Botanical Society of America's Statement on Evolution

The Botanical Society of America exists to promote botany, the field of basic science dealing with the study and inquiry into the form, function, diversity, reproduction, evolution, and uses of plants and their interactions within the biosphere. Our membership largely consist of professional scientists, scholars, and educators from across the United States and Canada, and from over 50 other countries. Most of us call ourselves botanists, plant biologists, or plant scientists, and members of our profession teach and learn about botanical organisms using well-established principles and practices of science. As such, we were asked by the National Center for Science Education (NCSE) if we could provide a statement outlining our view on evolution. On July 27, 2003, at the 2003 Annual General Meeting the BSA Council approved the statement to follow for use by the NCSE. [Published in the SKEPTICAL INQUIRER *by permission of the BSA.]*

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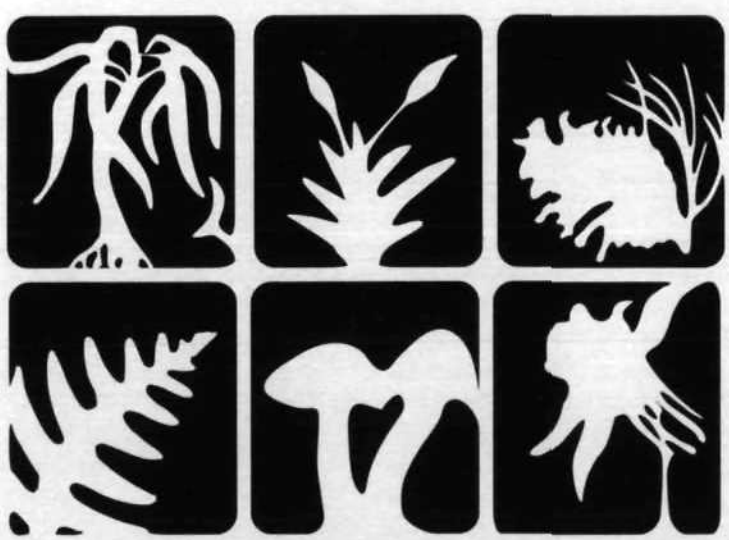
Evolution represents one of the broadest, most inclusive theories used in pursuit of and in teaching this knowledge, but it is by no means the only theory involved. Scientific theories are used in two ways: to explain what we know, and to pursue new knowledge. Evolution explains observations of shared characteristics (the result of common ancestry and descent with modification) and adaptations (the result of natural selection acting to maximize reproductive success), as well as explaining pollen: ovule ratios, weeds, deceptive pollination strategies, differences in sexual expression, dioecy, and a myriad of other biological phenomena. Far from being merely a speculative notion, as implied when someone says, "evolution is just a theory," the core concepts of evolution are well documented and well confirmed. Natural selection has been repeatedly demonstrated in both field and laboratory, and descent with modification is so well documented that scientists are justified in saying that evolution is true.



Some people contend that creationism and its surrogate, "intelligent design," offers an alternative explanation: that organisms are well adapted and have common characteristics because they were created just so, and they exhibit the hallmarks of intelligent design. As such, creationism is an all-inclusive explanation for every biological phenomenon. So why do we support and teach evolution and not creationism/"intelligent design" if both explain the same phenomena? Are botanists just dogmatic, atheistic materialists, as some critics of science imply? Hardly, although scientists are routinely portrayed by creationists as dogmatic. We are asked, "Why, in all fairness, don't we teach both explanations and let students decide?"

