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<u>In the Lab</u>

In Which I Am Mistaken For a Scientist And, Therefore, Drill Into a Rat's Skull

by Kevin Bullis
Scope Correspondent

I expected some sort of ritual, a rite of passage the equivalent of dipping holy water and making the sign of the cross, but I walked through the door into a neuroscience lab at MIT without even a shrug from those nearby. The door to the lab was open, and no one seemed to mind as I wandered around in my street clothes looking for Monica, a third year graduate student who had agreed to let me watch her perform a surgery.

Before I found her, I ran into the undergraduates, two neuroscience majors who were there to learn the ropes. Their post-doc mentor, the equivalent of a doctor just out of med school and doing her residency, was bragging about them.

"You should see them. They've only been here a week, and they've got skills, man."

One undergraduate was carefully setting up the dissection space with an absorbent pad, stainless steel pan, shiny scissors, probes, and a scalpel blade safely sterile inside its packaging. He moved slowly, but clearly knew what he was doing. Later I would watch him anesthetize a mouse and remove its head with a pair of heavy scissors as easily and noiselessly as cutting through string cheese.

I asked the post-doc where I might find Monica, and he took me to the *in vivo* room, the area where they run experiments using live animals.

When we arrived she had already anesthetized her rat and shaved its head.

"I've just started," Monica said after we exchanged greetings. "You can sit here."

Again I was surprised. I expected masks, scrubbing my hands and arms up to the elbows. Maybe even copious amounts of brown iodine.

"If you want to touch him, just put on some gloves," she said, focusing on her work.

As I pulled on the gloves and slid my office chair between carts cluttered with electronics, I tried to breathe slowly, to keep my germs hovering around my face instead of infecting the little rat. Monica explained that regulations for rat work required a clean, but not a sterile environment. They used sterile scalpels, but didn't worry about masks.

I watched as Monica struggled with a clamp-like device that would serve to keep the rat's head from moving. This was only the third time she'd done this operation. She apologized for how long things were taking.

"Arnie could do this in three seconds," she said, using a phrase that became a refrain during the surgery.

Arnie was a veteran, a demigod in the lab known for his steady hands, and, incidentally, his brilliant practical jokes. One April 1st, Mark Bear, head of the lab, nearly burst an artery as he read a carefully worded apology from the journal *Nature*, explaining that it could no longer publish his breakthrough paper because his rival had beat him to it by two weeks. Arnie now loves to drag out the letter, stained and water-damaged over the years, whenever he gets the chance.

With the rat's head secured, Monica cut through the scalp, exposing the skull. The purpose of the operation was to insert a set of electrodes, eight miniscule wires that together looked as thin as a hair, into the rat's brain. The electrodes would let her detect the firing of single neurons, and perhaps figure out what was going on in a little-understood area of the brain called the LGN. Results from earlier experiments had suggested that a widely accepted

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theory about how the brain adapts to new environments might be wrong.

Inserting the electrode meant drilling seven holes in the skull. Two would hold screws for anchoring ground wires. The screws in four more would serve to anchor the electrode assembly in place on the top of the skull, with the help of some pink dental paste. The last hole was for the electrode itself. The holes would each be only as thick as the tip of a ballpoint pen, all created by a cordless very-high speed drill.

But now Monica was having trouble. As she put in the second screw, it actually widened the hole in the thin bone. Instead of tightening securely, the screw just wobbled in place. It was time to call Arnie.

Three seconds or so after he'd arrived, Arnie had drilled another hole, and, of course, the screw went in fine. Then he turned his big face up at me and said, “You’re next.”

I laughed skeptically.

“Seriously. You’ll never learn if you don’t try.”

He thought I was one of the undergrads. When he realized his mistake, he apologized, but then said I should try anyway.

So I did. I drilled a hole in the rat’s skull.

As I sat, cotton swab in hand, dabbing at the fluid seeping out through the newly drilled hole, for a moment I felt I had become part of the lab. I wanted to stay. I wanted to help Monica figure out the LGN. I wanted a post-doc to brag about my skills.

"See. You're better than me," Monica said, breaking into my reverie. I smiled.

