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ON THE COVER: Many laundry and dishwasher detergents contain phosphates, whose unique scientific properties have raised warranted and unwarranted environmental concerns.

By the Numbers

Beyond propaganda and rhetoric, numbers tell the real story

ON THE 40TH anniversary of the lunar landing, the planet Jupiter was hit by a milewide asteroid, leaving a large black scar roughly the size of the Pacific Ocean on Jupiter's surface. The collision, which was discovered by an Australian amateur astronomer and came as a surprise to scientists, is a reminder that the universe is a dangerous place. Jupiter, the fifth planet from the sun, is 318 times larger than Earth and acts as a stellar vacuum cleaner, with a gravitational pull that attracts most of the asteroids that pass by. In March, however, Earth faced a close call as an asteroid named 2009 DD45 passed within 45,000 miles, mere inches on a cosmic scale. Its trajectory was discovered only three days in advance. The most famous recent example of Earth being hit by a so-called NEO (near-Earth object) is the 1908 Tunguska Event, when an asteroid with a diameter of 45 to 70 meters exploded over Tunguska in Siberia, unleashing the energy of 10 megatons of TNT, equivalent to a hydrogen bomb, and leveling about 100 million trees over an area of 800 square miles. If it had struck four hours later, St. Petersburg would have been wiped out. So far, some 6,200 NEOs have been discovered in our solar system, of which 1,000 are deemed "potentially hazardous," and 784 are registered as more than a half-mile wide. NASA's Jet Propulsion Laboratory keeps a running tally of NEOs at www.neo.jpl.nasa.gov/stats. Scientists believe there are plenty of similar NEOs that have yet to be discovered, and as the Jupiter collision proved, they might not be discovered before it is too late. At present, astronomers are tracking the asteroid 99942 Apophis, which has a slight chance of striking Earth in April 2036. Though it is reasonably small by asteroid standards — about 300 meters across — a collision would unleash a force about 60,000 times that of the Hiroshima nuclear bomb, enough to destroy an area the size of France.

For more information, visit www.theatlantic.com/doc/200806/asteroids.

This summer was the second-coolest in New York City since 1869, as July's average temperature clocked in at 71.7 degrees, 4.4 degrees below normal. As of July 20th, Staten Island Real-Time News reported that 18 out of 20 days had been below average temperatures, with no above-average temperatures. For the first time since 1996, temperatures did not reach 90 degrees in either June or July.

EVEN THOUGH THE United States has not signed the international environmental treaty known as the Kyoto Protocol, emissions here have been better controlled than in other countries. According to the U.S. Energy Information Administration, carbon dioxide emissions from the burning of fossils fuels only increased by 0.7 percent in the United States from 2000 to 2006, compared to 27.7 percent in India, 45.8 percent in Malaysia and 103 percent in China. Overall, emissions in Europe (up 4.9 percent) and Asia (up 52.3 percent) followed suit. By 2030, India and China are expected to account for 34 percent of the world's emissions, as growing populations move out of poverty and join the middle-class life enjoyed on average in richer, industrialized nations, thereby increasing their demand for energy. According to Drew Thornley, author of the new report "Energy & the Environment: Myths and Facts," international environmental treaties that penalize conventional energy sources make little sense if other countries swamp American reductions. The same goes for ambitious political initiatives. Rather, it would seem, we do better than others without adopting an international carbon-cutting regime.

For more information, visit www.american.com/archive/2009/june/emissions-control-myths-and-realities.

MORE THAN 55 million years ago, an extremely significant and rapid change in climate, referred to as the Paleocene-

The Third Degree

Test your reading of this issue of MichiganScience. Students in grades six through 12 can compete for a $100 gift certificate from Edmund Scientific. The winner will be determined by a random drawing from entries with all the correct answers. Please send entries to walker@mackinac.org.

1. According to the U.S. Energy Information Administration, by what level did carbon dioxide emissions from the burning of fossil fuels in the United States increase from 2002 to 2006?
   A. 1.7 percent. B. 7.1 percent.
   C. 27.7 percent. D. 0.7 percent.

2. What occurred in Tunguska, Siberia, in 1908?
   A. A hydrogen bomb exploded.
   B. A dynamite factory caught fire.
   C. An asteroid exploded.
   D. The planet Jupiter was discovered.

3. How did the mastodon discovered by Rich and Annette Schneider die?
   A. It was killed by hunters.
   B. Wasting disease.
   C. It was killed by wolves.
   D. Old age.

4. How many mastodon skeletons have been found in Michigan in the past 100 years?
   A. 250. B. 200.
   C. 2000. D. 275.

5. How many Michigan homes are anticipated to receive weatherization upgrades as part of the federal stimulus program?
   A. 3,300. B. 33,000.
   C. 13,000. D. 23,000.

6. What tool devised by Princeton researchers measures airtightness and locates heat leaks in homes?
   A. A vacuum door.
   B. A blower door.
   C. An insulation door.
   D. A resistance door.

7. What qualities do phosphates add to washing products?
   A. Raise wash efficiency.
   B. Prevents film forming on glassware.
   C. Both A and B.
   D. None of the above.

8. In 1977, the level of phosphates used in laundry detergents was lowered to what percentage?
   A. 1.7 percent. B. 8.7 percent.
   C. 30 percent. D. 0.5 percent.

9. According to University of Hawaii researchers, how much carbon dioxide was released from deep-ocean warming during the Paleocene-Eocene Thermal Maximum?
   A. 11 million tons. B. 11 billion tons.
   C. 11 trillion tons. D. 16 tons.

10. What percentage of the United States' electricity is derived from fossil fuels?
    A. Just over 91 percent.
    B. Just under 65 percent.
    C. Just over 75 percent.
    D. Just under 55 percent.

By the Numbers

Eocene Thermal Maximum, occurred during the Cenozoic Era. Temperatures increased between 5 and 9 degrees Celsius (between 10 and 18 degrees Fahrenheit), at a time when the world was warmer than it is now and held no surface ice. Researchers at the University of Hawaii at Manoa have released a study in "Nature Geoscience" that indicates global warming cannot be explained solely by a surge in carbon dioxide levels. By studying sediment cores from seabeds around the globe, the scientists have come to the conclusion that there were, in fact, additional factors. An initial trigger is believed to have been involved, such as a deep ocean warming that caused a cataclysmic release of methane from hydrate deposits under the sea bed. Much of the methane oxidizes into CO2 when released from hydrate deposits. It is estimated that the amount of CO2 released during the Paleocene-Eocene event was about 11 trillion tons, released over several thousand years, which led to a 70 percent rise in atmospheric CO2 levels from pre-event levels. But only about 1 to 3.5 degrees Celsius of the rise in temperature is explained by this event. The study suggests that there might be atmospheric or oceanic processes yet unknown that could have accelerated the warming. Some estimate CO2 levels could increase by 70 percent in this century, much faster than during the Paleocene-Eocene Thermal Maximum. The researchers hope the unknown processes can be identified to estimate their future potential effect on climate change.

For more information, visit http://in.reuters.com/article/worldNews/idINIndia-41050320090715?sp=true.

Field Trips

Area science museums host special programs of interest for budding scientists and their families

THE DETROIT SCIENCE Center is featuring a historic exhibition as 36 "accidental mummies" are seen outside of Mexico for the first time. The exhibition combines science, history and cultural anthropology to immerse the visitor in the world of a Mexican city more than 100 years ago, where deceased residents naturally mummified in their crypts. Visitors to the exhibit will see some of these accidental mummies, learn about life in their community, discover the modern-day forensic technology that helps scientists analyze them, and explore a culture that reveres and celebrates them.

Runs through Jan. 31, 2010. Detroit Science Center, 5020 John R St., Detroit. Center is open Monday through Friday, 9 a.m. to 5 p.m.; Saturday, 10:30 a.m. to 6 p.m.; and Sunday, noon to 6 p.m. $18.95 for adults, and $14.95 for children and seniors; includes museum admission. Discounted group rates available. Call 313-577-8400.

For more information, visit www.detroitscience-center.org or www.accidentalmummies.com.

IMPRESSION 5 IN Lansing has two new exhibits, both of which are open and ready for hands-on exploration. "Window on Water" lets you learn about groundwater by viewing a cutaway model of the water aquifer and reading about the spread of water contamination. Window on Water was designed to illustrate the importance of protecting sources of clean drinking water through a partnership between the Lansing Board of Water & Light and Impression 5. The "Giant Eye" is an 8-foot-tall model that lets you see the human eye from a new and exciting perspective. It's even possible to walk inside this enormous optical organ, which is the largest in the country.

Runs until the end of the year. Impression 5, 200 Museum Dr., Lansing, Mich., 48933. Museum is open Monday-Thursday, 10 a.m. to 5 p.m.; Friday-Saturday,10 a.m. to 7 p.m.; Sunday, noon to 5 p.m. Adults and students: $5; AAA members receive 10 percent discount. Call 517-485-8116, ext. 32.

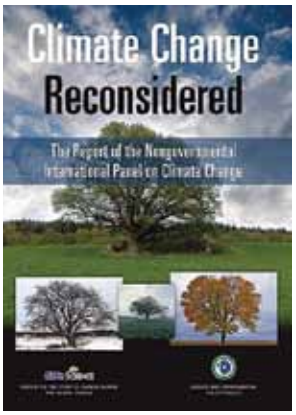
THE ALDEN B. DOW Museum of Science and Art in Midland is featuring the most comprehensive exhibit ever coordinated on the subject of Albert Einstein, organized by the American Museum of Natural History of New York. Widely regarded as one of the most intelligent human beings in history, Einstein reinterpreted the inner workings of nature, light, time, energy and gravity, and redefined the way we look at the universe. This exhibition will look into Einstein's life and times, his thinking and his legacy as a humanitarian and global citizen. It is highly interactive and inspires learning through its innovative exhibition and engaging activities.

