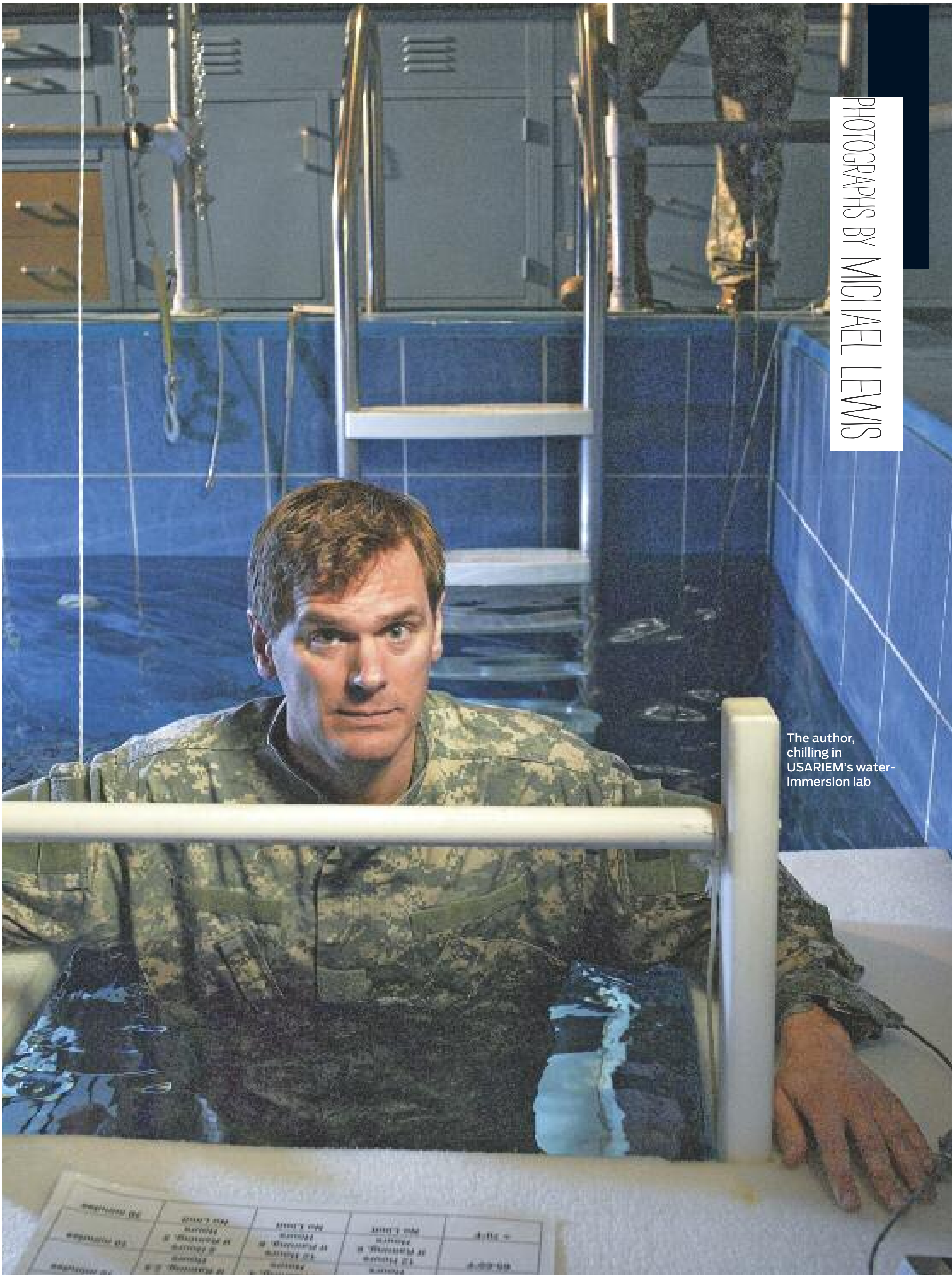


PHOTOGRAPHS BY MICHAEL LEWIS

The author, chilling in USARIEM's water-immersion lab

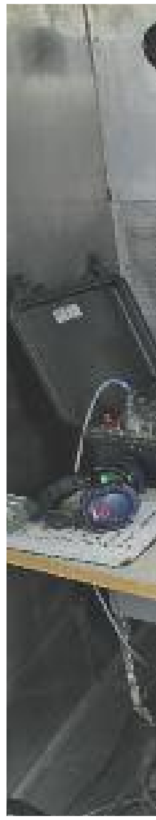
AN EXCLUSIVE LOOK INSIDE THE CUTTING-EDGE ARMY LAB THAT'S PINCHING, PRODDING, DUNKING, BRUISING, AND BUILDING THE SOLDIERS OF TOMORROW—AND REVOLUTIONIZING ADVENTURE FITNESS ALONG THE WAY

G.I. JOE AND THE HOUSE OF PAIN

2011 HUMAN PERFORMANCE SPECIAL

BY CHRISTOPHER SOLOMON

THE PILL IS SMALL, PURPLE, CYLINDRICAL—ABOUT THE SIZE AND OMINOUSNESS OF A .38-CALIBER BULLET.



I haven't known Robert Kenefick ten minutes when he hands me a rubber glove and tells me where I can stick it. Without wallowing in too much detail, let's just say the pill—which is really a wireless temperature sensor—isn't going in the easy way.

Kenefick is 45, bespectacled, with the ironed-khakis-and-Rockports appearance of the college professor he once was. He's not without sympathy. "I know most people want dinner and dancing before they do something like this," he jokes as he leads me to the restroom. Suddenly, I'm keenly aware of how bland my social life is.

Mission accomplished, I waddle back to the testing area. "Let's do it," says Kenefick. He opens a ponderous steel door, and we step into a metal-walled room that's precisely the suffocating temperature of a Tucson afternoon.

"Unnggh," I groan.

Kenefick is apologetic. Today the room is "only" 40 degrees Celsius—104 degrees Fahrenheit. The first time he ran this test, he says, "we had guys at 50 C," or 122 F. Somehow I don't feel shortchanged. The room's steel walls are hot. The steel floor is hot. Pumps roar as they exhale air that feels like a Bikram yoga lover's dream. Inside, I'll bake for the next three hours to get thoroughly dehydrated before I mount a stationary bike and pedal maniacally. The goal: to gauge just how much my performance craters when I'm hotter and thirstier than I've ever been.