The fairness argument implies that creationism is a scientifically valid alternative to evolution, and that is not true. Science is not about fairness, and all explanations are not equal. Some scientific explanations are highly speculative with little in the way of supporting evidence, and they will stand or fall based upon rigorous testing. The history of science is littered with discarded explanations, e.g., inheritance of acquired characters, but these weren't

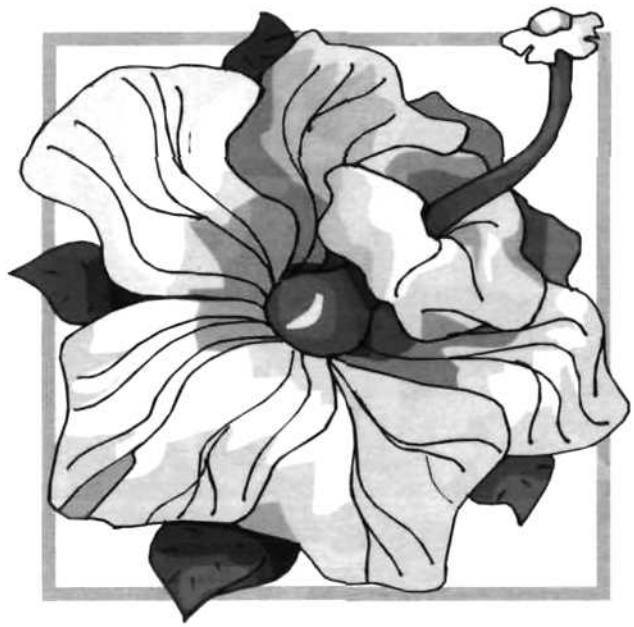
discarded because of public opinion or general popularity; each one earned that distinction by being scientifically falsified. Scientists may jump on a "bandwagon" for some new explanation, particularly if it has tremendous explanatory power, something that makes sense out of previously unexplained phenomena. But for an explanation to become a mainstream component of a theory, it must be tested and found useful in doing science.

To make progress, to learn more about botanical organisms, hypotheses, the subcomponents of theories, are tested by attempting to falsify logically derived predictions. This is why scientists use and teach evolution; evolution offers testable explanations of observed biological phenomena. Evolution continues to be of paramount usefulness, and so, based on simple pragmatism, scientists use this theory to improve our understanding of the biology of organisms. Over and over again, evolutionary theory has generated predictions that have proven to be true. Any hypothesis that doesn't prove true is discarded in favor of a new one, and so the component hypotheses of evolutionary theory change as knowledge and understanding grow. Phylogenetic hypotheses, patterns of ancestral relatedness, based on one set of data, for example, base sequences in DNA, are generated, and when the results make logical sense out of formerly disparate observations, confidence in the truth of the hypothesis increases. The theory of evolution so permeates botany that frequently it is not mentioned explicitly, but the overwhelming majority of published studies are based upon evolutionary hypotheses, each of which constitutes a test of an hypothesis. Evolution has been very successful as a scientific explanation because it has been useful in advancing our understanding of organisms and applying that knowledge to the solution of many human problems, e.g., host-pathogen interactions, origin of crop plants, herbicide resistance, disease susceptibility of crops, and invasive plants.

For example, plant biologists have long been interested in the origins of crop plants. Wheat is an ancient crop of the Middle East. Three species exist both as wild and domesticated wheats, einkorn, emmer, and breadwheat. Archeological studies have demonstrated that einkorn is the most ancient and breadwheat appeared most recently. To plant biologists this suggested that somehow einkorn gave rise to emmer, and emmer gave rise to breadwheat (an hypothesis). Further evidence was obtained from chromosome numbers that showed einkorn with 14, emmer with 28, and breadwheat with 42. Further, the chromosomes in einkorn consisted of two sets of 7 chromosomes, designated AA. Emmer had 14 chromosomes similar in shape and size, but 14 more, so they were designated AABB. Breadwheat had chromosomes similar to emmer, but 14 more, so they were designated AABBCC. To plant biologists familiar with mechanisms of speciation, these data, the chromosome numbers and sets, suggested that the emmer and breadwheat species arose via hybridization and polyploidy (an hypothesis). The Middle Eastern flora was studied to find native grasses with a chromosome number of 14, and several goatgrasses were discovered that could be the predicted parents, the sources of the BB and CC chromosomes. To test these hypotheses, plant biologists crossed einkorn and emmer wheats with goatgrasses, which produced sterile hybrids. These were treated to produce a spontaneous doubling of the chromosome number, and as predicted, the correct crosses artificially produced both the emmer and breadwheat species. No one saw the evolution of these wheat species, but logical predictions about what happened were tested by recreating likely circumstances. Grasses are wind-pollinated, so cross-pollination between wild and cultivated grasses happens all the time. Frosts and other natural events are known to cause a doubling of chromosomes. And the hypothesized sequence of speciation matches their observed appearance in the archeological record. Farmers would notice and keep new wheats, and the chromosome doubling and hybrid vigor made both emmer and breadwheat larger, more vigorous wheats. Lastly, a genetic change in breadwheat from the wild goatgrass chromosomes allowed for the chaff to be removed from the grain without heating, so glutin was not denatured, and a sourdough (yeast infected) culture of the sticky breadwheat flour

