ANIMAL BEHAVIOUR

How to confuse thirsty bats

D. NILL

Echolocating bats have a legendary ability to find prey in the dark — so you'd think they would be able to tell the difference between water and a sheet of metal. Not so, report Greif and Siemers in *Nature Communications*. They have found that bats identify any extended, echo-acoustically smooth surface as water, and will try to drink from it (S. Greif and B. M. Siemers *Nature Commun.* doi:10.1038/ncomms1110; 2010).

The way in which bats locate point objects has been studied extensively, but how they recognize extended objects, such as pools of water, isn't known. As pictured here, bats drink while on the wing. Greif and Siemers hypothesized that, when searching for a drink, the animals look for the echo-reflection signature of water surfaces — the only extended, acoustically smooth surfaces in a bat's environment.

When a bat sends an echolocation beam at a glancing angle to a water surface, most of the beam bounces off the surface away from the animal, like light off a mirror. But a small part of the beam travels vertically down from its source, and is reflected right back to the bat. This reflection pattern could act as a flag for water.

To test this idea, the authors conducted experiments on 15 species of wild bat, placing them in a room that had two large plates on the floor. The plates were made of one of several materials: wood, metal or plastic. Each of the surfaces was either smooth or textured. The smooth surfaces reflect echolocation beams in the same way as water, and, sure enough, thirsty bats repeatedly tried to drink from these surfaces, but ignored the textured ones (see movie at http://go.nature.com/pnpal8). The authors thus concluded that bats use echolocation to recognize bodies of water.

When Greif and Siemers trialled juvenile bats that had had no previous contact with ponds, the animals also tried to drink from the smooth plates, thus revealing the water-location mechanism to be innate. What's more, the authors found that echolocation overrides conflicting sensory stimuli such as vision, chemoreception and touch. For example, if a smooth surface was placed on a table, the bats tried to drink from it even if they had already flown under the table. The authors suggest that innate water recognition in bats could be used to study the neural basis of habitat recognition. **Stefano Tonzani**

FUNDAMENTAL CONSTANTS

Big *G* revisited

Measuring Newton's constant of gravitation is a difficult task, because gravity is the weakest of all the fundamental forces. An experiment involving two simple pendulums provides a seemingly accurate but surprising value.

RICHARD DAVIS

Newton's law of universal gravitation[1] is a pillar of classical physics. Here's a quick textbook example: the gravitational force between any two spherical objects is proportional to the product of their masses and inversely proportional to the square of the distance between their centres. If you know the value of each mass in kilograms and the distance between them in metres, the Newtonian constant of gravitation, G (aka big G), lets you calculate the gravitational force between the masses in units of ... newtons! Big G is one of the fundamental constants of physics[2]. Its value, which is roughly $6.674\times10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$, can be established only by measurement. However, experiments with the potential to yield a highly accurate value of G are notoriously challenging. In a beautifully written article in *Physical Review Letters*[3], Parks and Faller describe an experiment carried out at the JILA institute in Boulder, Colorado, that has allowed them to measure G with an uncertainty of 0.0021%, or 21 parts per million (p.p.m.). This is among the smallest uncertainties ever achieved, but the derived value of G is a surprise.

The basic idea of Parks and Faller's experiment can be illustrated by a simple pendulum (Fig. 1a). When a 'source mass' is brought near the pendulum's bob (the 'test mass'), the gravitational attraction between the two masses causes the bob to move a small distance, z, from its usual rest position. Of course, the design and analysis of the real experiment are much more sophisticated than this simple depiction. The authors' experiment has two pairs of tungsten source masses and two identical pendulums, the copper bobs of which are pulled in opposite directions, and a host of other clever features.

The distance each bob moves is small: z is of the order of 50 nanometres. Yet the authors show that such small displacements can be

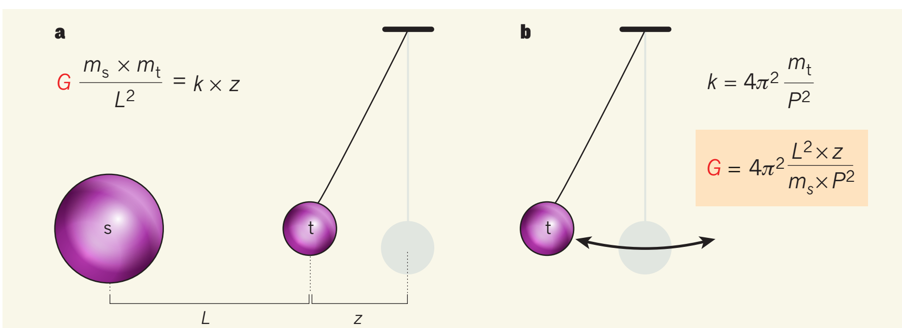

Figure 1 | The basic principle of Parks and Faller's experiment[3]. **a**, A spherical 'source mass' (m_s) is brought near a pendulum's spherical bob (the 'test mass', m_t) and causes the bob to move a small distance z from its usual resting position (grey). The gravitational force between the two masses (left side of equation), which depends on Newton's constant (G), can be obtained from a measurement of z provided that k is known (see **b**). **b**, The value of k is found by measuring the period (P) of the freely swinging pendulum. To compute the value of G, we need measurements of L, z, m_s and P (but not m_t). Parks and Faller's experiment was based on four cylindrical source masses of 100 kilograms each, two pendulums and many other refinements.

