Biology Teaching Has to Be Founded on the Theory of Evolution

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Abstract

Scientific revolutions may be characterized by the replacement of some fundamental theories by others, changes of scientific practices, transforming the world, and reaching popular consciousness. The theory of evolution by natural selection by Darwin is a good example. The expressions of the theory may change over time; Darwin's hypotheses were in an ordinary language, today often presented as mathematical models. Thus, the theory is explanatory only if the context is well-known and the concepts used are clear. Artificial and natural selection differ, as the (artificial) action based on the choices of acting individuals to reach specific long-term goals, are completely different from the (natural) act (active or passive) by organisms to achieve something within the next minute. Thus, for humans it may be hard to identify the natural selective forces leading to changes, although it is possible to use the perspective of Darwin on cultural activities. The theory of organic evolution was developed more than 150 years ago, and explains almost all of the phenomena in biology. Anyhow, the use of the theory in biology teaching is astonishingly low. Almost all teaching from primary schools to universities, is based on facts or simple mechanisms between individuals. Biological communities on different levels from biotopes to biomes may be included in the curricula but only a small number of students seem to understand the evolutionary background and its processes. In order to increase the understanding of evolutionary theory, some ideas how to reform teaching in general and how to create a better understanding, through fieldwork, observations in nature, discussions etc., are presented.

Keywords: *Biology teaching, Darwinism, evolution, natural selection*

1. Introduction

Scientific revolutions may be characterized by the replacement of one fundamental theory by another, thus changing the scientific practice, and further transforming the world it partly describes, and finally reaching popular consciousness. The theory of evolution by natural selection as originally described by Darwin is an example of a scientific revolution [1]. This theory, as many others, also may change over time. Darwin's hypotheses were expressed in a rather ordinary language but today these often are presented as mathematical models [2].

2. Contextual reality of the theory

Thus, today the theory may be explanatory only if the context is well-known and the concepts used are understandable. *Natural selection* differs from *artificial selection* not only because of the differences between the meanings of the concepts *natural* and *artificial* but also because of the actual differences between the two types of selections. The (*artificial)* action based on the choice of an acting individual to reach a specific long-term goal, is completely different from the (*natural*) act (active or passive) by an organism to achieve something within the next minute [3]. Thus, within the human cultural world it may be hard to identify the *natural* selective forces leading to changes in nature, although it may be possible to use the perspective of Darwin on, e.g. cultural activities as literature [4].

3. The theory of evolution in the school context

Although the theory of organic evolution is more than 150 years old, and may explain almost all phenomena in biology, the use of the evolutionary theory in the teaching of this subject is astonishingly low. From our experience, as educators of biology teachers, almost all teaching in biology from primary schools to universities, is based on facts or simple mechanisms including the interaction of, maybe, a couple of species. Although biological communities on different levels from biotopes to biomes may be included in the curricula only a small number of students seem to understand the evolutionary background and the ongoing processes within and between these [5].
Further, usually only minor parts of the content of different biological courses are presented as results of evolutionary processes. Variation and its maintenance are almost always possible to explain out of evolutionary processes. Likewise, similarities within or between taxa also may be explained by the theory out of environmental conditions often regardless the relationship in terms of genetic distance or evolutionary history.

4. Goals…

Based on our experiences of biology teacher training, some ideas about the reformation of the teaching in general may be suggested. We present these as they may increase the understanding and the teaching of the evolutionary theory. Primarily, we here focus on achieving a deeper knowledge of the dynamic processes of organic evolution among students. Simultaneously we try to show how it may be possible to stimulate a better understanding of what is going on in nature, by using a variety of pedagogic methods, like diverse types of fieldwork and observations, discussions, games.

The main challenge for the biology teacher is usually to design the teaching, in order to create the understanding of the dialectic dynamics of all the processes of life, from the regulation of the chemical processes in the cells up to the complex relations between organism constituting (and developing) their biomes on a global scale. The networks of relations between organisms create relatively stable societies but the large individual variation of characteristics almost always result in a number of different responses to the same stimulus. Thus, general principles may be regarded as general, but rarely in more than 70 % of the cases.

