The Air We Breathe

UM researcher finds young brains harmed by urban air pollution

By all appearances, Maria Fernanda is a normal 13-year-old girl. She comes from a good family, lives in a neighborhood with trees and dogs and attends a good school. She has a high IQ and is clinically healthy. There’s just one problem: The air she breathes is sabotaging the development of her brain.

Fernanda is a middle school student in Mexico City, the largest metropolis in the western hemisphere, home to 20 million people, roughly 4 million cars and some of the most polluted air on Earth. She should represent the best and brightest of her country’s future. Instead, her body bears the marks of air pollution’s most insidious side effects.

Because of the particulate matter entering her body with every breath, Fernanda’s lungs resemble those of a smoker. Her brain is spotted with lesions in her white matter — a condition seen in patients with Alzheimer’s disease and vascular dementia. Her heart is strained, her IQ has dropped six points in the past five years, and she’s having trouble focusing in school. Worse, in a city with 8 million children, Fernanda is far from alone.

“Everybody’s affected,” says Dr. Lilian Calderón-Garcidueñas, an associate professor at UM’s College of Health Professions and Biomedical Sciences who studies air pollution and brain development in Mexico City.

Calderón-Garcidueñas first became aware of the health effects of Mexico City’s air pollution when she was chief pollution — continued back page
Study of Mealybug Bacteria Reveals Secrets of Symbiosis

Mealybugs only eat plant sap, but sap doesn’t contain all the essential amino acids the insects need to survive. Luckily, the bugs have a symbiotic relationship with two species of bacteria — one living inside the other in a situation unique to known biology — to manufacture the nutrients sap doesn’t provide.

The net result: The bacteria get a comfy mealybug home, and the bugs get the nutrition they need to live.

UM microbiologist John McCutcheon describes such mutually beneficial relationships used to solve life’s little problems as “almost hilariously complicated. But animal-bacterial relationships are extremely common in nature, and it’s my goal in life to help people understand that it’s normal.”

McCutcheon and his research partners recently delved deeper into the genes involved in the “tripartite nested mealybug symbiosis,” and their work was published in the June 20 issue of Cell, a prestigious scientific journal. The researchers discovered the already complex three-way symbiosis actually depends on genes from six different organisms — three more than the number of species that now exist in the symbiosis.

*Tremblaya princeps* is the larger of the two bacteria species living within special organs inside mealybugs. *Tremblaya* houses the smaller bacterial species, *Moranella endobia*, within its cytoplasm. But what makes *Tremblaya* truly odd is the size of its genome, or genetic code. With only 120 genes, its genome is the smallest known and smaller than many scientists consider necessary for life. By comparison, common *E. coli* bacteria have about 4,200 genes and humans have about 21,000.

“We wanted to discover how this genome got so small,” McCutcheon says. “We suspected *Tremblaya*’s genome may have gotten smaller by transferring genes to the host animal, which is called horizontal transfer.”

The researchers looked for genes in the mealybug genome that resemble bacteria genes. However, after extensive analysis they only found one weak possibility for horizontal transfer from *Tremblaya*.

“Our hypothesis that *Tremblaya* was transferring genes to the host was dead wrong,” says McCutcheon. They did, however, find 22 other bacterial genes mixed in with the mealybug code — genes that seem to support activities missing in *Tremblaya*, *Moranella* and the mealybug.

How can this be?

“The genes are probably from historical bacterial infections,” McCutcheon says. “These bacteria are no longer present in the mealybugs we work with, but their horizontally transferred genes are, and these genes allow the symbiosis to work.”

The research team also examined a strain of *Tremblaya* that doesn’t have *Moranella* living inside it. This variety employs about 50 more genes than the one containing *Moranella*, which strongly suggests *Moranella* plays a key role in allowing the insect-dwelling *Tremblaya* to operate with such a tiny genome.

McCutcheon says *Tremblaya*, with its shrinking genome, in many ways resembles organelles called mitochondria — tiny structures found within all plant and animal cells that scientists believe started out as symbiotic bacteria in the early history of life. The mealybug/bacteria relationship he studies may illustrate one pathway bacteria take in becoming essential and highly integrated components of other cells.

“So this research really touches on some fundamental questions of the origin of life,” he says. “It’s exciting to see if we can get some insight into the origin of organelles.”

