Control[2,7,8]. We would certainly have liked to have performed PCR on these occasions, but were limited by the small quantity of specimens available in retrospect, particularly given the extremely low viral load (10^6 cells required for each positive culture and three copies of viral DNA per 10^5 cells by PCR at a separate time point).

As this is an unusual case, we undertook more stringent tests to demonstrate infection. We obtained two viral isolates cultured from the infant's blood at time points approximately 1 month apart, allowing us to compare these viruses and thus determine whether inadvertent contamination might have occurred on two separate occasions. Nucleotide sequence analysis of the two viral isolates demonstrated that these viruses are extremely closely related and distinct from other strains of HIV-1, including those commonly used in the laboratory, making contamination in the laboratory highly unlikely.

Given the limited sequence analysis, we did not attempt to establish an evolutionary relationship between the mother's virus and that of the infant (further correspondence arising from our paper will appear soon in *The New England Journal of Medicine*). Although the origin of the infant's virus as maternally derived has not yet been formally proven (studies are currently underway), the most likely route of infection would have been by vertical transmission.

In any event, the origin of the virus has no bearing on our central conclusion, that the infant was infected with HIV — as evidenced by the isolation of highly related virus on two separate occasions — and then became virus-free.

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Errata

IN the Scientific Correspondence "Another obese gene function" by M. T. Nakamura (*Nature* **374,** 124; 1995), the second paragraph incorrectly referred three times to normal mice as *ob/–*. This should have read *Ob/–* to denote the fact that the mouse carried at least one dominant normal gene (*Ob*). □

IN the Scientific Correspondence "Community response to IRONEX" by K. Banse (*Nature* **375,** 112; 1995), the second sentence of the table legend should have read: "Column 3. Initial, photosynthesis from outside the patch (equivalent to "out" in Fig. 3 of ref. 1), μg C per l per day." □

Origin of the Tunguska event

SIR — It is generally accepted that the Tunguska event resulted from the catastrophic disruption of a large meteor high above the ground. Previous studies have yielded diverse interpretations as to the meteor's size, composition, velocity and density before its arrival[1–3]. Nevertheless, there is consensus that the disruption occurred 6–10 km above the ground[4], depositing approximately 15 Mton energy[5] in a narrow altitude band. Turco *et al.*[3] concluded that the meteor was of cometary origin with an effective density of 0.003 gm cm^{-3} and a diameter of 1,200 m. In contrast, Sekanina concluded that the body was not a comet, but rather an Apollo-type asteroid 90–190 m across[2]. More recent work has suggested that the object was a stony asteroid perhaps 60 m in diameter[1]. In the same work, a carbonaceous body was noted as a possible, but unlikely, cause of the event. We argue here that a carbonaceous chondrite was in fact the most probable cause of the event.

The atmospheric trajectory of a meteor is influenced by mass loss due to ablation and fragmentation caused by enormous aerodynamic loads. The equations of motion for such a body have been described elsewhere[1,2]. An essential aspect of modelling the entry involves accurately calculating the radiation-dominated aerodynamic heating. This can be approximated using the Stefan–Boltzmann relation:

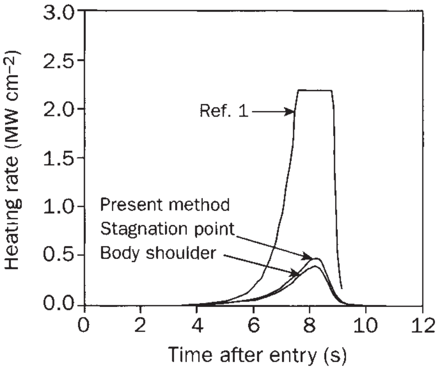
$$q_{R_{\mathrm{ad}}} = 5.67(T_2/1{,}000)^4 \ \mathrm{W\,cm^{-2}} \qquad (1)$$

where $q_{R_{\mathrm{ad}}}$ is the adiabatic radiative heat transfer rate, and T_2 is the temperature behind the shock wave (a function of velocity, altitude and shock angle). However, because of radiative emission from the shock layer, the flow is non-adiabatic. This effect can be accounted for following the method of refs 6 and 7:

$$q_R = q_{R_{\mathrm{ad}}} / (1 + 3.33\,\Gamma^{0.7}) \qquad (2)$$

where q_R is the non-adiabatic radiative heat transfer rate and $\Gamma = 4q_{R_{\mathrm{ad}}}/(\rho_a V^3)$, where ρ_a is the ambient atmospheric density and V is the meteor velocity. Moreover, ablation products in the shock layer will absorb some fraction of the radiation before it reaches the body. The significance of this effect has been analysed by Gupta[8] and depends primarily on the ratio of the freestream and ablation product mass flow rates.

