Science & Math CESE Education

The BEACON

News from

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President's Message

Another three months have passed since my last message. Somehow, it doesn't seem that long because a lot has happened. Let us start with a subject that we all are tired of hearing about, but cannot afford to ignore: intelligent design creationism. The ruling from the Dover trial (Kitzmiller v Dover Board of Education) has hung in strong, and seems to be affecting school board decisions and media viewpoints. If you do not recall, this is the decision in which federal judge John E. Jones, III ruled broadly that intelligent design and any of its pseudonyms (I'm paraphrasing) such as evidence against evolution, etc., were religiously based and were not appropriate for inclusion in the science classroom. This ruling seems to have significantly altered the Intelligent Design strategy in which they were at first pushing for teaching it in the science classroom. Now they have stated that it should not be taught in the science classroom—as if that were their own idea. Different variations of this are going around, but there is certainly a great deal of confusion in the intelligent design creationist ranks. Expect New Mexico to be besieged by more attempts to get "evidence against," alternate interpretations, etc. into science classrooms in the future. We do have a legislative session coming up in about a month. There may be some fireworks. Same old stuff; different packaging.

The Kitzmiller decision also seems to have rippled throughout some of the battleground states. For example, Kansas and Ohio have elected pro-science boards that want nothing to do with redefining science (Kansas) and eliminating one of Ohio's most steadfast troublemakers—an incumbent who lost by a two to one margin. Defeats of the anti-science people occurred in Michigan (Dick DeVos who was all for infusing "Christian" values into the public schools) and other areas, too. As I write this, South Carolina's race for the Superintendent of Public Schools (a powerful position) is still undecided. The whole state votes and the good guy is ahead by 483! This may be resolved by the time you read this.

Other interesting changes have occurred in given states, but I think it appropriate to comment on the overall changes in science and math education and research that "may" occur because of the national election outcome. Many people will see the switching of parties as a big plus for science and education. I see it as a big maybe. It doesn't take a lot of thinking back to remember all the public officials I have spoken with who are not well versed in database decision making regarding education or science. Almost none are science literate—regardless of political affiliation. Remember, the No Child Left Behind act is a terrible mess, asking for the physically impossible to occur (AYP, all students at proficient or above, multi-counting of student classifications, etc.). This was an overwhelmingly bipartisan bill. It showed significant lack of understanding of science and education by both parties. We can only hope that this changes. Regardless of our legislators' ideologies, they generally mean well, but will not always do the smartest thing concerning science and math education when they, themselves, are generally uneducated in those areas. Maybe we can do our small part to

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Dr. David Johnson, Webmaster

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help? There are a number who do listen! We just have to keep talking.

As Walt Murfin would say: the bottom line is that we can hope that there will be less ideological based posturing and decision making on both sides of the aisle, but we cannot count on it to just happen. We have to help.

And speaking of Walt, kudos for the job he has done with the Rio Rancho School system in analyzing the mid schools' performance. He spent a whole day presenting data to all the teachers at Eagle Ridge Middle School pointing out where they are excelling and where they can go to look for help in areas where other schools with similar demographics are outperforming in a given area in a specific grade. I sat in on the first presentation and think that Walt was great. Thanks, Walt.

Finally, Jack Jekowski, Marshall Berman, and I met with New Mexico Secretary of Education, Veronica Garcia and Rick Scott, Bureau Chief for Science and Math with the Publication Department (PED). In my mind, one of the major reasons for the meeting was to establish our availability and usefulness in helping the PED in any way we can. They do a great job but there is a tremendous amount of work to be done, and always a shortage of qualified personnel to do it. That seems to be the nature of public education. If we can help in any way, particularly in analysis of performance data to show where to look for successful programs, we shall do so.

Happy holidays to everyone! And, remember, keep alert!

