diversity exposed by the impact. Three types of meteorite found on Earth — eucrites, howardites and diogenites — are thought to be chips of Vesta, blasted away by the collision. Linking these convenient specimens to particular internal layers of Vesta is a key driver of the Dawn mission, notes Binzel.

"It's a little bit like the Humpty Dumpty problem — we've got a lot of pieces of Vesta and we'd like to see how they all fit together," he says.

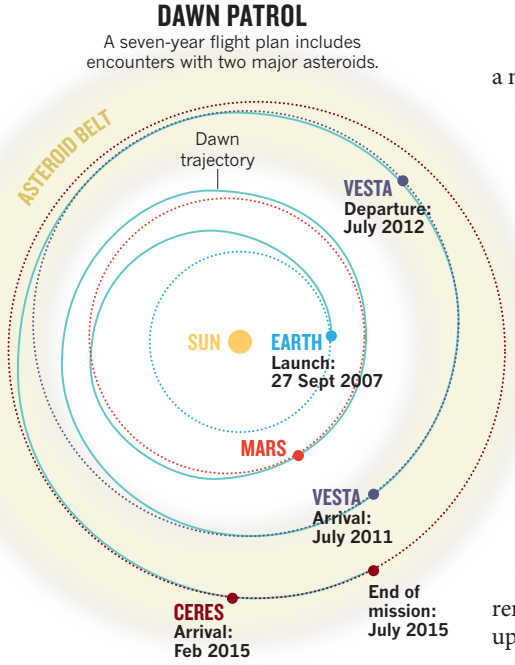
After its tour of Vesta, Dawn will fire up its ion thrusters — solar-powered jets that supply a weak but long-lasting push — and set a course for Ceres, which it will inspect over five months in 2015.

Before launch, budget issues caused the mission team to drop two instruments originally meant to fly aboard Dawn; one of them, a magnetometer, will be especially mourned once the craft reaches Ceres. The magnetometer could have looked for fluctuations in the strength of the asteroid's magnetic field that might have provided clues as to whether the body harbours a briny ocean. Losing the instrument "was a big blow", says Raymond.

Although Dawn has so far survived the ravages of budget changes, politics and four years in interplanetary space, Russell says that he won't relax until the craft enters orbit around Ceres. Casey Lisse, a planetary scientist at Johns Hopkins University's Applied Physics Laboratory in Laurel, Maryland, agrees. "We've learned most of what we can from remote observations of Ceres, and we need an up-close and personal look," he says. ■

DAWN PATROL

A seven-year flight plan includes encounters with two major asteroids.



EPIDEMIOLOGY

African outbreak stumps experts

With few leads to go on, researchers pursue the childhood malady nodding syndrome.

BY MEREDITH WADMAN

The boy was perhaps seven or eight, although he could have been older: among other things, the disease that afflicts him stunts growth. When a seizure began, his mother summoned Sudhir Bunga, who found the boy sitting under a tree in a school playground. "The child was staring blankly and his head was intermittently nodding every five to eight seconds," Bunga says. "This lasted about three minutes."

Bunga was not surprised by what he saw. A physician and epidemiologist with the US Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, he was in rural southern Sudan in May as part of an emergency-response team trying to assess a mysterious illness seen in children in the region. But despite his preparation, Bunga was deeply affected by his first encounter with 'nodding syndrome'. "Actually seeing it out in the community was overwhelming and distressing," he says. "The burden of the disease looked really high."

Nodding syndrome is a poorly understood and seemingly growing problem in eastern Africa, where it is devastating communities in South Sudan and northern Uganda. It has existed separately for decades in a secluded mountainous area of southern Tanzania[1]. In South Sudan, "it's affecting thousands of children," says Abdinasir Abubakar, a physician for the World Health Organization (WHO) based in South Sudan who coordinated the recent CDC trip. "Of course, the question is whether this syndrome is spreading to new communities."

For South Sudan, which achieved political independence only on 9 July, the syndrome raises the additional fear that the new nation's limited capacity to deal with an emerging medical threat will be quickly overwhelmed without outside resources and expertise.

"Nodding syndrome cannot be left with the nascent government in South Sudan," says Martin Opoka, an epidemiologist with the WHO's eastern Mediterranean regional office in Cairo. "They will certainly need assistance from the international community."