Runs through Dec. 6, 2009. Alden B. Dow Museum of Science and Art, 1801 W. Saint Andrews Road, Midland, Mich., 48640. Museum is open Wednesday, Friday and Saturday, 10 a.m. to 4 p.m.; Thursday, 10 a.m. to 6 p.m.; Sunday, 1 p.m. to 5 p.m.; closed Mondays and Tuesdays. Adults: $8, Children 4-14: $5. Call 989-631-8250 or 800-523-7649.

For more information, visit www.mcfta.org.

THE CRANBROOK INSTITUTE of Science, together with Cranbrook Art Museum, presents a pioneering exhibit titled "Artology: The Fusion of Art and Science at Cranbrook." Showcasing the work of artists whose creations intersect with and complement science at a fundamental level, the exhibit includes a large exhibition on the natural world and the way we attempt to classify nature scientifically, as well as an exhibition on art and climate change. Also featured is the acclaimed video project "Murmur," a study of starling migration in Europe.

Runs through June 2010. The Cranbrook Institute of Science, 39221 Woodward Ave. Bloomfield Hills, Mich., 48303. Museum is open daily from 10 a.m. to 5 p.m.; Friday from 10 a.m. to 10 p.m. Adults: $9; Children (2-12): $7. Call 248-645-3200.



Climate Change Reconsidered:
The Report of the Nongovernmental
International Panel on Climate Change
by S. Fred Singer and Craig Idso
Reviewed by Karl Bohnak

NO OTHER AREA of scientific study ignites more passion and emotion than climate science. This is because the subject deals not just with natural science; it has crossed over into the realm of political science. The U.S. House of Representatives recently passed a sweeping climate change bill that includes controversial cap-and-trade legislation to limit greenhouses gas emissions. The Senate will consider the same bill soon. While the bill was squeaking through the House by the slimmest of margins, government scientists issued a report that stated, "Observations show warming of the climate is unequivocal. The global warming observed over the last 50 years is primarily due to human-induced emissions of heat-trapping gases." Further, these scientists say that CO2 emissions from the burning of fossil fuels must be cut now to prevent runaway warming, serious environmental damage and social upheaval.

A substantial number of scientists disagree with the above statements. One such group recently put together a book published by the free-market think tank The Heartland Institute. "Climate Change Reconsidered: The Report of the Nongovernmental International Panel on Climate Change" provides a stark contrast to the certitude and alarming climate stories that emanate from major media outlets. This 880-page book argues that climate change — meaning human-caused climate change or global warming — is not a crisis.

The lead authors of the report are scientists S. Fred Singer and Craig Idso. Singer, an atmosphere and space physicist, is one of the most outspoken skeptics of man-made global warming. He has written numerous articles and editorial essays for major publications including Cosmos, The New York Times, The Washington Post and The Wall Street Journal. In 2004, he co-authored "Unstoppable Global Warming: Every 1,500 Years." Idso is a geographer with a doctorate from Arizona State University, where he has lectured in meteorology. He is the founder, past president and current chairman of the Center for the Study of Carbon Dioxide and Global Change.

Chapter by chapter, the authors dismantle fear of looming crises with published, often peer-reviewed work. The book is set up in such a way that one can access concise conclusions to each of the nine chapters in the opening executive summary. Each chapter deals with a specific area, beginning with the cornerstone of alarmist predictions, Global Climate Models (GCMs). The chapters are broken up into sections that outline studies and research from various parts of the world that question global warming orthodoxy. The end of each chapter contains a bibliography citing the research publications referred to in the text.

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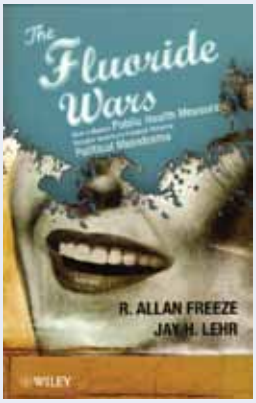

The Fluoride Wars: How a Modest Public
Health Measure Became America's
Longest-Running Political Melodrama
by R. Allen Freeze, Jay H. Lehr
Reviewed by Ken Braun

THERE IS A wickedly satirical game called "Illuminati," the goal of which is to construct an improbable political conspiracy and conquer the world. For example, a player can leverage his "Anti-War Activists" card into a cabal that secretly lords over the Federal Reserve Bank, the Republican Party and the KGB (with the Anti-War Activists in turn answering to the likes of the "Boy Sprouts" or the Post Office). The fun is in creating the most absurd organizational chart, and I was reminded of this as I read "The Fluoride Wars: How a modest public health measure became America's longest-running political melodrama," a new book from R. Allen Freeze and Jay H. Lehr. Of course, there is an Illuminati card for "The Fiendish Fluoridators," and this book will leave you thinking that no satire will ever compete with the real thing.

Readers are reminded on Page 5 of the greatest fluoridated water satire of them all: Col. Jack D. Ripper from the 1964 film "Dr. Strangelove," who went mad and started a nuclear war, convinced that fluoridated public water was a communist plot to rob Americans of their "precious bodily fluids." But in real-world 1950, the "threat" of Soviet water tampering was seriously advanced in Stevens Point, Wisc., as one of the reasons to vote down public water fluoridation. Well before

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the fictional Col. Ripper used bombs to fight off "commie fluoride," these real voters became the first community in America to get the job done with ballots.

Though the issues would change, Stevens Point would have many imitators in the decades that followed. Just during the 2000 election, 14 of the 26 communities holding a referendum on public water fluoridation voted against it.

Freeze and Lehr are both well-regarded researchers in environmental and water quality, and much of this book is a highly readable scientific history of why and how the introduction of fluoride to the American diet has radically transformed public health for the better by stamping out tooth decay. It is a fine science lesson regarding dosage and risk calculation, and a solid history book as well. If nothing else, it should substantially upgrade the waiting room reading material at many dental offices.

But it's much more entertaining than all that. It would be forgivable to assume (as I did) that the book should be strongly pro-science and thus contain much mockery of the anti-fluoridation zealots. This it does do, but that's far from the whole story. On Page 7, those with a "strong opinion" about the issue are warned that they should "try to park it in a corner for a while." Like the conspiracy game, it turns out that in "The Fluoride Wars," little is ever quite as you suspect.

For example, there is the ironic revelation that ol' Col. Ripper might have been just a tiny bit right! In 1994, a reputable FDA researcher recommended further investigation after finding hints of a potentially slight — but still statistically significant — correlation between communities with fluoridated water and decreasing fertility in women. (Thankfully, the research found no reason to mention the defunct Soviet Empire as an aggravating factor.)

As with many substances that are beneficial in small doses, fluoride in larger doses can cause harm that is known (such as discolored teeth and crippling skeletal fluorosis) or harm still unproven (such as infertility). In this, there is another historical irony: The original federal investigation into fluoridated water was undertaken to help prevent the discoloration of teeth that occurs when people live in communities with too much natural fluoride in their water supply. In the course of this research, the extraordinary cavity-fighting benefit of fluoride was discovered, leading to an about-face by the government and a decision to promote adding fluoride to the vast majority of water supplies that don't have it naturally.

The authors take the reader through the morass of potential and proven side effects, and also pay a prolonged visit to the completely outrageous and baseless health allegations made against fluoride. In all of this there are whiplash-inducing ideological turns as fears from the political "Right" about Soviet plots morph into (or just join with) unhinged accusations from the "Left," such as one which holds that the Aluminum Corporation of America (Alcoa) foisted water fluoridation on Americans as a profitable means of getting rid of their industrial pollutants. Pretty soon, you get the impression that the "Fiendish Fluoridators" have enemies everywhere, including at the Natural Resources Defense Council, the Center for Science in the Public Interest, and even the labor union that represents the research employees who help establish safe drinking water standards for the federal government.

But as it turns out, some of these critics are not anti-science zealots, and they have serious points worth considering. While there is no question that fluoride makes a valuable health contribution in countries (such as this one) with citizens who consume refined sugar by the truckload, Freeze and Lehr believe that we should give more thought to what a proper dosage is. Unlike in 1945, when Grand Rapids, Mich., became the first municipality to get fluoridated water, today, nearly all toothpaste is heavily fluoridated. We also now have routine applications of fluoride from dental offices; mouth rinses contain it; and many of the packaged foods and beverages we buy are made with fluoridated water. "The Fluoride Wars" makes a convincing case that if you are at least a middle-income American with access to dental care, yet with no fluoride in your tap water, then you are still very likely to get more than the optimal fluoride dose needed to protect your teeth.

So, are Americans living in fluoridated water communities flirting with overdose? Well, in 1997, the authors of one of the most popular dental school textbooks called for a 30 percent reduction in the recommended supplemental fluoride dosage added to municipal water systems. Freeze and Lehr state that the "need for a reduction in overall fluoride levels was in the air" when the American Association of Public Health Dentistry's annual conference in 1994 featured a symposium titled "Fluoride: How Much of a Good Thing?"