Kim Johnson
President

Evolutionary Medicine

by Dr. Burt Humburg - <burt@dochumburg.com>
Excerpted from a medical presentation
(Edited by Marshall Berman)[1]

Earlier this year, Dr. Nesse and his colleagues wrote in Science magazine,[2] "Training in evolutionary thinking can help both biomedical researchers and clinicians ask useful questions that they might not otherwise pose." The name of the article was "Medicine Needs Evolution." What the authors were calling for was the teaching of evolutionary medicine.

Evolutionary medicine is the application of evolutionary biology to the practice of clinical medicine. Evolutionary medicine assumes that some diseases may be the result of evolution. By knowing evolution and by applying that knowledge to clinical care, we can treat our patients better and advance the standard of care.

In this short paper, we will discuss how evolution informs medicine already, present an example from the new field of evolutionary medicine, and discuss some possible criticisms.

How does evolution already inform medicine? Research on non-human organisms is applied to humans, reliably. For example, the mechanism of the action potential was worked out by research on squid. So why is research performed on non-human models so reliably useful to clinical practice? The answer is evolution - in this case, common descent.

Common descent allows animals to take our place in scientific experiments, on the basis that, on average, they share many of our genes with us. Since animal research is ubiquitous in medicine already, evolution already informs medicine.

But that is not what evolutionary medicine is. To be an example of evolutionary medicine, we would have to apply the concepts of evolutionary biology to clinical practice and patient care, and not simply use evolution to test a therapy in a non-human organism. Some background in evolution follows.

Organisms don't evolve. Or rather, organisms don't just evolve. Organisms co-evolve. Predators co-evolve with their prey and parasites co-evolve with their hosts. For example, consider the garter snake and the rough-skinned newt. Garter snakes eat rough-skinned newts. But the little newt is not without his own defenses.

These newts secrete a very powerful neurotoxin. Garter snakes that aren't resistant to that neurotoxin that eat those newts can die or get very sick. Since the non-resistant snakes die off, what you're left with is a population of snakes that are relatively resistant to newt toxin.This, in turn, drives the newts to become even more toxic. Which drives the snakes to become even more resistant, and so on until at some point, you get very powerful toxins.

So when an adaptation in one species drives a counter-adaptation in another species, you get what is known as an evolutionary arms race. That is how newts like these can develop toxins that are so powerful that just a few micrograms can kill.

Now how do the snakes develop resistance to the deadly toxin? Some resistance can be provided by a slightly modified neural cell receptor, one which doesn't bind the newt's toxin as well. However, it also doesn't transmit nerve signals very fast, the result of which is that snakes with resistance to toxin tend to be slower than snakes that are not resistant. This makes a bit of a puzzle. Which snake is going to win, in terms of better passing on its genes to the next generation? The answer is that it's impossible to predict - without knowing the kind of prey that the snakes will be feeding upon. If the newts have toxin, the toxin-resistant but slower snakes will win. If the newts don't have toxin or if the snakes can find other prey, then the faster snakes will win.

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1. ***Ed. Note:*** *This article is the first of a series that will present new scientific research in the medical field. We hope that many of you will find this information useful. Not a single practical piece of research has ever resulted from "creation science" or "Intelligent Design," and nothing ever will. Perhaps in the future, scientists can stop wasting time refuting vacuous and inane creationist claims, and continue to improve the quality of life for everyone.*

2. Randolph M. Neese, Stephen C. Stearns, and Gilbert S. Omenn, *Science* 24 February 2008 311: 1071 (in Editorial)

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This is important to understand about evolution. Evaluating the "adaptiveness" of a particular trait requires that you know the environment a trait is in. Consider a tiger. Big teeth, big body, quick. A tiger seems really adapted, right? Now dump it in the middle of the ocean. He'll die. Now consider a shark. As strong as it is, if it wound up in the middle of the jungle, it would be dead meat. Seldom can one say that a particular trait is adaptive in and of itself. Rather, traits should only be considered adaptive or maladaptive with respect to a particular environment.

