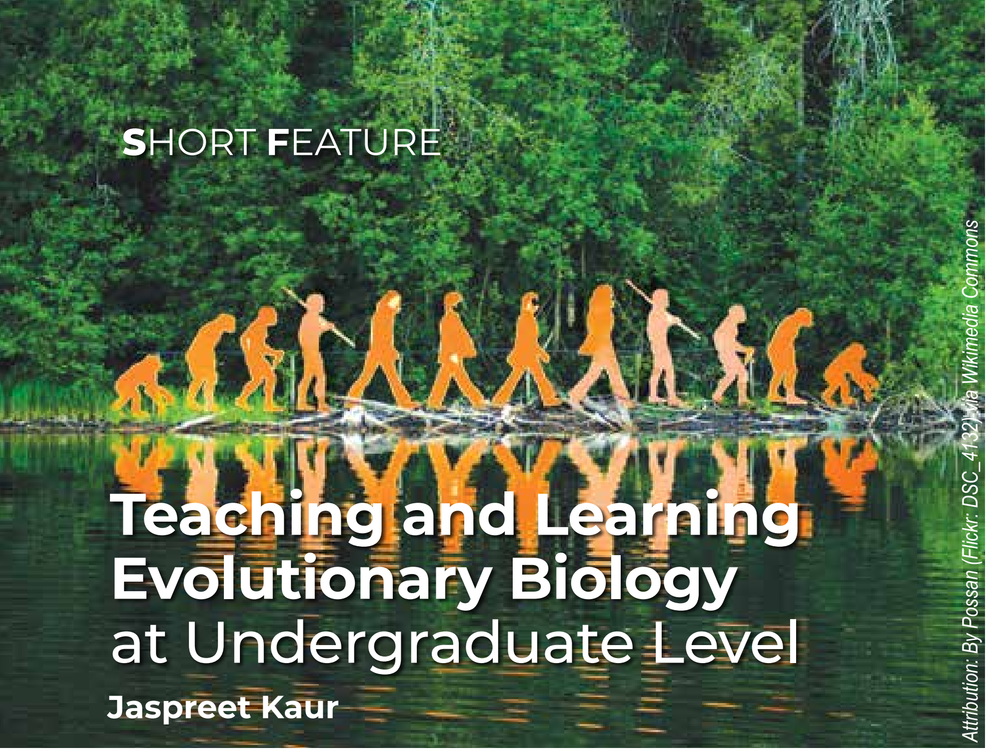
SHORT FEATURE



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Teaching and Learning Evolutionary Biology at Undergraduate Level

Jaspreet Kaur

OFTEN students perceive evolution as a 'boring' and 'lifeless' subject at the undergraduate level. One of the major reasons for such a reaction is that students find it hard to relate some principles of evolutionary biology with their everyday lives, which are quite difficult to observe such as speciation, genetic drift, etc.

Evolution as a science heavily relies upon the evidence of the outcome or products of the evolutionary processes that happened in the past. However, it also relates to the ongoing processes as well as predicting the changes, which may happen in the future. So, as a student, it becomes hard to imagine such a situation as an ongoing 'process' and not simply an 'event' that happened and came to an end. With such preconceived notions, it becomes a challenging task for the teacher to make this subject 'interesting' and 'full of life'.

The powerful explanatory nature of this subject enables answers to almost every scientific question and to 'make sense' in biology, as T. Dobzhansky (1973) stated in his famous quote "*Nothing in Biology makes sense except in the light of evolution*".

As an educator, I feel that small changes in the style of teaching evolution can help in motivating students as well as creating major impact on their learning. The relevance of evolutionary biology as a discipline is extremely important and can be understood clearly once a student has studied other major disciplines of biology like cell and molecular biology, genetics, biochemistry, computational biology etc. This observation is supported by the fact that the subject of evolutionary biology has been placed in the last semester in the current syllabus of Zoology course under choice-based credit system implemented in colleges of the University of Delhi. So, it can be said that evolutionary biology is a unifying theme in the study of biological studies.

One of the most interesting concepts that provides a conceptual framework in order to understand evolution is 'population genetics', wherein the changes in population are measured in terms of gene and allele frequencies. Notably, the *inclusion of mathematical explanations* for each concept makes it a 'real-life' experience and not simply an assumption.

For instance, we conclude that populations are evolving (under the forces of natural selection or migration or mutation) when the allele frequency of a respective gene in that population does not remain constant over subsequent generations, and hence violating Hardy-Weinberg equilibrium. Such calculations can be easily done to demonstrate 'evolution in action'.

