# Michigan Science

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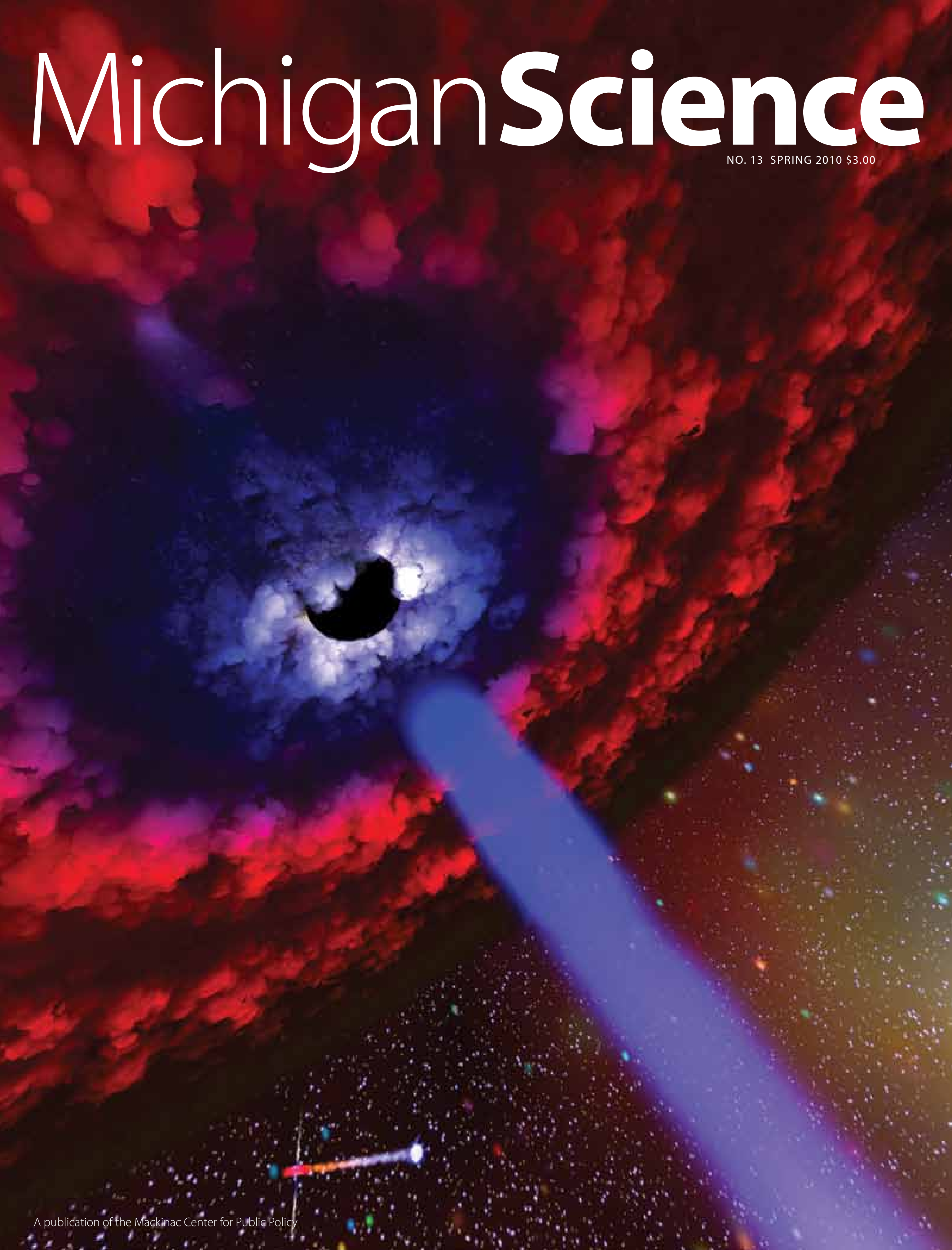


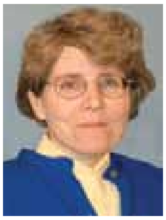
A publication of the Mackinac Center for Public Policy

# Contributors To This Issue

**DR. ROBERT MEEKS** retired from Dow Corning Corp., where he served as manager of toxicology; principal toxicologist; scientific director of toxicology and risk assessment; and senior scientist. Dr. Meeks was associate professor of public health and the director of the toxicology program in the School of Public Health at the University of Alabama at Birmingham; director of toxicology at Southern Research Institute; and a senior staff fellow with the National Cancer Institute at the National Institutes of Health. He has been a member of the Society of Toxicology since 1983. He holds a Ph.D. from Ohio State University and is a diplomat of the American Board of Toxicology.

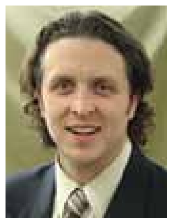
**Robb Frederick** is the environmental reporter for the Erie Times-News in Erie, Penn., and teaches journalism at Penn State University. He has worked in Pittsburgh, Chicago and Washington, D.C. Frederick earned a Bachelor of Arts in communications from Penn State University in 1992 and a Master of Arts in journalism from Northwestern University in 1993.

**BRUCE EDWARD WALKER** is under contract with the Mackinac Center as managing editor of MichiganScience. He has writing and editing experience in a variety of publishing areas, including reference books, newspapers, magazines, media relations and speechwriting.



**LORIE SHANE** is the managing editor of Michigan Education Report, the online education policy journal of the Mackinac Center for Public Policy. She is a former reporter and feature editor with the Midland Daily News and former instructor in the journalism department at Central Michigan University.