So, with that understanding of evolution, we can move to my example of evolutionary medicine. Parasites like intestinal worms are highly adapted to living inside their hosts. There is a rich literature to support the conclusion that worms modulate the immune systems of their hosts. However, the ability to modulate the host's reactions tends to be species-specific. This is fairly straightforward—we take our dogs in to the vet each summer to get heartworm shots, but we humans don't get heartworm infestations. Now consider inflammatory bowel disease. IBD is an inappropriately exuberant inflammatory response of the gut, presumably to unknown antigens or stimuli. IBD was first described at Mount Sinai Hospital in the early 1900s, an era where not all cities had good sewer treatment facilities or public health systems. IBD is known to have a higher incidence in the Northern areas of Europe and the US. IBD doesn't affect developing nations as much as it does advanced ones. Although we've discovered a few antibody response patterns, the etiology of IBD is as yet unknown.

Now, put all that together in the light of evolutionary medicine. Is it possible that our ancestors evolved in the presence of parasites that modulated their inflammatory reactions? Did our ancestors adapt to those worms by upregulating the inflammatory reactions of their gut? Was the local immune modulation by worms and the upregulation of gut inflammation by human progenitors an evolutionary arms race?

Is it possible that the reason we haven't been able to find the cause of inflammatory bowel disease is because we have been looking for a cause that *might* be there instead of a cause that's no longer there? Is IBD caused by a *lack* of a worm infestation?

Now think about the clinical implications of this new model. Do we give worms to our patients who suffer from Crohn's disease flares? In 2005, Summers and his colleagues at the University of Iowa published the results of their research in which they did just that. They obtained pig whipworm eggs from the US Dept. of Agriculture and cleaned and sterilized them to remove bacteria and viruses. Trichuris suis was a great choice for this trial for two reasons: First, because of that host specificity thing I talked about earlier, T.suis organisms can't really stay inside the human body very long before our immune systems kill them; Second, the eggs of T. suis require maturation in the ground for about two weeks before those eggs are infective, which makes less likely the possibility of cross-contamination of the patient's social contacts. After Summers' group verified the ova were viable, he made up doses of his egg-laden slurry. He also made up doses of placebo.

54 patients with active colitis were recruited and randomized into receiving either placebo or ova. These subjects returned to the clinic every two weeks for double-blinded monitoring, labs, and dosing. At weeks 0 and 12, the subjects underwent endoscopy.The results of their research were striking. A favorable response was noted in 43% of patients receiving ova and only 17% of patients receiving placebo.

These ova-treated patients had significant improvements in all measures of the ulcerative colitis scale. Everything from stool frequency to blood in the stool to mucosal appearance during endoscopy. The placebo controlled patients did not fare so well - only stool frequency improved to the point of clinical significance, and only barely so.

There is another test to determine ulcerative colitis intensity of disease. This test, the Simple Index, doesn't require endoscopy to measure; all it requires is an exam and a few questions or labs, so the researchers were able to obtain data at every clinic visit. The placebo-treated patients continued to suffer bad disease. Indeed, within the margin of error, they didn't get statistically better from when they were recruited into the study. The ova-treated patients, however, did improve, and statistically speaking by the 10th week of therapy. (The patients continued to improve the full 12 weeks.)

These data are consistent with the view suggested by evolutionary medicine—that a lack of a worm colonization may predispose individuals, well adapted to fighting parasites, to IBD. This qualifies as an example of using a therapy suggested by our evolutionary heritage to directly advance patient care; this is an example of evolutionary medicine. Biological therapy is emerging as a promising method of treating inflammatory bowel disease. [When the NY Times or CNN start talking about this in a few years, remember you read it in the Beacon first!]

I close this brief illustration of evolutionary medicine with two criticisms I have of this nascent field. The first criticism I have is that there is a tendency to misapply evolution. Take the example of septic shock. As many know, someone in septic shock shows many different pathological phenotypes, including hypotension and the consumption of blood products required for clotting. How could it be the case that, after so many eons of evolution, here we stand "well adapted" for our environments, and yet we have evolved reactions to bacterial infections that would at least *seem* to make us sicker than just the bacteria alone would cause. It has been suggested that this trait was adaptive because it was nature's way of improving the gene pool, specifically that individuals who were so sick from infections must have genes that predispose to those infections and therefore a negative selective pressure was actually adaptive for the species, even though it was maladaptive for the individual. The problem with his explanation, of course, was that *any* maladaptive trait could be explained by appeal to the idea that it was better for the species that those with those traits should die off: Crohn's disease might have been considered nature's way of keeping the gene pool clear, etc.