We have attempted to determine the type(s) and size(s) of the objects that could have caused the Tunguska event. The equations of motion were numerically integrated for a wide range of bolides and entry conditions, while the body's mass was decreased according to the ablation rate. For asteroids, entry velocities of 12.5–20 km s^{-1} were considered, while for comets, entries were examined at the approximate lower limit of 20 km s^{-1} (ref. 9). At each time step, the temperature distribution behind the shock was calculated by solving for the equilibrium species concentrations. These temperatures were used to determine the local heating rates, which were corrected for non-adiabatic effects and radiative blockage using the techniques of Goulard and Gupta[6,8]. The drag coefficient, C_d, of 1.2 which was assumed for the nominal case corresponds to a blunted ellipsoid. (The value of 1.7 used in ref. 1 is appropriate for a flat-faced, sharp-edged cylindrical body with its axis aligned with the flow. A naturally occurring meteor would have rounded edges, particularly after even a brief period of atmospheric passage; this rounding decreases C_d substantially.) Chyba's model of mechanical deformation was adopted, and the physical characteristics of the bolide materials were based on ref. 1.



Heat transfer rate versus time for a carbonaceous body. Entry velocity, 15 km s^{-1}; body density, 2,200 g cm^{-3}; entry angle, 45 °; body diameter, 68 m; C_d = 1.2.

The figure shows a heat-transfer pulse calculated as described above for a carbonaceous meteor and also for the same body using the method of ref. 1 (which assumed a uniform, constant shock layer temperature of 25,000 K). Our calculations yield temperatures which for most cases are below 20,000 K in the stagnation region and rapidly decrease towards the edge of the body because of the smaller shock angle. As a result of these lower temperatures and our analysis of the non-adiabatic effects and radiation absorption, the current method yields much lower heating rates than those calculated in refs 1, 2.

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Although previous studies suggest that carbonaceous bodies would probably have released their energy too high in the atmosphere to have been responsible for Tunguska, our work, because of the more realistic, lower drag coefficient and the less severe calculated heating loads, indicates that a given meteor would airburst at a significantly lower altitude than previously believed[1,2]. As a result, carbonaceous chondrites 50–100 m in diameter are found to airburst in the 6–10-km range characteristic of the Tunguska object. Because these are the most common type of meteor to enter the Earth's atmosphere, they must be considered the most probable cause of the Tunguska event.

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Tuned directionality in cricket ears

SIR – Crickets (*Gryllus bimaculatus*) listening to the 4.5-kHz calling song have excellent directional hearing: the tympanal vibrations vary much with the direction of sound incidence[1,2], but the amplitude of sound pressure at the ears is almost constant[3]. The reasons for this apparent paradox are that sound reaches both the outer surface of the tympanum and the inner surface (through tracheal tubes from the ipsi- and contralateral thoracic spiracles, respectively; see Fig. 1*a*), and that the relative phases of the three sounds depend on the angle of sound incidence.

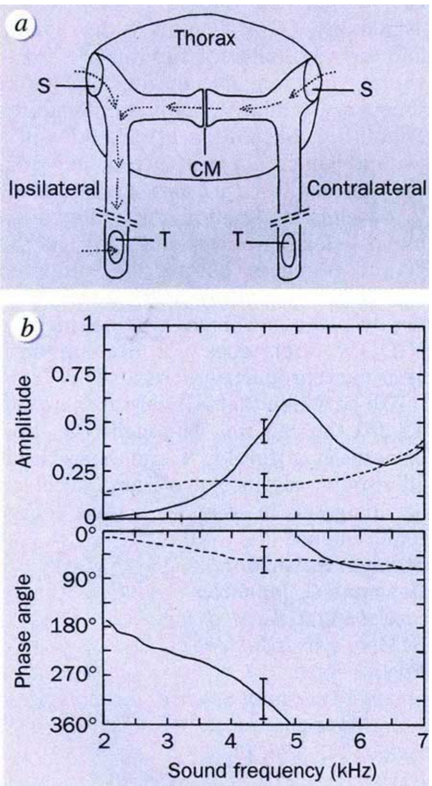

FIG. 1 *a*, The cricket hearing organ. CM, central membrane; S, spiracle (opening on thorax); T, tympanum (in front leg). Dotted arrows, sound paths. *b*, Amplitude and phase of sound arriving at the inner surface of a tympanum from the contralateral spiracle. Solid line, intact; broken line, perforated central membrane. The sound at the spiracle is set to an amplitude of 1 and a phase of 0°. Standard deviations indicated at 4.5 kHz ($n = 5$).