Yet the federal government's recommended dosage for fluoride content in municipal water systems has remained virtually unchanged. Why? Loosely paraphrasing and somewhat oversimplifying a more complex argument, the book concludes that this is because after fighting for decades with anti-fluoridation zealots (and often getting beaten by their propaganda at the local ballot box), some of the strongest proponents of public water fluoridation in the dental establishment started refusing to pay attention to any evidence undercutting the wisdom of their past recommendations, often out of a subconscious fear that it would put

too much intellectual ammunition into enemy hands. For legitimate American researchers who have uncovered hints of harm relating to our current fluoride dosage level, this institutional phobia has sometimes meant difficulty in getting published in American dental journals and even career-threatening ostracism. (Tellingly, many of those excluded do manage to publish instead in comparable European journals.)

It should be no surprise that the anti-fluoride zealots have long alleged a dark corporate and/or governmental conspiracy to suppress the "real story" about the evils of fluoride toxicity. But as it turns out, clumsy attempts by the champions of fluoridated water to hide real information appears to have come about because of — and as a paranoid defense mechanism against — those very accusations by anti-fluoride zealots regarding far more sinister and elaborate plots. In "The Fluoride Wars," you discover that it is the conspiracy theorists themselves who secretly hold the puppet strings — even though they don't know it.

How much fluoride should we put in the water? The authors conclude that it's a question that isn't easy to answer when the people looking into it are screaming at each other, making things up (some of the louder anti-fluoride zealots), or hiding some of the truth because they're afraid of what might be done with it (some dogmatic pro-fluoridation proponents). This book isn't really about teeth and fluoride; it's about how we go about making informed decisions regarding science and public policy. And no matter what you think you already know about that, Freeze and Lehr have something to teach you. ■

Would you like to comment on this book or this article? Send an e-mail to walker@mackinac.org, and we may print it in our next issue of MichiganScience.

THE LABORATORY LIBRARY *continued from page 7*

In Chapter 1, a question is posed: "Are GCMs capable in principle of producing a reliable forecast?" The authors say the answer is a resounding "No." It is shown that in effect, these models are mathematical representations of assumptions the scientists constructing these models have about how the global climate works. GCMs are shown to have deficiencies in their representation of the earth's radiation budget, clouds and precipitation. These and other physical properties are still not well understood. Since these models start out with faulty assumptions, their output is likely to be wrong. In addition, the book references the work of experts in scientific forecasting, which demonstrates that forecasts issued in 2007 by the U.N.'s International Panel of Climate Change violate more than half of the 140 principles of scientific forecasting.

The ensuing chapters deal with climate sensitivity, temperature, observations of glaciers, sea ice, precipitation and sea level. The role of the sun in global climate is examined in Chapter 5. Conventional global warming science assumes that the sun provides a relatively constant source of energy and any subtle changes in energy output are now dwarfed by growing concentrations of atmospheric carbon dioxide. Key findings from around the world show that solar variability has a history of producing profound global climate changes and correlates much better with temperature and precipitation trends than levels of atmospheric CO2.

The concluding chapters examine extreme weather events, the biology of CO2 enhancement, species extinction and human health effects of CO2. One of the most ominous alarmist claims is that global warming will cause more extreme weather events. Peer-reviewed research shows no upsurge in such events over the last century. In fact, evidence is presented that explains that historically, extreme weather events like floods and droughts have occurred more frequently during colder episodes like the Little Ice Age. In the biological realm, increased CO2 is shown to be beneficial for most herbaceous plants. Experiments were done where CO2 levels were raised and plant yields increased. Production rates were even higher for woody plants when CO2 levels were raised. In the species section, the state of the poster-animal of global warming alarmism — the polar bear — is among the topics reviewed. Here, research shows that virtually all scientists agree that populations of this carnivore have increased since the 1970s, casting doubt on predictions that a warming world will threaten the animal. As for humans, there is no evidence that disease has increased with the minimal warming of the late 20th century. Life span has increased in all areas of the world due to technological advances fueled by carbon-based energy.

"Climate Change Reconsidered" is an excellent overview of the available peer-reviewed and other research that questions the premise that human emission of CO2 will cause catastrophic climate change. The work contains an exhaustive collection of scientific studies in support of this thesis, arranged in a well-organized format. It provides substance for the scientist while staying accessible to the layman. The book is an indispensable document cataloguing the case for skepticism of orthodox global warming science. It is a must-read, particularly for policymakers charged with the task of shaping America's environmental laws and energy future. ■

Would you like to comment on this book or this article? Send an e-mail to walker@mackinac.org, and we may print it in our next issue of MichiganScience.

By David Pontoppidan

Family Discovers 10,000-Year-Old Mastodon Skeleton in Backyard

May help reveal background for the mastodon's extinction

FOR RICH AND Annette Schneider of Portland, Mich., the digging of a new pond in their backyard suddenly turned into an excavation of ancient bones, as they uncovered parts of a grown mastodon — a mammoth-like creature that entered the North American continent about 15 million years ago.

"We pulled up a thigh bone and we knew there was something going on. We didn't know what was going on, but quickly started pawing through the excavated dirt and found rib bones, a tusk and more," Rich Schneider told MichiganScience. "Everyday we went out there, we found more pieces, including some that were still embedded in the pond bed itself."

The mastodon in question is believed to be about 10,000 years old, from right around the time the species went extinct. Professor Daniel Fisher from the University of Michigan studied the excavation and bones and believes the animal was most likely killed by humans and butchered. The bones are believed to have been placed in a pre-existing pond by Paleo-Indians who arrived on the continent around 13,000 B.C. and would submerge part of their captured prey in water to store it for later use.

"We thought it was the right thing to donate the bones to science, since the scientists can extract a wealth of information from them and do a lot better with them than we can," Schneider said.

Fisher is very grateful for the donation and hopes to learn a lot from the bones and tusk. Specifically, they may reveal information on the general health of the animal, since a large debate surrounds how mastodons actually became extinct. Some scientists believe they died out as a result of climate changes and subsequent food scarcity, which would be revealed in the fossilized remains of the mastodons. For the most part, however, this has not been the case, and Fisher believes instead that they were hunted to extinction by humans who may have specialized in big-game hunting. A mastodon would be the size of a present-day elephant, but more heavily built and easily weighing about six tons.

"Would it be hard to hunt down a mastodon? Well, it would be hard for you and me. But in terms of what they (Paleo-Indians) were capable of doing, I don't think there is any question they were capable of hunting these animals," Fisher told MichiganScience. "Whether they did so systematically is a controversial issue though."

This is not the first time mastodon remains have been found in Michigan. In the last 100 years, parts of about 250 mastodons have been uncovered in Michigan. In 2007, archeologists discovered a boulder in Grand Traverse Bay with what looked like drawn markings resembling a mastodon with a spear in its side, indicating that humans hunted them frequently. ■

By Drew Thornley

The Myth of Fossil Fuels, Alternative Fuels and Renewable Energies

SPECULATION ABOUT DWINDLING oil supplies and concern about the increasingly detrimental effects of climate change have pushed renewable energies to the forefront of U.S. energy-policy plans. As a result, the United States may derive a larger share of its energy and electricity from renewables, such as wind power, in the years ahead. However, the rise of renewables will not be as rapid as many believe, and fossil fuels and uranium[1] will continue to supply the bulk of our energy and electricity in the near term. It's worth looking at the current and projected future contributions from renewable energy sources—as well as the widespread public misconceptions about them.

[The United States] is home to significant reserves of fossil fuels. Putting aside the issue of whether domestic energy resources are currently available for extraction—and not counting the abundant natural resources available to the U.S. in the global marketplace—the Energy Information Administration's most recent statistics reveal that, as of the end of 2007, the U.S. possessed more than 21.3 billion barrels of proved oil reserves,[2] more than 237.7 trillion cubic feet of dry natural gas, and more than 9.1 billion barrels of natural gas liquids.[3] Even more abundant than our oil and natural gas reserves is our stock of coal. As of January 1, 2008, our demonstrated reserve base (DRB)[4] contained 489 billion short tons of coal. However, because of property-rights issues, land-use conflicts, and physical and environmental restrictions, the EIA estimates that only half of the DRB may be available or accessible for mining (262 billion short tons, as of January 1, 2008).[5] Finally, though not a fossil fuel, uranium—the primary fuel used to produce nuclear energy—is abundant in the United States. As of December 31, 2003,[6] given forward costs of $30, $50, and $100 per pound, U.S. uranium reserves totaled 265 million pounds, 890 million pounds, and 1,414 million pounds, respectively.[7] Should renewables not advance as rapidly as many expect or hope, the nation's fossil-fuel and uranium reserves should alleviate some concern about our overall electricity and fuel supply.