**DAVID PONTOPPIDAN** was an IHS Summer Fellow with the Mackinac Center for Public Policy in 2009. He is finishing a master's degree in sociology at the University of Copenhagen in his home country of Denmark, and has been a graduate exchange student at Yale University. He has previous experience in writing about natural science, having worked on biofuels as a lobbyist stagière for the Danish Dairy Bureau in Brussels, and as a spokesperson on a CO2 reduction campaign for the Danish Ministry of Environmental Affairs. He will be applying for a Ph.D. after completing his degree.



**DANIEL MONTGOMERY** designs MichiganScience. He is marketing and design director for the Mackinac Center for Public Policy.

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MichiganScience NO. 13 SPRING 2010



ON THE COVER: The Dassault Systèmes Planetarium at the Detroit Science Center presents "Black Holes."

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MichiganScience

BECOMES

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# By the Numbers

*Beyond propaganda and rhetoric, numbers tell the real story*

**THE NATIONAL OCEANIC** and Atmospheric Administration's National Climatic Data Center recently released research findings for October 2009. Nationally, the United States experienced its wettest October in the 115 years that data has been collected. Precipitation nearly doubled from the long-term average of 2.11 inches to 4.15 inches in 2009. The NOAA Midwest Regional Climate Center in Champaign, Ill., reported that more than half of its Midwest stations recorded one of the five wettest Octobers on record, with one out of five recording the wettest. For NOAA purposes, nine states are categorized as Midwestern: Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio and Wisconsin. For Michigan and Indiana, October was the fourth-wettest. Snowfall in that month ranged from one to five inches across northern Wisconsin and the Upper Peninsula of Michigan. All told, the Midwest recorded far cooler temperatures than are considered normal for October. Data indicates that the month was the seventh coldest on record for the region.

For more information, visit www.ncdc.noaa.gov/sotc/?report=national&year=2009&month=10.

**THE WORLD HEALTH** Organization reported that more than 36 million individuals were cured of tuberculosis over the course of the past 15 years, and that as many as 8 million TB deaths were averted through WHO's Directly Observed Therapy Short-Course strategy. Over the 12-month period from December 2008 to December 2009, WHO recorded the highest number of TB patients cured – 2.3 million, totaling 87 percent of treated patients and exceeding the 85 percent global target. TB is the second-leading cause of death internationally, behind only HIV/AIDS. In 2008, 1.8 million people died from TB.

For more information, visit www.who.int/mediacentre/news/releases/2009/tb_report_20091208/en/index.html.

**IN NOVEMBER 2009,** the U.S. Environmental Protection Agency released a study titled "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2009." The EPA reports that fuel economy has increased over the past five years with a proportional decrease in carbon dioxide emissions. The EPA projected that average fuel economy would increase from 21 miles per gallon in 2008 to 21.1 mpg in 2009. Fuel economy has increased 9 percent (1.8 mpg) since 2004. Average CO2 emissions decreased 8 percent (approximately 39 grams per mile) over the same period.

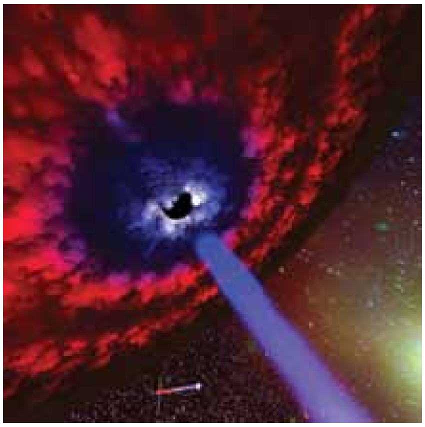
For more information, visit www.epa.gov/oms/fetrends.htm.

**GLOBAL TEMPERATURES HAVE** not risen since 2000, according to meteorologist Mojb Latif of the Leibniz Institute of Marine Science in Kiel, Germany. This assessment was backed by Jochem Marotzke, director of the Max Planck Institute for Meteorology in Hamburg, Germany. According to Latif, global temperatures rose 0.7 degrees Celsius (1.25 degrees Fahrenheit) from the 1970s to late 1990s. The Hadley Centre for Climate Prediction and Research in Great Britain released calculations that the planet warmed 0.07 degrees Celsius between 1999 to 2008 rather than the 0.2 degrees Celsius reported by the United Nations Intergovernmental Panel on Climate Change. Hadley scientists assert that the temperature fluctuation is due to natural climate occurrences El Nino and La Nina, and compensating for those two phenomena reduce the temperature change calculations to 0.0 degrees Celsius.

For more information, visit www.spiegel.de/international/world/0,1518,druck-662092,00.html.

# Field Trips

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



**THE DASSAULT SYSTÈMES** Planetarium at the Detroit Science Center presents "Black Holes." This three-dimensional journey explains what black holes are, shows how they are formed and explores whether or not Earth could be swallowed by one. Viewers will discover that nothing — not even light — can escape the mysterious pull of black holes.

For show times, visit www.detroitsciencecenter.org or call 313-577-8400. Detroit Science Center, 5020 John R St., Detroit, Mich., 48202. Center is open Tuesday through Friday, 9 a.m. to 3 p.m.; Saturday and Sunday, 10 a.m. to 6 p.m.; closed on Monday. Adults: $13.95; children (2–12) and seniors (60+): $11.95.

For more information, visit www.sciencedetroit.org/planet.html.

**THE ALDEN B.** Dow Museum of Science and Art in Midland is featuring "Waterworks: Soak Up the Science!" Visitors can make a rainbow, play water pinball, pilot a model submarine, and learn about water cycles and transformations through the adventures of "Walter the Water Molecule." Interactive exhibits show how to harness the power of water and describe the importance of water's role in everyday life.