KENEFICK IS A PHYSIOLOGIST at the U.S. Army Research Institute of Environmental Medicine (USARIEM)—a vanilla-sounding name for a cluster of gee-whiz laboratories, little known even inside the military, whose mission is to build soldiers capable of enduring anything Mother Nature throws their way. Though primarily a defense project, the institute's work also trickles down to civilian life, affecting how the rest of us run, drink, eat, exercise, and survive in the outdoors.

Kenefick specializes in heat problems. Army brass call when they want to know whether slathering on the insect repellent deet makes it harder for soldiers to sweat and cool off. (Nope.) Or when they want to learn how to make soldiers acclimate faster in sweltering conditions. (He's working on it.)

Just now I'm duplicating a recent experiment that was aimed at answering a crucial question among thermal researchers: Why do we bonk when the going gets hot? A standard hypothesis, Kenefick explained earlier, is that failure is wired into our brains. "You have a set point in your hypothalamus," he says, referring to the portion of our gray matter that, among other jobs, regulates body temperature. "When you get too hot, your brain says, 'You're way too hot!' and tells your body to slow down." Lab studies done elsewhere suggest that a body temperature of 104 degrees Fahrenheit is the crisis point at which the mind begs for mercy.

Kenefick and his colleagues don't buy it. They studied athletes who ran with the same little purple thermometers stuck inside, he says, "and what we saw was that runners who got to 40 C actually accelerated—they went faster." Kenefick thinks something else is going on when you sputter in the heat: namely, that there's not enough blood to go around. Your body has to push blood simultaneously to your muscles, your heart, your brain, and—to cool you down—your skin. Dehydration reduces total blood volume, and your body fights over the oxygen and nutrients contained in what's left. Eventually, you crash. Finishing a marathon in Phoenix is low on the priority list, much less kicking down an insurgent's door in Kabul.

This isn't some arcane disagreement among lab coats. Understand what's going on in the body, Kenefick says, and you may find ways to alleviate the problem.