Given our abundance of fossil fuels and uranium, their dominance in our nation's electricity supply—they collectively accounted for just over 91 percent of U.S. electricity generation in 2007—is not surprising. The EIA projects that these »

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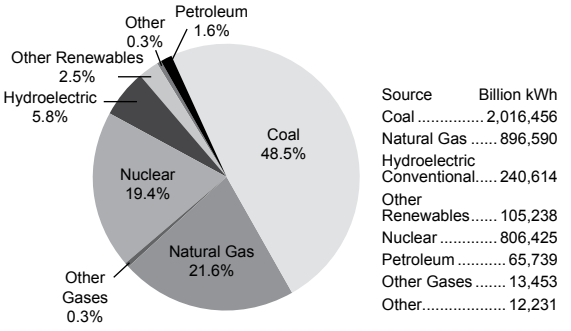
U.S. Electric Power Industry Net Generation, 2007



Source	Billion kWh
Coal	2,016,456
Natural Gas	896,590
Hydroelectric Conventional	240,614
Other Renewables	105,238
Nuclear	806,425
Petroleum	65,739
Other Gases	13,453
Other	12,231

Sources: Energy Information Administration, Form EIA-923, "Power Plant Operations Report" and predecessor form(s) including Energy Information Administration, Form EIA-906, "Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

fuels will still account for 85 percent of our total electric generation in 2030.[8] Moreover, though petroleum generated only 1.6 percent of our electricity in 2007,[9] it accounted for 96 percent of our nation's transportation fuel.[10]

For many, however, the amount of such reserves and their collective contribution to our energy supply have no bearing on whether, or how quickly, we should transition to renewable sources of energy. Shouldn't we be moving toward renewables anyway, in order to become energy independent? Ironically, because renewables are not commercially viable technologies, the goal of energy independence is at odds with reducing our use of conventional fuels. Unless we are willing to cut our energy use drastically, cutting back on imported fuel means that our consumption of domestic fossil fuels and uranium must increase. Moreover, even if everyone agreed that we should replace such fuels with renewables, significant economic and technological barriers stand in the way of a quick and easy transition.

Almost half (49.4 percent) of [individuals polled by the Manhattan Institute] believed that renewable sources of energy—hydroelectric, geothermal, wind, solar, and biomass—are on track to replace fossil fuels in the near future. While the possibility of a rapid increase in the contribution of renewables cannot be ruled out entirely, current growth trends do not put us on a track to replace fossil fuels anytime soon.

Renewable energy sources met about 7 percent of our total energy needs in 2007. Of this 7 percent, biomass energy contributed 53 percent, hydroelectric energy contributed 36 percent, wind energy and geothermal energy contributed 5 percent each, and solar energy contributed 1 percent.[11] Renewable energies accounted for 8.3 percent of the nation's electricity generation in 2007,[12] down from 9 percent in 2003[13]—though the EIA projects the share to increase in the years ahead. The largest share of renewable-generated electricity in 2007 came from hydroelectric energy (71 percent), followed by biomass (16 percent), wind (9 percent), geothermal (4 percent), and solar (0.2 percent).[14]

Given renewable energies' current costs and technological limitations, as well as the limitations of an electricity grid and fuel-pipeline system designed for traditional power sources and fuels, renewables are not expected to be major players in our fuel-supply mix in the near term. The EIA projects that renewables—including hydroelectric power—will account for 14 percent of total U.S. electricity generation in 2030.[15] (Wind energy generated 0.77 percent of U.S. electricity in 2007[16] and is projected to generate 2.5 percent of U.S. electricity in 2030.)[17] This translates to an average annual growth rate of 3.2 percent, the largest increase of any fuel type.[18] The EIA says that this growth will be "fueled by the rapid expansion of non-hydro renewable generation technologies that qualify to meet State mandates for renewable energy production."[19]

An oft-repeated refrain is that renewable energies, in addition to being cleaner, are cheaper than their conventional fuel counterparts. Thus, it is not surprising that a majority (53.7 percent) of [individuals polled] indicated that it is cheaper to generate electricity from renewable fuels like wind or the sun than it is to produce electricity from fossil fuels, like coal or natural gas. However, there is a difference between the cost of renewable fuels and the cost of producing energy from such fuels.

Though wind and solar rays are indeed free, wind energy and solar energy are costly, compared with the costs of conventional power generation. Several factors make renewables more expensive, including high costs of materials and skilled labor, added operations costs to electric grids that were not built for intermittent resources, and lack of adequate transmission lines to carry power from remote areas (where the wind and the sun are most plentiful) to densely populated

Subsidies and Support to Electric Production by Selected Primary Energy Sources

Subsidies for various fuel sources differ widely, when compared with the amount of electricity generated by each source

Primary Energy Source	FY 2007 Net Generation (billion kilowatthours)	Subsidies and Support Allocated to Electric Generation (million FY 2007 dollars)	Subsidies and Support per Unit of Production (dollars/ megawatthour)
Natural Gas and Petroleum Liquids	919	227	0.25
Coal	1,946	854	0.44
Hydroelectric	258	174	0.67
Biomass	40	36	0.89
Geothermal	15	14	0.92
Nuclear	794	1,267	1.59
Wind	31	724	23.37
Solar	1	174	24.34
Refined Coal	72	2,156	29.81

Source: Energy Information Administration, Federal Financial Interventions and Subsidies in Energy Markets 2007, SR/CNEAF/2008-1 (Washington, DC, 2008).

demand centers. In addition, large federal subsidies and state renewable energy mandates shift many costs of renewable energy production from generators to electric ratepayers, disguising the true costs of these technologies.

In addition, subsidies for wind and solar energy — which together generated less than 1 percent of our nation's electricity supply in 2007 — are significantly more generous than subsidies for conventional power generation, considering the amount of electricity generated by each source.[20] In 2007, wind energy received $724 million in federal subsidies, valued at $23.37 per megawatt hour (MWh) of wind-generated electricity, while solar energy took in $174 million, at a subsidy-per-MWh value of $24.34. By contrast, coal received a subsidy of 44 cents per MWh, natural gas and petroleum liquids received 25 cents each, hydroelectric energy took in 67 cents, and nuclear power grabbed $1.59.[21] Without these generous taxpayer-funded subsidies, renewable energies would not be competitive with conventional energy sources.

Like renewable energies, hybrid cars and alternative-fuel vehicles (AFVs), including electric cars, have become more prominent in fuel-policy discussions, and they are more prevalent on U.S. roads than ever.[22] Almost two-thirds (62.7 percent) of respondents believed that such vehicles will constitute a large portion of all U.S. automobiles in ten years—but again, projections are less optimistic.

From 2003 to 2006, AFV use increased by an annual average of just over 6.27 percent[23]—but, with 250,851,833 registered vehicles in the U.S. in 2006,[24] AFVs made up just one-quarter of 1 percent of all registered vehicles in 2006. And, according to J. D. Power & Associates, sales of hybrid cars—which run on either gasoline or diesel and electricity generated onboard—will account for just 7 percent of the car market in 2015, up from 2.2 percent in 2007.[25]

As our energy economy increasingly relies on electricity, it is important to assess whether electric cars and plug-in electric hybrids (PHEVs), which are powered completely and partially, respectively, by batteries charged by electric grids, are ultimately more environmentally friendly than hybrid cars or even vehicles that run on conventional fuels. Opinions vary. "Odds are those batteries won't be recharged with solar or wind energy," writes John Voelcker in Spectrum, the flagship publication of IEEE, formerly known as the Institute of Electrical and Electronics Engineers, Inc.[26] "In most places, grid power is for many decades going to come from the burning of fossil fuels, which generate their own emissions."[27] In other words, if coal plants supply the electric grid with the bulk of the power needed to charge electric cars, will overall greenhouse-gas (GHG) emissions increase? Voelcker writes, "The moral of the story: If you're concerned about the carbon footprint of your vehicle travel, definitely buy a plug-in—if you live in Norway, Brazil, France, or other areas with largely carbon-free electricity. Otherwise, have a look at your local grid—and think twice if you live in a place with lots of old coal-fired power plants. For you, a conventional hybrid may be kinder to the planet."[28]

On the other hand, many studies reveal that replacing conventional vehicles and hybrids with electric cars and PHEVs will lead to an overall reduction in GHG emissions. The American Council for an Energy-Efficient Economy writes that PHEVs "will reduce both their fuel consumption and their emissions of various pollutants relative to current vehicles, including non-plug-in hybrid-electric vehicles" and that "the advantage of plug-ins over hybrids is large in areas where electricity is generated with low-carbon fuels, and much more modest elsewhere."[29] Using three scenarios for

the level of PHEV market penetration and three scenarios for electric-sector carbon-dioxide intensity, the Electric Power Research Institute and the National Resource Defense Council produced nine possible outcomes for PHEVs' effects on overall GHG emissions. Their study concluded that annual and cumulative GHG emissions would decline significantly under each outcome and that each region of the country would see reductions in GHG emissions.[30]

As politicians and policymakers continue to worry about climate change, foreign oil dependence, and the availability of domestic energy resources, renewable energies and alternative fuels will potentially play larger roles in meeting our country's energy needs. However, because of the high costs of renewable energies and alternative transportation fuels relative to their conventional counterparts and because of technological limitations and transmission-infrastructure inadequacies, conventional power sources and transportation fuels will remain the dominant suppliers of our nation's energy for years to come. ■

1 Uranium is the fuel most commonly used by nuclear power facilities. See EIA, "Nuclear Fuel—Uranium," http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/nuclear.html#Nuclear%20Fuel.

2 See EIA, "Table 1. Total U.S. Proved Reserves of Crude Oil, Dry Natural Gas, and Natural Gas Liquids, 1997–2007," http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/crude_oil_natural_gas_reserves/cr.html. Proved reserves of 2007 were 345 million barrels (or 2 percent) more than proved reserves of 2006. As defined by the EIA, proved reserves are "estimated quantities that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions" (EIA, "World Proved Reserves of Oil and Natural Gas, Most Recent Estimates," August 27, 2008, http://www.eia.doe.gov/emeu/international/reserves.html).

3 See EIA, "Table 1. Total U.S. Proved Reserves of Crude Oil, Dry Natural Gas, and Natural Gas Liquids, 1997–2007," supra, n. 18.

4 The demonstrated reserve base is composed of coal resources that have been identified to specified levels of accuracy and may support economic mining under current technologies. See EIA, "Coal Reserves Current and Back Issues," http://www.eia.doe.gov/cneaf/coal/reserves/reserves.html.

