

Lamarck vs. Darwin: Dueling Theories

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Scientists and science educators are in virtual agreement as to the importance of an understanding of evolutionary principles as the unifying theme for acquisition and internalization of information about the origin, history, and diversity of life on earth. Yet despite this agreement, evidence from a myriad of sources indicates that most students enter and leave our classrooms with great and grave misconceptions of this vital concept. It appears these misconceptions can be divided into two major categories:

1) epistemological misconceptions - those dealing with the nature of science, that is, evolution is only a theory, evolution has never been proven correct, or, because biologists cannot see species evolve, evolution is not a true science, and so on;

and

2) content misconceptions - those dealing with the process of evolution, that is, humans evolved from monkeys, through evolution organisms get what they need, organisms progress from "lower" to "higher" forms, and so on.

Although abandoned over 150 years ago, Jean Baptiste de Lamarck's theory of acquired characteristics - the concept that changes acquired during an organism's lifetime are somehow transferred into genetic information and passed on to the offspring - is perhaps more commonly held as the mechanism of how evolution works, than the more scientifically supported Darwinian concept of variation and selection (Deadman and Kelly 1978; Firenze 1997; Greene 1990; Humphreys 1996; and Settlage, 1994). It is easy to see the appeal of this theory since it seems to follow the logic of our everyday experiences where the term "adaptation" is often thought of as a change occurring within the individual organism. After all, most of our students have been repeatedly told that as they mature they will need to "adapt" to a variety of situations they may encounter in the real world (presumably this means the world outside of the educational system). However, it is up to us, as science educators, to help our students discover the scientific flaws in this theory and replace it with a more powerful and accurate explanation for the diversity of life.

LEARNING ABOUT SCIENCE

Constructivist learning theory tells us that changing this misconception will only take place if our students' minds have an active cognitive involvement in the processes that allow for the accommodation of new "replacement" knowledge. Mechanisms such as hands-on / minds-on laboratory activities, developing alternative hypotheses, designing evaluative experiments, and arguing about the phenomena under study facilitate this active involvement (Saunders 1992). This is especially true if the work is done in small groups and the students are asked to explain and/or defend their thinking to their peers-who may compare and contrast these ideas with their own constructions. The National Research Council (1996) tells us that teaching science as inquiry is the basic underlying principle of science education as well as the ultimate organizing concept for the selection of student activities. These activities should include: 1) asking appropriate questions, 2) planning and conducting investigations, 3) appropriate tools and techniques to gather data, 4) thinking critically and logically about the relationships between evidence and explanations, and 5) communicating scientific arguments. Following these recommendations, as well as the 5E cycle (engage, explore, explain, elaborate, and evaluate), this exercise is an attempt to accomplish the previously mentioned tasks by allowing the student to discover the inherent flaws in the Lamarckian view, while at the same time encouraging the appropriation of a more Neo-Darwinian concept.

The Conceptual Change Model (CCM), first introduced by Posner (1982) and recently investigated and modified by Demastes (1996) and Jensen and Finley (1996), shows us that in order for a misconception to be abandoned, the learner must come to see it as unsatisfactory, while the new conception must be intelligible, plausible, and fruitful. Here lies our problem: how best to make Lamarck's view the unsatisfactory concept, while showing Darwin to be more intelligible, plausible, and fruitful?

ENGAGE

The class should be shown an exciting video of some unusual morphological, physiological, and/or behavioral adaptation. As we all know our students are steeped in a visual world of rapid fire stimuli. The chalkboard or overhead projector stand little chance to excite them. Good examples, that can be found in David Attenborough's *The Trials of Life*, are:

- the speed and grace of a cheetah in pursuit of a prey species
- blind and/or albino cave-dwelling animals
- the social behavior and morphology of the naked mole rat

EXPLORE

The class should be broken into small groups (4 or 5) and presented with the following questions:

1. Cheetahs can run faster than 60 miles per hour when in pursuit of prey. How would an evolutionary biologist explain how this ability evolved, assuming their ancestors could only run 20 miles per hour?
2. Many cave organisms are blind. In fact, for many, their eyes have become vestigial structures. How would an evolutionary biologist explain how this inability to see evolved from sighted ancestors? (Both questions 1 and 2 have been modified from Bishop and Anderson 1986)
3. Naked mole rats have several morphological as well as behavioral adaptations which allow them to live in a eusocial system within a harsh and unforgiving environment. Make a list of as many of these characteristics as you can. How would an evolutionary biologist explain how these unique characteristics evolved from ancestors which did not possess these traits?

Each group is given ample time to research and discuss the question(s).

EXPLAIN

The groups then present their explanations to the class as a whole to foster comments, critiques, and criticisms of their hypotheses. It should be pointed out here that dissent, argument, and disagreement are all integral components of the scientific process. They are not negative, but rather positive, attributes of science. More than likely, many of the groups will present Lamarckian ideas. Therefore, the important points that need to be illustrated and discussed by the teacher, especially if they do not arise from student discussion, are:

1. Evolution proceeds by the process of variation, a genetically random process, and selection, an environmentally driven non-random process.
2. Organisms do not get what they "need" through "inner wants" or through "use and disuse" Individual intentions do not play a role.
3. Acquired characteristics are not passed on to offspring,
4. Mutations are not directed for the benefit of the individual.
5. Evolution is neither random nor teleological. It is, in fact, driven by both historical contingencies and the non-random, yet non-directed, process of selection.

ELABORATE / EVALUATE

Feedback on the progress and effectiveness of the learning activity can be used to evaluate its success and to adjust the ongoing process. This "formative evaluation" can be accomplished informally during the preceding stage. More formal assessment of the outcome at the end of the process (summative evaluation) can be performed by offering similar problems for each student to solve on the evaluation tool of one's choice-An example follows:

Many insular species of both plants and animals have lost defense mechanisms that are frequently found on their continental relatives. Several species of birds and insects have become flightless and many plant species have lost defense mechanisms such as thorns or toxic chemicals. How would an evolutionary biologist explain how these losses came about?

CONCLUSIONS

On the surface it seems that to replace the conceptual belief that species change is driven by characteristics acquired during the organism's lifetime with one based on the processes of random variation and non-random selection should be rather an easy task. However, personal experience, as well as most of the research cited, indicates this is not the case. Let's face it, misconceptions concerning evolution are deeply embedded and the concept itself is a lightning rod - one that many of our teachers fear holding in the tempest of today's classroom. As minor as it may seem, the alleviation of any misconception dealing with biology's most important central theme, as well as its most misunderstood concept, is a major step in the right direction for science education. As Bumbry (1979) has pointed out, the acceptance of Lamarckian beliefs, for all intents and purposes, totally blocks the learning of Darwinian principles. Obviously this must be changed. I have found the preceding exercise to be one of the most fruitful in accomplishing this goal.

The term eusocial as defined by Krebs and Davies (1993) includes animals that exhibit: 1) cooperative care of the young; 2) a reproductive division of labor - that is, some castes or classes are less fecund or sterile; 3) an overlap of at least two generations; that is, the offspring assist the parents during some period of their life.

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