Evolutionary biology is not simply a prism through which to view medicine or disease entities. There is a science to it. You have to go out and get the data and run the calculations to find out whether the plausible explanation is actually the probable one. Making these kinds of determinations scientifically requires highly advanced training. I think, even if evolutionary medicine is taught in our medical schools, that MDs will not be the ones carrying out these kinds of calculations. My guess is that it will be like biostatistics or epidemiology, where MDs are conversant in the field, but where specialists will work alongside MDs, guiding their research and helping them.

The other criticism I have of evolutionary medicine is that it is a basic science, which, by definition is not necessary for the practice of medicine.That might sound like a shocking statement, but it's true.

Say that the therapy I discussed previously becomes the standard of care and that in the next 50 years, physicians in training will be expected to know to inoculate all our patients with inflammatory bowel disease with worms in the hopes that they will develop an infestation. A medical student living in that era will not need to know the first thing about evolution in order to give his patients worms. All he would need to do is follow the standard of care, and give the worms. Knowing evolution is not essential to the clinical practice of medicine.

But I could also say that biochemistry is not needed for the practice of medicine. You don't have to know how aspirin acetylates and irreversibly inhibits cyclooxygenase—all you have to do is give people aspirin after they have a heart attack, which is the standard of care. Similarly, you don't have to know anything about embryology to be a good pediatric surgeon—all you have to do is watch a lot of pediatric surgeries and know what they cut and what they don't and practice the standard of care. I am conceding nothing when I say that evolutionary medicine is unnecessary because it's a basic science; it's possible to take all our current standards of care and divorce them from their evidentiary underpinnings; of course, the basic science involved is extremely important.

Evolutionary medicine is a basic science tool; one can either learn to use that aspect of basic science—applying the latest in the research from the field and possibly advancing the state of the art of medicine—or one can choose to not use it—relying instead on previous standards of clinical practice to guide patient care.

The clues for the evolutionary etiology of inflammatory bowel disease came from myriad different sciences. Our understanding of action potentials came from research on squid, a non-human organism. Doctors aren't in the habit of giving infections to cure disease, yet this is a pretty apt summary of the bourgeoning use of biological