Runs through April 25, 2010. Alden B. Dow Museum of Science and Art, 1801 W. Saint Andrews Rd., Midland, Mich., 48640. Museum is open Wednesday, Friday and Saturday, 10 a.m. to 4 p.m.; Thursday, 10 a.m. to 8 p.m. (through April 25); 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.

**IMPRESSION 5 IN** Lansing is hosting "Your Spitting Image," a traveling exhibit devoted to oral health. The exhibit not only promotes proper oral hygiene, it also explores the fascinating world of forensic dentistry and the wonders of saliva. Visitors discover how forensic scientists make identifications using dental records and DNA samples collected from toothbrushes. Hands-on displays reveal the remarkable properties of saliva. Visitors learn how much saliva humans produce each day, peer through a magnifying glass at saliva molecules and discover how saliva can be used as a diagnostic tool.

Runs through August 2010. Impression 5 Science Center, 200 Museum Dr., Lansing, Mich., 48933. Center is open Monday through Friday, 10 a.m. to 5 p.m.; Saturday, 10 a.m. to 7 p.m.; Sunday, noon to 5 p.m. Adults and children (5 and up): $5; children under 5: pay your age; seniors: $4.50. AAA members receive 10 percent discount. Call 517-485-8116, ext. 32.

For more information, visit www.impression5.org/index.php.

**THE CRANBROOK INSTITUTE** of Science and Cranbrook Art Museum present "Cape Farewell: Art and Climate Change." In 2002, artists and scientists traveled on a schooner to the Arctic. Cape Farewell features the results of this mission with photography, video, installations and prints.

Runs through June 13, 2010. Cranbrook Institute of Science, 39221 Woodward Ave., Bloomfield Hills, Mich., 48303. Institute is open daily from 10 a.m. to 5 p.m.; Friday from 10 a.m. to 10 p.m. Adults: $9.50; children (2-12) and seniors (65+): $7.50. Call 248-645-3200.

For more information, visit www.science.cranbrook.edu.

# Michigan's Departments of Natural Resources and Environmental Quality report on the state of the environment

**POSSESSING MORE THAN** 3,000 miles of Great Lakes shoreline, 11,000 inland lakes, abundant forests and diverse wildlife, Michiganders have reason to pride themselves on their surroundings. Protecting the state's natural resources is of great concern for many Michigan residents.

Fortunately, Michigan is doing relatively well on the environmental front, according to the 2008 first triennial report on the state's environment. Published by the Michigan departments of Natural Resources and Environmental Quality, the report examines indicators that reflect biological, chemical and physical aspects of the environment.

## FORESTS

Michigan has some of the most diverse forests in the United States, with more than 75 different tree species. Between 1980 and 1993, maple, birch and beech trees have increased by nearly 1 million acres, and are expected to increase based on existing conditions. The report concludes that standing timber volumes tripled since the 1950s, which means that Michigan is regaining much of the mature forest lost from fires and logging in the 1800s and early 1900s. Furthermore, the report states: "This expanding volume also indicates that more growth has been continuously added to the forest than what has been removed or died through natural causes. Annual growth has steadily increased over the past 50 years."

## GREAT LAKES

According to the report, water levels in the Great Lakes Basin normally fluctuate between 12 inches to 24 inches in a single year. By this standard, water levels remained relatively steady.

## MAMMALS

The population of wolves in the Upper Peninsula has shown a steady growth since 1989, and from 1994 to 2007 the population increased at an average annual rate of 19 percent, which the report claims "is a positive indicator of ecosystem health." Similarly, the bear population has shown a general increase.

## BIRDS

Over the last 25 years, grassland species of birds and transitional species have declined in numbers in favor of more generalist species such as the house finch, northern cardinal, house wren and eastern bluebird, all of which have increased significantly in population. This shift has been attributed to changing habitat conditions, including human activity and the continued maturing of Michigan's forests.

The bald eagle population is a success story in Michigan. From just 50 nests in 1961, 2007 yielded a record number of 526 nests, of which 67 percent produced young, up from 42 percent in 1961. Because the bald eagle is at the top of its food chain, its population is also a good indicator for monitoring changes in levels of contaminants in the environment, such as PCBs (polychlorinated biphenyls) and mercury. In general, the levels of PCBs in the blood of bald eagles were dramatically lower in the 1999-2004 period compared to a decade ago for both the Upper and the Lower Peninsulas. This is in spite of the fact that Michigan has more PCB-contaminated hot spots than any other Great Lakes state, an issue that is being addressed with both federal and state funds.[1]

1 'Teams targeting poison in the River Raisin' by Tina Lam, Detroit Free Press, July 2, 2009.

## FISH

The population of walleye fluctuates heavily since their presence is strongly related to annual variation in reproductive success. In the late 1970s and early 1980s, their presence was low, after which it peaked in 1989. From 2000 to 2003, their abundance declined to the lowest level observed since 1978, but rebounded in 2004 to the highest level in a decade and has since declined again.

Lake trout populations, on the other hand, are nearly rehabilitated to pre-1940s levels in all areas of Lake Superior except Whitefish Bay. Lake trout populations decreased significantly in the 1940s and 1950s due to commercial over-fishing and parasitism by sea lamprey. Successful programs to restock lake trout populations and control sea lamprey in the 1970s and 1980s sparked a rebound in trout populations, which is considered a positive indicator of the overall health of Michigan's Great Lakes ecosystem.

Since the 1970s, efforts to control pollution have resulted in a significant reduction of contaminants. PCBs in lake trout from the Great Lakes have decreased dramatically.

The potential incursion of Asian carp into the Great Lakes is perhaps the biggest threat to the Great Lakes ecosystem.