McCutcheon says this study involved an international cast of 12 collaborators. Filip Husnik, the study’s lead author, is a Czech doctoral student from the University of South Bohemia who worked in McCutcheon’s UM lab. Other team members were from Japan, England, California, Utah and Florida.

The study was funded by a $529,000 grant from the National Science Foundation.

“Our work illustrates how an animal’s interactions with bacteria can drive hidden organismal complexity,” McCutcheon says. “A tree is more than a tree, and an animal is more than an animal. They are really mosaics of plants and animals and bacteria all working together.”

Award to Study Hospital Discharge Process in Rural Areas

UM researchers, in partnership with Missoula’s Providence St. Patrick Hospital, will use a new funding award to investigate how the hospital discharge process affects the treatment outcomes of patients from rural areas and to explore ways to improve those outcomes.

The $1.85 million award was presented through a highly competitive process by the Patient-Centered Outcomes Research Institute, an independent nonprofit organization authorized by Congress in 2010. PCORI funds research that provides patients, caregivers and clinicians with evidence-based information needed to make better health care decisions.

“This award will be used initially to understand the experiences people have when they discharge from St. Patrick Hospital to one of the more-rural counties in western Montana,” says Craig Ravesloot, director of Rural Health Research with the UM’s Rural Institute on Disabilities. “We worked with the hospitals in Plains, Polson, Deer Lodge and Dillon, which serve large rural counties. The partnership with those hospitals was key to the success of our proposal.”

The researchers will investigate what patients from rural counties need for recovery following discharge from St. Patrick Hospital. Compared with Missoula, patients going home to rural areas typically have less access to needed services.

Dr. Joseph Knapp, a cardiologist with St. Patrick’s International Heart Institute, says they want to discover whether all patient needs are being met after they are discharged and if they might develop a new model for coordination between the Missoula hospital and the four critical access hospitals in the outlying communities.

“Fifty-three percent of St. Patrick Hospital’s patients come from outside Missoula County,” Knapp says. “Together we seek to optimize the health care experience in western Montana.”
Autism Waiver Program Shows Promising Results

UM Associate Professor Ann Garfinkle recently published a report documenting the results of the first 43 children to complete an intensive early-intervention autism program that launched in 2009. The Montana’s Children’s Autism Waiver Report documents positive outcomes in children who recently completed the intensive three-year program. According to the report, the Montana Department of Public Health and Human Services’ program that provides early intervention to children age 15 months to 5 years old with autism is “on par with published results from the best national programs” and has been “incredibly successful.”

To determine program effectiveness, the report focused on common measures, including if the child still exhibits symptoms that would result in an Autism Spectrum Disorder diagnosis, if the child is able to receive general education services and if the child has full, moderate or limited community access. In addition, 65 percent are receiving general education services in public school.

The program is designed to deliver 20 hours a week of direct intervention services to each participant at a cost of about $43,000 per year for each child for a three-year time period. The annual program cost is about $2.1 million.

In the report, Garfinkle also touches on savings to both the state and families. “While these children may need additional services in the future ... their functioning level reduces the need for families to miss work or to fund additional therapies,” the report reads. “These savings, while challenging to predict, will be in the millions of dollars.”

Both the executive summary and full report are available online at http://www.dphhs.mt.gov.

Innovation and Imagination: Events highlight research and scholarship

UM recently celebrated research, creative scholarship and entrepreneurship during “II2013 — Innovation and Imagination 2013.” Eleven events spanned seven days in mid-April. Events were designed to showcase UM’s advances in innovation and imagination and one day was dedicated to category-focused sessions.

“I believe the events helped members of the UM community, as well as the Missoula area, gain a greater appreciation for the high level of entrepreneurship, research and creative scholarship being accomplished by our students and faculty,” says Scott Whittenburg, UM vice president for research and creative scholarship.

Rus Lea, CEO of the National Ecological Observatory Network, delivered the keynote address, which provided an in-depth look into the world of his organization, which provides ecological data on everything from climate change to impacts of invasive species.

Joe Fanguy, UM’s director of technology transfer and president of MonTEC, moderated a session on nurturing a campuswide entrepreneurial culture at UM. Lively audience discussions followed presentations by Cameron Lawrence on the future model of the business school in higher education and Christina Henderson on the efforts of the UM Entrepreneurship Club to start new student-led businesses.

During a panel session about nurturing creative scholarship and research at UM, speakers provided an informative and fascinating look at creative scholarship across three seemingly disparate disciplines.

