Summary: This paper is fatally flawed in numerous ways. I illustrate in detail below.

MAJOR PROBLEMS

PROBLEM #1: UNSUPPORTED ASSERTIONS ABOUT "ESSENTIALLY UNSOLVED" PROBLEMS IN EVOLUTIONARY BIOLOGY

"While it is absolutely correct that evolutionary biology per se is entirely uncontroversial within science, and is not in any way disputed by the great majority of researchers, many important areas of the theory do remain very controversial and have certainly not been settled. In particular, the origins of complex structures and systems, the creation of biological information, developmental evolution and morphogenesis remain essentially unsolved."

This statement is untrue. For example, the origin of new genetic information is explained by the well-known process of gene duplication followed by one or more rounds of mutations (of various well-known sorts) and selection. New genes with modified sequences and different functions are new information on any reasonable criterion of what "information" means.

Required references, which would have to be argued with in detail to have even a hope of making a successful contrary argument:

1. Long et al. (2003). The origin of new genes: glimpses from the young and old. Nature Reviews Genetics

(20+ examples of the origin of new genes, some of them in which the origins are known in much detail, although a few need updates due to newer research—I am unconvinced by the claim of a new plant plasmid gene that is a chimera due to lateral gene transfer, this is likely just an artefact of the phylogenetic analysis of the original paper, which I have looked at.

2. R Ponce, DL Hartl (2006). â€œThe evolution of the novel Sdic gene cluster in Drosophila melanogaster.: Gene 376(2), 174-183.

The novel gene Sdic explained in great detail.

The above problem with the information argument stands despite the endless arguments of creationists and a few other cranks. I have extensive experience with this literature, and it always boils down to use of a subjective and inconsistent definition of "information", which is then employed to avoid all of the obvious and overwhelming counterexamples, like those mentioned above (although the mass of counterexamples is virtually always not even cited, itself an unforgivable scholarly mistake).

Although this ambiguity is often concealed with a great display of technical-sounding language about information theory, they can typically never explain why, for instance, the origin of Sdic or Jingwei is not an example of the natural origin of new genetic information.

Bozorgmehr (2010; http://onlinelibrary.wiley.com/doi/10.1002/cplx.20365/full), cited in this article, *does* review some of the well-known cases where new genes have originated recently, e.g. Sdic and Jingwei—but even Bozorgmehr, despite some minor quibbles in places, is forced to concede that it looks like natural evolutionary processes have successfully produced these new genes!

In fact, they are new information even on Bozorgmehr's own personal definition of "information", as he defines it thusly: "Therefore, I have decided to define any gain in exonic information as: 'The qualitative increase in operational capability and functional specificity with no resultant uncertainty of outcome.'" Typically in the cases of these new genes, the ancestral gene(s) are retained, and the new gene has a new function and new expression pattern (at least as far as we can tell, given that we don't always know the exact function of a new gene). All of the old genes + a new gene with new information = more information than you had before. That is GAME OVER for the "natural evolution can't produce new genetic information" argument.

This is the case even if new genes typically lose some exonic material during their evolution. All of the old genes + a *shorter* new gene with new information STILL equals more information than you had before.

Bozorgmehr (2010), after reviewing a bunch of cases of the origin of new genes and more-or-less admitting that natural evolutionary processes have produced them, writes a very puzzling conclusion that basically says "Never mind that all of these new genes evolved and their evolution can be reconstructed in some detail even with the limited information available in the 21st century with only a small proportion of species sequenced; I'm going to make a wild assertion that the origin of information is still a mystery."

E.g., in the conclusion of Bozorgmehr (2010), he writes,

"The various postduplication mechanisms entailing random mutations and recombinations considered were observed to tweak, tinker, copy, cut, divide, and shuffle existing genetic information around, but fell short of generating genuinely distinct and entirely novel functionality."

Here, Bozorgmehr (2010), like many creationists and similarly uncritical and uninformed critics, moves the goalposts for evolutionary theory. No longer is the goal just "new information", it is "entirely novel functionality". But this new line that evolution has to cross has many problems:

(a) it is not rigorously defined—the reader has no way of knowing what evolutionary demonstration would satisfy Bozorgmehr. He could always just move the goalposts again and say, "Oh, that wasn't *entirely* novel."

(b) As many, many biologists have observed and written (notably Darwin, Mayr, Gould, etc.), virtually any feature in biology that one examines is not "entirely novel"—it is a modified version of something else. Was the origin of the mammalian middle ear "entirely novel"? No, actually we know that the middle ear evolved from modified jawbones. How about the origin of the jaw? No, it traces back to the gill arches of early chordates. How about vertebrate wings? Modified forelimbs. The archaeal flagellum? A modified Type 4 secretion system. The bacterial flagellum? A modified Type 3 secretion system (although it may or may not be sister to known, modern nonflagellar T3SS; the phylogeny here is unresolved), together with a number of other proteins coopted from nonflagellar systems (e.g., MotAB are homologous to TolQR and ExbBD).