50 Years Ago

'Anatomical evidence for olfactory function in some species of birds' by Betsy Garrett Bang

It seems curious that the large olfactory organs of certain species have so often been pointed out by anatomists, yet most olfactory learning studies have been done on feebly equipped birds such as pigeons, and have tended to keep alive in the text-books the idea that the chemical sense in birds is minimal or lacking … In dissecting the nasal tissues of birds for work on natural defences against respiratory disease, I have been repeatedly impressed by the size of some of the olfactory conchae … Of the species thus far dissected, by far the largest and most heavily innervated organs have been seen in the turkey vulture, *Cathartes aura*, the Trinidad oilbird, *Steatornis caripensis*, and the Laysan and black-footed albatrosses, *Diomedea immutabilis* and *D. nigripes*, each of which types represents a separate order with quite dissimilar feeding and nesting habits … There is no question of degenerate or indifferent function of the olfactory organs of these birds.

From *Nature* 12 November 1960

100 Years Ago

'The Cocos-Keeling Atoll' — During a very short visit to these islands some years ago I was taken across the lagoon in a light canoe, and when wading to land, about a quarter of a mile distant, over the rough surface of fresh coral branches, I suddenly crashed downwards for about 2 feet into a mass of rotten coral which spread over an irregular area some 20 or 30 yards across. I did not investigate this further, as a shark's fin appeared above the water off shore, but Mr. Ross informed me that a good deal of the coral in the lagoon had been "killed" at various times by sulphurous exhalations from below.

From *Nature* 10 November 1910

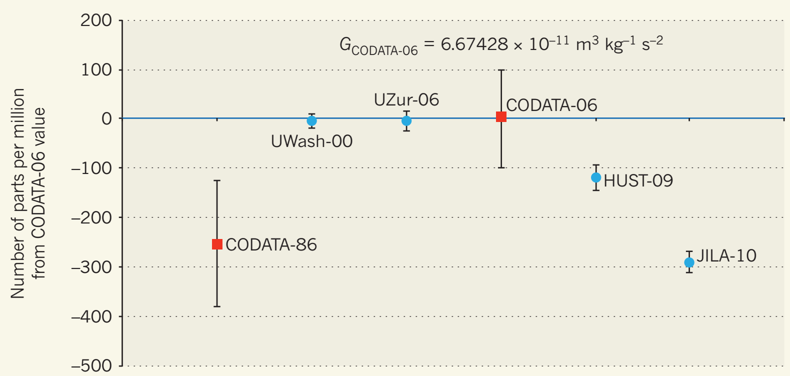

Figure 2 | Parks and Faller's estimate of big *G* in context. Parks and Faller find[3] a value for *G* (JILA-10) in agreement with the estimate of the CODATA-86 Task Group on Fundamental Constants but in disagreement with the CODATA-06 value[4]; from time to time, CODATA reviews and combines results from various experiments. Two of the measurements with the smallest uncertainty, UWash-00 (ref. 6) and UZur-06 (ref. 7), have been taken into account in determination of the CODATA-06 value. HUST-09 represents the culmination of an experiment that appeared in ref. 5 as HUST-99. All error bars denote 68% confidence levels.

measured with high accuracy. To measure the analogue of *z* in their experiment, Parks and Faller attached mirrors to the bobs and used modern optical techniques. Because precise optical measurements are impossible if the pendulums are swinging, the researchers installed powerful, permanent magnets beneath each bob so that a phenomenon called eddy-current damping would keep them still without affecting the values of *z*. But the magnets did create some small, subtle problems, which had to be identified and solved.

As a final step, the authors removed the magnets and source masses so that each pendulum could swing freely. This allowed the researchers to measure the period of each pendulum — the time it takes for the bob to complete one full swing — and, in turn, to derive the value of *G* from the measured distance (corresponding to *z* in Fig. 1b).

Here's the surprise: Parks and Faller's result[3] does not agree with the previous best estimate[4] of *G*, which was provided by the CODATA Task Group on Fundamental Constants (Fig. 2). CODATA regularly publishes an in-depth review of relevant experiments, followed by a list of recommended values and uncertainties for the fundamental constants of physics, including *G*. The last such publication, CODATA-06 (ref. 4), considered all results that were available until the start of 2007. (Earlier reports were dated 2002, 1998, 1986 and so on.)