## EXOTIC SPECIES

Currently, 46 exotic plant and animal species are known to have invaded the Great Lakes Basin. One of the most serious of these threats is the emerald ash borer, native to Asia. It has destroyed millions of ash trees across the Lower Peninsula.

Efforts to stop the spread of and eradicate the pest are underway, from implementing quarantines and an inspection station at the Mackinac Bridge to forming the Emerald Ash Borer Task Force, which has begun using an insecticide that kills all of the borers when injected through the bark at the base of ash trees.

## AIR

The air quality in Michigan has improved significantly over the last 35 years. Six criteria pollutants are routinely monitored: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter and sulfur dioxide. In 2008, all areas of Michigan were in compliance with the EPA's criteria pollutant standards except for ozone and particulate matter less than 2.5 micrometers in diameter, for which the EPA implemented new standards in 2008.

### Carbon Monoxide

Michigan's on-road motor vehicle sources account for 69 percent of the state's carbon monoxide emissions, whereas non-road vehicle sources, such as aircraft, marine vessels and railroads, account for 28 percent. Only 2 percent of emissions come from Michigan's industries. There has been a 50 percent decrease in the average carbon monoxide levels every 10 years since 1984, even though the number of vehicle miles driven has increased.

### Lead

Currently, smelters and battery plants are the major sources of lead worldwide. Since the 1970s, lead levels in gasoline have been controlled, and since then, concentrations of lead in the air have decreased steadily. In the Detroit area in 2006, the average air quality concentration for lead was 98 percent lower than the high in 1983. Average quarterly lead levels across Michigan are about 50 times below the air quality standard.[2]

### Nitrogen Dioxide

Nitrogen dioxide levels in Michigan have remained near the 0.02 parts per million level since 1992, less than half of the amount deemed unsafe by the federal government.[3]

### Ozone

Ozone occurring naturally between 10 and 30 miles above the Earth's surface forms a protective layer against harmful solar rays. In the Earth's lower atmosphere, however, ground-level ozone is a pollutant formed when solar activity initiates a chemical reaction with air pollutants. This usually occurs during warm summer months from reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs). Within Michigan, 63 percent of the ozone-producing pollutants are emitted by vehicles, whereas the remaining 37 percent come from combustion of fuels, chemical and petroleum manufacturing and natural vegetation such as terpene emitting from resin. In July 2005, the EPA designated 25 Michigan counties as being in "non-attainment" with a new, more stringent ozone standard called the eight-hour standard. This standard was updated in March 2008.[4] Currently, 30 counties are in non-attainment under the new standard.

### Particulate Matter

Particulate matter is a broad classification for material that consists of solid particles, fine liquid droplets or condensed liquids absorbed into solid particles. Particulates with a diameter of less than 10 micrometers are referred to as PM10, whereas very fine particles, equal to or less than 2.5 micrometers in diameter, are referred to as PM2.5.

Michigan is in attainment with the PM10 standards[5]; often well below at most locations. Seven counties in Michigan are in nonattainment with the PM2.5 standards,[6] which are new since 2006.

### Sulfur Dioxide

Sulfur dioxide often comes from coal-burning power plants. Levels of sulfur dioxide have fallen to one-fourth of the annual standard[7] since 1991.

### Greenhouse Gas Emissions and Air Toxics Release

The report states that total greenhouse gas emissions in Michigan increased 9 percent in 2002 over the 1990 emissions baseline.[8] Conversely, the Air Toxics Chemical Release Inventory reported a decrease of 8 percent from 2005 to 2006, which the authors stress does not indicate either an upward or downward trend, since many levels are self-reported. These may be estimates rather than actual measurements, and do not include all industries active in the state. ■

2 The air quality standard for lead is 1.5 micrograms per cubic meter.

3 EPA National Ambient Air Quality Standards list 0.053 ppm as the average 24-hour limit for $NO_2$ in outdoor air.

4 The original standard was based on concentrations exceeding 0.12 parts per million during one hour. The stricter standard from 2005 is based on concentrations exceeding 0.08 ppm over eight hours. The newest standard from March 2008 is based on concentrations exceeding 0.075 ppm over the course of eight hours.

5 The PM10 standard is 150 micrograms per cubic meter over the course of 24 hours.

6 The PM2.5 standard is 35 micrograms per cubic meter over the course of 24 hours.

7 The annual standard for sulfur dioxide is 0.03 ppm.

8 Total greenhouse gas emissions in Michigan during 2002 amounted to 62.59 million metric tons carbon equivalent (MMTCE) in comparison to the 1990 baseline of 57.42 MMTCE.

# TOO CLEVER BY MATH

BY LORIE SHANE

**THE REV. PAULA** Timm stands in a small pantry in the basement of Harbor Beach United Methodist Church, looking over the stock of canned fruit, boxed cereals and oatmeal. This is the "breakfast" section of the room. Further along the shelves come "lunch" and "dinner."

Every Tuesday and Saturday, volunteers package these foods for free distribution to area families. It's no surprise that business is up, Timm says, given the state of the Michigan economy.

Giving food to the needy is one of the oldest of church ministries, but with the help of students from nearby Harbor Beach High School, this particular food pantry is going digital.

Students in the calculus and trigonometry classes at the school have designed a Web site for the pantry as well as a computerized record-keeping system that will allow volunteers to maintain basic information about recipients, number of visits and the type and amount of food distributed to each.

That will make it easier for Timm to turn in activity reports that the state requires for grant funding, and also will improve accountability by tracking the history of each recipient.