5 See ibid.

6 The 2003 uranium-reserves assessment is the EIA's most recent assessment. See EIA, "U.S. Uranium Reserves Estimates," June 2004, http://www.eia.doe.gov/cneaf/nuclear/page/reserves/ures.html.

7 See EIA, "U.S. Uranium Reserves by Forward-Cost," June 2004, http://www.eia.doe.gov/cneaf/nuclear/page/reserves/urescost.html: "Uranium reserves that could be recovered as a by-product of phosphate and copper mining are not included in these reserves. Reserves values in forward-cost categories are cumulative; that is, the quantity at each level of forward cost includes all reserves at the lower costs."

8 EIA, "Table A8. Electricity Supply, Disposition, Prices, and Emissions," Annual Energy Outlook 2009, http://www.eia.doe.gov/oiaf/aeo/pdf/appa.pdf#page=17.

9 See EIA, "Figure ES 1. US Electric Power Industry Net Generation, 2007," http://www.eia.doe.gov/cneaf/electricity/epa/figes1.html.

10 See EIA, "Petroleum Products: Consumption," supra, n. 9.

11 EIA, "How Much Renewable Energy Do We Use?," http://tonto.eia.doe.gov/energy_in_brief/renewable_energy.cfm.

12 See EIA, "Figure ES 1. U.S. Electric Power Industry Net Generation, 2007," supra, n. 25.

13 See EIA, "Electric Power Annual 2003" (Figure ES 2), http://tonto.eia.doe.gov/FTPROOT/electricity/034803.pdf.

14 EIA, "Total Renewable Net Generation by Energy Source and State," May 2008, http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table6.html.

15 EIA, "Table A8. Electricity Supply, Disposition, Prices, and Emissions," supra, n. 24.

16 EIA, "Net Generation by Other Renewables: Total (All Sectors)," http://www.eia.doe.gov/cneaf/electricity/epm/table1_1_a.html.

17 EIA, "Year-by-Year Reference Case Tables (2006–2030)" (Tables 8 and 16), http://www.eia.doe.gov/oiaf/aeo/aeoref_tab.html.

18 EIA, "Table A8. Electricity Supply, Disposition, Prices, and Emissions," supra, n. 24.

19 EIA, "How Much Renewable Energy Do We Use?," supra, n. 27. "However, EIA projects renewable energy's share of total worldwide electricity generation will decrease slightly: from 18 percent of generation in 2005 to 15 percent in 2030. Although worldwide renewable energy is expected to increase, it will be outpaced by growth in other electricity generation sources" (EIA, International Energy Outlook 2008 [Tables H7 and H12], June 2008). According to the EIA, "World electricity generation nearly doubles in the IEO2008 reference case from 2005 to 2030. In 2030, generation in the non-OECD countries is projected to exceed generation in the OECD countries by 46 percent. Over the next 25 years, the world will become increasingly dependent on electricity to meet its energy needs. Electricity is expected to remain the fastest-growing form of end-use energy worldwide through 2030, as it has been over the past several decades. Nearly one-half of the projected increase in energy consumption worldwide from 2005 to 2030 is attributed to electricity generation in the IEO2008 reference case. Since 1990, growth in net generation has outpaced the growth in total energy consumption (2.9 percent per year and 1.9 percent per year, respectively), and generation is expected to increase at an average annual rate of 2.6 percent through 2030 as the growth in demand for electricity continues to outpace growth in total energy use (Figure 52)" (EIA, International Energy Outlook 2008 [Chapter 5—Electricity], June 2008, http://www.eia.doe.gov/oiaf/ieo/electricity.html).

20 See Gilbert E. Metcalf, "Taxing Energy in the United States: Which Fuels Does the Tax Code Favor?," Manhattan Institute, January 2009, http://www.manhattan-institute.org/html/eper_04.htm.

21 See EIA, "How Much Does the Federal Government Spend on Energy-Specific Subsidies and Support?," http://tonto.eia.doe.gov/energy_in_brief/energy_subsidies.cfm. Robert J. Michaels, professor of economics at California State University, Fullerton, writes, "According to the U.S. Energy Information Administration, wind's costs per kilowatt-hour hit bottom in 2002 and have since increased by 60 percent. In 2004, the levelized cost of a coal-fired kilowatt hour was 3.53 cents, compared to 4.31 cents for nuclear, 5.w47 for gas and 5.7 for wind. According to a study by Gilbert Metcalf of Tufts University for the National Bureau of Economic Research, removing subsidies to nuclear and wind power takes the former to 5.94 cents and the latter to 6.64" (Robert J. Michaels, "Hot Air and Wind," National Review Online, December 20, 2007, http://article.nationalreview.com/?q=MTIhN2I4ZDhmZTg2N2NmM2EzNmExYTEwNWRjNzU3Mzk).

22 Hybrid cars are powered by electricity and either gasoline or diesel. Alternative-fuel vehicles include electric cars and cars that can run on natural gas or an E85 blend (85 percent ethanol / 15 percent gasoline). Hybrids are not considered AFVs, according to the Department of Energy. See EIA, "Table V1. Estimated Number of Alternative Fueled Vehicles in Use in the United States, by Fuel Type, 2003–2006," May 2008, http://www.eia.doe.gov/cneaf/alternate/page/atftables/afvtransfuel_II.html#inuse.

23 EIA estimates the following number of AFVs in use in the U.S. from 2003 through 2006: 533,999 (2003); 565,492 (2004); 592,125 (2005); 634,562 (2006). See EIA, "Table V1. Estimated Number of Alternative Fueled Vehicles in Use in the United States, by Fuel Type, 2003–2006," supra, n. 38. "In 1997, some vehicle manufacturers began including E85-fueling capability in certain model lines of vehicles. For 2006, the EIA estimates that the number of E-85 vehicles that are capable of operating on E85, gasoline, or both, is about 6 million. Many of these alternative-fueled vehicles (AFVs) are sold and used as traditional gasoline-powered vehicles. In this table, AFVs in use include only those E85 vehicles believed to be used as AFVs. These are primarily fleet-operated vehicles" (ibid.).

24 See Bureau of Transportation Statistics, "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," http://www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html.

25 See "J. D. Power Sees Three-Fold Growth for Hybrids by 2015," HybridCars.com, April 8, 2008, http://www.hybridcars.com/news/jd-power-forecasts-three-fold-growth-hybrids-and-diesels.html.

26 John Voelcker, "How Green Is My Plug-In?," IEEE Spectrum, March 2009, http://spectrum.ieee.org/mar09/7928. "A non-profit organization, IEEE is the world's leading professional association for the advancement of technology" ("About IEEE," http://www.ieee.org/web/aboutus/home/index.html).

27 Voelcker, "How Green Is My Plug-In?."

28 Ibid.

29 James Kliesch and Therese Langer, "Plug-In Hybrids: An Environmental and Economic Performance Outlook," American Council for an Energy-Efficient Economy, September 2006, http://www.aceee.org/store/proddetail.cfm?CFID=1941952&CFTOKEN=35186425&ItemID=418&CategoryID=7.

30 See "Environmental Assessment of Plug-In Hybrid Electric Vehicles, Volume 1: Nationwide Greenhouse Gas Emissions," Electric Power Research Institute and National Resource Defense Council, July 2007, http://mydocs.epri.com/docs/public/000000000001015325.pdf.

By David Pontoppidan

UNDER THE WEATHER?

Ailing buildings may not benefit from federal weatherization funds

AS PART OF President Obama's stimulus package, nearly $5 billion has been distributed nationwide since March 12 to promote home weatherization, the process of reducing energy bills by upgrading the insulating capability of houses. Michigan has received about $243 million to benefit low-income families by improving the energy efficiency of their homes, a huge increase from the $15 million Michigan usually receives each year to weatherize homes. The plan vows not only to make Michigan more energy friendly, but also to lower energy costs for low-income families, create jobs and improve the resale value of houses. In general, homes with occupant incomes below 200 percent of the federal poverty level or 60 percent of state median income (whichever is greater) are eligible to receive weatherization subsidies. Both homeowners and renters are eligible for weatherization services, and a total of 33,000 homes are expected to be weatherized, with a maximum of $6,500 spent per house.

Weatherization can be accomplished by insulating ceilings and walls; replacing water heaters and furnaces; or replacing windows and sealing air leaks.

Home weatherization research took off in the 1980s at the Princeton Center for Energy and Environmental Studies. During a project looking at low-income housing, researchers measuring the heat transfer from living spaces into the attic found that heat losses were three to five times larger than what was predicted by the routine calculations. The reason was that the materials used in walls and ceilings were full of holes and cracks, which allowed air to move through the insulation. Insulation is measured by its resistance (R), which can be degraded by as much as 70 percent, so that R19 insulation may end up only providing an R6 effect, depending on the house in which it is installed. Since R value in itself was not a sufficient measure, the researchers at Princeton developed what is known as the "blower door," a »

diagnostic tool that is used to blow air into a building and measure its airtightness and locate leaks, determining where insulation should be put. In the original article on the research featured in National Geographic, Kenneth Gadsby and Gautam Dutt estimated that by fitting all of the nation's residences with adequate insulation, the U.S. could save the equivalent of two-thirds of its foreign oil imports.

One of the people who worked with the Princeton team was Don Nelson, now president of D.R. Nelson and Associates. His company pioneered the application of so-called building science innovations in America in theearly 1980s, and has delivered solutions to more than 100,000 homes since.