From the editor —

The latest issue of **Scope** contains a medley of stories. They include a visit to a neuroscience lab, a look at industry versus academia, lessons on physics, an essay on life’s meteoritic accretions, and the review of a new exposé on drug companies. And, although the season is spring not fall, the love life of turkeys is scientifically examined as well.

Careers in Science

Grass Looking Greener In Industry

by Emily Kagan
Scope Correspondent

Anna spoke softly, avoiding eye contact as I asked her about her herself. A chemistry graduate student, she had come to MIT at the recommendation of a professor from her undergraduate home, Brandeis University. “He thought it would be good fit for me,” she said, jamming her hands between her knees. Anna (whose real name is being concealed at her request) works for Steve Lippard, the head of the MIT chemistry department. When I asked her if she was excited to be in this lab, she shrugged, as though her acceptance to one of the best chemistry programs in the world were as incidental as the freckles that dotted her nose.

But when I asked Anna what she was working on, she came to life. Whisking me through the lab, she brought me over to a fume hood and pulled out a glass bulb with a canary yellow chalk caked around the inside. On the surface of the bulb she had drawn the intricate structure of the dry powder. The hexagonal shapes and zigzag lines represented a cisplatin molecule, a powerful anti-cancer agent, attached to a variant of estrogen. “I made it this morning,” she said, glowing with pride.

Her hands, gloved in blue latex, deftly maneuvered the flask back into the fume hood as she continued to explain her project to me, her voice now full of confidence and conviction. It is clear that Anna loves what she does, but when I asked her if she wanted to have a lab of her own some day she said no. No way. She wanted to have kids.

“I don’t know any female chemistry professors who have children.” Anna lamented. “It’s just too hard to build a name for your self and start a family.” In light of the recent comments from Harvard’s president about the abilities of women in the fields of math and science, the feminist in me was dismayed to hear this response. But this sentiment was echoed by almost everyone I met as I wandered from bench to bench in the Lippard lab. Both men and women shook their heads at the mention of a career in academia. Student after student cited the perils that a researcher must face if they want to have their own lab.

After spending five to six grueling years as a graduate student, chemists must then find a postdoctoral position. During their year or two as a postdoc, the researcher is expected to publish impressive work if they ever hope to win a spot on the faculty of a university. If the postdoc does manage to land a professorship, they must then usually build a lab from the ground up. Adam, a fourth year undergrad who works in the MIT lab, said that new professors often spend long hours working at the bench, along with their graduate students. They are in a race to produce enough high-quality research so that they can continue to receive funding and, hopefully, tenure. The old rule of "publish or perish" is as controlling as ever, and many students simply don't see the point.

"Industry wants you to have a family," said Eric, another graduate student in Lippard's lab who saw a more attractive alternative to the university. He cited vacation time, 9 to 5 workdays, and job security as the main draws for a career in industry. Eric, who also works on the cancer drug cisplatin, says that helping people through chemistry is really important to him. "That's what gets me through my day." He doesn't want to do chemistry just for chemistry's sake. He feels that a job in industry will give him the chance to do the science he loves with a practical application at the other end.

Perhaps the academic lab is a weeding process that works to the benefit of universities. Only those who are willing to work the hardest will throw themselves into the academic gauntlet. But with the growing number of jobs in industry, there may not be enough students left who are willing to forgo larger paychecks and easier workloads for the life of an academic researcher. How will the face of chemistry, for example, be changed if its best and brightest are lured away by industry?

If MIT is worried about this problem, you can't tell by looking at the chemistry department's web site. Page after page links students to industry jobs. A calendar is posted listing all the companies that will come to recruit on campus. Students can sign up for interviews with a click of a mouse. There is a link to www.chemjobs.net, a job-listing site for chemists. A quick search of its listings for the past thirty days revealed a mix of academic and industry positions. But not a single university job got the web site's highest approval rating as a "top job!" Back on the MIT page, clicking on a link for postdoctoral fellowships at MIT, returns the following response: file not found.

Insight on Physics

Symmetry of Opposites

by Siri Steiner
Scope Correspondent

Many of us find comfort in the symmetry of opposites: the best cookies have bittersweet chocolate chips, and a really good movie makes us laugh *and* cry. In 1931, physicist Paul Dirac had an idea that took this aesthetic to a new level. He came up with a theoretical basis for the opposite of matter, a tangible yin to our material yang. He called it antimatter.

