferred.

This description of the evolutionary theory from the view of information processing has the potential of extending the classical theory of evolution and building a bridge over into the field of cybernetics. If we look at the evolution of living organisms and the theory of evolution from the viewpoint of potential mechanisms of information assimilation, then the problems can be viewed from a new perspective – a perspective which was missing in the purely biological approach and which contributes to a uniform standardization of natural sciences.

The classical question of the theory of evolution addresses the point of survival and the advantages guaranteeing or safeguarding it. In an enhanced theory of evolution, this question is complemented by questions around the subject of information reception/assimilation and the direction of the flow of information. In the future, only those approaches are accepted which are valid for biological, societal, and technical systems all the like. Only by focusing on the common denominators it is possible to recognize the most abstract interrelationships.

Now what is the common denominator between a flat iron and a protozoa?

The protozoa is subject to evolutionary pressures and, as a system capable of procreation, it will try to evade them by adapting to the given circumstances. The system assimilates information about the conditions it is subject to and integrates that information into its evolutionary history. It will succeed in actively moving in several dimensions and to actively adapt to certain tasks.

If a system adapts another system, in this case a technical one (the flat iron), to its requirements, then the above-mentioned general evolutionary criteria are valid once again. In this way, the constructing engineer projects the prerequisites to a successful sale into his product. The source of information telling the engineer what a flat iron has to look like is the consumer – in most cases. The engineer adapts the shape of his product, at first on a trial-and-error basis and later with the experiential data gained, to the particular requests of the customer, the criterion.

In the past, flat irons were heated up on a stove. As this was highly impractical and unhandy, irons were then built which could be filled up with red-hot coals. This helped to increase the efficiency of the iron. The criterion of efficiency is thus always included implicitly, even if we are not able to identify it when dealing with the particular demands of a construction. At little bit later, irons appeared on the market which were electrically powered, including a thermostat which relieved the housewife from the concern over the correct temperature.

An individual function of the overall system moved out into the periphery, and the control center was unburdened with regard to this particular function. The only thing subject to any preset from the control center is the set temperature, depending upon the kind of fabric to be ironed – and even this only for as long as it takes to develop temperature sensors automatically recognizing the kind of fabric under the iron at any given time.

We need to recognize that the description of evolutionary processes functions well if we, on the one hand, consider the flow of information and its source, and on the other hand, inspect the ways and means of transporting that information.

Even protozoa have developed cascades of regulatory mechanisms. They also picked up the information generated within them by the state of order around them from the given conditions for survival. However, there was no engineer who constructed protozoa. The process of natural selection transported the information and consistently improved its product. In doing so, it improved itself as well. The evolutionary criteria are not only valid for its product but also for itself. Natural selection was complemented by active assimilation of information, active adaption, and learning. It was also complemented by action and construction, intervention into the environment, and the conflict/contest of active systems – the battle of systems.

The evolutionary process is directed at itself, as was pointed out above; it is a recursive, self-referential process. In this way, it projects that which is driving the organism to action into its product, life. Life collects information from the environment and from the process bringing it into existence. As such, it can outperform the generative process in terms of complexity, and eventually arrives at a conscious understanding of it. It comprehends that a simple reduction of energy can include the impetus for the accumulation of information.

Life will evolve further, and the evolutionary processes within society and technology will one day be the dominating factors, because they will then run much faster than those of the individual human being. In the final analysis, these developments will continue that which originally began on a purely biological basis. Technical systems and societies will determine the course of further developments. What remains are the fundamental rules of evolution which can be heralded into the universe by robots having mastered these rules so that they can flourish and prosper everywhere.

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