Then the undergraduate and graduate research conferences were held in conjunction with each other over two consecutive days. The conferences offered opportunities for UM students of all majors to present their research and creative scholarship through oral presentations, posters, performances and exhibits.

“Innovation and Imagination” will be an annual series of events, and ‘II2014’ will build upon the success of this year’s events,” Whittenburg says. “The primary themes of entrepreneurship, research and creative scholarship will remain the same with different campus units taking the lead on planning and hosting the themes.”

Paper Details Stressors Faced by Sexual Minority Vets

A recent paper published in the Journal of Homosexuality by UM psychology Associate Professor Bryan Cochran, UM doctoral graduate Annesa Fientje and authors from other institutions indicates that lesbian, gay and bisexual veterans of the U.S. military endorse higher rates of depression, post-traumatic stress disorder and alcohol problems than the general veteran population.

The study surveyed 409 LGB veterans — all of whom served before the repeal of “don’t ask, don’t tell” — about their military experiences, current mental health symptoms, LGB-related stressors and specific experiences associated with being an LGB service member. A comparison sample of veterans was retrieved from a Veterans Affairs database.

Results indicated that more than two-thirds of LGB veterans experienced anxiety or fear about having their LGB identity revealed while in the service and that they were constantly trying to conceal their sexual orientation while in the service. Almost one-fifth of LGB veterans indicated that they perceived their military discharge to be related to their orientation.

The researchers identified an association between current mental health symptoms of LGB veterans, such as depression and PTSD, and anxiety experienced around concealment of their sexual orientation while in the service. Despite this association, it is impossible to conclude that concealment of one’s sexual orientation caused later mental health difficulties.
The limits of human endurance, and the study thereof, are challenged by many factors: physical and mental fitness, terrain, heat, even the willingness of a test subject to provide a rectal thermometer reading in the field. Athletes can exercise their bodies and prepare their minds, they can plot out the physical path of least resistance, but until recently, exercise physiologists struggled to ease the discomfort of taking accurate core temperatures while collecting data reliably.

UM Professor Brent Ruby and his fellow researchers at UM’s Montana Center for Work Physiology and Exercise Metabolism have turned their frustration at losing data into a simple, modern solution: an app.

Ruby has studied heat stress in wildland firefighters battling a blaze and ultramarathon runners racing more than 100 miles through Death Valley’s Badwater Basin. It’s no wonder it’s sometimes difficult to get these subjects to provide the gold-standard core temperature measurement.

“The instrumentation is pretty crude,” Ruby says. “There’s the classic rectal thermometer, which is a piece of glass.

The type of probes we use are flexible, but they’re wired and have to be plugged into a data unit and battery charger or wall for power."

If it’s so difficult to gather, it’s a wonder researchers even bother with core temperature. But a person’s physiological strain index, the composite score of heart rate and a rectal temperature, provides vital information on how well a body is performing under heat stress, and if measured in time, can indicate the potential for sometimes deadly heat injury.

In the mid-2000s, new body-temperature sensors were developed that a person could swallow like a pill. When the capsule reached the small intestines,
core temperature data could be collected remotely without having to take a subject out of the field for an intrusive reading.

Ruby used these sensors as he began to gather data to develop and evaluate an equation, a predictive model that could capture overall physiological stress, as part of a U.S. Navy grant.

But as Ruby and other researchers soon discovered, the capsule sensors were prone to failure, sacrificing the integrity of data and time spent on a study.

“The devices didn’t work all the time,” he says. “Breakdowns, failures. It’s expensive to use the equipment and lose the data 30 percent of the time.”

To avoid that loss, UM researchers built off the equation they were developing to create a predictive model that could give the same information with easy-to-gather metrics.

Using Bluetooth sensors to measure heart rate and skin temperatures, the team now feeds data into a simple app, developed on the Android platform, to monitor a person during an activity.

Though the app originally was developed to help the team accurately capture their data, the ability to monitor heat stress live has changed the way researchers or even trainers and coaches can interact with the information.

While data gathered during an activity and later loaded into a system can tell a person that they did in fact surpass their comfortable core temperature just minutes before they collapsed, a live feed of the data can predict and prevent that heat injury.

“The app captures measures of the heart rate and temperatures, integrates those two and builds the heat stress score,” Ruby says. “That number can be used to make decisions on whether you should slow down, get in the shade or tell you if you’re having issues.”