It's easy to imagine opposite sides of a coin, or opposing political views, but what would be the opposite of matter? To understand this, we have to think small. Everything that exists is made of tiny atoms, which can be broken down into even tinier particles called protons, neutrons, and electrons. In chemistry class we learn that protons have a positive charge, while electrons have a negative charge. When it comes to antimatter, though, this simple rule turns on its head. Antimatter electrons, called *positrons*, actually have a positive charge. Likewise, anti-protons have a negative charge. Yet, all of these anti-particles act just like the old-fashioned stuff that populates most of our visible universe. An antiproton can join up with a positron to form an atom of anti-hydrogen, and positrons repel each other. Because antimatter perfectly mirrors matter, we would not know the difference if we were observing antimatter alone in distant space.

Dirac stumbled on the concept of antimatter as he was combining quantum mechanics—the newly emerging theory that energy exists in discrete "quanta"—with Einstein's special theory of relativity. To his surprise, he found that he could plug either a positive or negative value into his equations without changing his results. Just as 4^2 and -4^2 both equal 16, electrons could have either a negative or a positive charge. Dirac's predictions were confirmed just a year later, when positrons were found in a cloud chamber studying cosmic rays. It was the first time anyone had predicted the existence of a new kind of matter from solely a theory.

Einstein's famous equation, $E=mc^2$, tells us that mass (m) can be created from very large amounts of energy (E). Dirac's observations added a new twist. Anytime that mass is formed from energy, there should be an antiparticle for every particle created. Conversely, when a piece of antimatter recombines with matter, they both lose their mass in an explosion of pure energy. Like the confetti companion of each hole punched in notebook paper, there should be a piece of antimatter floating out there for all the matter created in the big bang. But if this is true, asked Dirac's contemporaries, why don't we see flashes of energy in space as the yin and the yang of our universe continually bump into each other?

Dirac assumed that antimatter randomly clustered somewhere else, allowing our corner of the universe to stay intact. He said, "We must regard it rather as an accident that the Earth (and presumably the whole solar system) contains a preponderance of negative electrons and positive protons." In other words, Dirac believed that dumb luck had made our children, our lovers and our stars out of matter. Was there, he wondered, an equally elaborate realm of antimatter somewhere?

Over the last twenty years, scientists have looked for rogue antiparticles from antimatter galaxies. Detectors aboard balloons and satellites have been sent high above the Earth, in hope of catching stray big bang antiparticles before they are annihilated by the stuff in our atmosphere. Though scientists have found small pockets of newly-made antimatter, there has not been any conclusive evidence of leftover antimatter from the big bang.

The most popular explanation for why we don't see such leftovers says that there were slightly different amounts of matter and antimatter just after the big bang. For every 1,000,000,000 particles of antimatter, there were about 1,000,000,001 bits of matter. All of these particles destroyed each other, except for that tiny surplus of matter that stuck around. Today, everything in the material universe is made of the one extra matter particle per one-billion-one that was not turned back into energy.

If this is true, our proverbial "chips" are less bittersweet than we like to imagine. We may exist only out of the small and unexplained excess that was created at the birth of our universe.

Insight on Physics

Nature's Polarizing Outlook

by Maureen McDonough
Scope Correspondent

Rolling along like waves upon the sea, light waves travel from the sun, through the vacuum of space, into the earth's atmosphere. But ocean waves are confined to the surface of the sea, moving up and down, up and down, while making their journey to the shore. Waves of light, on the other hand, roll up and down, left and right, and at any angle in between—all the while continuing steadfast on their path towards earth. This light that rolls, or vibrates, every which way is called unpolarized light. Most of the light we are all familiar with is unpolarized.

A wave of unpolarized light, vibrating at various angles, is actually a composite of two directions. As you draw a diagonal line on a piece of paper, you will see that your hand is moving both vertically and horizontally across the page. Your line is a combination of these two directions. In the same way, waves of light are also composed of horizontal and vertical components.

