



Helmet lab: From left, Ray Daniel, Steven Rowson, and Stefan Duma measure the effects of various applied linear and rotational forces on helmets and dummy heads.

together to ask such questions as, When is it safe to return to play? What are the lasting implications of concussions? Who is most susceptible to long-term damage from concussions?

"Our first focus has been to assess structure after a concussion—the integrity of the white-matter fiber tracks in the brain," says Annegret Dettwiler-Danspeckgruber, who studies head injuries at Princeton University. With diffusion tensor imaging (DTI)—a variation on magnetic resonance imaging (MRI)—scientists can look at the movement of water as a way to assess axonal injury (see also the story on page 20). "We don't

know if it's the myelin sheath [around an axon] or the axon that is injured when anisotropy [of water movement] is changed," she says. "But we can say there is an injury to the nerve track."

Functional MRI (fMRI) can detect changes in blood oxygenation and blood flow that occur in response to activity in the brain. Naznin Virji-Babul of the University of British Columbia works mainly with kids and teens who have suffered concussions. "Using both fMRI and DTI, we can see changes in structure and function," she says.

Virji-Babul also uses high-density electroencephalography. "EEGs are

going to be good for diagnostics," she says. "An MRI costs \$500. EEGs have minimal cost, and you can see disruptions in the functional connectivity of the brain." And researchers are beginning to use positron emission tomography to look at chemical and metabolic processes in the brain after concussion.

A major problem in concussion research, says Virji-Babul, "is that there is no way to say that a [given] person has never had a concussion." The overall aims are to link genetics, brain injury, and recovery and to correlate changes in the brain with behavioral changes.

"Open the door to therapy"

So far, concussion studies tend to follow professional or college football or hockey teams for a sports season. Scientists conduct preseason baseline scans and neuropsychological tests, and then follow up after injuries. The dream of concussion researchers is to monitor the same players over much longer time scales.

In addition, research is expanding to youth, who don't recover from concussions as well as adults. Among its other recommendations, the National Academies report encourages the establishment of a national system to keep track of sports-related concussions and calls for research on the consequences of single and repeated head impacts.

A key goal is to "nail down long-term neurodegenerative changes," says Smith. "They seem to occur in about one-third of severe cases." The ability to diagnose at the time of injury who will have long-term problems is "really exciting. That opens the door to therapy."

Toni Feder

Ban on US-China space-program ties means missed opportunities for NASA

Sino-US cooperation could stretch budgets and benefit both countries in space science and human flight.

Although it was chalked up to a misunderstanding, a well-publicized—and rescinded—barring of Chinese scientists from a NASA conference on exoplanets in November highlighted a congressionally imposed ban on bilateral cooperation between the space agency and China. In effect for the past two years, the ban has kept NASA from partnering with one of the world's leading and most rapidly growing space powers.

"China can't even talk to the United

States to coordinate different activities in space science because of the ban," says Gregory Kulacki, a China expert at the Union of Concerned Scientists. Such discussions would help the Chinese and US programs to avoid duplication in the construction of space instruments and would ensure that "both can make meaningful contributions to space science," he says.

"There are a lot of areas, especially in space science, that are noncontroversial and that could benefit both. People

are afraid to [engage in them] because they are unclear on the ban's implications," Kulacki says.

Letter of the law

The ban, authored by Representative Frank Wolf (R-VA), limited the range of discussion that NASA administrator Charles Bolden could have with Chinese government officials when he visited Beijing in October. First enacted in NASA's fiscal year 2011 appropriations, Wolf's provision included an exception that allowed Bolden to meet with Chinese Academy of Sciences (CAS) president Bai Chunli while the NASA chief was in China to attend an International

Astronautical Congress (IAC) meeting in September of this year.

NASA spokesman Allard Beutel says that Bolden followed the law's requirement to notify Congress at least 30 days in advance that his bilateral discussions would have no harmful effect on US national security or economic interests and to certify that the government officials Bolden met had no direct involvement in human rights violations. Bolden's discussions with Bai were limited to a single narrow topic: the resumption of a joint activity with CAS that had been suspended as a result of the Wolf clause. "We had a preexisting agreement that we coordinate our Earth observation data with the idea of improving environmental decision making in a particular region, the Himalayas," says Beutel. The data collection is coordinated through the International Centre for Integrated Mountain Development, a Nepal-based scientific organization.

Wolf, who chairs the appropriations subcommittee that funds NASA, is a vociferous critic of the Chinese regime, citing its human rights violations, its sponsorship of hacking and industrial espionage, and other issues. In March Wolf raised concerns over an incident in which a Chinese citizen working as a contractor at NASA's Langley Research Center was arrested as he tried to leave the country. Although the computer and other electronics he was carrying were found to contain no sensitive information, Bolden, at Wolf's urging, nevertheless instituted a moratorium on issuing new credentials to individuals from designated countries, including China, while the agency reviewed the adequacy of its background-check requirements.