Which brings us back to the heat chamber. After three hours of treadmill work, I've sweated out more than 2 percent of my 185 pounds of body weight—nearly four pounds of liquid. I'm parched like never before, and I can't even imagine reaching the 4 percent dehydration level of Kenefick's original volunteers, who were all enlisted soldiers. When research coordinator Brett Ely puts an oxygen-sensing tube in my mouth, I gum it dryly. When she takes it out, I start moaning for the lost drool.

"You are the first person who has asked to drink the spit reservoir," she observes.

Hours before, I'd straddled a stationary bike and pedaled all-out to establish how much work I could do in 15 minutes. Now I climb on the bike again, this time in the heat chamber. At first I churn steadily. But something happens at five minutes: I slow down, and I can't regain the pace. At nine, I hit a wall. Six more minutes seems like an eternity. "I'm so out of shape!" I wail. Kenefick and his staff look on blankly, not permitted to offer encouragement.

Later, after I chug three quarts of Gatorade

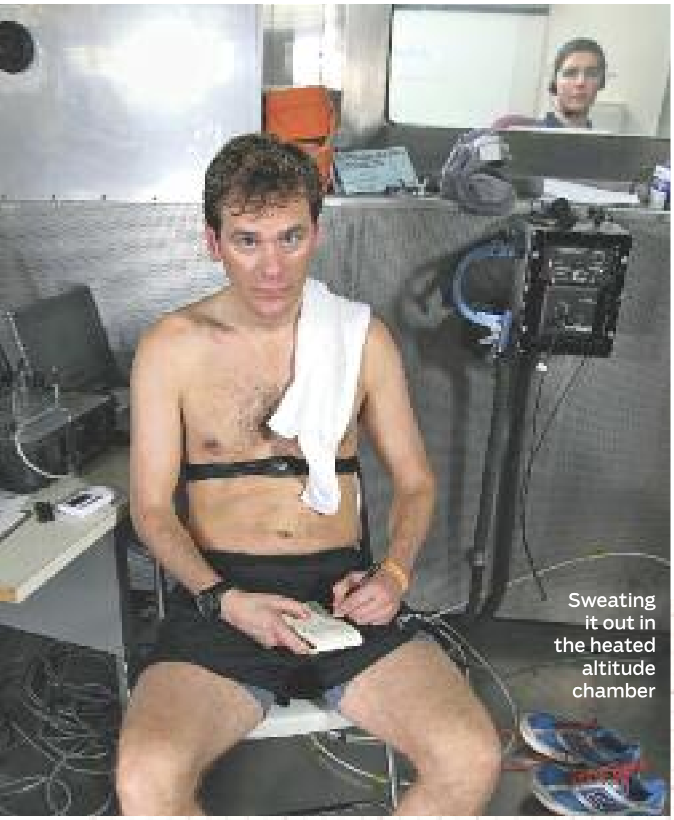
THE OUTER LIMITS

Q. When will somebody run a marathon in less than two hours?

A. Ethiopia's Haile "Geb" Gebrselassie ran the fastest marathon ever (2:03:59) in September 2008 on the sunny streets of Berlin. (Eight of the ten fastest marathons have been run in Berlin or Rotterdam, home to flat, low-altitude courses.) Since then, nobody's come close to beating that time—the next best is a 2:04:27 run by Kenya's Duncan Kipkemboi Kibet at Rotterdam in 2009—and most experts think it will be a while. Running a marathon four minutes faster would require putting down 26 consecutive four-and-a-half-minute miles—a feat that "will not be achieved in my lifetime by an athlete who is clean and not genetically modified," says Timothy Noakes, a sports-science professor at the University of Cape Town and the author of *Lore of Running*.

Elite runners tend to perfect their 10,000-meter time before advancing to marathons, and a fast 6.2 miles on a track often translates to a fast 26.2. (It's no coincidence that Geb held the world record in the 10,000 until 2005.) Once an athlete can run that distance 30 to 45 seconds faster than Geb's time, he might have a shot at a sub-two-hour marathon. But Noakes thinks it's "biologically impossible for the foreseeable future."

