Abstractions

SOLE AUTHOR

Seismologists first detected Earth's 'hum' — the low frequency oscillations identified in seismic records — almost a decade ago. Since then, scientists have been searching for its source. At frequencies close to 10 millihertz, the hum cannot be heard by humans. Yet the hum's amplitude is equivalent to that of a magnitude 5.75 earthquake. Earthquakes have been ruled out as a source because the hum can be detected in their absence. The presence of seasonal energy peaks pointed to either atmospheric turbulence or wave action. But it took the knowledge of oceanographer turned seismologist Spahr Webb, at Columbia University in New York, to show that the hum is driven by ocean waves travelling over continental shelves (see page 754).

Can you describe Earth's hum?

It's long been known that Earth vibrates in a series of tones — much like ringing a bell — after large earthquakes. As seismometry improved, the hum was detected as a series of these tones that are constantly excited.

Why has it been so hard to determine the hum's origin?

The hum's signal is barely detectable. Even though it has a lot of energy, this is distributed over the entire planet and it takes a good seismometer to see the oscillations clearly. The hum's seasonal variation is thought to be due to changes in either wave or wind energy, which are directly related.

Why was atmospheric turbulence first thought to be the hum's source?

The Sun oscillates in a similar way to Earth, and the Sun's hum is excited by turbulent convection. But fluid mechanics shows that the weak turbulence of Earth's atmosphere isn't effective at driving such long-wavelength modes. Over large areas, the regions of high and low pressure under turbulence almost balance out.

How does energy from ocean waves become long-wavelength seismic waves?

The low-frequency waves are created as swell and wind waves come ashore. As these waves travel back over the continental shelf, they interact with others to form a standing wave. The centre of the standing wave's mass moves vertically as the surface changes from flat to wavy, applying a force over a large area of continental shelf that translates into seismic energy.

Why did we need to find the hum's source?

It's an interesting coupling between oceanography and seismology and it proves to be the ultimate detection limit for small earthquakes. ■

MAKING THE PAPER

John Tooby

Pin-pointing behavioural cues that make for happy families.

Do humans behave altruistically towards family members to help to ensure that their common genes make it to the next generation? And are humans somehow wired to prevent incest? Two pioneering, seemingly opposing theories propose that families treat kin better to pass on genes but avoid reproducing with each other, suggesting that the brain must have a means of detecting those to whom an individual is genetically related. John Tooby, of the University of California in Santa Barbara, has come up with a possible mechanism (see page 727).

According to work by William Hamilton and George Williams in the 1950s and 1960s, if a gene prompts behaviour that enhances the fitness of relatives while lowering that of the individual displaying the behaviour, it may still increase in frequency, because relatives often carry the same genes. Thus, the enhanced fitness of relatives can compensate for the fitness loss incurred by the individuals exhibiting the behaviour.

It was known even earlier that mating among family members lowers the fitness of offspring. In 1891, Finnish sociologist Edward Westermarck proposed that living together as children prevents sexual attraction among siblings, underpinning the 'incest taboo' in human societies. But the idea was ridiculed by Sigmund Freud, who held that the earliest expressions of childhood sexuality have strong elements of incestuous behaviour. Thus, the incest taboo, said Freud, existed to counteract a strong natural inclination. Tooby and his colleagues provide, for the first time, evidence of a biological mechanism by which humans detect their kin.

A handful of anthropological studies made during the past 50 years showing that unrelated children raised together are less likely to marry each other than are children raised separately and, when they are forced to marry each other, have fewer children, seemed to bolster Westermarck's hypothesis. "These studies were limited to indirect measures of sexual attraction and did not look at relatives," explains Tooby. "We wanted to have a more natural, direct measure of behaviour." As an evolutionary psychologist, Tooby also wanted to know how the mind figures out who is a relative and who is not.

He first pondered the question during his graduate studies at Harvard University in Massachusetts during the 1970s, but couldn't work on the topic until the mid-1990s. "There is no funding support for these kinds of studies," says Tooby, who conducted the study with his wife and colleague Leda Cosmides and collaborator Debra Lieberman.

Their idea was that there must be ancestrally valid cues in the environment that allow the human brain to determine whether someone is related to them. One cue, they reasoned, would be seeing one's mother care for another infant. Younger siblings would have to rely on a different cue: the length of time spent living with another person. This would generally have been true for humans' forager ancestors, Tooby observes. "When food supplies were scarce they would break up into small groups to search for food," he says. "A mother and her children would generally be in the same group."

The researchers asked more than 600 people questions relevant to these two cues. They then tested how the cues correlated with two different motivational outputs: sibling altruism and disgust at the prospect of incest. For older siblings, exposure to their mother caring for their infant sibling caused altruistic motivation and sexual aversion. For younger siblings, time spent living with the older sibling had the same effects.

"The conclusion is that there are internal monitoring systems in the brain for these two cues that evolved over time," explains Tooby. In turn, this monitoring system functions to regulate altruism and sexual attraction. "We found that it was not our subjects' beliefs about who was and was not a genetic relative that generated sexual disgust and altruism, but rather their exposure to these two cues." ■

KEY COLLABORATION

Probing the nature of elementary particles and their interactions requires a lot of energy. For the past 20 years, physicists have sought an alternative to conventional particle colliders: plasma wakefield accelerators, which are theoretically thousands of times more powerful. But these were thought to be difficult to handle because plasma wakefields have many unstable features. "We started plasma acceleration work in the 1980s at the University of California, Los Angeles (UCLA) when most people doubted that a coherent accelerating structure could be established in a plasma," says Chandrashekhar Joshi, Director of UCLA's Center for High Frequency Electronics.

In 1998, Joshi's UCLA team joined forces with scientists at the Stanford Linear Accelerator Center in Menlo Park, California, and the University of Southern California at Los Angeles.

"The specific aim of the collaboration was to take plasma-acceleration research to the next level," says Joshi. Most recently, electric fields were used in plasmas to double the energy of electrons (see page 741). The method can generate ultra-powerful beams with narrow energy spread, invaluable for high-energy physics applications. "This work shows that plasma accelerators can produce the kind of energy that high-energy physicists really care about," says Joshi. ■