The transmission of sound from a spiracle to the tympanum can be studied by using the tympanal vibrations (recorded with laser vibrometry) for measuring the sound at the inner surface[3]. Sound from the contralateral spiracle is delayed by no less than 313° at 4.5 kHz when it reaches the tympanum (Fig. 1*b*, solid line). This is exactly right for the sound to be almost in phase with the (vectorial) sum of the other two sounds when the sound direction is ipsilateral, and almost out of phase for contralateral sound[3]. The result is the directional diagram in Fig. 2*a* (solid line).

The physical distance from the contralateral spiracle to the tympanum is much too small to account for the 313° delay, so some other factor must be responsible for the large delay. A central membrane (Fig. 1*a*) in the transverse trachea is involved. Holes of 10–25% of its area (made with the tip of a human hair) cause the phase at 4.5 kHz to drop to 54°, and a change is also seen in the amplitude of the transmitted sound (Fig. 1*b*, broken line). The result is a dramatic decrease in the directionality (broken line in Fig. 2*a*), previously observed using electrophysiological techniques[4]. Especially important for crickets walking towards singers is the disappearance of the gradient of auditory sensitivity in the forward direction (Fig. 2*b*, where 30° and 330° are typical extreme positions during phonotactic meandering).

In the intact animal, the change of phase varies much with frequency (Fig. 1*b*). A proper phase, which is a prerequisite for the high directionality of the ear, only exists within a narrow band around the calling song frequency (Fig. 2*b*). The mechanical phase shifting thus tunes the directionality of the ear.

Small animals living on the ground have a frequency band of only a few kilohertz available for long-distance communication. They are too small to emit low-frequency sounds, and high-frequency sounds suffer much attenuation and scattering[5]. They are thus forced to communicate at relatively low frequencies, at which directional hearing is difficult.

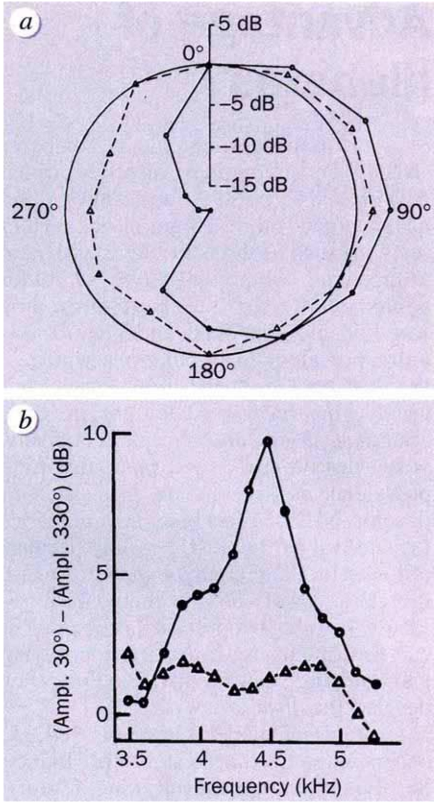

FIG. 2 *a*, Directional dependence of tympanal vibration at 4.5 kHz in a cricket with intact (solid line) and perforated central membrane (broken line). 0°, forward; 90°, ipsilateral sound direction. *b*, Difference between the tympanal vibrations at 30° and 330°. Solid and broken lines as in *a*.

Small grasshoppers with a pressure-difference hearing mechanism similar to that of crickets do not have a mechanical phase shifter in their interaural tracheal air sacs, and their directional hearing around 5 kHz is not very impressive[6]. Calculations show, however, that a much more useful directionality would exist if the sound arriving at the inner surface from the other ear had been more delayed.

The cricket thus stands out as an animal that has solved a major problem in auditory biophysics. It is tempting to speculate that the pure tone calling songs of crickets may have evolved as a consequence of the excellent directional hearing made possible within a very narrow frequency range by the mechanical phase shifter.

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