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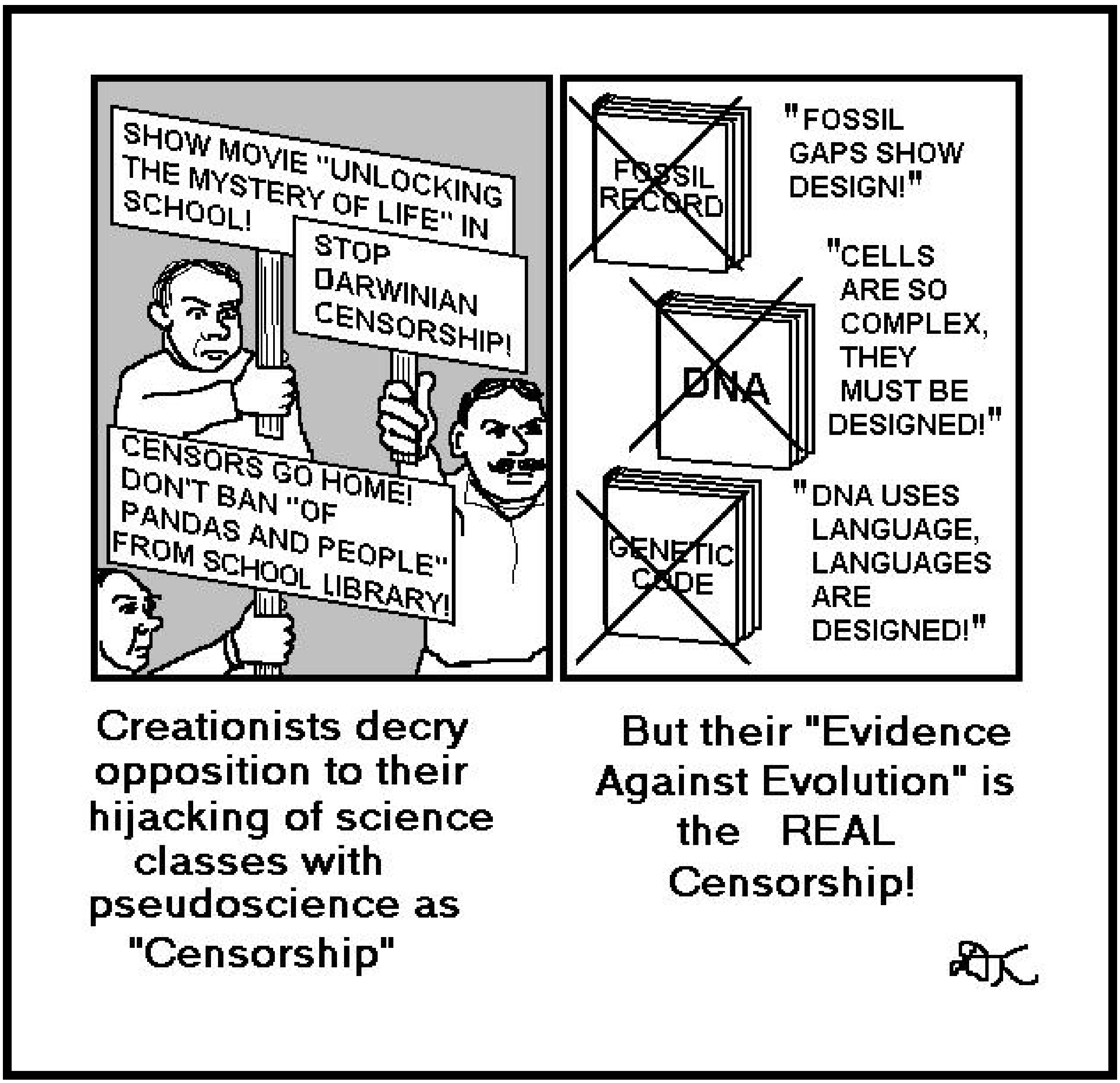
therapy in medicine. The fact is, breakthroughs that advance our patient's care can come from anywhere in science. Those who don't know evolution or any of the basic sciences, are not as well-positioned to think up new therapies as those who do.

Our evolutionary heritage should be celebrated, not feared. One who understands evolution can perform the task of healing the sick better than one who does not know evolution. Our common descent does not render life bleak and pointless. On the contrary, as Charles Darwin said,"there is grandeur in this view of life."

TOON BY DAVID THOMAS



Every School Left Behind

NCLB requires every subgroup of 25 or more in every school to achieve 100% proficiency in mathematics and reading by 2014. If any subgroup of 25 or more students fails to make Adequate Yearly Progress (AYP) the school fails. One of the listed subgroups is Students with Disabilities (SD)—i. e., special education students. At almost every school, the SD group has the lowest proficiency.

AYP is demonstrated by a proficiency at least equal to the 99% lower confidence bound of "Annual Measurable Objectives" (AMO), which increase from 2005 to 100% in 2014. Figure 1 shows the AMOs for mathematics and reading for typical middle schools, i.e., schools covering grades 6 through 8. Some middle schools and junior high schools have slightly different grade structures. AMOs for other middle school grade configurations differ very little from those in Figure 1.

The 99% lower confidence bound depends on the number of students tested. For example, if the target proficiency is 40%, the 99% LCB is 14.27% at N=10 and 25.64% at N=50.