"They're awesome," Timm said of students like Jessica Roggenbuck, a Harbor Beach senior who helped develop the system. The students used Intuit QuickBooks as a base program, modifying it to fit the pantry's needs and adding a password-protect system to limit access, Roggenbuck said.

The students also taught Timm how to use the program and will do the same for volunteers in other pantries throughout the region.

Compared to doing the same project as a classroom exercise, Roggenbuck said, "This is much more hands-on. We're teaching others, so it's really engraved in our brains."

"I'm a social person," added classmate Ethan Booms. "If it was a make-believe pantry, I wouldn't get into it so much."

This combination of academics and community service is exactly the goal of the "Engineering Projects in Community Service-Learning" program. Headquartered at Purdue University in Indiana, EPICS High challenges students to use engineering, technology and computer science skills to solve real-world problems in their home communities.

In Harbor Beach, that problem was food pantry record-keeping. In Caseville and Bad Axe public schools, one problem was how to water athletic fields efficiently. Owendale-Gagetown Area Schools wanted to reduce energy costs. In all, seven school districts in Michigan's Thumb area are now working on multi-year EPICS High projects.

Teenagers want to make a difference in the world, said William Oakes, EPICS High director, but many of them don't think of engineering, computer science or math as a way to do it.

"In science and math, kids struggle to see, 'Where would I use this on something that matters?'" said Oakes, a Harbor Beach native. "They care, but we in the field aren't saying, 'Here's how you can make an impact.'"

The point of EPICS is to bridge that gap by linking student teams with not-for-profit organizations or schools that have a particular technical need but don't necessarily have the time, budget or staff to design and implement a solution, Oakes said.

In Caseville Public Schools, one of the first EPICS High projects was to design a way to use "backwash" from the water treatment plant next door to irrigate the community and school athletic fields.

Backwash is water washed backward through the plant's filters to clean them, explained Dave Quinn, Caseville Department of Public Works supervisor.

The backwash normally is piped outside to a settling pond and eventually returned to Saginaw Bay, Quinn said. Now, some of it is being pumped from the pond a short distance to the Caseville baseball diamonds and soccer field for irrigation.

In coming years, the EPICS team at the school plans to draw enough additional water to fill a schoolyard pond where students can study plants and fish, junior Jessica Strozeski said.

"It's more than just doing a paper," Strozeski said. "You realize this can have an impact on the community."

Similarly, the EPICS team at Bad Axe High School knew that hauling out a large hose and sprinkler wasn't the best way to irrigate the soccer field, freshman Scott Hunsanger said.

It was fun for the sweaty players to run through the spray, Hunsanger and freshman Colburn Hanson said during a presentation about their work, but "pretty much most of it evaporated."

Working with a local company, the EPICS team designed an underground irrigation system that will use less water but have more effect, Hunsanger said. Later this spring, the team plans to build an outdoor classroom for school and community programs.

The EPICS High program (there is a separate collegiate EPICS program) is funded by a variety of grants and sponsorships from the federal government, corporations and Purdue itself. Participating school districts are required to have a community partner, which in Huron County is the Square One Education Network.

Formerly called the Convergence Education Foundation, Square One is based in southeast Michigan but is active in school-based engineering and technology projects across the state. Those include hybrid-electric and batterypowered vehicle design projects in Ferndale to a remote-operated underwater vehicle program in Traverse City that may be on track to becoming a larger water-quality assessment program.

Square One provided a local matching grant to bring EPICS High to Huron County because it believes in project-based learning, executive Karl Klimek told MichiganScience. He measures success in terms of "a-ha" experiences that students have as they solve problems, often followed by a growing interest in learning more.

"We aren't trying to make everybody a scientist or engineer," he said, though boosting interest in science and math is one of the EPICS goals.

No matter which career field they choose, students who participate in EPICS High will know more about using science and technology to solve problems in the real world, Klimek pointed out, and will have the soft skills that employers say they want today: teamwork, leadership, project management, communication across disciplines and the ability to present ideas well.

Those skills are evident at the Harbor Beach community food pantry, Timm said, where many of the students who designed the computer system have become pantry volunteers. It's a side benefit that pleases Timm as much as her new digital capabilities.

"Our project is really hitting the community service angle," she said. "It's a melding together of gifts and graces." ■

# CONTEST WINNER: 'FIXING STUPID'

MACKENZIE ROMAN, a 17-year-old student at Glen Lake Community School, will receive a $500 scholarship from MichiganScience for her winning submission to our contest, "If You Had the Chance to Address One Global Issue Right Now Scientifically, What Would You Do and Why?" In her essay, "Fixing Stupid," Roman states that she would find a way to increase the functionality of the human brain. She argues that finding such a means through meditation, technology or medicine might expedite the discovery of innovative and creative solutions to the world's problems.

Roman will graduate this spring in the top 10 in her class. She was recently accepted to the University of Michigan, where she will seek a degree in nuclear engineering and radiological science.

## FIXING STUPID by Mackenzie Roman

The formation of a world in which everyone commands an immense amount of intellect seems philosophical, but I do not propose a utopia where people can take a pill and become smart. My plan will instead "fix stupidity" through the study of the brain and how people can maximize their capacity for knowledge. The brain is the storehouse of knowledge and therefore must be unlocked by discovering methods that help people learn to develop their mind.

It has been hard for the average human mind to keep up with the advances of technology and, although people are still advancing to new levels of intelligence, there are still many problems that have not been solved due to the immaturity of the human brain. It is also said that humans only use 10 percent of their brain, but many call this a myth. Myth or not, it is true that humans do not use all of it, especially at once. Science has proven that the brain has multiple parts that deal with specific thoughts, so in order to solve the brain problem humanity must make it a priority to discover exercises, tactics or chemicals that can help individuals utilize each area.