Once the researchers realized the potential benefits of real-time monitoring, they got in touch with Joe Fanguy, UM director of technology transfer. Fanguy and MontEC, the business incubator based at UM, help researchers and small businesses develop the entrepreneurial potential of their ideas.

Working with Fanguy, the team determined that the algorithm, not the hardware, is the piece of the project with commercial promise.

“Brent and his team are extremely creative and always coming up with new ideas,” Fanguy says. “True to their creativity, this particular innovation is quite different, one where the commercialization strategy doesn’t necessarily involve patents for equipment or processes, but more along the lines of trade secrets.”

The University currently is exploring product development options with a major sports equipment company, aiming to find a partner well-suited to design, manufacture and distribute a product based ultimately on Ruby’s research.

The app currently isn’t available on the Android or any other app market, since Ruby and his team just use it in their research, but the future of the tool is unknown. Ruby even sees potential in a multiuser live feed.

“It would be really cool to watch a football team of people who have been identified at risk of heat injury and monitor them to make sure they don’t get there,” he says.

Although a rectal reading remains the most accurate measure of core temperature, the heat stress score displayed by the app can help people see a heat injury coming.

“Rectal temperature is too slow,” Ruby says. “If you wait for someone to say, ‘Oh, I don’t feel good,’ it’s too late. If you could have intervened 30 minutes before, they wouldn’t have even gotten to that point.”

— By Bess Pallares
Engraved tablets and boundary stones from the ancient Near East add an aura of deep mystery to the famed Louvre museum in Paris. The relics span 9,000 years from prehistory to the early Islamic period. Some are hidden from public view in back rooms. Many artifacts are etched with the lettering of extinct languages.

Nathaniel Levtow is one of a handful of scholars who can read the cryptic words. He is a lifelong student of Phoenician, Akkadian, Aramaic and Hebrew. This summer, the UM religious studies professor traveled first to Jerusalem and then to the Louvre in Paris, where he studied early inscriptions that include boundary stones and law codes from the excavations of Susa, once ancient Iran. Some of these stones were carved in Mesopotamia 4,000 years ago but abducted by the king of Susa 1,000 years later.

To the casual visitor to the Louvre, the imagery and writing are inscrutable. To Levtow, the stones reveal an unfolding drama. Upon close examination, for example, the stolen stones of Susa reveal erasures of text and new writing over the old.

“You have to read them yourself,” he says. “The languages are the windows to the ancient world.”

Levtow seeks patterns in the early stone writings. Rather than focusing on the creation of texts, he looks for repeated acts of text destruction, which are associated with violence against people.

The Hebrew Bible itself has been a target of destruction, he points out. And within its pages is the famous scene of Moses smashing the two tablets inscribed with the Ten Commandments. That was no random fit of anger, he explains. Rather, the scene from Exodus exemplified a long tradition of the consequence of breaking law codes. When Moses saw his people worshiping a golden calf in violation of “thou shalt have no other gods, no graven images or likenesses,” he destroyed the divine text.

A two-month grant from the National Endowment for the Humanities provides the funding for explorations that further Levtow’s overarching endeavor to find new perspectives on the Bible through understanding the cultures and practices of the times its writers lived in.

What Levtow knows so far about stone carvings might add fodder for a whole new genre of “Da Vinci Code” thrillers. Translations of the rune-like lettering on Mesopotamian artifacts often reveal weighty curses meant to protect the engraved names of kings and gods, as well as entire law codes.

For instance, if a person dared to erase a name on a stone, he would face “the obliteration of his city, the dispersion of his people, the supplanting of his dynasty and the blotting out of his name and his memory from the land.”

Those are words in the Akkadian language on the famed Stele of Hammurabi displayed at the Louvre. The Stele, an inscribed stone slab, bears a law code from Babylon from about 1772 B.C. (and it, too, was abducted to ancient Susa). The laws of Exodus and
Deuteronomy in the Bible also contain warnings to not change or alter what’s written — admonitions that follow from cultural practices of guarding the written words of gods and kings, Levтов says.

The practice of writing curses suggests to Levтов that they arose for a reason. But why would people care enough to steal stones, erase names and replace the name of one king with another?

Energetic and curious, Levтов takes a fresh approach to the question of divine presence on Earth. His scholarly terrain takes him into a world of priests, secret rites and numinous images. Since he arrived at UM in 2006 for his first full-time teaching position armed with a doctorate from Brown University and master’s from Harvard Divinity School, Levтов has offered courses that border on the magical, such as Prophecy.