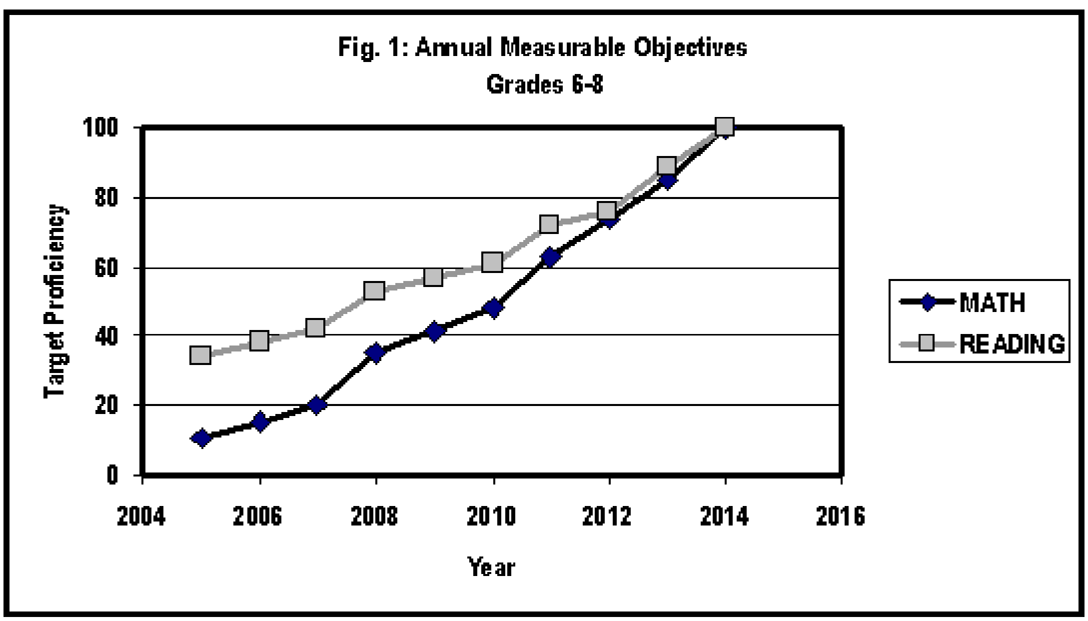
I analyzed all the middle schools and junior high schools in the state in which at least 50 full academic year students were tested in the spring of 2006, a total of 141 schools. Only 130 of those had at least 10 SD students tested; the state did not report proficiency for any subgroup of less than 10.

The average proficiency for the SD students was 6.8% in mathematics and 14.5% in reading. The average increase from 2005 to 2006 was less than one percentage point in mathematics, and there was a decrease of 1.6 points in reading.

Figure 2 shows the mathematics proficiency of special education students against the number of SD students tested. The smooth curves show the 99% lower confidence bounds for 2006, 2007, and 2008. Each symbol represents the percent proficient of the SD students at one school. About one-third of all schools achieved AYP for this group in 2006. Unless the performance of SD students improves markedly, only a handful of schools will achieve AYP in 2007, and it is likely that only a tiny fraction will pass in 2008.

The situation in reading is especially bleak, as shown in Figure 3. Only 12 of the 130 schools made AYP in 2006. Absent a marked improvement in SD reading performance, hardly any schools will pass in 2008. Note that there has actually been a decrease over the past two years.

Every school must make AYP in both math and reading. Unless there is a major increase in performance for this group, almost all middle schools in the state will probably fail by 2008. A few schools might survive by the "Safe Harbor" provision: a subgroup can pass if the number of non-proficient