Things get interesting when nature or human ingenuity discovers ways to cancel out either the horizontal or vertical component, so that the resulting wave of light vibrates in only one direction. That's what cuttlefish skin and Polaroid filters do. The man-made filters are made of long-chain molecules that are stretched out and aligned in the same direction. When molecules are aligned in the vertical direction, the vertical component of light is absorbed, but the horizontal half passes right on through. Conversely, when the molecules are aligned in the horizontal direction, the horizontal component is absorbed and the vertical half proceeds unhindered. All of the waves that pass through a Polaroid filter vibrate in the same direction. This is called polarized light.

Light can also become polarized when it's reflected off of a nonmetallic surface, such as water. Waves reflected off the surface of a lake become partially polarized in the direction parallel to the water's surface. People see this polarized light as glare. Fishermen are particularly familiar with this problem because the glare prevents them from seeing fish below the water's surface. That's why fishermen find Polaroid sunglasses so handy. The glasses are made with absorbing molecules horizontally aligned, so that the polarized waves of light coming off the surface of the water are blocked. If you were to rotate the sunglasses 90 degrees, so that the molecules were vertically aligned, all of the light coming off of the water would pass through and the glare wouldn't be reduced.

The human eye can't detect the difference between polarized and unpolarized light, but other species can. Many insects and sea creatures have eyes sensitive to polarized light, which scientists think provides them with information similar to what we gain from color vision, enhancing detection and recognition of objects.

Octopuses are some of the lucky creatures able to analyze polarized light, by what is called polarization vision. They use it to hunt for food. When light passes from the air through the surface of the water, it is refracted, which means that the direction of the light is changed. This happens when light passes from one material to another. When light is refracted it is also partially polarized, which octopuses see as a distinct backdrop of their watery world. They see their world as partially polarized, just as we see our sky as blue. When a transparent object, such as a delicious jellyfish swims by, an octopus can see the jellyfish against the polarized surroundings. It's as if the octopus is seeing a white barnacle resting on a dark rock: easy pickings. Another favorite food of octopuses is the crustacean, which reflects light off its smooth surfaces. This reflected light is strongly polarized and again catches the octopus's eye against the ocean's partially polarized backdrop. A glimpse of reflected light may mean crab is on the menu.

Another ocean dweller that has Polaroid vision is the cuttlefish, a squid-like creature. Scientists discovered prominent patterns on the arms, around the eyes, and on the forehead of cuttlefish that can only be seen by humans when viewed through a camera that detects polarized light. These ten-armed magicians have the ability to change their skins' color and pattern, and some of their magic acts can only be detected with polarization vision. This gives cuttlefish a stealthy way to communicate with other cuttlefish, because the message is concealed from most predators.

Some iridescent butterflies also use polarization of light to communicate. Their prismatic scales refract light, which is recognized by other members of their species as a mating signal. While many butterflies simply use their brightly colored wings to help them find a mate, iridescent butterflies are typically found in deeply forested areas, where light and shadow can make color recognition more difficult. Since these butterflies have polarization vision, the polarized light from the wings is more easily detected than color in their specific environment.

Humans and other species alike have found ways to manipulate, recognize, and utilize polarized light. This fundamental property of light may be invisible to our naked eyes, but we should not let the glare of our own perceptions prevent us from seeing beneath the surface of the natural world.

Essay

Love in the Time of Accretion

by Jennifer Boyce
Scope Correspondent

Sixty-five million years ago a piece of rocky debris, unclaimed in the formation of the solar system and left thereafter to wander inner space, is nudged out of its trajectory by the earth's gravity. Come to me, the earth croons, and I will come to you. Helpless to resist, like Lot's wife turning back for one last look at Sodom and Gomorrah, the wanderer obeys the siren's call. What choice does it have, really? There are forces in nature and in ourselves that even the strongest among us are not able to withstand, even when we know surrender may spell our ultimate destruction.

On comes the hapless voyager, hurtling toward the appointed rendezvous just off what is now Mexico's Yucatan Peninsula. Burning in its impatience to meet its destiny, the meteorite-to-be races faster and faster toward the much larger earth, which leans ever-so-slightly toward the traveler before receiving it in a cataclysmic embrace. One moment intoxicated by the force of overwhelming attraction, the next devoured by the instantaneous conflagration—and nothing for either of them will ever be the same.

Love can be like that.

On a sparkling spring morning, my doorbell rings. A pleasant-looking man says politely "Process server, ma'am; please sign here." I manage to comply as an electric shock radiates limbward from my solar plexus, at what must surely be twice—three times!—the speed of light.