It took Kenenisa Bekele, another Ethiopian, seven years to take five seconds off Geb's 26:22:75 record in the 10,000. If this trend continues, 29 to 50 years will pass before the necessary track times are achieved and another few before a sub-two marathon time is recorded. Still, there's hope. "I truly believe it will happen," says running coach and former Olympian Jeff Galloway. "The human spirit is programmed to keep pushing." At 65, however, Galloway, like Noakes, doesn't believe he'll be around to witness it. —WHITNEY DREIER



Sweating it out in the heated altitude chamber

Robert Kenefick (right) assesses the damage during the bake-and-bike test.

AFTER THREE HOURS PEDALING in the heat chamber, I'm parched like never before. "You're the first person who's asked to drink the spit reservoir," SAYS RESEARCH COORDINATOR Brett Ely.

and get a good night's sleep, Kenefick will explain that my anemic output was exactly what he'd expected. In his study, the dehydrated soldiers who pedaled inside a 104-degree room did nearly 25 percent less work than they did at normal room temperature.

Kenefick hopes to create a mathematical model demonstrating precisely how much performance erodes in the heat, allowing troop commanders to predict temperature-induced drag during long, hot marches. He and his colleagues also want to design ways to beat the fatigue. Kenefick is coy about what the solution might involve—that's a secret—but in the not-too-distant future, he suggests, a soldier in the desert could wear a lightweight liquid-cooled jacket to keep from overheating.

On the bike, talk of hypothetical relief is of no solace to me. I want to stop, but pride keeps me mashing the pedals. Hot, thirsty, and weak, I spin deeper into the pain cave.

USARIEM IS HOUSED at the Natick Soldier Systems Center, a sprawling facility in Boston's western suburbs that has the tired appearance of an aging community college. Looks are deceiving, though, because this may be the most interesting 78 acres in the Army. If a soldier eats it or wears it, chances are it was developed here. In one building, researchers create precision-guided supply parachutes; in another, Ph.D.'s tinker with shirts made from threads that expand in response to electrical current, resulting in a warmer garment. It's like *The Dirty Dozen* meets *Popular Mechanics*.

Off near a corner of the base sits a building that looks like it might contain the campus physics department. Inside are a mix of civilian and military scientists, some 200 physiologists, psychologists, biomathematical modelers, dieticians, nutritionists, physicians, veterinarians, and support staff. Wall posters describe experiments with catchy titles like "Plasma Soluble Cytokine Receptor Levels Are Elevated During Heat Stroke Recovery in Mice."

This is USARIEM. While the rest of the base focuses on the stuff outside a soldier's skin—uniform, gear—the institute works on improving how the inside performs. "We're like exercise physiologists for athletes," says Lieutenant Colonel William Latzka, 54, the institute's deputy commander. Only, in this case, the athletes carry M4 carbines.

The Army spends $18 million annually running the institute, and for good reason. "Wars are fought outdoors," says Stephen Muza, 59, leader of the high-altitude-research team for USARIEM's thermal and mountain medicine division. More precisely, they're fought in the finger-aching cold. They're fought on mountainsides. They're fought hungry and thirsty. Despite all our advances, drones, and smart bombs, it's the effort of soldiers on foot that most often determines military outcomes. That's especially true today, since terrorists and insurgents are frequently based in forbidding terrain like jungles and mountains.

USARIEM was born 50 years ago out of forerunners like the groundbreaking Harvard Fatigue Lab, launched in 1927 to study the effects of heat, cold, and exhaustion on workers in extreme environments. continued on page 96

THE FUTURE BODY: TURN THE PAGE FOR AN IN-DEPTH LOOK AT HOW SCIENTISTS ARE TRANSFORMING THE WAY WE PLAY, PERFORM, EAT, RECOVER FROM INJURY, AND STRIVE FOR UNIMAGINABLE NEW HEIGHTS.

G.I. JOE **continued from page 89**

After World War II, military officials realized they needed a better understanding of how climate chews up soldiers in the field. Today, USARIEM is the main setting for this research, which happens in a wonderland of modern tools and technology.