"The rate of air leakage," Nelson told MichiganScience, "affects how everything else in the house performs, such as insulation. In building science, we take a look at how the house performs as a system and how all the elements go together, and air leakage is the key element."

Nelson, however, calls the nation's focus on weatherization a "cookie-cutter approach," with its primary focus on windows and insulation of ceilings, even though those are the least cost-effective changes in a state like Michigan, where winters are harsh and summers are mild.

"It's as if they didn't learn anything from the '80s," he said. "After President Carter, there was a fair amount of federal money aimed at low-income people to try and do weatherization programs. The problem was that money was simply put at windows or ceiling insulation."

Nelson points to Washtenaw County, which is set to receive $4.2 million to be used for weatheriation over the next three years and talks about blower doors in a 2009 proposal, but does not outline aims for performance testing or goals for how airtight structures must be.

In Michigan, the administration of the weatherization money is being carried out by the Michigan Community Action Agency Association. Jim Crisp, executive director, says the 30 member organizations of MCAAA can sometimes spend as much as $25,000 weatherizing a house,

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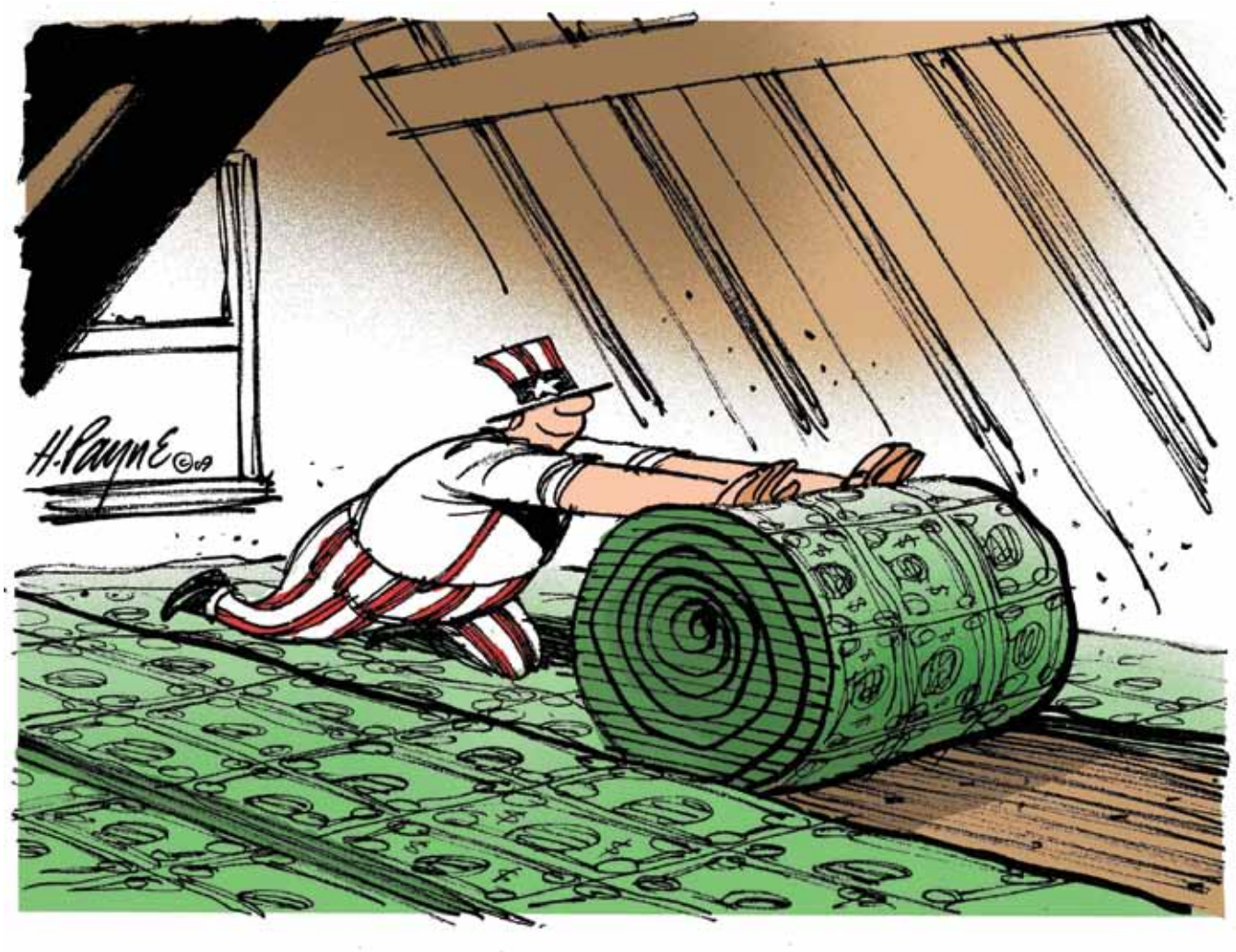


By Dr. Robert Meeks

GOOD OR BAD?

LIMITING PHOSPHATES IN DETERGENTS

PHOSPHATES ARE USED in detergents to bind mineral ions and improve overall washing performance. They have low toxicity and are generally considered safe to use, but overabundance in a natural body of water can stimulate excessive plant growth and cause an over growth of algae. This has caused some states to enact stricter regulation of the level of phosphates in detergents.

Detergents, both laundry and dishwasher, have the ability to dissolve grease by allowing oil and water to mix so that grime can be removed during rinsing. The efficiency of detergents, however, is reduced in the presence of mineral ions that bind up the grease-soluble portion of the detergent molecule and precipitate out of the water. This precipitate creates a scum, which is why washing dishes in "hard" water — high in mineral salts such as calcium and magnesium — often results in a residue left on the dishes.[1] To overcome this problem, laundry and dishwasher detergents consist of a surfactant (a wetting agent) and a binder, as well as enzymes. Surfactants lower the surface tension of water, essentially making it wetter so that it is less likely to stick to itself and more likely to interact with oil and grease. The binder serves to bind up the mineral ions.[2] Phosphates — i.e. compounds containing phosphorous, oxygen and hydrogen — are excellent binders. Phosphates are capable of tying up calcium, magnesium, iron and manganese, thereby improving the washing performance by aiding in suspending certain types of particulate matter in water.[3] They also are effective in:

- dispersing dirt and soil,
- preventing the formation of scale and films during washing and rinsing of tableware and glasses,
- maintaining dirt in suspension in the wash and rinse water, and
- maintaining pH value (a measure of acidity), thereby ensuring effective operation of surfactants and wash chemicals for sanitation.[4]

If phosphates are not used in detergents, especially dishwasher detergents, the result is lower wash efficiencies, which increase environmental burden due to larger dosing and re-washes necessary due to performance issues.

The major drawback is that wastewater treatment plants are not efficient at removing phosphates from their influent. Therefore, a substantial amount of phosphate is released from wastewater effluents into natural bodies of water, such as streams, lakes and estuaries, which will increase phosphate levels and can effect growth in plants, such as algae. These are photosynthetic organisms that occur in most marine and freshwater habitats, and vary from small single-celled forms to complex multi-cellular forms of life. Algae are important as primary producers of organic matter at the base of the food chain, and also provide oxygen for other aquatic life.[5]

Phosphorous is a nutrient essential for algae growth, as are carbon and nitrogen.[6] Phosphorous, along with other nutrients extracted by plants in water, plays an essential role in photosynthesis

1 A.M. Helmenstine, "How Do Detergents Clean?" About.com Chemistry, 2009, http://chemistry.about.com/od/howthingswork/f/detergentfaq.htm?p=1 (accessed Oct. 14, 2009).

2 A. Turk, J. Turk, and J.T. Wittes, *Ecology, Pollution, and Environment* (Philadelphia: W.B. Saunders Co., 1972), 217.

3 P. ReVelle and C. ReVelle, *The Environment: Issues and Choices for Society*, 3rd ed., (Boston: Jones and Bartlett, 1988), 749.

4 Centre Europeen d'Etudes des Polyphosphates (CEEP), "Phosphates in Automatic Dishwasher Detergents," August 2007, http://www.ceep-phosphates.org/Files/Document/83/CEEP%20phosphates%20in%20dishwasher%20detergents.pdf (accessed Oct. 14, 2009).

5 Smithsonian Institution, "Algae Research: Introduction," http://botany.si.edu/projects/algae/introduction.htm (accessed Oct. 14, 2009).

6 R.G. Wetzel, *Limnology*, 2nd ed., (Philadelphia: Saunders College Publishing, 1983), 767.

LIMITING PHOSPHATES IN DETERGENTS

and is critical for plant growth. The rate of algae growth is controlled and limited by the nutrient in least supply relative to the demand for it. In most water systems, phosphorous is the limiting nutrient. In other words, the rate of algae growth in water systems is proportional to the supply or input of phosphorous. Overabundance of a nutrient such as phosphorous in a body of water can stimulate excessive plant growth, thereby causing eutrophication.[7]

Eutrophication is a natural process that occurs in an aging lake or pond as that body of water gradually builds up its concentration of plant nutrients.[8] Eutrophication, which in Greek means "well-nourished" or "good food," is not necessarily harmful or bad. However, artificial or human-caused eutrophication has become a common phenomenon and the word has come to mean a harmful increase and acceleration of nutrients. Human activities almost always result in the creation of waste, and many of these waste products contain nitrates and phosphates. Nitrates are a compound of nitrogen and are used in fertilizers, and as noted, occur in waste products. The human use of detergents and chemical fertilizers has greatly increased the amount of phosphates and nitrates that are washed into our lakes and ponds. When excessive amounts of phosphates are added to a body of water, the plants begin to grow explosively and algae takes off or "blooms." In the process, the plants and algae consume greater amounts of oxygen in the water, causing fish and mollusks to suffocate.[9]

Phosphate input to surface waters from wastewater effluent, however, does not always impact eutrophication.[10] An increase in phosphate levels may have little or no effect on algae growth when growth is being limited by other factors, such as lack of another nutrient. There can also be more significant contributors to phosphate levels in surface waters, including agricultural sources, fertilizers, human waste in sewage, industrial discharges and natural bedrock erosion.