I know what this is. A year and a half ago my life was nudged out of its trajectory, making this rendezvous—my own instantaneous conflagration—inescapable. Opening the envelope, reading the unfamiliar return address—Burns and Levinson, LLP, Attorneys-at-Law—I shake out the thick sheaf of papers inside to be informed that I, Jennifer Boyce, am the defendant in a divorce action filed by the plaintiff, my husband, to be heard in the Probate Court of Middlesex County, Commonwealth of Massachusetts, etc., etc. *Defendant?* Such a pernicious, blame-filled word. *It can't be*, my mind repeats stupidly. *Not me. I wasn't raised to be a defendant!* This is my first glimpse of the bleak, officious format of a civil complaint filing; something tells me it won't be my last.

I have fourteen days to respond, but what response can there possibly be? Like the rocky wanderer hitting the Yucatan, in less than a second I have ceased to be what I was: a married mother, an integral part of that product of emotional accretion, a nuclear family. Without volition, drawn in by forces beyond my power to resist, the old me has been annihilated on impact. I am now that shattered being, a single parent—a testament to the first rule of accretion, whether emotional or physical: sometimes things stick and sometimes they don't. Life will go on, but as the cosmic wanderer learns too late on embracing the earth, nothing will ever be the same.

At the moment of impact, much of the meteorite's kinetic energy is abruptly converted to heat, enough to melt vast quantities of rock. Wide regions of India, on the other side of the world, are flooded as newly molten basalt boils up from deep within the crust. Other volcanoes roar to life. A continent-wide firestorm ravages North America, ignited by a blast of superheated air. For the dinosaurs, dominant inhabitants of this Cretaceous world, it can't be good news. Their doorbell has rung, casting a shadow over this bright moment of life.

I know how they feel; all around me, my own North America is scorched earth.

Like a black widow spider, the planet is fickle and treacherous. It soon finds another mate, then another—taking what it can each time, never satisfied. Each time, the wooed one is dispatched with a great outpouring of energy followed by cold indifference. But there is a price to pay for this promiscuity.

Each coupling leaves its mark. This time, a sprinkling of iridium, gift of the vanquished traveler and borne aloft by global winds, settles over the surface like dust on a new-polished table. There it is, buried by 65 million years of the earth's restless shifting; it becomes part of the earth itself. The meteorite is destroyed, yes, but it is also subsumed, leaving this clue to the history of the wanderer's brief but fateful wooing.

The terrene surface is creased and pitted and seamed. Scars of concupiscence are telltale: perfectly round, with raised rims and sunken centers. On a geologic time scale, the craters don't last long. The earth has powerful healing processes: weathering and plate tectonics will smooth over the superficial damage with time. But the ultimate effects of the meteorite's immolation are felt much deeper than the deepest subduction zone and last far longer than any mere surface feature could. Each impact makes the earth as a whole more massive, stronger—and more attractive to future travelers.

A haze of dust, kicked up by the collision and the volcanoes it spawned, fills the sky. Water droplets condense on the tiny grains, then coalesce into veiling clouds to block the warming rays of the sun. Habitats disappear. New ones emerge, for which many species are ill-adapted. Those who can't or won't change—the dinosaurs—will die. Those who can change—the mammals—will be stronger, like the earth. Like me?

When I pick up the pieces, I can fashion something new. Accretion, with its aches and pains and body slams, is a messy way to grow, but if it works for the earth, I guess it can work for me. Like the planet, I have come to see my weathered surface as a fair exchange for my newly-tempered core. Like the planet, I have come to see cataclysm as an inevitability of existence in this universe. Meteorites happen, after all, whether they come in the form of an itinerant planetesimal or a polite stranger with an envelope in his hand. No body, human or celestial, is immune.

Finally ready for reassembly, I am surprised to discover that the fragments of the old me have grown larger and more numerous since the day I fell apart. Can I hold them together? Can I make them stick? According to the laws of Newton I, like the earth, will be stronger for it—more attractive even.

As the doorbell's chime slowly fades on that about-to-be-dimmed spring morning, I start for the front door, unaware that an unexpected new me is standing on the other side, escorted by a pleasant-looking man, both of them waiting for me to open up.