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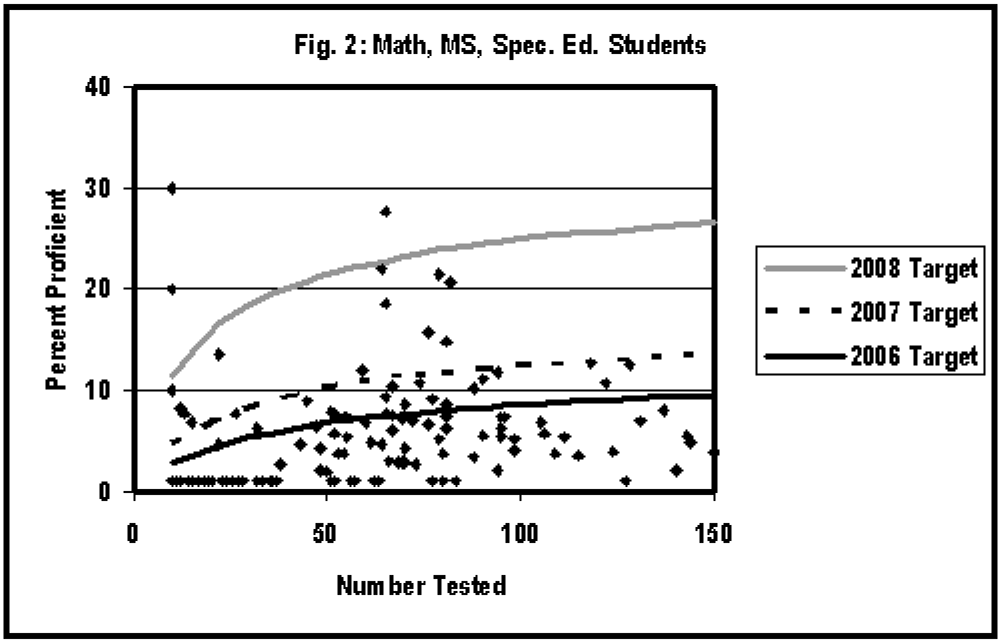
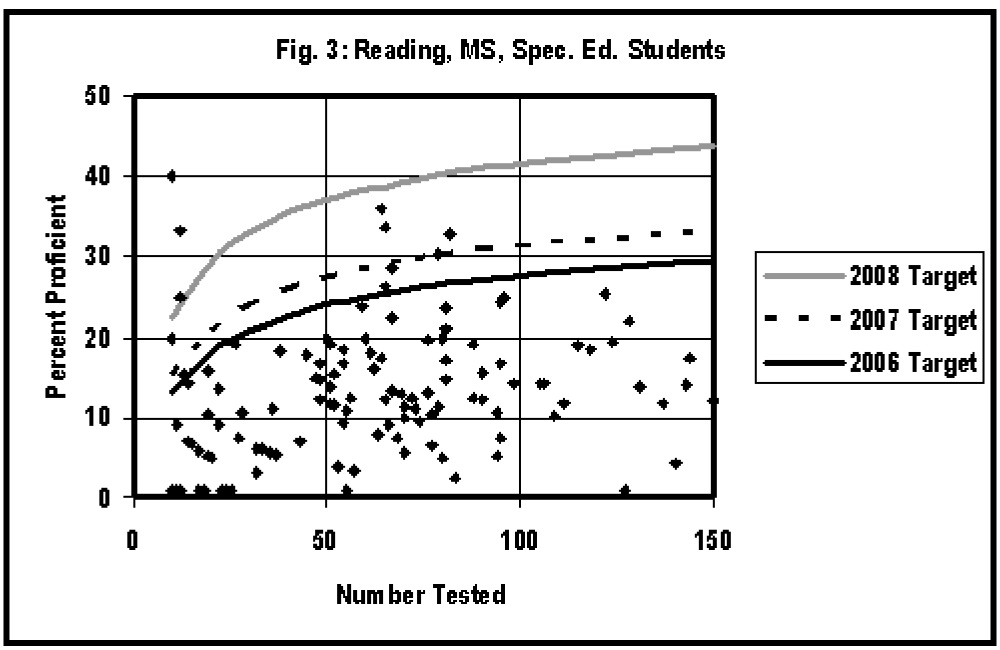
students is reduced by 10% or more. However, even this escape clause will not save schools for long. The situation for elementary and high schools is similar. The performance of special education students is understandably low and the goal is impossibly high.





Walt Murfin
CESE Statistical Analyst

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