This is a ubiquitous and extremely well-confirmed pattern across biology, it doesn't just apply to recently-evolved new genes. One cannot just insert a dubious hidden premise into an argument, like the idea that "entirely novel functionality" is ubiquitous in evolution and needs to be explained by normal evolutionary mechanisms, without an extensive justifying argument. Well, you can do it, and you might even get it past some reviewers, but it is mere rhetorical posturing and not a coherent argument. It is not the kind of thing that will change the minds of experts in the field who know that virtually every complex system in biology appears to be a modified version of something else.

PROBLEM #2

Another example—the "origins of complex structures and systems" is actually reasonably well-understood in many cases. The only problem is that antievolutionists ignore the relevant literature, as is being done by Bozorgmehr in his paper here. No scientific paper can claim the opposite without responsibly addressing the relevant literature, which has been laid down in front of the antievolutionists many, many times, for example, here:

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Scott, E. C., and Matzke, N. (2007). "Biological design in science classrooms." Proceedings of the National Academy of Sciences. 104(suppl. 1), 8669-8676.

http://www.pnas.org/content/104/suppl.1/8669.full

[...]

The ID movement's common claim that evolution cannot produce “new genetic information” is contradicted by numerous papers documenting the origin of new genes (e.g., ref. 32) or even entire multiprotein catabolic pathways for artificial compounds that humans have released into the environment in recent decades (33, 34). Behe's claim has been rebutted in general (35-37) and for specific complex systems such as bird wings (38), the vertebrate blood clotting cascade (39), the vertebrate immune system (40), and the ID movement's favorite system, the bacterial

flagellum (23, 41, 42).

23. Pallen MJ, Matzke NJ (2006) Nat Rev Immunol 4:784–90.

[...]

33. Johnson GR, Spain JC (2003) Appl Microbiol Biotechnol 62:110–123.

34. Copley SD (2000) Trends Biochem Sci 25:261–265.

35. Miller KR (1999) Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution (Cliff Street Books, New York).

36. Thornhill RH, Ussery DW (2000) J Theor Biol 203:111–116.

37. Matzke NJ, Gross PR (2006) in Not in Our Classrooms: Why Intelligent Design Is Wrong for Our Schools, eds Scott EC, BranchG(Beacon Press, Boston), pp 28–56.

38. Gishlick A (2004) in Why Intelligent Design Fails: A Scientific Critique of the New Creationism, eds Young M, Edis T (Rutgers Univ Press, New Brunswick, NJ), pp 58–71.

39. Davidson CJ, Tuddenham EG, McVey JH (2003) J Thromb Haemost 1:1487–1494.

40. Bottaro A, Inlay MA, Matzke NJ (2006) Nat Immunol 7:433–435.

41. Miller K (2003) in God and Design: The Teleological Argument and Modern Science, ed Manson N (Routledge, London), pp 292–307.

42. Musgrave IF (2004) in Why Intelligent Design Fails: A Scientific Critique of the New Creationism, eds Young M, Edis T (Rutgers Univ Press, New Brunswick, NJ), pp 72–84.
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In the face of all of this, I have never seen an example of an antievolutionist doing any better than a sputtered "well, I just don't believe it". It is only very occasionally that one can get them to read the literature at all, and even then I've never seen them deal with this research in the responsible, academic way that science absolutely requires—dealing with the facts rather than dismissing them, and proposing a more explanatory, more testable explanation.

PROBLEM #3: QUOTE-MINING

Monteiro and Podlaha (2009) state that, â€œthe genetic origin of new and complex traits is probably still one of the most pertinent and fundamental unanswered questions in evolution today.:

The reference here is:

Wings, horns, and butterfly eyespots: how do complex traits evolve?

Bozorgmehr is misusing this paper, which I have read. The paper is devoted to testing several already existing, already known-to-be plausible explanations for the origin of complex traits and complex developmental gene networks. These are all just sub-hypotheses for one of the well-known and long-established general explanations of new complex traits, known as cooption or exaptation (see Mayr 1960, cited in Scott & Matzke; and of course this explanation goes back to Chapter 6 of Darwin's Origin of Species, which Bozorgmehr mentions but does not grapple with—like virtually all). Cooption, in turn, is one of several specific evolutionary hypotheses that may be employed to explain complex traits within the general hypothesis that the complex trait evolved via descent with modification, with natural selection as a major force.

To wit, the authors write, "Here we propose an empirical test that will help distinguish instances of gene network co-option from de novo network evolution."