would inflate (rise) from the trapped carbon dioxide.

The actual work was done by many plant biologists over many years, little by little, gathering data and testing ideas, until these evolutionary events were understood as generally described above. The hypothesized speciation events were actually recreated, an accomplishment that allows plant biologists to breed new varieties of emmer and bread wheats. Using this speciation mechanism, plant biologists hybridized wheat and rye, producing a new, vigorous, high protein cereal grain, *Triticale*.



What would the creationist paradigm have done? No telling. Perhaps nothing, because observing three wheat species specially created to feed humans would not have generated any questions that needed answering. No predictions are made, so there is no reason or direction for seeking further knowledge. This demonstrates the scientific uselessness of creationism. While *creationism explains everything*, it offers no understanding beyond, "that's the way it was created." No testable predictions can be derived from the creationist explanation. Creationism has not made a single contribution to agriculture, medicine, conservation, forestry, pathology, or any other applied area of biology. Creationism has yielded no classifications, no biogeographies, no underlying mechanisms, no unifying concepts with which to study organisms or life. In those few instances where predictions can be inferred from Biblical passages (e.g., groups of related organisms, *migration of all animals from the resting* place of the ark on Mt. Ararat to their present locations, genetic diversity derived from small founder populations, dispersal ability of organisms in direct proportion to their distance from eastern Turkey), creationism has been scientifically falsified.

Is it fair or good science education to teach about an unsuccessful, scientifically useless explanation just because it pleases people with a particular religious belief? Is it unfair to ignore scientifically useless explanations, particularly if they have played no role in the development of modern scientific concepts? Science education is about teaching valid concepts and those that led to the development of new explanations.

Creationism is the modern manifestation of a long-standing conflict between science and religion in Western Civilization. Prior to science, and in all non-scientific cultures, myths were the only viable explanations for a myriad of natural phenomena, and these myths became incorporated into diverse religious beliefs. Following the rise and *spread of science, where ideas are tested* against nature rather than being decided by religious authority and sacred texts, many phenomena previously attributed to the supernatural (disease, genetic defects, lightning, blights and plagues, epilepsy, eclipses, comets, mental illness, etc.) became known to have natural causes and explanations. Recognizing this, the Catholic Church finally admitted, after 451 years, that Galileo was correct; the Earth was not the unmoving center of the Universe. Mental illness, birth defects, and disease are no longer considered the mark of evil or of God's displeasure or punishment. Epileptics and people intoxicated by ergot-infected rye are no longer burned at the stake as witches. As natural causes *were discovered and understood*, religious authorities were forced to alter long-held positions in the face of growing scientific knowledge. This does not mean science has disproved the existence of the supernatural. The methodology of science only deals with the material world.

Science as a way of knowing has been extremely successful, although people may not like all the changes science and its handmaiden, technology, have wrought. *But people who oppose evolution*, and seek to have creationism or intelligent design included in science curricula, seek to dismiss and change the most successful way of knowing ever discovered. They wish to substitute opinion and belief for evidence and testing. The proponents of creationism/intelligent design promote scientific ignorance in the guise of learning. As professional scientists and educators, we strongly assert that such efforts are both misguided and flawed, presenting an incorrect view of science, its understandings, and its processes.

Authored by: J. E. Armstrong and J. Jernstedt, officers of the BSA. Approved by the BSA Council: July 27, 2003. P.O. Box 299, St. Louis, MO 63166-0299. Web site: www.botany.org. □