Several studies conducted in the late 1950s and early 1960s concluded that the discharge of phosphates primarily from detergents was causing eutrophication of nearly 10,000 lakes in the United States and that the lakes and streams nationwide were getting more polluted each day.[11] At that time, essentially all laundry detergents contained between 30 and 50 percent phosphate binders. Following a series of congressional hearings, major detergent manufacturers were required to lower the level of phosphates in laundry and dishwasher detergents to 8.7 percent.[12] The report also suggested that state and local jurisdictions could take further actions they deemed necessary to protect lakes and streams.[13] In 1977, laundry detergent phosphate levels were limited to 0.5 percent, with many state and local jurisdictions instituting an outright ban on phosphates in laundry detergents. A legal loophole, however, still left phosphate levels in dishwasher detergents at 8.7 percent, which was the original level set in 1972.[14] Recently, concern over phosphate levels has sparked a number of municipalities and states to enact legislation either banning phosphates in dishwasher detergents or restricting their level to no more than 0.5 percent, the same as for laundry detergents.

While limiting the level of phosphates in dishwasher detergents may have a beneficial impact on lakes, streams and estuaries, it should be noted that phosphate-free alternatives are not without issues.[15] Phosphate-free dishwasher detergents tend to be insoluble and therefore coat tableware and glasses with residue and scum. Even in soft water, or dishwashers operating with a water softener, a binding agent is necessary because food waste and soil on tableware contains calcium, magnesium and other ions. Thus, to be effective, phosphate-free dishwasher detergents need to contain a larger number of chemicals such as chelating agents, increased enzyme content, increased surfactant content and active chlorine content to compensate for poor soil removal. These other compounds also raise issues of environmental risks, such as higher toxicity, poor biodegradability and increased organic load to sewage plants. Lower performance of phosphate-free dishwasher detergents can also increase energy and water consumption if users decide to wash the same load multiple times.

While there may or may not be room for the debate of the potential harm of phosphates in dishwasher detergents, it seems clear that excess phosphates in these products can lead to damage to lakes and streams. There are technical ways to deal with this problem that would allow for continued use of phosphates, but appropriate modifications to wastewater treatment plants would cost millions of dollars, which would require municipalities and other jurisdictions to charge the public higher fees for wastewater treatment. Given their reluctance to do so, it is unsurprising that the restriction of phosphate levels is chosen as the most expeditious way to deal with this problem. ■

7 Ibid.

8 Science Clarified, "Eutrophication-Too Much of a Good Thing," http://www.scienceclarified.com/El-Ex/Eutrophication.html (accessed Oct. 14, 2009).

9 Ibid.

10 Congressional Report HR 92-918, "Phosphates in Detergents: Government Action and Public Confusion," (Conservation and Natural Resources Subcommittee, 1972).

11 P. ReVelle and C. ReVelle, *The Environment: Issues and Choices for Society*, 3rd ed., (Boston: Jones and Bartlett, 1988), 749; and Congressional Report HR 91-1004, "Phosphates in Detergents and the Eutrophication of America's Waters," (Committee on Government Operations, 1970).

12 R. A. Vollenweider, *Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, With Particular Reference to Nitrogen and Phosphorous as Factors in Eutrophication*, (Paris: Organization for Economic Cooperation and Development, 1969), 192.

13 Congressional Report HR 92-918, "Phosphates in Detergents: Government Action and Public Confusion," (Conservation and Natural Resources Subcommittee, 1972).

14 Ibid.

15 Centre Europeen d'Etudes des Polyphosphates (CEEP), "Phosphates in Automatic Dishwasher Detergents," August 2007, http://www.ceep-phosphates.org/Files/Document/83/CEEP%20phosphates%20in%20dishwasher%20detergents.pdf (accessed Oct. 14, 2009).

RISK ASSESSMENT

THIS IS THE first in a series of four MichiganScience articles on risk assessment. These articles will be designed to acquaint and provide the reader with information that will allow him or her to understand and evaluate potential risks to human health resulting from exposures to chemicals, including drugs. In other words, this series of papers on risk assessment will not be designed to present the reader with an in-depth treatise on the complexities of risk assessment, but rather will provide a high-level overview of the process. The hope is that enough information will be presented such that the reader, when faced with having to understand and make decisions relative to risk, will have the basic tools necessary to make an informed decision.»

RISK ASSESSMENT

The question of whether and to what degree chemicals present in air, food, drinking water, pharmaceuticals, consumer products and occupational settings pose a threat to human health is obviously of enormous social and medical importance. Many chemicals, such as asbestos, arsenic and dioxin, have a bad name. On the other hand, many chemicals have clearly transformed modern life in extremely beneficial ways. We have drugs to prevent and cure disease, pesticides to protect and increase crop production, preservatives to protect our food, as well as plastics, fibers, metals and thousands of other chemicals that enhance the pleasures and safety of life as we know it today.

Assessing potential risk resulting from chemical exposure is a complex scientific process and involves the following four steps:

Hazard identification: the determination of whether a particular chemical is or is not causally related to particular health effects.

Dose-response: the determination of the relation between the magnitude of exposure and the probability of occurrence of health effects in question.

Exposure assessment: the determination of the extent of human exposure from all sources. It includes the population(s) that may be exposed and the pathways of exposure, i.e. the potential for exposure via a particular pathway, such as ingestion, inhalation or skin contact.

Risk characterization: the description of the nature and often the magnitude of human risk, including all sources of uncertainty implicit in the above steps.

HAZARD IDENTIFICATION

The first step in understanding the risk assessment process is hazard identification, which requires a basic understanding of the field of toxicology. Quite simply, the science of toxicology is defined as the study of the adverse health effects of chemicals (including drugs) on health and of the conditions under which those effects occur.

All chemicals, whether they are man-made or naturally occurring, can be toxic, and therefore have the potential to cause adverse health effects in humans. To assess the toxicity of a chemical, we need to develop an understanding of the dose or concentration that can cause the effect. The hazards of chemicals are not equal. Some chemicals are much more toxic than others. To illustrate, Table 1 presents a conventional rating scheme for lethal doses in humans following oral ingestion. This table clearly shows that toxicity can be rated from practically non-toxic to supertoxic based on the dose. An example of something that is supertoxic is botulinum toxin and something that is practically non-toxic is water.

Table 1 - Probable Lethal Oral Dose for Humans

Toxicity Rating	Dose (mg/kg b.w.)	For Average Adult
1. Practically non-toxic	More than 15,000	More than 1 quart
2. Slightly Toxic	5000-15,000	1 pint-1 quart
3. Moderately Toxic	500-5000	1 ounce-1 pint
4. Very Toxic	50-500	1 teaspoon-1 ounce
5. Extremely Toxic	5-50	7 drops-1 teaspoon
6. Supertoxic	Less than 5	Less than 7 drops

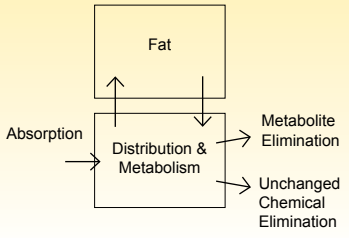
In addition to dose, we need a fundamental understanding of how much of the chemical to which we are exposed gets into the body, where it goes and what it does, how long it stays in the body and how it leaves. These processes are referred to in toxicology as absorption, distribution, metabolism and elimination (ADME).

There are three primary routes by which a chemical can enter the body: ingestion, inhalation and skin contact. If the chemical is ingested, then it can be absorbed into the body from the stomach. If inhaled, then the chemical can be absorbed from the airways or the lungs. If exposure is by skin contact, then the material must be absorbed through the outer layers of the skin into the underlying blood supply. Quite often, it is observed that the dose required to produce a toxic effect will vary according to the exposure route. Once the toxin is inside the body, the question becomes: Where does it go while it is there? Usually, the material can distribute itself equally throughout the body depending on the blood supply to any given site. However, if the chemical in question happens to be lipophilic (prone to sequester itself in fat tissue), it can stay in the fat for long periods of time and slowly be released back into the blood stream.

As the blood containing the chemical passes through the liver, there are enzymes present that can convert or metabolize the chemical to a different form. The

products of metabolism (i.e., metabolites) are generally more soluble in water so that they can be eliminated from the body in the urine. It should be noted, however, that some chemicals can be readily excreted from the body unmetabolized because they are already water-soluble enough when they enter the body. While the process of metabolism is primarily a process to convert a chemical to a form that can be eliminated from the body, cells in the skin, lungs, intestines and kidneys can also play a role in metabolism. This whole process of ADME can be summarized in Figure 1.