This perspective is already common in different fields. For example, “biotechnology may have future applications for a concept called “personalized medicine”. The explanation is precisely what it sounds like - the move away from a “one size fits all” mentality to healthcare tailored to the unique needs of the patient considering lifestyle and genetics, using targeted therapies, treatments and care [6]. Also, in architecture, “technologies need to be thoroughly integrated into the building fabric; they will also be influenced by the physical and climatic conditions of the site. The nature of the problem is therefore site specific. There will never be a standard "one size fits all" solution [7]. Similarly, the evolutionary results are products of the interactions between the present state of the organic world and the, mainly genetic, variation between actors, from cells to communities, on different levels in the ecosystems.

5. … and how to achieve them

In order to, among the students, create a general understanding of the evolutionary development the teacher has to acknowledge the variation of biological processes and the fairly common absence of mechanistic relations. This is true, not only within the subject that is being taught, but also among the students in the classroom. The teacher has to accept that even an excellent pedagogic method, selected for teaching a specific subject, only will result in high quality learning among about one half of the students. In order to reach everybody, the teacher has to use a variation of methods palatable for different students and take into account their different learning strategies.

The usefulness of the knowledge content of the students depend on their possibilities to understand the theories and how to make practical use of them. With this in mind the teacher may promote learning of high quality for all.

Primarily, and basic, is the understanding of the processes described by the theory, not the exact facts of previous evolutionary events. Many teachers are aware of the necessity to meet or teach students differently depending on the students´ learning strategies. Nevertheless, most of them don’t acknowledge the similarities between teaching and evolutionary processes: The variation of characteristics within a group generally result in a variation of the responses to a specific stimulus. In the organic world there will almost always be more than one reaction to one specific action. Here, not only the genetic background and the previous experiences of the organisms are important for the results, but also the organic and inorganic environment may be influential.

In order to create an understanding for the possible variations of the outcome of an evolutionary event, the teacher has to focus on the processes creating new situations rather than descriptions of previous events. From our experience, the different reactions of the students in the classroom on an event or incident, may be used as examples or parables of evolutionary development. If students may react differently also other organisms may show different responses to specific stimuli. By using examples of this type, based on events in the classroom, the teacher may create an understanding of evolutionary processes, based on individual responses but further developed by different kind of communications in the group. In the long run this may change the learning in the class from the individual to the group. When students realise the differences in their learning outcomes and how these differences are beneficial for everybody’s learning and also changes the learning culture, they also realise the possibility of the diversity in and between different evolutionary developments.

6. Conclusions

In order to develop an evolutionary based teaching of biology the teacher needs two main competences in this teaching strategy: 1) Personal understanding of the evolutionary processes and how they may work on all levels from single cell organisms to the complete organic world (including all

organisms on the Earth); and 2) skills to create situations stimulating learning of all students independent of their different learning strategies.
The first competence may be obtained not primarily by detailed studies of the history of organic evolution but also by own reflections and discussions with others about the processes and the impact of (natural) variation. This may be based on specific cases, but should preferably be made with an open mind, avoiding mechanistic explanations only including a low number of participants. It is always important to have in mind the dynamics of the relations between the performers (on different levels) in the organic world and remember how (genetic) variation always produces different outcomes.
The teachers´ own learning experiences are important to share with the students. ”But I think I learned much just because of you, we were reflecting but you were thinking, because you had achieved something or learnt something and gave ideas how we could transform specific areas within biology“ [7].
The skills of creating active learners in the classroom may be developed by thinking evolutionary. How do we create opportunities for a group of students in order to enhance their learning and understanding of the subject? The answer may be easy but anyhow hard to realise. Use the same evolutionary processes you are supposed to teach. The class is a group of organisms developing together under the supervision of the teacher, who also is a part of this community and its processes.
Thus, the content of the teaching and its organisation has to be closely related and may be used in order to enhance the learning and understanding of the on-going evolution on the Earth.

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