There are already many ways that people have discovered to tap into their own mind and into those of others. The medical community already has the technology, called magnetic resonance imaging, which shows certain activity in certain parts of the brain. There are also physiological ways to tap into different parts of the brain, like hypnosis. There are even some religions that allow people to study and observe the brain through meditation.

The fact that society has already gotten this far shows the potential of the little amount of brain that humans do use. Humans have landed on the moon, discovered flu vaccines, created an atomic bomb and even cloned animals —all things that were thought impossible not more than 100 years ago. The mysteries of time travel might be solved, or, more realistically, humans could find a way to live and travel further into space. Using all of the brain might even unlock the power to control the elements — earth, wind, fire and water — through telepathy or other means. The possibilities could be endless.

The brain has many unlocked mysteries and it has already helped the human race in extraordinary ways. The brain has brought the human race this far; it would be a crime not to take a deeper look. Being able to utilize the brain would open up more chances at finding cures to diseases; inventions for making life easier; and more effective ways to treat mental illnesses. For students, it would open up new techniques in learning and a greater understanding on how they, too, can help "fix stupid." ■

BY ROBB FREDERICK

# A SUREFIRE CURE FOR AN UNLIKELY MELTDOWN

**ON OCT. 1,** 2009, the Michigan Department of Community Health offered a $63,000 fix for what it called an "impossible" scenario: a disaster at one of the state's three nuclear plants.

If radioactive material spread across a 10-mile area, and if residents were told to take shelter in their homes rather than evacuate (the preferred action in the state's emergency plan), the affected population might survive the initial damage — thermal burns, internal bleeding, leukemia and cataracts — only to suffer, 20 years later, from symptoms of thyroid cancer.

They likely would survive that, too, as 95 percent of all radiation-related thyroid cancers are curable.[1]

It's a worst-case scenario with the best possible ending. And there is virtually no chance of it happening.

"The assumptions that were used in our models of a catastrophic accident at a U.S. nuclear plant were so conservative that they were unrealistic," says Patricia Milligan, the senior adviser for emergency preparedness and response at the U.S. Nuclear Regulatory Commission. "It just isn't likely to happen."

So why has the commission purchased 14 million tablets of potassium iodide, also called KI, to be given to Americans who live within 10 miles of a nuclear facility? And why do it now?

The NRC has provided the pills to 23 states. In Michigan, the MDCH has issued them to pharmacies, which will make them available at no charge to anyone who lives near the state's three nuclear facilities: the D.C. Cook plant in Berrien County, the Palisades reactor in Van Buren County and the Fermi plant in Monroe County.

The nuclear companies will pay the state $63,000 to advertise and distribute Michigan's 1.3 million tablets. The NRC paid for the pills.

The tablets saturate the thyroid gland. If taken within hours of a nuclear release, they can block the body from absorbing radioactive iodine, which can cause thyroid cancer.

The KI program is a direct response to the Chernobyl accident, which contaminated much of Belarus, Ukraine and Russia in 1986. The incident is the worst nuclear failure on record: More than 240,000 people were exposed to high doses of radiation, and another 346,000 had to relocate.[2]

Radioactive iodine from the Chernobyl reactor was disbursed into nearby farm pastures. The cows that grazed in those areas passed the contaminant into their milk, which was bottled and served to local children.

More than 5,000 of those children now have thyroid cancer, the World Health Organization reports.

Chernobyl is not a perfect case study. The reactor did not operate with the safeguards in place at modern nuclear facilities in the U.S. MDCH officials point to that in a fact sheet explaining the KI program:

"Michigan's (nuclear power plants) are extremely safe," the paper says. "In fact, an accident like that at Chernobyl or Three Mile Island would be impossible because of the design of Michigan's plants." (A partial meltdown at the Three Mile Island nuclear plant in Pennsylvania on March 28, 1979, was the worst nuclear accident in U.S. history; no deaths or health effects were reported.)

So why bother?

The answer stems from a very different event: the Sept. 11, 2001, terrorist attacks.

The NRC, having completed its Chernobyl studies, required that states consider KI distribution beginning in April 2001. That September, after the attacks on the Pentagon and World Trade Center, states began to request the tablets.

"A lot of people assumed that the KI program was a response to the Sept. 11 attacks," Milligan says. "It wasn't. But Sept. 11 did make some states more aware of the political pressures."

New York asked for tablets first. Several New England states followed. Actual demand for the tablets was another matter: Just 10 percent of the eligible population responded to New York's initial KI distribution, the NRC says.

Michigan waited for additional KI studies. In 2004, the National Research Council endorsed KI programs, which had begun in 21 states.[3] Officials at the MDCH and the Michigan Department of Environmental Quality began discussing how best to distribute the pills.

Some in the state already had access to them. The Emergency Management and Homeland Security Division of the Michigan State Police has maintained a 3,200-bottle stockpile of KI since the early 1990s. That program will continue, the MDCH says.

The state requested an additional public supply of KI in February 2008. A manufacturing delay postponed the program for more than a year, as several states had ordered new batches of KI to replace their tablets, which had expired before anyone needed them.

That will happen again. The NRC has assumed the cost of replenishing the KI stockpiles.[4] The commission plans to spend between $4 million and $5 million every six years to refresh the pill supplies. ■

1 "Thyroid Cancer - Papillary Carcinoma," The New York Times, March 21, 2008, http://health.nytimes.com/health/guides/disease/thyroid-cancer-papillary-carcinoma/overview.html (accessed Jan. 13, 2010).

2 World Health Organization, Fact Sheet No. 303, April 2006.

3 "Distribution and Administration of Potassium Iodide in the Event of A Nuclear Incident," National Academies Press, 2004.