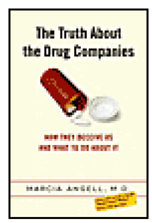
> "Science is nothing but trained and organized common sense."
>
> — Thomas Huxley

Book Review

First Practice to Deceive

by Emily Kagan
Scope Correspondent

At first there were just scattered incidents, explainable as flukes or exceptions to the rule. But the stories are piling up—pills recalled from the market, FDA officials working for the industry they are paid to regulate, U.S. consumers paying through the nose for drugs sold more cheaply overseas. Our awareness of the shady dealings of drug companies seems to be reaching a critical mass. Simply look at the number books published in the last few years on this subject; almost a dozen books have appeared in stores, bearing titles like *The Big Fix: How the Pharmaceutical Industry Rips Off American Consumers* and *Over Dose: The Case Against the Drug Companies: Prescription Drugs, Side Effects, and Your Health* (by Katharine Geirder and Jay Cohen, respectively).



The Truth About Drug Companies

By Marcia Angell

305 pages. Random House. $24.95

But pharmaceutical companies did not turn into profit-centered drug pushers overnight. The changes were incremental—a law here, a merger there. Eventually the pharmaceutical industry had staked itself out as the largest lobbying force in Washington, the best investment on Wall Street, and a persuasive voice at the ear of your doctor. It's hard to know who or what to be mad at. But Marcia Angell's new book *The Truth About Drug Companies: How They Deceive Us And What To Do About It* points the finger at specific faults in the system.

Angell, the author of *Science on Trial: The Clash of Medical Evidence and the Law in the Breast Implant Case*, comes to this debate from a position of authority. Not only is she a physician on staff at the Harvard Medical School, she is also the former editor-in-chief of the New England Journal of Medicine. She dealt with the drug industry as both a physician and a critical analyst of their research. Up front she reminds the reader that drug companies provide an extremely valuable service, and they deserve to be paid well for it. But this industry is responsible for the health of millions of people. Drug companies cannot operate with the same independence of other manufacturing industries. It performs a vital public service and must be held to a higher standard. Angell book goes on to elaborate on seven major ways that the industry is falling short.

First, Angell challenges the drug companies' claim that they are a fountain of new and innovative drugs. She says most drugs coming to market are not truly innovative, but instead are "me-too" drugs, or drugs that are essentially the same as ones already on the market. "Of the seventy-eight drugs approved by the FDA in 2002, only seventeen contained new active ingredients, and only seven of these were classified by the FDA as improvements over novel drugs," Angell notes. Of those seven drugs, not a single one was developed by a major U.S. drug company. But Malcolm MacCoss, a vice president of basic chemistry and drug discovery at Merck Pharmaceutical disputes this point. In a separate interview, MacCoss said that since drugs take an average of 13 years to come to market, the spat of me-too drugs is not due to the drug companies simply copying one another. The companies just happen to all read the same literature and simultaneously begin working on similar projects.

Angell also criticizes the fact that drug companies spend enormous amounts of money fighting legal battles to extend the life of their patents and gain exclusive marketing rights. She faults loopholes in patent law for this problem. One particularly glaring example is a rule that grants a six-month extension of patent life if the drug is tested on children. Because of this rule, many drugs never intended for children undergo pediatric testing simply to add more time to the drug's patent.

Some of Angell's critiques are symptomatic of the larger problem of the medical establishment's move toward becoming a profit-based industry. In this kind of climate, money talks, and conflicts of interest abound. For example, the Food and Drug Administration collects a fee for every drug that it reviews. These fees have become the FDA's major source of funding, forcing this agency to become wholly dependent on the industry it regulates. In addition, many people who serve on FDA advisory boards are also consultants for drug companies, creating further conflicts of interest. A USA Today study examined the FDA hearing records for 2000 and found that "at 92 percent of the meetings at least one member had a financial conflict of interest," and "at 55 percent of meetings, half or more of the FDA advisers had conflicts if interest."

The drug companies have also used their huge financial power to corner the market on physician education. Because these companies sponsor medical meetings and professional societies, it is now difficult for doctors to attend any kind of post-graduate education training that isn't in some way tied to the pharmaceutical industry. By lavishing doctors with gifts, free samples, and trips to medical meetings in exotic locations, the drug companies can essentially pass bribes along to doctors under the auspice of "medical education" about their products.