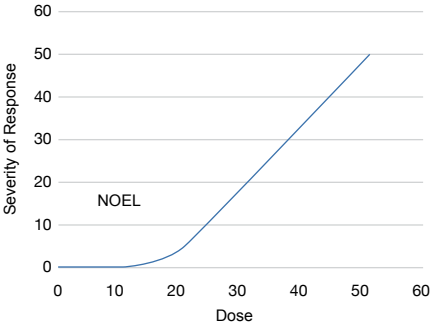
Figure 1 - ADME Process



While the chemical resides in the body, the question becomes what dose level has the potential to cause harm. Some chemicals can cause damage to organ systems such as the liver, lungs, kidneys, spleen, etc. Other chemicals can cause damage to the reproductive, immune, nervous and other systems and can cause birth defects and cancer. But again, whether or not a chemical causes toxicity is dependent on the dose or concentration of the chemical that makes it into the body. A central paradigm of toxicology comes from Paracelsus (c. 1493-1541), a Swiss physician and alchemist. He is noted for his recognition that "all substances are poisonous, there is none which is not a poison. The right dose differentiates a poison and a remedy." In short, the dose makes the poison.

This brings us to the concept of dose-response. Many individuals have experienced or are familiar with this phenomenon in a mild way (consider the relationship between the amount of alcohol consumed and the various stages of intoxication). It is a well-documented principle of toxicology that for all chemicals, there is a range of doses over which no apparent toxicity can be identified in exposed individuals (No Effect Level, or NOEL) and there is a higher range of doses over which the toxic properties begin to appear. This is shown in Figure 2.

Figure 2 - Dose-Response



The region of the dose-response curve that makes the transition from "no-toxicity" to "toxicity" is called the threshold. The threshold dose is the dose immediately above which the response (or toxicity) begins to manifest itself. Implied in this concept is the fact that an individual can be exposed to a dose below the threshold for a lifetime and not suffer adverse health effects. However, it must be noted that the actual threshold dose varies from person to person (i.e., inter-individual variation), but there is clearly a "no effect" or sub-threshold range for everyone. In other words, some individuals may be more sensitive than others to the effect of a given chemical.

Finally, toxic effects can be defined as acute, subchronic or chronic, based on duration of exposure. An acute effect is one of very short duration often involving a single exposure at a very high dose. A subchronic exposure is generally viewed as exposure, generally daily, over some period of time less than the whole lifetime. Chronic exposure generally is viewed as a daily exposure lasting over a whole lifetime and beginning at an early age. It should be emphasized, however, that care should be exercised to distinguish subchronic and chronic exposure from subchronic and chronic effects. Subchronic and chronic effects are meant to convey that the adverse effect does not appear immediately after exposure but that the effect occurs after some delay following exposure. In fact, the effects may not appear until close to the end of life (e.g., cancer) even if exposure begins early in life. Furthermore, chronic effects may or may not need chronic exposure to manifest.

In summary, this first article has discussed the process of hazard identification, which is the first step in a human health risk assessment and provides basic information related to how the hazards or toxic properties of chemicals are assessed. The next article in the series will provide an overview of how dose-response and exposure data are used in the risk assessment process. Subsequent articles will deal with the process of risk characterization, risk management, regulatory implications of risk assessment, as well the application of the precautionary principle in protecting human health in the absence of scientific data necessary for assessing risks. ■

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UNDER THE WEATHER *continued from page 16*

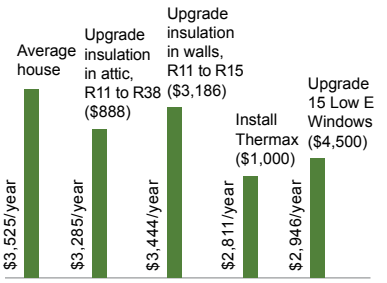
including money from the Department of Energy and the Michigan State Housing Development Authority.

"We can do sidewall insulation or attic insulation, or we insulate basements," Crisp told MichiganScience. "The savings-investment ratio has been re-evaluated from 2:1 to 1:1, meaning that for each dollar spent, there has to be $1 in energy savings. We find that our usual investment in the project is usually around $2 back for every dollar spent."

But as Nelson explained, fixing windows and ceilings are the least effective ways of spending money on weatherization. Using software developed under contract from the U.S. Department of Energy and the Environmental Protection Agency, he has analyzed how energy efficient a house can be with different forms of weatherization. Take for example a typical 1,000-square-foot ranch built in the 1950s with low-grade insulation. Nelson can predict how much money and energy it would take to heat and cool the house.

Furthermore, there's a direct correlation between energy consumption and carbon exhaust that can be measured as well.

Average heating bill for a 1000-square-foot ranch in Detroit



Source: Don Nelson. Calculated via software from the U.S. Department of Energy and the Environmental Protection Agency.

Nelson's calculations are shown in the chart.

"Perhaps it's not wise to spend $6,500 on every house," he said.

Iain Walker, a researcher at Lawrence Berkeley National Laboratory and a specialist in thermal distribution systems and ventilation, says windows are the last thing that should be done to improve a home's energy efficiency.

"Windows should only be replaced for energy conserving reasons if you have already done everything else," Walker explains, "although there are other excellent reasons for window replacements which override energy conservation efforts, such as condensation resistance or if the old windows are rotted out."

He emphasizes how important it is to have aims for performance testing and goals for how airtight a structure should be, for example when performing blower door tests.

"We don't know much about houses, but we do know that if you don't measure things like airtightness, you have no idea how much you improved a home," Walker said.

According to Stacie Gibson of the Michigan Department of Human Services, which administers the weatherization funds, a pre-inspection done by contractors on the local level determines which methods meet the savings-investment ratio and are most cost-effective.

"It can be attic, floor and foundation insulation, air sealing, electric baseload measures or appropriate ventilation," she told MichiganScience. "The primary focus is on achieving the maximum energy savings possible in the home with the dollars available." ■

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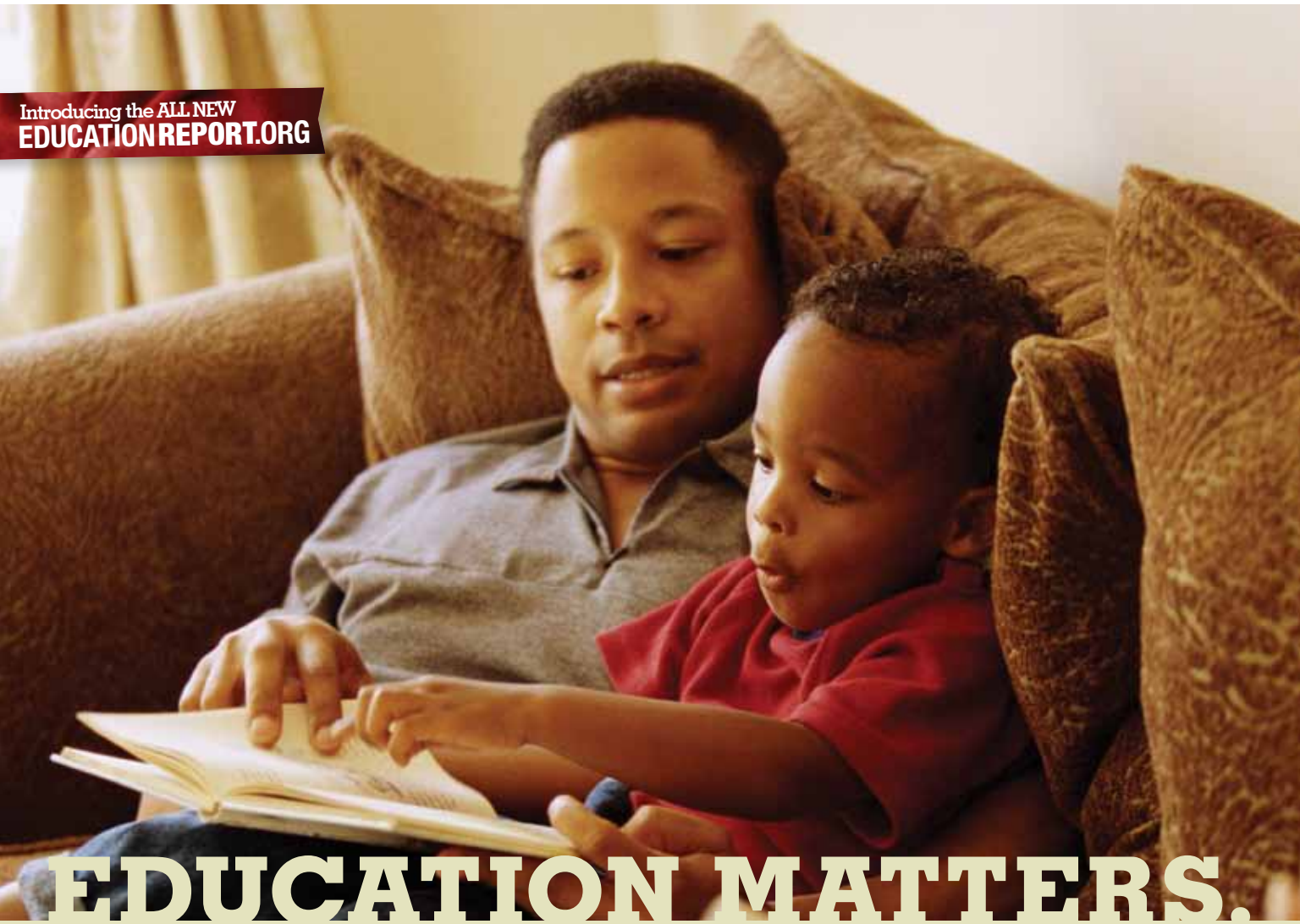

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