Both are plausible, although they suggest (and I and most biologists would likely agree) that gene network co-option is more likely to be the more common explanation, and it is debatable whether or not even the very limited dramatic language that the authors use is warranted (such phrases are common in scientific papers, as papers are much less interesting to editors if you play up the significance of what you are doing, rather than play it down). But either way, "unanswered question" does not equal "evolution in crisis" or whatever. It is clear that Bozoghmehr isn't arguing for teaching students about two sub-hypotheses of cooption in high school biology, he wants them to be taught e.g. that common ancestry might be wrong, which is scientifically unwarranted, undoubtedly therefore would happen for religious motivations only, and thus would be unconstitutional as well as poor education.

PROBLEM #4: BEGGING THE QUESTION

"Science is supposed to be a pluralistic enterprise, inclusive by its very nature, welcoming virulent debate and arousing the deepest sense of curiosity in those pursuing it. Without continually raising objections, it is impossible the test the worth and resilience of an idea. This is what differentiates science from dogma."

As Carl Sagan once said, the openness of science has to be coupled with very skeptical critical scrutiny. Every aspect of modern evolutionary theory is continually being poked, prodded, and tested by evolutionary biologists in the field, in museums, and in the lab. Many of these investigators are tenured professors who face no danger to their salary or employment if they were to dissent from the consensus—indeed, many of them (like Gould) have launched various mini-revolutions within the field, and furthermore, they all know that worldwide fame and credit would accrue to someone who could come up with a better overarching theory than the theory of evolution. And yet, despite all of this testing and motivation to overturn orthodoxy, it hasn't been done. All the experts still agree on common ancestry, on natural selection as an important force, on the ability of natural forces like selection to produce complexity, etc. The fact that there are debates (minor debates in the grand scheme of things) about all sorts of details does not contradict this big picture. All active sciences have innumerable such debates going on. That is how we move from ignorance to knowledge.

The kinds of criticisms that Bozorgmehr is talking about, though—those that suggest that evolution is just wrong, that the origin of complex structures, of information, etc. is a complete mystery and/or requires a miracle—these come from the absolute fringes of the biological field, if one is speaking very generously, and if one is speaking fairly, they are coming from cranks far removed from the actual data and practices of the actual science of evolutionary biology. Fair-mindedness does not mandate the inclusion of crank science, done with poorly-informed, half-baked arguments by armchair critics, in scientific debate. Peer-review mostly excludes crank material from the scientific literature, although peer-review occasionally fails.

Even if we were to include crank arguments in scientific journals, this would still beg the question of whether or not it deserved serious discussion in **introductory biology classes in high schools**. There are a million-and-one topics, just in biology, that don't get mentioned in high schools, purely because introductory classes have to have introductory material, biology is a huge discipline, and there is very limited time amidst all of the other classes students have to take. Even in an ideal situation, students are unlikely to get more than a few weeks devoted to evolutionary theory. What should be cut, to include the crank material that Bozorgmehr would like educators to include?

Furthermore, Bozorgmehr's criteria—any topic that gets into a peer-reviewed journal, whether legitimately or not, whether it is being miscontrued or not, deserves to be included in introductory science classes—would lead to complete chaos if consistently employed. Bigfoot and other forms of cryptozoology, astrology, homeopathy, cold fusion, and numerous other forms of pseudoscience have a tiny-but-nonzero presence in the peer-reviewed journals. Some of this is crank journals, some of this is cranky editors, some of this is cranks resubmitting articles to journals until they catch an obscure journal with an editor or reviewer having an off-day, and some of this is mistakes due to optimistic statistical analysis or fluke instances of statistical significance, which will happen by chance quite often.

Should all of this junk be taught in the public schools, just because it is "in" the peer-reviewed literature?

Bozorgmehr's argument would suggest this. To reach an alternative conclusion, he would have to present a philosophy of education that somehow included fringe antievolution arguments but excluded all of the other fringe and crank pseudoscience that is out there. I wish him luck, but he has not even attempted this task here.

My philosophy of education is that students deserve to learn the *best* and *most important* science that is available, scaled to be age-appropriate of course. This includes major organizing explanatory theories like evolution, and ideas that are driving the forefront of science, again like evolution. Including poorly-supported crank criticisms of dominant theories, even those derived from the peer-reviewed literature (technically, the dark dregs of the peer-reviewed literature) does not fit with this vision.

If the crank criticism actually is correct, the proper way to promote it is *not* to try to coral the power of the government to promote your fringe idea in the introductory classes in the public schools. The dissident's *only* job should be to attempt to convince the relevant scientific community. That's what academia and scientific communities are *for*.