Perhaps one of the biggest problems with the drug industry is its lack of transparency. "Important information about research and development, marketing, and pricing is kept secret," says Angell. And this kind of secrecy has led to many of the problems read about in the news. The recall of the drug Vioxx was scandalous in part because Merck had conducted trials that showed the drug might cause heart damage but simply never published the results. The drug companies can get away with this by hiring private research companies to conduct their clinical trials. By their rationale, since they've paid for the research it's their right not to publish it.

This secrecy has also led the American consumer to pay far more money for drugs than any other consumers in the world. For example, in an interview with the *New York Times* Representative Dan Burton (R-Ind) pointed out that his wife's breast cancer drug costs $360 a month in the US but only $60 a month in Germany. On this point, the pharmaceutical industry has no defense. "Its true," said MacCoss. "The American consumer is sponsoring the rest of the world."

This is due in large part to the fact that America is the only Western country that does not impose price caps on pharmaceuticals. Because of huge lobbying power at the state and federal level, the drug companies are trying to maintain their price controls. The consumer advocacy group Public Citizen calculated that between 1997 and 2002 "the pharmaceutical industry spent nearly $478 million on lobbying." But Americans are catching on, and many are traveling abroad to buy their drugs.

Angell backs up all of her arguments with documentation. The book is annotated as well as any scientific paper that Angell might allow into the New England Journal of Medicine—citing everything from newspapers and interviews to congressional records and financial reports. This kind of careful research is helping to fuel public outrage and making it harder for pharmaceutical companies to deny culpability. Perhaps the most appealing aspect of this book is that it offers constructive criticisms. No one can deny that millions of Americans depend on the life-saving drugs produced by this industry. In her last chapter, Angell offers practical, if a bit idealistic, solutions for reform. For one, she suggests creating an independent federal agency to conduct all drug trials that would be supported by annual dues paid by each pharmaceutical company. She also suggests reforming patent laws to close loopholes. Angell's suggestions all seek to ultimately improve the drug industry and not to merely humble it.

For this reason, Angell's book stands apart from many other books tackling this subject. The drug companies have perfected the art of deflecting criticism. They seem to have an answer for everything. For this reason, Angell's book is an excellent resource for concerned consumers. The book lays out the facts about the process of bringing a drug to market, pokes holes in industry propaganda, and gives practical advice about what people can ask of their congressmen, senators, and doctors.

Angell's book falters only in its tone. Angell is so evidently angry that she ends up casting herself as a partisan. Some editing could have cleaned up some off-handed comments she makes that ultimately do nothing to bolster the claims of the book. The facts speak for themselves. Angell is best when she to sticks to them.

Angell's book seeks to both anger and mobilize her readers by providing them with concrete solutions that they can put into action. While the prospect of reforming a huge, well funded, politically powerful industry is daunting, it is not without precedent. A critical mass of frustration was at last reached with big tobacco companies. Articles were written, books were published, and slowly but surely the American public had a change of heart. They concluded that tobacco companies could be held to different standards than other industries because of the consequences of their products.

Are we now reaching that point with the pharmaceutical companies? Perhaps. Surely the days of unregulated drug prices are nearing a close. Busloads of disgruntled senior citizens routinely head across the Canadian border to buy drugs in defiance of federal law. And when septuagenarians get angry enough to risk prosecution, you'd better believe things have gotten bad. A Merck representative mentioned in an interview that several drug companies are funding a public registry for clinical trials so that no data goes unpublished. Change will come, but only if people stay angry and continue to push for reforms. They will certainly not come from the good will of politicians, doctors, and drug companies alone.

Evolutionary Biology

Brotherly Love, Turkey Style

by Kevin Bullis
Scope Correspondent

Nature documentaries and action flicks depict males as mindless competitive freaks. Rams butt heads; lone human heroes pose with muscles flexed, sweating, draped with bandoliers of machine gun rounds. "Every man for himself" might seem to apply most rigidly when it comes to mating rituals, when evolutionary survival is on the line, but this is not the situation with wild turkeys. The most successful breeders bring their brothers along to help out with the courtship dance. And the helpful brothers seem to get nothing out of the deal.