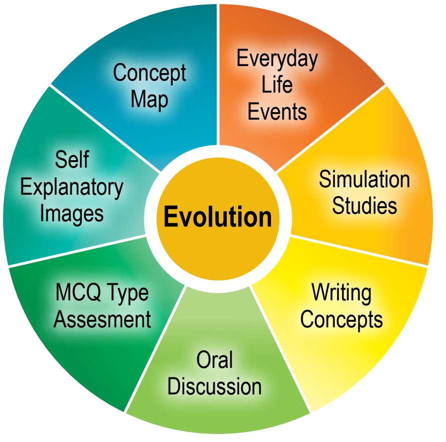
Consider a situation in which thickness of tortoise shells (regulated by dominant allele 'T') affects their survival, wherein the thick-shelled tortoises are naturally selected as they repel their predators in contrast to thin-shelled tortoises (regulated by recessive allele 't'), which fall prey to predators and hence are not selected. In this example, if we have the information on the frequency of tortoises with different genotype frequencies (i.e., TT, Tt & tt) affecting the shell thickness in a population and their resulting survival rates, then we can actually calculate the respective allele frequency in the gametes producing the next generation. Thus, mathematically, we can calculate the effect of natural selection as an evolutionary force on the change of allele frequency in generation after generation in a population.

In addition, providing examples from everyday life as well as published data helps students to appreciate the subject even better. For example, discussions on drug-resistant bacteria can help students to understand the intricacies of evolution and how its lack of understanding can have a major impact on human health. The subject has gained strength with the ongoing research and development in the field of molecular genetics.

With availability of sequences (DNA, RNA or protein) and with help from bioinformatics, it has become quite easy to 'visualise' some 'abstract' topics and actually see the changes happening. This helps in engaging students – they also appreciate the discipline of 'evolution' to a greater extent. For instance, a simple exercise of phylogenetic analysis using gene sequences helps students understand the key concepts of speciation, homologs, ancestry, etc.

Also, simulation studies using beads, which again help in actually looking at the 'real' calculated mathematical values, can help students to extrapolate such results over organisms in natural populations. Students realise the fact that evolutionary studies are no longer limited to the study of fossils or bones or taxonomic classification, but have indeed extended their boundaries far beyond imagination. This observation has been exemplified in the restructuring of the syllabus of evolutionary biology since the last two decades in the University of Delhi, wherein additional layers of information have been added for concepts like 'population genetics' as well as giving due emphasis on bioinformatics and biostatistics.

An important key in discussing the evolutionary concepts is the use of self-explanatory graphic images and graphs, which can be interpreted in order to make the concepts crystal clear. Additionally, encouraging students to construct a 'concept map' for a specific topic...



An important key in discussing the evolutionary concepts is the use of self-explanatory graphic images and graphs, which can be interpreted in order to make the concepts crystal clear. Additionally, encouraging students to construct a 'concept map' for a specific topic helps them to visualise the key terms and their connection between them as well as with other topics. This is particularly true in teaching evolution wherein the continuity of topics is essential to understand a particular topic in its true sense.

One of the key requirements for teaching evolutionary biology, which in fact holds true for all subjects, is that the teacher has to read a lot. Continuous reading and updating the discussion material with recent happenings becomes absolutely necessary while explaining a particular topic. This prepares the teacher to confidently handle the students' questions, which at times may be challenging.

Teachers should also encourage students to use the correct keywords to construct complete statements in scientific explanations during class discussions. For instance, consider a response from a student: "organism changes in response to environment".

Now, a better explanation for this statement can be "organisms respond to changes in environment over time". The first naïve statement implicates that the organism has to change and knows a target destination to achieve, which is not completely accurate with no indication of evolutionary time interval. The second statement is more scientific unveiling the true nature of evolutionary changes, which may or may not happen in response to the environmental conditions as it is a continuous process. So, repeated use of 'naïve' statements tends to create misconceptions in the students' knowledge base, which if not corrected at the right time may persist in later stages of the academic career.

An interesting study by Nehm in 2011 highlighted such an observation in a group of individuals consisting of students who fall in the non-majors, majors and advanced major courses in evolution as well as experts (including PhD students, assistant and associate professors and professors) in the field of evolution. In the study, it was found that though misconceptions about evolutionary aspects decrease with advanced level of education, they do not disappear completely.

An additional role of teachers is to guide and give directions to the ongoing class discussion, wherein students get connected to the topic more and find it interesting. In other words, students learn more when the teacher speaks less and students discuss more on the given subject. For better understanding, teachers must encourage students to question an 'accepted hypothesis' for a particular topic and seek alternative ones and let the students accept or reject them and finally come to a conclusion.

Some may object to this practice on the grounds that it is not feasible under the restrictions of time and the challenge of completing the entire syllabus in a short span of a working semester. But, without such active discussions, almost no critical thinking can occur and science shall falls prey to 'rote-learning'.

Apart from the teaching-learning strategies, special attention should be given on the methods by which students are evaluated. While conducting the students' assessment, it has been observed that students find it difficult to explain a particular concept in writing or even orally.

They may have the concepts clear in their mind but do not succeed well when they encounter questions pertaining to their cognitive ability, such as finding the most suitable answer in a multiple choice test. They also find those questions challenging that demand the use of their knowledge in order to create functional explanations for a particular problem. Just like if you know the parts and tools needed to assemble a furniture, this does not mean that you can build the furniture also (National Research Council, 2012).

To conclude, let me quote Ignacio Estrada, an educational consultant:"*If a child can't learn the way we teach, may be we should teach the way they learn.*"

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