Carved into the building's basement is a water-immersion lab where soldiers are brought to the threshold of hypothermia, at a body temperature of 95 degrees. Down the hall, there's a three-room altitude-simulation chamber that can take people to the top of a virtual Mount Everest while submitting them to temperatures ranging from five to 104. Across the street sit two of the largest environmental chambers in the world—rooms the size of tennis courts in which soldiers might be seared with 250-watt heat lamps, hit with minus-70-degree refrigeration, or buffeted with high winds and four inches of rain per hour—all while they march on giant treadmills. "Here on the post we can basically re-create almost any environment on earth," says John Castellani, a 46-year-old research physiologist.

All the brainpower and bang-up facilities have led to groundbreaking work and valuable solutions. Diamox, the anti-mountain-sickness drug that's now part of many Himalayan alpinists' medical kit, was clinically tested here in the seventies and early eighties. Work done on heat and dehydration in the sixties and seventies led to new guidelines about how much people should drink and wear while performing various activities in the heat—guidelines that are still used in military and civilian workplaces. During the past 50 years, USARIEM has provided answers to everything from how much sodium Americans should consume daily to what sort of heat stresses NASA astronauts will experience upon reentry.

This research reaches the rest of us chiefly through peer-reviewed biomedical journals like those of the American College of Sports Medicine, which are then picked up by doctors, physical therapists, and the media. On average, scientists at USARIEM contribute at least 100 such articles each year.

The work never stops: Across the street, biomechanical researcher Joseph Seay is looking into how much weight soldiers can carry on their backs without injury. Down the hall, a colleague is studying whether a diet heavy in zinc or omega-3 fatty acids can aid recovery in soldiers who suffer traumatic brain injury from roadside bombs.

> COMMANDERS IN THE FIELD could punch in a few variables—how high their soldiers are going and how acclimatized they are—and a computer would TELL THEM THE ODDS THAT SOLDIERS will be laid low.

In academia, research at the cellular and molecular levels is usually focused on curing disease, leaving USARIEM with a wide-ranging field of study that receives minimal funding elsewhere. "Getting money for research is competitive, and compared with curing cancer, no one really cares about making people bigger, better, and stronger," says Maria Urso, a 35-year-old biochemist who's working on new ways for soldiers to boost strength and muscle mass through exercise. "But in the military, it's a matter of life and death."

NEVER ENTER AN ALTITUDE chamber feeling cocky.

When I'd approached USARIEM about giving me an unprecedented lab-rat's view of its testing, the Army bureaucracy responded with a seven-page liability waiver that required a doctor's signature. I laughed, got the signature, and sent it back. How bad could a few abbreviated experiments be?

Now, staggering through a five-mile run on a treadmill while "flying" at 10,000 feet in the altitude simulator, I take it all back. I'm a junk show. I'm tooting like a brass band. And I keep looking around to see who slipped the bowling balls into my 40-pound rucksack.

A few minutes earlier, the door of the altitude chamber closed with a forbidding thunk. "We're going up," said Muza. The walls of the room creaked and popped with the changing pressure. An aircraft altimeter spun its numbers higher. Within ten minutes, we leveled off at 9,843 feet above sea level. For safety reasons, USARIEM officials wouldn't let me test any higher than that.

"You feeling different? Maybe a beer or two?" asked Sergeant Mark Kryskow, 28, who helps coordinate research for the thermal and mountain medicine division. "The initial feeling is sometimes euphoria. Some people get giggly."

Muza is a garrulous guy with a push-broom mustache and an altimeter watch on his wrist. He likes to drink from a souvenir coffee mug that says PIKES PEAK—the home of USARIEM's other main facility, a field lab that sits atop the famous fourteener near Colorado Springs. The three-room hypobaric chamber here in Natick is Muza's baby. It's one of the few environmentally controlled altitude enclosures in North America, able to roast or freeze its occupants while taking them to Himalayan heights. One room of the chamber has space for test subjects to exercise; a second has several bunks for resting during longer tests. Between them is a toilet equipped with vacuum pumps so that any business done here doesn't come rocketing back into the depressurized room. Researchers affectionately call it the Strato-Shitter.