Alan Krakauer of the University of California, Berkeley, recently published research that is settling a long-running debate about what's going on in this case. Krakauer won his new evidence with a combination of new technology and what he pictures as cold-hearted deviousness.

When turkey brothers go out to win a female, the assistant turkey fans his tail, fluffs his feathers, and works himself up until his throat turns a garish bloody red, his face smurf blue, and his bald pate an attractive ultra-violet invisible to us but apparently alluring to birds. He'll pose, looking sexy, and keep an eye out for other guys who want some action, chasing them away.

Meanwhile, his brother, likewise colorful, begins the dance. He lowers his wings and rustles them against the ground. Every now and then he murmurs a deep WHOMP-brrrrr that sounds a little like a distant truck starting. After a while the female crouches down in front of him, the turkey version of "Take me, you hunk. I'm yours."

The hot turkey jumps on her back and, while he performs the unusually extended avian foreplay that consists of treading on her back like he's tenderizing meat, his helpful brother continues to keep watch. Eventually the deed is done, following an impressive bit of bird contortionism that makes up for the fact that, while the tom is on top, his target is on the hen's underside.

Teamwork might make sense if the brothers took turns, as seems to be the case in human societies in Tibet that practice polyandry, in which two men, usually brothers, share the same wife. Scientists had long suspected, however, and Alan Krakauer has now confirmed, that only one of the brothers ever manages to reproduce.

Krakauer's research went on to answer what was in this gig for the helpful brother. In other species that show similar kinds of cooperation, the obsequious birds are either angling for territory or hope to score a little on the side, when the dominant male is distracted. But with turkeys, the brother is a swell fellow, who doesn't cheat.

Why hasn't natural selection eliminated dupes who put all their effort into helping their brothers? Shouldn't this kind of bird have died out long ago with no offspring to carry on its short-sighted altruism?

Answering such questions took Krakauer some five years. Every January, starting in 1999, he would set out for the hills of the Hastings Reserve in Monterey County, California, a combination of open oak woodlands and chaparral. First, he scouted out a group of turkeys and set up a hunter's blind, which looks something like a camouflaged tent. Then he'd scatter some cracked corn nearby, which was the beginning of his devious plan to lure the turkeys into a sense of security. After days of getting them used to the corn and his blind, he introduced a wire cage trap. Several days later, after the turkeys got used to eating corn around the trap, he dropped some inside. When a turkey finally wandered inside, Krakauer yanked on a length of fishing line and released the trap door.

Having captured the birds, he tagged them and drew their blood. Krakauer's breakthrough findings depended on relatively new DNA tests that can determine paternity, even between potential fathers as genetically similar as brothers. This was impossible 34 years ago when C. R. Watts and A. W. Stokes in a *Scientific American* article first suggested what the helpful brother was up to. Without DNA, their hypothesis was impossible to test rigorously, in part because turkeys are too sneaky. In five years of study, Krakauer saw plenty of courtship dances, but only one through to the end; it's nearly impossible to know which brother does the actual mating.

With the blood sample from the adults serving as a paternity reference, Krakauer also had to sample the offspring of the group. At first he tried chasing down young chicks, risking the ire of the mothers. But too many got away. Finally, he resorted to what he calls a "heartless" tactic. As soon as the eggs were laid, he gathered them, incubated them until he had enough material for a DNA sample, and then destroyed them.

The data showed that the helpful brother had no kids of his own—but also that the teamwork helped the sex-machine brother have on average six more kids than turkeys that tried to make it on their own.

This provided the answer Krakauer sought. According to the kin selection theory that Watts and Stokes had advocated in *Scientific American*, close family members benefit from helping each other have more kids. Brothers actually have half of their genes in common. This means that some of a brother's genes actually get passed on in his brother's kids. If teaming up means one brother can outscore loner birds by a wide enough margin, the strategy pays off, even if one brother has no kids of his own.

And so it worked out. According to Krakauer's calculations, the helping brother actually had the equivalent, genetically speaking, of 1.7 more offspring than solo turkeys because of the genes passed on by his brother.

Krakauer believes the main reason a few turkeys go it alone is they just don't have a brother to work with. "If you're the last of your set of brothers, then you're kind of screwed."

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