Organizers of the Kepler exoplanet science conference at NASA's Ames Research Center mistakenly believed that the moratorium remained in place, and acting out of what NASA spokesman Beutel described as "extreme caution," informed six Chinese scientists that they could not attend. The Chinese were re-invited after Wolf publicly informed Bolden that the clause did not apply to nongovernment Chinese individuals. Bolden blamed the mix-up on "midlevel managers" at Ames. The 17-day October government shutdown complicated matters, as NASA employees were prohibited from working.

According to the recently published book *China in Space: The Great Leap Forward* (Springer Praxis Books, 2013), China in 2011 overtook the US in the

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An artist's conception of China's space station, planned for completion in 2020. The US rebuffed Chinese efforts to join the International Space Station.

number of space launches. Its 2012 space budget is estimated at \$3.4 billion, making China's the world's fifth largest space program. "NASA is missing out on the opportunity to cooperate with one of only three countries that know how to put humans in space," notes John Logsdon, a space policy expert at George Washington University. China, he adds, is "clearly an emerging leader in space."

Daily routine

The European Space Agency has no restrictions on cooperation with China. The two parties are to hold a workshop in February to discuss what Fabio Favata, head of the agency's space science coordination office, says will be a relatively small mission, to be selected in "bottoms-up" fashion, from peer-reviewed proposals solicited in Europe and China. "Cooperation is a way of ensuring that you have the best brains

on the problem," he says. "China is an additional partner in a landscape in which international cooperation is part of our daily routine." Joining forces provides scientific communities in the partnering nations with a broader range of opportunities, he adds.

Rebuffed by the US a decade ago when it sought to join the International Space Station (ISS) partnership, China is now working on its own station. The first module is scheduled to orbit in 2018, and construction is expected to be completed around 2020. With the ISS scheduled to be decommissioned in 2020, "it's almost like we're setting up a baton pass" to China, says Leroy Chiao, a former astronaut and chemical engineer who serves on the NASA advisory council's human exploration and operations committee.

Chiao says that studies have shown the ISS could be operated through 2028, but if its life is to be extended, decisions

will have to be made soon. Even if the US were to invite China to join the ISS now, perhaps to build a module, it's unclear they would accept. "They've developed things pretty far now because we have held them at arm's length. They may decide 'We'll do a little cooperation, but we're still going to do our own thing,'" he says.

Chiao, who attended the IAC meeting in Beijing, says the leader of China's human spaceflight program met with officials from eight space agencies during the conference. All countries contacted expressed interest in cooperating on research and having their astronauts fly aboard China's *Shenzhou* spacecraft.

Kulacki notes that as in the US, Chinese scientists debate the relative values of human spaceflight and unmanned missions. Chinese authorities haven't decided on the next step beyond their space station, although there has been talk of a manned mission to the Moon in the mid 2020s. Chiao thinks the Chinese should join an international coalition headed by the US to move humans beyond low Earth orbit. "It's a fallacy to say that the Chinese are only doing what the US did 50 years ago," or that they have simply copied others' technologies, he says. Although the *Shenzhou* is based on the Russian Soyuz series, China has taken the design further, he says. And unlike the US, China currently has vehicles capable of launching space station modules.

David Kramer

A nuclear bomb worth more than its weight in gold?

Administration officials say refurbishing the B-61 will permit the retirement of the only other bomb in the stockpile.

Costing up to \$10 billion over a dozen years, the refurbishment of what is planned to be the last class of US nuclear bombs is the lowest-cost option for extending its life for several decades, officials from the Departments of Defense and Energy insist. But some critics of the B-61 life extension program (LEP) question whether the program is necessary. At least one of the modifications planned for it—a new guided tail kit supplied by the US Air Force—would increase its military capabilities, not just ensure its reliability and safety.

Obama administration officials appearing before a 29 October House

Armed Services Committee hearing said modifying the B-61, the oldest warhead in the nuclear stockpile, will produce bombs that are more accurate, yield smaller explosions, and contain smaller quantities of highly enriched uranium.

But some lawmakers, arms control advocates, and government watchdog groups contend that the B-61 LEP is overkill. The B-61 is the only US weapon deployed in Europe—an estimated 150 to 200 are located at bases in five NATO member nations—and critics have questioned what useful purpose it serves there. Senator Dianne Feinstein (D-CA), who chairs the appropriations



A replacement radar device for the modernized B-61 nuclear bomb was drop-tested from a helicopter in Nevada this summer.