In the years following the invasion of Afghanistan, the U.S. military has been knocking on Muza's door more frequently

THE OUTER LIMITS

Q. How deep can a human freedive in the ocean—and live?

A. Around 500 feet … at least that's what Austrian freediver Herbert Nitsch was told ten years ago, when most people believed that diving deeper meant certain death due to nitrogen narcosis, oxygen toxicity, and the paralyzing effects of decompression sickness (the bends). Since then, however, that mark has been smashed many times, and Nitsch, 41, has become the "deepest man on earth" by plunging to 702 feet—about 70 stories—beneath the ocean's surface on a single breath. In November he plans to go a lot lower, attempting a "no limits" dive to a staggering 1,000 feet.

Freediving can be a confusing sport, since there are numerous genres, including no-limits (which permits any means necessary to achieve depth, from weights to watersleds) and unassisted (just you and your straight-down swimming stroke). Even in the unassisted style, old assumptions have been cast aside. Last December, New Zealand's William Trubridge—the current unassisted record holder—made it down to 328 feet in the Bahamas, surviving water pressure that reduced his lungs to the size of oranges.

The risks are compounded for no-limits divers. Before Nitsch, the two male divers to attempt 500-foot-plus no-limits dives—Benjamin Franz and Carlos Coste—ended up paralyzed for years. (Franz still hasn't fully recovered.) The former female record holder, Audrey Mestre, passed out and drowned in 2002 during a 561-foot attempt. Somehow, Nitsch doesn't seem fazed. "If you think about what is impossible tomorrow," he says, "the day after tomorrow you laugh about it." —JAMES NESTOR than ever. "Most of the border between Afghanistan and Pakistan, which anyone who follows the news knows is a hot area for insurgents, is at altitudes ranging from 5,000 feet up to, in some cases, 18,000 feet," he says. The Army wants to know as much as it can about how altitude affects the functioning of soldiers.

Thanks largely to work done here, researchers already know quite a bit. At about 4,000 feet, performance as indicated by VO_2 max—a measure of aerobic capacity—begins to erode. "Interestingly, high-performing athletes are more impacted by altitude than lower-performing people are," Muza says. "They have highly developed their use of oxygen. And as soon as their body is denied even a little bit, their physical performance declines measurably."

At about 8,000 feet, acute mountain sickness (AMS)—the headaches and nausea that can hit during your first days of a ski vacation—begins to rear its ugly head; Muza says that about 20 percent of people who ascend to this height too suddenly develop some form of AMS. Vision also begins to deteriorate as the rods and cones in your retinas are starved of oxygen, a problem that even acclimatization won't fully remedy. The cones let you see color, while the dark-and-light-sensing rods help you make out shapes. "So if you're a soldier, let's say at 10,000 to 12,000 feet, and you're trying to see differences in another soldier's uniform—camouflaged clothing, say, compared with surrounding rocks—your ability to discern that is diminished," says Muza.

At about 12,000 feet, cognitive problems set in. It takes longer to make correct decisions—potentially lethal in a firefight or high up a mountain at nightfall. The most dangerous altitude maladies, HAPE and HACE—high-altitude pulmonary edema and its cousin, cerebral edema—are likely to appear.

It only gets worse from there. March to between 14,000 and 18,000 feet without acclimatization or medicine and you're nearly certain to get altitude sickness, perhaps fatally. Then there are the mood changes. "As you spend time at altitude, especially above 14,000 feet, you become somewhat withdrawn from the rest of the group, you tend to become more aggressive and less cooperative," says Muza. "This can have significant impact on the cohesiveness of a small unit, the ability to make decisions and work together as a team under stressful conditions."

But how much, exactly, does physical and mental performance erode at altitude? That question is why I'm now slogging on the treadmill at nearly 10,000 feet: Muza wants to apply hard numbers to crappy performances like mine. "It's no use to commanders

Solomon humps at altitude while Mark Kryskow (left) and Stephen Muza observe.

to know, well, the higher you go, the slower you'll go," he explains. In today's military of coordinated attacks, "they want to know precisely what the impact is going to be." Otherwise, he says, "someone's going to be late to the party."

WITHIN A FEW YEARS, Muza and his colleagues hope to turn what they're learning into an app: field commanders could punch in a few variables—for instance, how high their soldiers are going and how acclimatized they are—and the computer would tell them how much longer a hike will take and the odds that some soldiers will be laid low.