Opoka helped to investigate the occurrence of nodding syndrome in southern Sudan as part of a WHO team in 2002, and returned to the region this year to assist the CDC investigators. The CDC team — consisting of four physician-epidemiologists with specialities in paediatrics, neurology and nutrition — was dispatched by the US agency's Division

S. BUNGA/CDC

In some villages in South Sudan, almost every family has a child affected by nodding syndrome.

of Global Disease Detection and Emergency Response (GDDER). The division undertakes a number of missions each year at the invitation of local health authorities, to plumb mysterious or troublesome outbreaks. "Most commonly, we know the cause either before we go out or by the time we come back," says Scott Dowell, the GDDER director. "But we do have a handful of enigmatic outbreaks."

Nodding syndrome is one such enigma. Most children it strikes are aged between 5 and 15. It impairs both physical growth and cognitive development. Its hallmark head nodding — often brought on by eating, and sometimes by cold — occurs when abnormal brain activity causes a brief lapse in neck muscle tone, causing the head to fall forwards. Electroencephalograms conducted by CDC investigators and others have shown subtler, sub-clinical seizures in many children, and some magnetic resonance imaging scans have revealed brain atrophy and damage to the hippocampus and to supportive brain cells known as glia.

Once the seizures begin, the health of children with the disease goes downhill. Perhaps because the onset of seizures inhibits eating, they suffer from malnutrition. They are also prone to accidents such as drowning and burning. Many stop attending school, and some are isolated because of fears of contagion. "Once they have it, they are going to die with it, and much earlier than they would have otherwise," says Dowell.

The condition was first documented in 1962 in southern Tanzania[1], but its incidence now seems to be rising rapidly in South Sudan (see map) and in a non-contiguous area of northern Uganda where, in late 2009, the ministry of health reported that more than 2,000 children were affected. In May, the CDC team arrived in Juba, now South Sudan's capital, and journeyed in armoured vehicles to villages where nodding syndrome is making its presence felt.

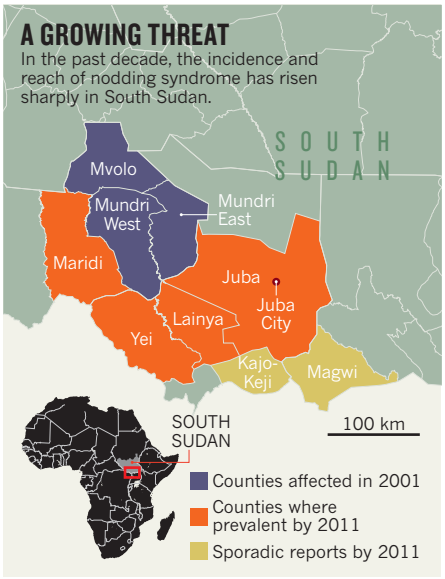
The poorest children seem to be the most susceptible. Community focus groups convened by CDC teams have not turned up any changes in dietary or cultural practices that could account for the syndrome's emergence. In South Sudan, the CDC is probing whether population displacements and associated chemical exposures during wartime could have played a part. And although a study in southern Tanzania showed familial clustering[2], genetics alone cannot explain the rapid emergence of so many cases. In one village that the CDC team visited during the recent trip, almost every family had an affected child. "We have chased a lot of dead ends," says Dowell.

Investigators have wondered whether *Onchocerca volvulus*, the blackfly-borne parasite that is best known for causing river blindness, might be the culprit. The CDC's work in northern Uganda showed a higher prevalence of nodding in children whose blood samples revealed infection with the parasite. However, the recent Tanzanian study[2] failed to find significantly elevated antibodies to the parasite in cerebrospinal fluid samples from affected children.

"We could not establish any hint that *Onchocerca volvulus* is actually going into the brain," says Andrea Winkler, first author on the study[2] and a consultant neurologist at the Technical University of Munich in Germany. "But what we cannot exclude is that there is an autoimmune mechanism going on." Even if that were the case, an association between the parasitic disease and nodding syndrome would not explain why adults and people in other areas where onchocerciasis is endemic are not affected by nodding syndrome.

The CDC team is also investigating whether deficiency of vitamin B6, or pyridoxine — which is common in children with nodding syndrome — could be the cause. Dowell notes that a rare genetic disease called pyridoxine-responsive epilepsy causes infants to have seizures, which disappear when the babies are given high-dose vitamin B6. In a return trip planned for late this year, the team hopes to run a clinical trial examining whether the vitamin can also alleviate nodding syndrome.

Opoka hopes that the increased attention will finally shed light on the condition and, ultimately, point the way to a treatment. Nodding syndrome "is silently increasing", he says. "If nothing is done we don't know what the end result will be." Bunga remains optimistic that something will come out of the data that the team gathered. "Did I come back with any clear answers? No," he says. "But there are still multiple paths of investigation open." ■



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