

about the hips<sup>6–8</sup> and by back extension; weight support is biased towards the forelimbs<sup>8</sup>. This mechanism is characteristic of cursorial quadrupeds. It is associated with muscular hip retractors and with forelimbs that are dominated by bone, tendon and highly pennate muscles, which act almost like passive springs<sup>9,10</sup> and are capable of opposing considerable weight-induced forces. This means that the muscles that power greyhounds are virtually independent of weight support and so are not affected by an increase in effective weight.

James R. Usherwood\*, Alan M. Wilson\*†

\*Structure and Motion Laboratory, The Royal Veterinary College, North Mymms, Hertfordshire AL9 7TA, UK

e-mail: jusherwood@rvc.ac.uk

†Centre for Human Performance, University College London, Stanmore, Middlesex HA7 4LP, UK

- Greene, P. R. *J. Biomech.* **20**, 667–680 (1987).
- Weyand, P. G., Sternlight, D. B., Bellizzi, M. J. & Wright, S. *J. Appl. Physiol.* **89**, 1991–1999 (2000).
- International Association of Athletics Federations [www.iaaf.org/news/kind=4/newsId=24423.html](http://www.iaaf.org/news/kind=4/newsId=24423.html) (2005).
- Alexander, R. McN., Maloiy, G. M. O., Hunter, B., Jayes, A. S. & Nturi, J. *J. Zool. Lond.* **189**, 135–144 (1979).
- Witte, T. H., Knill, K. & Wilson, A. M. *J. Exp. Biol.* **207**, 3639–3648 (2004).
- Gray, J. *Animal Locomotion* (Weidenfeld & Nicolson, London, 1968).
- Alexander, R. McN. *J. Zool. Lond.* **173**, 549–573 (1974).
- Lee, D. V., Bertram, J. E. A. & Todhunter, R. J. *J. Exp. Biol.* **202**, 3565–3573 (1999).
- Gregersen, C. S., Siverton, N. A. & Carrier, D. R. *J. Exp. Biol.* **201**, 3197–3210 (1998).
- McGuigan, M. P. & Wilson, A. M. *J. Exp. Biol.* **206**, 1325–1336 (2003).

Supplementary information accompanies this communication on Nature's website.

Competing financial interests: declared none. doi:10.1038/438753a

## ASTROPHYSICS

# Is a doomsday catastrophe likely?

The risk of a doomsday scenario in which high-energy physics experiments trigger the destruction of the Earth has been estimated to be minuscule<sup>1</sup>. But this may give a false sense of security: the fact that the Earth has survived for so long does not necessarily mean that such disasters are unlikely, because observers are, by definition, in places that have avoided destruction. Here we derive a new upper bound of one per billion years (99.9% confidence level) for the exogenous terminal-catastrophe rate that is free of such selection bias, using calculations based on the relatively late formation time of Earth.

Fears that heavy-ion collisions at the Brookhaven Relativistic Heavy Ion Collider might initiate a catastrophic destruction of Earth have

focused on three possible scenarios: a transition to a lower vacuum state that propagates outwards from its source at the speed of light<sup>2</sup>; formation of a black hole or gravitational singularity that accretes ordinary matter<sup>2</sup>; or creation of a stable 'strangelet' that accretes ordinary matter and converts it to strange matter<sup>3</sup>. A careful study<sup>1</sup> concluded that these hypothetical scenarios are overwhelmingly more likely to be triggered by natural high-energy astrophysical events, such as cosmic-ray collisions, than by the Brookhaven collider.

Given that life on Earth has survived for nearly 4 billion years (4 Gyr), it might be assumed that natural catastrophic events are extremely rare. Unfortunately, this argument is flawed because it fails to take into account an observation-selection effect<sup>4,5</sup>, whereby observers are precluded from noting anything other than that their own species has survived up to the point when the observation is made. If it takes at least 4.6 Gyr for intelligent observers to arise, then the mere observation that Earth has survived for this duration cannot even give us grounds for rejecting with 99% confidence the hypothesis that the average cosmic neighbourhood is typically sterilized, say, every 1,000 years. The observation-selection effect guarantees that we would find ourselves in a lucky situation, no matter how frequent the sterilization events.