In 2011, he received UM’s prestigious teaching award for junior professors, the Helen and Winston Cox Educational Excellence Award. Levтов is a gifted scholar as well. In 2006, he earned the outstanding dissertation award in the humanities from Brown University.

“Nat is a genius at being able to present the scholarly perspective,” says longtime UM religious studies Professor Paul Dietrich. He admires Levтов’s critical eye and ability to apply social science theories to idolatry and iconoclasm in religion.

Levтов says he often turns to the fields of cognitive science and neuroscience to better understand human perceptions from thousands of years ago. He’s most interested in the ancient Near East from 2500 B.C. to 500 B.C., especially Syria, Babylon, ancient Israel and Egypt. There, Levтов studies the earliest stories of warring gods, where destruction appears to be pivotal to a society’s creation.

“The battle between gods is as old as the hills,” Levтов says. “Such battles or ‘combat myths’ often show up in many religious texts, including the Hebrew Bible.”

The gods of the ancient world were thought to have a physical presence on Earth first through statues and the earliest writings. Destroying a statue or other image, the practice called iconoclasm, was a powerful act. Levтов suggests that the Bible’s condemnation of worshipping images coupled with promoting only one universal god, is another variation of the ancient war of gods, where the winner destroys or takes over the other’s images.

His new research into text destruction flows from prior studies of iconoclasm, the subject of his dissertation and a 2008 book, “Images of Others: Iconic Politics in Ancient Israel.”

“I’m very interested in learning what it means to interrelate with a statue as if it were a living god,” he says.

Levтов studied Mesopotamian “mouth-washing” rituals where priests imbued statues with life and divinity after stonecarvers, woodsmiths and metal-workers finished their works. Statues that today we might admire for their artistic beauty were once considered living gods.

In ancient wars, battles often involved horrific losses of limbs and lives, yet the ultimate defeat only happened through the loss of a statue embodying the divine presence of a god. To gain more power over the losers, the victors often would not break statues, but abduct them and place them before their own divine statues in their own temples.

“You have this in the Bible, too,” says Levтов. “The ark functions like a divine statue. The Israelites take the ark into battle, and when they are defeated the ark is stolen and taken to the temple of their victorious enemy’s god and placed before its statue.”

The Ark of the Covenant was the chest built at the command of God to hold the tablets of stone containing the Ten Commandments, as described in Exodus. If statues could be divine, then so could ancient writings, Levтов points out. Similarly, if statues could be destroyed or usurped, then so could the texts.

That’s where the curses come in. The earliest texts of ancient Sumeria in the third millennium began as writing on objects and images. The first texts were often names of kings engraved on stone statues. Later came the curse, created to protect the name and statue.

“The curses basically say that if you destroy my statue or name, your name will be destroyed, and your son will die, and your dynasty will end,” Levтов says. “So, in the world’s oldest known texts, the destruction of writing engraved on the images is linked to the death of people. It’s one interlocking reality.”

Levтов believes that special rituals surrounded early writing. Toss out any vision of a lonely scholar scribbling with a calligraphy pen. Instead, writing was a sacred performance art practiced in temples. Since few people could write in the ancient world, those who did had special powers, he says. The words, like statues, came to life as a physical expression of the divine.

“We find here the origin of the holy word,” he suggests.

Levтов’s summer excursion exposed him to writings from long ago and to more evidence of deliberate and ideologically motivated text destruction in Mesopotamian, Egyptian and Levantine artifacts. While much of his research focuses on archives of museums and libraries, he visited archeological excavations, including one outside of Jerusalem that is unearthing compelling artifacts from the time of the biblical King David.

As Levтов weaves together the threads of image and text destruction as symbolic violence in the ancient world, his findings may help both to explain motivations for similar acts in the modern world and to inform policies in the volatile Middle East and Central Asia.

He gives one memorable example of a recent act illuminated through the lens of studying the past. When the Taliban in March 2001 blew up the world’s two largest standing Buddhas in Afghanistan, that action was a deliberate public display of image destruction based on a very ancient tradition.

“In today’s world, the study of religion, culture and history are more important than ever,” he says.

UM’s Liberal Studies Program now offers a religious studies option with courses on religions of Near Eastern/Mediterranean origin and on South and East Asian religions. Other course offerings cover topics ranging from American Indian religions to Tibetan civilization.