4 Notation vote, "Recommendation for Future Replenishment of Potassium Iodide," March 3, 2009.

# RISK ASSESSME
# PART III

BY DR. ROBERT MEEKS

**THIS IS THE** third in a series of four MichiganScience articles on risk assessment. These articles are 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 is not designed to present the reader with an in-depth treatise on the complexities of risk assessment, but rather to 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.

In the first two articles in this series, we discussed three of the four fundamental elements of a risk assessment:

- Hazard Identification, which is the process of determining whether a particular chemical is or is not causally related to particular health effects and involves characterizing the nature and the strength of the evidence of causation.
- Dose-Response, which is the process of characterizing the relationship between the dose of a chemical administered and the incidence or the probability of occurrence of the health effects in question.
- Exposure Assessment, which is the process of measuring or estimating the intensity, frequency and duration of exposure to a chemical from all sources. It includes the population(s) that are potentially exposed and the pathways of exposure (ingestion, inhalation and dermal contact).

In this article, we will touch on the final step in a risk assessment — risk characterization. As before, this will be a high-level overview rather than an in-depth presentation of the complexities of a risk characterization.

Quite simply, risk characterization is the process of estimating the degree of safety associated with exposure to a chemical or the incidence of a human health effect under the various conditions of exposure described in the exposure assessment. It is performed by combining the exposure and dose-response assessments and includes a description of the uncertainties in both. For example, what is the risk someone will develop neurological disorders from being exposed to mercury? What is the likelihood someone exposed to benzene in gasoline will develop cancer? For non-cancer causing chemicals, risk is determined by estimating the margin of exposure (MOE) or hazard quotient (HQ). For cancer-causing chemicals, the risk is a probability and is expressed and as a fraction. The risk in both cases is unitless.

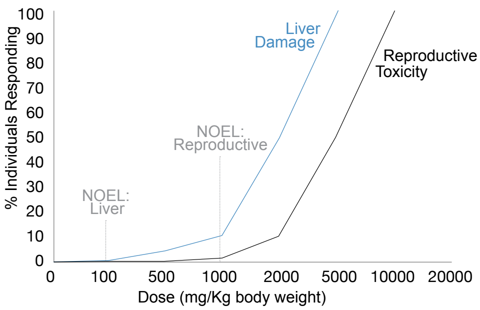
The concepts of chemical risk and how they are expressed are sometimes difficult to grasp. People are more familiar with the discussion of risks related to other sorts of activities, such as the annual chance of dying in an automobile resulting for people who drive an average number of miles per year. This risk is about one in 4,000. The risk of dying from lung cancer for individuals who smoke one pack of cigarettes per day beginning at age 15 is about one in 800. The primary difference between these sorts of risks compared to risks associated with chemical exposure is that these risk estimates are much more solid and are derived from years of extensive and substantial statistical data. Risks associated with chemical exposures are filled with uncertainties, which have been described in previous articles.

We have discussed in previous articles the first three steps in the risk assessment process that lead to the final step — risk characterization. The first three steps provide all that is necessary to answer the ultimate risk questions: What type of toxicity is expected in the exposed population (neurotoxicity, birth defects, reproductive effects, cancer, etc.), and what is the risk of it occurring in the exposed population?

A key component of the risk characterization is an analysis of the uncertainties. The two critical areas of uncertainty are the relevance to humans of the animal toxicity findings (hazard assessment) and the dose-response relations at the human levels typically associated with the chemical in question (high-dose to low-dose extrapolation). These uncertainties are generally dealt with by applying uncertainty factors to the NOEL (no observed effect level) or BMDL (benchmark dose low) to establish an RfD (reference dose), for ingestion, or RfC (reference concentration), for inhalation. The uncertainty factors are usually 10 for animal to human extrapolation and 10 for high-dose to low-dose extrapolation. In the case where a NOEL was not determined in a toxicity study and the LOEL (lowest observed effect level) has to be used in the dose-response assessment, a third uncertainty factor of 10 is used.

So, how does this whole process work? Let's assume we have chemical X that is subjected to a complete hazard assessment using the ingestion (oral) route of exposure. The results of the study showed that this chemical has liver toxicity in repeated dose studies and a reproductive effect in female rats in a standard study to assess male and female reproductive effects. Both effects occurred in a dose-related manner as shown below.

**Dose-response function with a no-effect region**




The most sensitive endpoint for chemical X is liver damage, where endpoint is defined as an effect observed in a toxicity study. The apparent NOEL for the liver damage is 100 mg of X/kg body weight (BW) and the apparent NOEL for the reproductive effect is 1,000 mg of X/kg BW, making the liver effect the most sensitive endpoint. Using an uncertainty factor of 100 gives an RfD of 1 mg of X/kg BW and 10 mg of X/kg BW for the liver and reproductive effects, respectively. An exposure assessment showed that the intake of chemical X by humans from all sources and by all routes of exposure is 0.5 mg of X/kg BW.