But Muza also wants to soften the blow whenever possible, and he's already having success. Take, for example, carbohydrates. Scientists long assumed that increasing carb intake wouldn't boost performance at altitude; the limiting factor seemed to be oxygen. A few years ago, Muza and his colleagues trashed that idea by showing that if you steadily ingest carbs the higher you go, you increase performance by nearly 25 percent. The discovery coincided with the introduction of a high-carb snack pack now available to soldiers serving at altitude.

Another discovery with promise is the use of tyrosine, an amino acid found in meats and some nuts that's a building block for adrenaline, dopamine, and noradrenaline. Researchers found that soldiers placed in stressful environments—like cold water—gained back about half their degraded marksmanship and thinking skills after taking tyrosine. Now the institute's nutrition division is looking at using it as a food additive for soldiers. It's not hard to imagine mountaineers giving it to addled comrades to help them regain their senses and descend to safety.

That we'll one day be able to pop a pill to acclimatize "is a long-term goal," says Muza. In the meantime, as researchers understand more about how we adjust, they're making good on that information. Scientists here recently started testing N-acetylcysteine, or NAC, an antioxidant available at vitamin stores that's also used in emergency rooms to counteract Tylenol overdose. "It appears to affect how we regulate breathing and especially how the chemoreceptors in our carotid arteries sense the low levels of oxygen at altitude," says Muza. There's evidence that people taking NAC breathe more when in hypoxic situations. And breathing more—essentially hyperventilating—is one of the normal adaptations to higher altitude because it pushes more oxygen into the bloodstream.

USARIEM researchers have also found that the old rule "climb high, sleep low" while acclimatizing is truer than anyone realized. Another study in the altitude chamber showed that people who spent as little as four hours a day at high altitudes but slept near sea level adapted just as quickly as people who remained at high elevations for longer periods.

As Muza explains, however, USARIEM research often involves disproving rather than proving. "Sometimes it's simply, 'Don't do that. It doesn't help,'" he says. Investigators had high hopes for antioxidant vitamins to alleviate symptoms of AMS. Antioxidants neutralize radical oxygen species like peroxides that cause tissue damage, possibly contributing to development of altitude sickness. But the studies didn't pan out. "We liked to joke that all you had was a lot of very expensive urine," Muza says.

Another surprising dud: the hypoxic tents still used by competitive cyclists and other athletes. Muza found that they didn't acclimatize soldiers because the tents simulate a lack of oxygen but not a decrease in barometric pressure, which emerging evidence suggests is an important factor in altitude adjustment.

USARIEM also looked at EPO—the banned blood booster of choice for many athletes, especially cyclists—in hopes that the hormone's ability to spur the production of protective proteins in the brain could shore up neurons against the lack of oxygen at high elevations. The EPO didn't do anything, says Muza, but that doesn't mean it won't. "The level of EPO," he notes, "needs to be probably three or four times higher than is currently FDA approved in the United States." So, at least for the foreseeable future, blood-doping infantry is off the table.

BACK ON THE TREADMILL, I can barely pay attention to Muza's talk about what works and what doesn't. I'm hating it. Too spanked by the altitude to jog, I've been reduced to a fast walk. I finish with a time nearly 25 percent slower than my first march—a not unusual degradation, says Muza. For the second time in one day, I realize I'm no tough guy, especially when compared with some of the Army-trained test subjects who've come through USARIEM's labs over the years.

In 1985, for example, nine volunteers lived in the altitude chamber for 40 days during a simulated ascent of Everest. Some had to exercise flat-out on the "summit" with catheters inserted into their hearts. The Navy once borrowed the altitude chamber to simulate conditions inside a submarine trapped at the bottom of the sea. To gauge how mariners would react to a high-carbon-dioxide environment in a disabled sub, eight Navy divers lived in the chamber for a week, lying in their cots and scarcely moving, at temperatures near freezing and in high humidity. In another test a few years ago—designed to study the physiological effects of a sustained military operation—researchers kept volunteers moving and sleepless for three days.

The Army, sensitive to criticism that it's ordering soldiers to submit to abusive research, makes a point of saying that the institute's experiments are all vetted for safety, just as they would be at any other research institution. And all of the soldiers who participate—many of whom are recent enlistees who volunteered to spend three months here before being shipped out to their first deployments—are allowed to pick and choose which experiments they sign up for.