From a personal standpoint, Levтов admits to the pure delight of scholarly time travel that he experiences when pursuing the origin of western religion in the ancient Near East.

“I find it very interesting to spend my time in the ancient world where the gods are everywhere.”

— By Deborah Richie
Pollution — continued from front

of research at the Naval Medical Center there. Visiting staff members complained of nosebleeds and headaches whenever they came to the city. Calderón-Garcidueñas started researching the effects of pollution on the hearts and lungs of dogs. Then her daughter, who was in medical school at the time, suggested she look at the dogs’ brains. What Calderón-Garcidueñas saw was disturbing. Dogs as young as 11 months had brain lesions that were reminiscent of Alzheimer’s disease.

The implications were troubling. An 11-month-old dog is equivalent in age to a 7-year-old child. Could children be suffering from the same lesions? Calderón-Garcidueñas shifted her research from dogs to humans, leading her to children such as Fernanda.

Calderón-Garcidueñas has studied Fernanda closely since she was 5 years old. In that time, the lesions in her prefrontal cortex have expanded, impairing her problem-solving skills, attention span and goal-directed behavior. As a result, Fernanda’s cognitive performance for select tasks is several years below her age.

The delay in her brain’s development doesn’t bode well for Fernanda’s teenage years, when her stunted decision-making skills may make her vulnerable to peer pressure. Fernanda’s stable family will help her navigate those difficult times, but not all children are as lucky. And not all conditions are common in people younger than 30. Adults, in general, present with fewer symptoms.

The effects of pollution can be detected empirically. First, many people have lost their sense of smell. Calderón-Garcidueñas says that in the dogs and humans olfaction is one of the first parts of the brain damaged by air pollution. Second, people’s memories are poor.

“You ask them what they had for dinner, and they look at you blankly,” Calderón-Garcidueñas says. Road rage on the traffic-choked streets also is common. Air pollution causes neural inflammation, which alters the brain’s behavioral control centers and leads to increased aggression, Calderón-Garcidueñas says.

The effects of air pollution have implications at home, at work and in between. But the citywide scale of the symptoms also helps obscure them. “Many people are not aware of their deficiencies,” Calderón-Garcidueñas says. “Everybody has the same problems, so it becomes normal. And people adjust.”

Mexico City certainly isn’t the only city where pollution causes major health risks. Tokyo, New Delhi, Shanghai and other global megacities all have alarming levels of air pollution. “I don’t know of any major city that’s clean,” Calderón-Garcidueñas says.

But Mexico City’s pollution is compounded by its unique geography and sheer size. The city’s factories constitute a major part of the national economy. Their emissions are the collateral damage of a booming industrial sector.

Meanwhile, these emissions are inhaled by children such as Fernanda. Particulate matter in the air is passing through her blood brain barrier and causing lesions in her white matter — the tissue that connects the regions of the brain. Calderón-Garcidueñas estimates that in 50 years, children like Fernanda will develop full-blown Alzheimer’s or Parkinson’s disease.

“There is a 50-year window of opportunity to avoid a 10-year-old kid becoming a 60-year-old who says, ‘I don’t know where I put my car,’” Calderón-Garcidueñas says. “By the time you get to that stage, there’s nothing I can do, as a physician, to help you.”

In the meantime, however, some activities can help mitigate the damages to children’s brain development. Chief among them is building up a child’s cognitive reserve through mental calisthenics such as learning a second language. Exercise helps, too, although it must be done indoors to be beneficial.

A good diet also is important. Calderón-Garcidueñas recently found that doses of dark chocolate reduced neuro-inflammation in mice. Broccoli has been shown to do the same. You can’t take all the children out of Mexico City, Calderón-Garcidueñas says, so you have to find ways to help them where they are.

Now Calderón-Garcidueñas is turning her attention to the factors that make children more susceptible to the pollution. Is it genetics? Stress? Nutrition? “Who is most affected?” she wonders. “And more importantly, how can we help them?”

The fate of Mexico City’s children — and children in cities around the world — hangs in the balance.

“Millions of exposed children need to be protected from the harmful effects of air pollution,” Calderón-Garcidueñas says. “Preventative medicine is our goal.”

The issue is an urgent one. Learning how pollution damages the brain, and what can be done to prevent it, will help children like Maria Fernanda grow into the healthy, smart young woman that she should.

— By Jacob Baynham

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