Having the hazards indentified, the dose-response relationship evaluated, and the potential human exposure dose or intake, we can assess whether the level at which humans are exposed are safe or without appreciable risk of adverse non-cancer health effects over a specified period of time. This can be accomplished in one of two ways, which yield different answers but in reality are comparable. The first approach is to divide the NOEL by estimated daily human exposure determined in the exposure assessment. Remember that the NOEL will not have the uncertainty factors (100) applied to it. In the case of our chemical X, the MOEs (margins of exposure) would be:

*Liver Effect:*

*MOE = (NOEL)/estimated human exposure = (100 mg X/kg BW)/(0.5 mg X/kg BW = 200*

*Reproductive Effect:*

*MOE = (NOEL)/estimated human exposure = (1000 mg X/kg BW)/(0.5 mg X/kg BW = 2000*

Since the MOEs are greater than 100, human exposure to 0.5 mg X/kg BW is judged to be safe or without appreciable risk if exposed to this level everyday for a specified duration of time (generally a lifetime). The second approach is to use the RfD, which has the uncertainty factors of 100 applied to the NOEL and to calculate what is called a Hazard Quotient (HQ). The HQ is calculated by dividing the estimated human exposure dose by the calculated RfD. The HQs for chemical X are:

*Liver Effect:*

*HQ = estimated human exposure/RfD = (0.5 mg X/kg BW)/(1.0 mg X/kg BW) = 0.5*

*Reproductive Effect:*

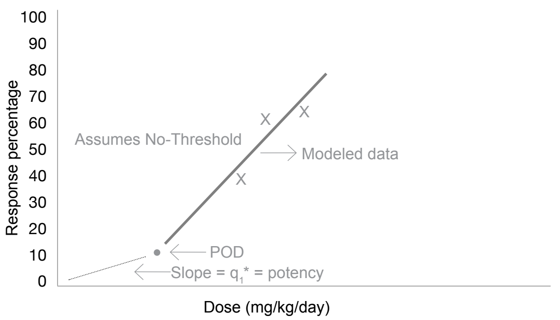
*HQ= estimated human exposure/RFD = (0.5 mg X/kg BW)/(10 mg X/kg BW) = 0.05*

For each effect for chemical X, the HQ is less than 1.0, which indicates that the 0.5 mg of X/kg human exposure by all routes and sources is without appreciable risk. It needs to be noted that this is not an expression of probability of an individual suffering and adverse health effect but serves more as a guide of what would be considered a safe level of exposure or an absence of risk.

In the first two articles in this series and the first part of the current article, we focused primarily on a discussion of the approach to assessing risks to human health from chemicals demonstrating a threshold effect in the hazard identification studies. We mentioned that the approach to assessing the risks from exposure to chemicals classified as carcinogens is different. The reason for this difference is that chemicals that cause cancer are considered to have no threshold, because they are generally considered to interact with and damage genetic material (DNA) in cells, which can be passed on from one generation of cells to the next. It is considered that a single molecule of carcinogen interacting with DNA can potentially lead to cancer, and because of this, it is generally accepted that there is no safe dose or level of exposure for these kinds of compounds. The dose-response for a carcinogen is considered linear especially in the low-dose region of the dose response curve, which means for every incremental increase in dose there is an increase in response. Benchmark dose modeling is used on the actual dose-response data to estimate the BMD and the BMDL (sometimes referred to as the ED10 and LED10), which is the dose corresponding to a specified increase in the probability of a specified response or effect. The BMD (or ED10) is usually the estimated dose corresponding to an increase of 10 percent (or increase of 0.1 in probability) of the specified response relative to the probability of that same response at zero dose. The BMDL (or LED10) is statistically the 95 percent lower confidence interval of the BMD (or ED10). This estimated point on the dose response curve is sometimes referred to as the Point of Departure (POD).

The dose-response curve for a carcinogen is assumed to be linear from the POD down to zero dose. The slope of the extrapolated linear curve is referred to as the potency of the carcinogen, which reflects the lifetime cancer risk associated with one unit of average daily lifetime dose. The slope of the extrapolated curve is the rise of the line — the increased risk shown on the vertical axis — for each unit increase in dose, shown on the horizontal axis) (below).

### Dose Response Relationship, Carcinogens




The more potent the carcinogen, the steeper the slope compared to less potent carcinogens.

Since there is essentially no safe dose with carcinogens, one has to estimate a level of risk that would be considered acceptable. This is a probability that lifetime exposure to a chemical, under specified conditions of exposure, will lead to an excess cancer risk, which generally ranges from 1/10,000 to 1/1,000,000 and means that one in 10,000 or one in 1 million people exposed is expected to develop cancer. It is important to note again that this is a probability and there is no way to identify which, if any, of the 10,000 to 1,000,000 people exposed will develop cancer. To calculate excess lifetime cancer risk, the estimate of human exposure dose is multiplied by the potency factor.

So how does this work? If, for example, a population of individuals is exposed to 0.0014 mg of a cancer-causing chemical per kg BW per day for a lifetime and the potency factor is 0.006 risk per mg BW per day, then the excess lifetime cancer risk is:

*Risk = (0.0014) x (0.006) = 0.000008*

This means, then, that eight people out of 1 million experiencing an average intake of the carcinogen each day for a full lifetime will develop cancer over that lifetime, or in other words, the human population would need to have the exposure level reduced to 0.00017 mg of this cancer-causing chemical in order to give an excess lifetime cancer risk of one in 1 million people exposed.

In summary, we have in three articles led the reader through the four steps of a risk assessment:

- Hazard Identification
- Dose-Response Assessment
- Exposure Assessment
- Risk Characterization

We have attempted to show at a very high level how the process works for both non-carcinogens and carcinogens. It must be reinforced that these articles were a very general overview of each step in the process. While the actual process may be more complex, these articles provide the basic tools to evaluate information presented in news media or other sources. All that needs to be done is a little investigative work to gather some of the basic data needed to perform independent risk assessments of particular chemicals. The next article in this series will focus on how regulatory agencies such as the U.S. Food and Drug Administration and U.S. Environmental Protection Agency use risk assessment to manage risk and set levels of exposure to chemicals in an attempt to protect public health. ■

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FOR PUBLIC POLICY
MichiganScience
140 West Main Street P.O. Box 568
Midland, Michigan 48640