You might reasonably assume that these volunteers, being volunteers, would routinely cry uncle and quit. You'd be wrong. "I actually was running a subject on the treadmill with a mouthpiece in—this was years ago—and all of a sudden the data on my computer stopped coming through," Muza recalls. "I'm saying, 'What happened to my data?' And I look up and the guy's still got the mouthpiece and the noseclip on, and there's the hose, and then I look back and I'm like, 'What is that in the hose?' And the hose is full of vomit. He was literally vomiting right into my instrument. He was Special Forces. He was not going to stop."

Kenefick, talking about his heat experiments, recalls similar moments. "We get guys throwing towels over their heads, we get crying—"

"But nobody asks for a break," Ely interjects. "Nobody asks to stop."

"They buy in that what we're doing is important," says Kenefick.

One of the hardest of the hard men is Sergeant Kryskow, a recreational rock and ice climber who has participated in "eight or nine studies," including one designed to test a helmet prototype that cooled the wearer's head with streams of air coming from the lining. Researchers wanted to know if cooling the head cooled the body as well. To test this, Kryskow and others walked for hours on a treadmill in 120-degree heat, fitted with anal and esophageal temperature probes.

"It was kind of miserable," Kryskow tells me, suddenly transported back to that test. "You're tired, you're dehydrated, you've got a probe in your ass and another down your throat. But I like the challenge."

"FIFTY-EIGHT-POINT-TWO Fahrenheit," Castellani says, calling out the temperature of the water beneath my feet. "That's New England waters." He flashes a smile. "You will experience shrinkage today."

Castellani, a Philadelphia Italian with a chakra bracelet on one wrist, specializes in how the human body reacts to cold. He's happy to oblige my curiosity about his work by giving me a guided trip to the edge of hypothermia. Now, standing in Army fatigues at the rim of a nipple-deep cold-water pool, rectal thermometer in place, I'm ready. I visualize skinny-dipping in my favorite mountain lake, step down onto the pool's underwater treadmill, and get sucker punched in the solar plexus by Jack Frost.

"Oof."

Earlier, Castellani explained the reason for this line of suffering. In 1995, four Army Ranger recruits died of hypothermia after prolonged immersion while training in the wintertime waters of a north Florida swamp. In the aftermath, the Army asked Castellani and his colleagues to check the existing models for safe exposure to cold water.

"We basically simulated a swamp crossing or a river crossing in the lab," he says. "We monitored core temperatures while volunteers walked—and we had them walk and walk, for up to four hours. To be honest, we had only two people make it to four hours. It was a nasty little study."

The results revamped the guidelines. These days, regulations require that a soldier immersed in waist-deep water that's 52 degrees—the water temperature in that Florida swamp—remain there no longer than an hour and a half. Former guidelines permitted three hours.

Some of the institute's most intriguing findings, and the inventions they'll spawn, are yet to come, of course. Castellani is hoping to start work soon on a way to keep bare hands warm in the cold. "We're going more toward a digital battlefield," he says. "Lots of computers out there. And the use of your hands is so important."

Castellani won't discuss the details, but he says the solution could be a nano-device that helps warm the blood before it reaches the hands, yet is small enough that soldiers—or skiers, or civilian workers like electrical linemen—would be willing to wear it.

That's all in the future. Back in the chilly present, I'm hanging tough after 15 minutes of walking in the pool. My core temperature has dropped less than a degree. Hey, I think to myself, this isn't so bad. I could do this for hours, the cold needling my legs be damned.

Five more minutes and something changes. My legs begin to feel like I'm slogging through wet concrete. At 24 minutes, a bony finger draws up my spine and rattles my skull. Soon everything above the waterline is shaking. My teeth are castanets. At 30 minutes, Castellani signals for me to climb out. I could go longer. But, as was true with most everything experienced at the institute, I'm glad I don't have to. o

CORRESPONDENT CHRISTOPHER SOLOMON WROTE ABOUT DISABLED SKIER-PHOTOGRAPHER KEVIN CONNOLLY IN NOVEMBER.