Figure 1 indicates how we derive an upper bound on the cosmic catastrophe frequency  $\tau^{-1}$  that is free from such observer-selection bias. The idea is that if catastrophes were very frequent, then almost all intelligent civilizations would have arisen much earlier than ours. Using data on planet-formation rates<sup>6</sup>, the distribution of birth dates for intelligent species

can be calculated under different assumptions about the rate of cosmic sterilization. Combining this with information about our own temporal location enables us to conclude that the cosmic sterilization rate for a habitable planet is, at most, of the order of 1 per 1.1 Gyr at 99.9% confidence. Taking into account the fact that no other planets in our Solar System have yet been converted to black holes or strange matter<sup>1–3</sup> further tightens our constraints on black hole and strangelet disasters. (For details, see supplementary information.)

This bound does not apply in general to disasters that become possible only after certain technologies have been developed — for example, nuclear annihilation or extinction through engineered microorganisms — so we still have plenty to worry about. However, our bound does apply to exogenous catastrophes (for example, those that are spontaneous or triggered by cosmic rays) whose frequency is uncorrelated with human activities, as long as they cause permanent sterilization. Using the results of the Brookhaven analysis<sup>1</sup>, the bound also implies that the risk from present-day particle accelerators is reassuringly small: say, less than  $10^{-12}$  per year.

Max Tegmark\*, Nick Bostrom†

\*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

e-mail: tegmark@mit.edu

†Future of Humanity Institute, Faculty of Philosophy, University of Oxford, Oxford OX1 4JJ, UK

- Jaffe, R. L., Busza, W., Sandweiss, J. & Wilczek, F. *Rev. Mod. Phys.* **72**, 1125–1140 (2000).
- Hut, P. & Rees, M. *J. Nature* **302**, 508–509 (1983).
- Dar, A. & De Rújula, A. *Phys. Lett. B* **470**, 142–148 (1999).
- Carter, B. in *IAU Symposium 63* (ed. Longair, M. S.) 291–298 (Reidel, Dordrecht, 1974).
- Bostrom, N. *Anthropic Bias: Observation Selection Effects in Science and Philosophy* (Routledge, New York, 2002).
- Lineveaver, C. H., Fenner, Y. & Gibson, B. K. *Science* **203**, 59–62 (2004).

Supplementary information accompanies this communication on Nature's website.

Competing financial interests: declared none. doi:10.1038/438754a

## CORRIGENDUM

### Avian flu: Isolation of drug-resistant H5N1 virus

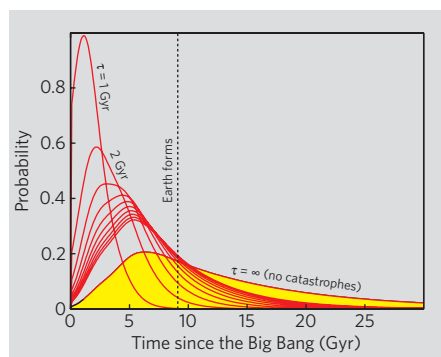
Q. Mai Le, Maki Kiso, Kazuhiko Someya, Yuko T. Sakai, T. Hien Nguyen, Khan H. L. Nguyen, N. Dinh Pham, Ha H. Ngyen, Shinya Yamada, Yukiko Muramoto, Taisuke Horimoto, Ayato Takada, Hideo Goto, Takashi Suzuki, Yasuo Suzuki, Yoshihiro Kawaoka  
*Nature* **437**, 1108 (2005)

We omitted the accession numbers for the sequences of the A/Hanoi/30408/2005 clones, which are registered in the DNA Data Bank of Japan. These are:

AB239125 20051020120345.25409 for the haemagglutinin gene in clone 9; and  
AB239126 20051020122743.63420 for the neuraminidase gene in clone 7.

doi:10.1038/438754b

BRIEF COMMUNICATIONS ARISING online  
♦ [www.nature.com/bca](http://www.nature.com/bca) see Nature contents.



**Figure 1 | The catastrophe timescale cannot be very short.** The probability distribution is shown for observed planet-formation times, assuming catastrophe timescales,  $\tau$ , of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Gyr and infinity (shaded yellow), respectively (from left to right). The probability of observing a formation time  $\geq 9.1$  Gyr for Earth (area to the right of the dotted line) drops below 0.001 for  $\tau < 1.1$  Gyr.