To put the authors' work in context, it is helpful to know a bit of the recent history of big-*G* measurements. Typically, the set of credible *G* results available to CODATA is not consistent[5] for reasons that are seldom clear. Nevertheless, CODATA must produce its recommendation. In 1995, a new and highly discrepant experimental result led CODATA to increase the uncertainty assigned to *G* from 130 p.p.m. (1986) to a whopping 1,500 p.p.m. (1998), although it decided that the recommended value of *G* should not be changed. This unsatisfactory situation was a call to action, eventually leading to many new experimental results. By 2005, CODATA had sufficient reasons to exclude the discrepant 1995 value from further consideration[5].

The CODATA-06 recommended value for *G*, and the four experimental results that have the smallest estimated uncertainties ever reported, are shown in Figure 2. Interestingly, no two of these experiments use the same method to determine *G*. An uncertainty of only 14 p.p.m. is claimed by the University of Washington team[6] in Seattle (UWash-00), and this is still the record. This experiment[6] is elegant in both conception and execution. The University of Zurich group[7] (UZur-06) produced a remarkably similar result using a completely independent method. Problem solved? Not quite. The CODATA-06 error bars reflect the considerable scatter among the total set of *G* data that were considered[4] (only the two values with the smallest claimed uncertainties are shown in Fig. 2, and these results happen to agree perfectly). More recently, the group from the Huazhong University of Science and Technology in China (HUST-09) announced its final result[8]; and now, after extensive checking failed to uncover any errors in their work, Parks and Faller finally published[3] their *G* value (JILA-10).

Could something really fundamental be going on here? Probably not. It seems most unlikely that any discrepancies between different values could be due to a failure of classical physics to apply perfectly well to all of these experiments. Parks and Faller point out that their result agrees well with the CODATA-86 recommended value (Fig. 2). It is therefore interesting that CODATA has previously explained why it considers the key datum in the 1986 analysis to have been superseded by later work[5].

Ironically, because the authors' experiment has no evident flaw, their measurement may lead CODATA to increase the uncertainty of its next recommended value of *G*. Stay tuned. ■

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EVOLUTIONARY GENOMICS

When abnormality is beneficial

One might think that aneuploidy — having an abnormal number of chromosomes — would be harmful, and would reduce an organism's fitness. Not necessarily: it all depends on the type of aneuploidy and the associated conditions. SEE LETTER P.321

JUDITH BERMAN

Most cancer cells are aneuploid, and contain an unbalanced number of chromosomes. The question is whether aneuploidy can cause the unbridled growth of cancer cells, as Bovary proposed more than 100 years ago[1]. On page 321 of this issue, Pavelka *et al.*[2] demonstrate that different constellations of aneuploid chromosomes can confer a growth advantage on cells when they are exposed to stress conditions. This paper adds fuel to a long-standing controversy[3,4] over whether aneuploid chromosomes are good or bad for cell proliferation, and highlights the point that 'good' and 'bad' are relative terms that are highly dependent on the conditions under which they are measured.

Pavelka *et al.* exploited the facile genetics of the budding yeast *Saccharomyces cerevisiae* to produce a set of aneuploid strains in an unbiased manner. They first constructed strains that had three or five complete sets of whole chromosomes (triploids and pentaploids), instead of the usual two (diploids), and then induced them to undergo meiotic cell division. The odd numbers of starting chromosome sets ensured that a high frequency of spores would carry multiple aneuploidies. Other strengths of the study were the large number of genetically identical aneuploid strains generated (38), and the focus on strains that were stable and had undergone few cell divisions.

The authors analysed the progeny soon after birth — before single-nucleotide mutations could accumulate, as assessed by whole-genome deep sequencing. They found that most strains had decreased growth rates in nutrient-rich media, as well as under several stress conditions. Notably, however, most of the aneuploid strains grew faster than their parent strain on transfer to at least one stress condition, such as exposure to a chemotherapeutic agent or an antifungal drug. So it seems that some combinations of aneuploid chromosomes proliferate better under stress conditions, despite having had no prior exposure to that condition.

Intriguingly, in a number of cases, different constellations of aneuploid chromosomes conferred a similar growth advantage. This indicates that there is more than one way to get the job done. Whole-genome deep sequencing confirmed that no single-nucleotide mutations had accumulated in the five isolates Pavelka *et al.* analysed for messenger-RNA and protein composition; thus aneuploidy alone was sufficient to confer the growth advantages. The authors also show that an extra copy of a single gene, *ATR1*, conferred resistance to a tumorigenic compound. This bolsters previous observations in *S. cerevisiae*[5] and in another fungal species, *Candida albicans*[6], that aneuploidy can confer a selective advantage through the increased expression of one or more genes.

This paper, however, reaches different conclusions to those of Torres *et al.*[7,8], who reported that a single-nucleotide mutation in a deubiquitinating enzyme, which arose during the evolution of one aneuploid isolate, leads to improved proliferation of a few, but not all, strains. Pavelka *et al.*[2] find that aneuploidies alone — without any mutations — can confer improved growth under some stress