Historical burdens on physics

Introduction into the series of articles

Today's science curriculum is the result of a process of evolution. It reflects the process of the development in great details. Those who are learning science have to follow a path that is very similar to the course of the historical development. They have to take detours, to overcome unnecessary obstacles and to reproduce historical errors. They have to learn inappropriate concepts and employ outdated methods. When developing the Karlsruhe Physics Course we have tried to eliminate such obsolete concepts and methods.

In the history of science it happened time and again that important works and results were not accepted by the scientific community: When they arrived it was too late. A change, – although it might have been extremely useful – had become too tedious. Here are three examples:

1. The physical quantity entropy had three chances to become a quantity that would be easy to grasp, even for a beginner; the first chance was after the works of Joseph Black and Sadi Carnot, the second after the work of H. L. Callendar and the third through the book *A new concept of thermodynamics* by Georg Job. All of these chances were neglected. The corresponding ideas had been incorrectly interpreted or simply ignored.

2. The physical quantity force with the corresponding terminology – a sophisticated construction of Newton – turned out to be the strength of the current of momentum. The corresponding publication from 1908 by Max Planck remained virtually unnoticed.

3. The first 50 years after the introduction of the energy into physics it was not clear if energy obeys a local conservation principle. It was expected but not proven. For that reason a terminology came into use that took these doubts into account. The publication of 1898 by Gustav Mie, in which it is shown that energy obeys a continuity equation did not lead to a more appropriate and simple language. We still speak about energy as if we had to be prepared that one day actions at a distance might be discovered.

In a certain sense, the growth of scientific knowledge is similar to the evolution of biological systems. Every person who is teaching science acquired his scientific knowledge before. Thus, facts are first received and later transmitted. This transmission, however, doesn't proceed without changes, because research brings new results and the teaching person will try to take these results into account. Such changes can be compared with mutations in genetics.

Generally, the changes and improvements a teacher makes concern only his specialty, whereas the general structure of science will be transmitted without alterations. Thus, the basic knowledge is not subject to the same selective pressure as more recent developments. Accordingly, the new knowledge is essentially attached to the old one without questioning the old nucleus. In the theory of evolution this phenomenon is known as *prolongation*. A greater restructuring will be more and more difficult, whereas the driving force for such changes becomes weaker and weaker. In other words: The more complex a system is the more conservative it will be. For this reason, the scientific knowledge reflects quite accurately its historical development. This statement reminds us of a rule which every student of biology has to learn: E. Haeckel's biogenetic law according to which "ontogeny recapitulates phylogeny".

As a result, detours in the development of scientific knowledge may be preserved. Constructions which, in a larger context, reveal to be superfluous or inappropriate may be maintained. An old transient state may survive as a *living fossil* as geneticists like to call such a phenomenon. Even apparent errors may survive. Considering the actual physics syllabus very much can be learned about the history of physics. Indeed, one can even pursue a kind of archaeology in this manner. As a consequence, every student has to reproduce the historical developments. The individual student's process of learning proceeds, often up to the details, according to the same pattern as the development of science as a whole.

By citing the analogy between the evolution of science and that of biological systems, we want to show that the development of science toward more and more inflexibility is an inevitable and normal process and it is not a daring accusation to say that science is unnecessarily complicated and cumbersome. When we claim that science, as a whole, is in a bad state we don't mean that scientists have been incompetent. Those who worked for the advancement of science usually did the right thing in their time. Just like a biological fossil in a remote time accomplished an important function, many components of science, which nowadays may be considered to be superfluous or inappropriate, have played an indispensable part in the past.

For many years, we have been searching systematically for subjects in the physics syllabus which might be considered historical burdens, i.e. superfluous or inappropriately presented subjects. Since 1994 they appear regularly as a column in the school science review *Praxis der Naturwissenschaften*.

In order to discover such obsolete concepts a certain attitude is necessary which might be considered a lack of respect. Indeed, it is a kind of disrespect in view of convictions which have developed by mere habit and indolence. It is no disrespect, however, for the achievements of the scientists who developed a new concept in the first place.

Each of the articles is structured in the same manner. First, we introduce the *subject*. Then we describe what we believe is the inappropriateness or obsoleteness in the subject: the *deficiencies*. Next, we briefly explain how the subject came into being, i. e., what was the positive role it had played in the past: the *origin*. And finally some comments are made about how to cope with the problem: the *disposal*.

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