OTHER PROBLEMS

I have already dealt with the content of Bozorgmehr (2010). It is also worth pointing out that Bozorgmehr apparently submitted to and was rejected by a large number of journals before getting accepted (according to discussions I have seen on the internet, where he inhabits various creation/evolution forums under the name "Atheistoclast".

It is also worth noting that there are peer-reviewed journals and peer-reviewed journals. The journal "Complexity" is an online-only (as of 2011) journal, outside of the field of biology, with a below-average impact factor (stats below:

mean of 500 random impact factors I downloaded from ISI's 2010 Journal Citation Reports:
(the first 500 in the JCR list; the max download size is 500)
2.112799

Nature's IF
36.101

Science's IF
31.364

PNAS
9.771

mean of the top 500 impact factors I downloaded from ISI's Journal Citation Reports:
10.16963

Complexity
1.367

Even an article in a top journal wouldn't really establish that a particular topic is worthy of inclusion in introductory science classes. Nature published "memory water", Science recently published the incorrect reports of arsenic-DNA, PNAS has had various crank contributions published by a sometimes-eccentric NAS member like Lynn Margulis, etc.

Peer-review only *starts* with review at the journal. If an article is published, it gets processed by the scientific community. Sometimes the status of the article goes up; often, the status of the article goes down; very often, the

work is ignored. Students deserve to get the best stuff, not "all the stuff" (as if the desire for "teach everything" wasn't a cheap rhetorical ploy in the first place, designed to provide cover for "teach crank antievolutionary stuff!").

Other notes on cited articles and other assertions:

Behe (2010), like Bozorgmehr, reviews a number of cases where evolution (lab evolution, in Behe's case) is shown able to produce new biochemical functions, the ability to process new food sources, and the like. But then he sets up some new, arbitrary, more obscure "line in the sand" for evolution, and then claims that evolution is unable to cross *that* line—never mind that the line was set up to be just outside the capabilities of what simple lab experiments (short time periods, simple selection forces, simple environments, clonal populations) can observe. It is like saying in 2005 that "current extrasolar planet detection techniques have only detected gas giant planets, therefore smaller planets don't exist."

Lambert (1984) is pointless to cite, as the DNA/protein "chicken and egg" problem was solved in the mid-1980s by the RNA World hypothesis.

Re: Kitzmiller—the lack of peer-reviewed literature was only one of many problems with ID. And the ID guys did introduce various things that they *claimed* were peer-reviewed literature (much of this is in the DI list that Bozorgmehr cites)—but it all fell apart on cross-examination, or, often, wasn't introduced in the first place, for fear of cross-examination, despite being cited in expert reports. Philosophy journals, review articles, articles by ID personalities but that don't mention ID, claims that are directly contradicted by data, etc. —none of this adds up to a record of empirical research literature. And, of course, even having such a record is a long, long ways from being "the *best* and *most important* science that is available" and thus deserving of inclusion in introductory science classes.

Ewens and Wilf (2010)—rebutting creationist silliness is a legitimate activity, for the purposes of educating the public and the broader academic community. It in no way justifies the inclusion of the rebutted crank ideas in introductory classes. And, anyway, Ewens and Wilf (2010) didn't actually cite any creationist literature, if I recall correctly (see the Scott & Matzke 2007 PNAS article for that).

"A practical and rational philosophy of science instruction can be expected to yield the most benefits to society. This prevents the ossification of didacticism as a rigid induction into what the body of science actually represents."

If students were to be taught scientific topics in proportion to what the scientific community thinks is important, I would support that; but this, too, would leave no room for fringe and crank pseudoscience.

"The use of informative and appropriate material taken from peer-reviewed journal articles, and where relevant to the science curriculum, can serve as an educational supplement to that of the traditional textbooks. Journal articles are where scientific research is announced and these findings are reviewed - it is important for teachers to describe just how science works. Such an exercise should prove to be acceptable to all parties when it is realized that the ever-increasing understanding of students requires a better method of formal education."

This whole article is just an attempt of Bozorgmehr to continue his one-man campaign against evolution by harassing various journals until occasionally something gets published. This article is basically mostly about communicating "nyah, nyah, I got my [deeply-flawed] article published in [insert obscure non-biology journal]' to NCSE.

As I have shown in this review, the article contains numerous scientific errors, and fails to even attempt to make the kinds of arguments that would have to be made to make a serious case for including Bozorgmehr's work or similar work in introductory high school biology classes. Thus there would be no reason for NCSE Reports to publish it, except with a rebuttal like the above, which would serve as a primer for the sadly inevitable day when Bozorgmehr or someone similar starts waving around an article like Bozorgmehr's in front of some bewildered school board.

I recall that I think I have seen Bozorgmehr post the rejection reviews he has received from other journals online. I suppose this is up to the NCSE Reports editor, but I have no objection to this, as long as my review is posted in its entirety without modification, and my name is attached.

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