Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

These findings indicate that, even in formerly endemic areas, iodine deficiency is no longer a problem in Greece, mainly because of improved socioeconomic and nutritional conditions, and increased use of industrially produced foods.

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1 Vitti P, Delange F, Pinchera A, Zimmermann M, Dunn JT. Europe is iodine deficient. *Lancet* 2003; **361:** 1226.
2 Malamos B, Miras K, Koutras DA, et al. Endemic goiter in Greece: metabolic studies. *J Clin Endocrinol Metab* 1966; **26:** 696–704.
3 Doufas AG, Mastorakos G, Chatziioannou S, et al. The predominant form of non-toxic goiter in Greece is now autoimmune thyroiditis. *Eur J Endocrinol* 1999; **140:** 505–11.
4 Markou K, Michalaki M, Makri M, et al. Iodine intake and thyroid function in villagers and city dwellers in southwestern Greece (SWG). *Thyroid* 1996; **1** (suppl)**:** S79.
5 Zois C, Stavrou I, Kalogera C, et al. High prevalence of autoimmune thyroiditis in schoolchildren following elimination of iodine deficiency in northwestern Greece. *Thyroid* 2003; **13:** 485–89.

Panspermia—true or false?

Sir—In their Correspondence letter (May 24, p 1832),[1] Chandra Wickramasinghe and colleagues suggest that many microbial eukaryotes, bacteria, and viruses that are found on Earth could be of extraterrestrial origin. Their conclusion is based on an observation that bacterial and fungal microorganisms with known affiliations on Earth (*Bacillus simplex*, *Staphylococcus pasteuri,* and *Engyodontium album*) were cultured from samples of stratospheric air (altitude 41 km).[2] If substantiated, this idea has several important implications.

First, the extraterrestrial source of DNA/RNA-based life must sustain ecological conditions similar to Earth, allowing for cellular growth and divisions to create a continuous flow of viable cells and viruses to Earth (about 1 tonne of bacterial material daily, according to Wickramasinghe and co-workers). However, unlike Earth, this extraterrestrial source of life must allow vast amounts of biological material to leap off into space. The similarity in DNA sequences between the space-derived cells and microorganisms found on Earth (99·9–100%, 16S rDNA)[2] also presuppose the latter to have derived from space fairly recently to account for lack of evolutionary genomic change.

Second, specialised pathogens must have extraterrestrial hosts similar to those on Earth, such as vertebrates, to evolve and survive.

Third, the extraterrestrial source must be quite close to Earth, since vertebrate-specific RNA viruses can only survive hours to days outside of their hosts.

Finally, any space-derived life needs to cope with high degrees of ultraviolet radiation in the stratosphere[3] known to modify cellular DNA/RNA in a lethal manner. Although cells with special adaptations, such as bacterial endospores—eg, of type bacillus and staphylococcus—might have such abilities,[4] the ultraviolet barrier is likely to be a mortal constraint for most cell types.

No extraterrestrial source with the above-mentioned Earth-like characteristics has been identified, despite numerous long-distance observations and missions to space. The conclusion by Wickramasinghe and colleagues rests on the fundamental assumption that terrestrial life cannot cross the tropopause, a natural barrier about 17 km above the Earth's surface, and hence life above this point must originate from space. However, NASA has collected dust in the stratosphere since 1981, including large amounts of terrestrial dust (wind-blown dust, volcanic ash, and aerosols).[5] Since wind-blown terrestrial dust can reach the stratosphere, terrestrial single cells are likely to as well, providing a simpler and more credible explanation of the results referred to by Wickramasinghe and his team.

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1 Wickramasinghe C, Wainwright M, Narlikar J. SARS—a clue to its origins? *Lancet* 2003; **361:** 1832.
2 Wainwright M, Wickramsinghe NC, Narlikar JV, Rajaratnam P. Microorgaisms cultured from stratospheric air samples obtained at 41 km. *FEMS Micobiol Lett* 2003; **218:** 161–65.
3 Wallington TJ, Nielsen OJ. Atmospheric degradation of anthropogenic molecules. In: Boule P, ed. The handbook of environmental chemistry. Berlin: Springer, 1999: 63–99.
4 Nicholson WL, Munakata N, Horneck G, Melosh HJ, Setlow P. Resistance of bacterial endospores to extreme terrestrial and extraterrestrial environments. *Microbiol Mol Biol Rev* 2000; **64:** 548–72.
5 Allen C. Terrestrial dust. http://www-curator.jsc.nasa.gov/curator/dust/tersmpl.htm (accessed July 1, 2003).

Sir—Chandra Wickramasinghe and colleagues[1] suggest that the causative agent of the severe acute respiratory syndrome (SARS) epidemic might have an extraterrestrial origin. Their unstated assumption is that the emergence of life and the sudden appearance of several global epidemics are the outcomes of a continuous bombardment of Earth with bacteria and viruses, originating in the interstellar grains and comets.[2]

This theory is unlikely. Delivery of exogenous material to the Earth's surface is a well documented phenomenon. It includes extraterrestrial organic compounds present in carbonaceous chondritic meteorites and interplanetary dust particles, which seem to be related to cometary nuclei. However, there is no basis for the claim made by Wickramasinghe and colleagues that there is a daily influx of about 1 tonne of extraterrestrial microbes, which they assume corresponds to one hundredth of the daily infall of cometary material. The present dust infall is 4×10^7 kg per year and, although its organic composition is poorly understood, there is no evidence that it includes extraterrestrial prokaryotes or other forms of microbial life.[3] The few individual molecules that have been characterised in interplanetary dust particles are polycyclic aromatic hydrocarbons,[4] none of which are bona-fide biosignatures. Although this material could have played a part in the origin of life, its connection with extant evolutionary processes is tenuous at best, and probably has no relevance in the appearance of infectious diseases.

Wickramasinghe and co-workers also argue that the microorganisms they collected at high altitude lend support to their hypothesis of an extraterrestrial origin of epidemics. The organisms they found include two bacteria that are firmly placed within the bacillus and the staphylococcus clades on the basis of 16S rRNA sequence comparisons. The presence of these microbes at 41 km from the Earth's surface is consistent with the presence of different bacterial species and fungal spores collected from clouds,[4] but cannot be evidence of an extraterrestrial origin. If life exists

elsewhere in the Universe, it is extremely unlikely that it would have independently evolved macromolecules, such as 16S rRNA, or other intracellular components homologous to those of their terrestrial counterparts. This would be especially true of viruses, whose dependence on the intracellular molecular machinery of their hosts to complete their biological cycles would make their survival and evolution within the terrestrial biosphere unlikely should they have an independent, extraterrestrial origin.

The comment that some epidemics "bear the hallmarks of a space incident component" is particularly amusing. Our inability to reconstruct the complete chain of events cannot be considered evidence of an extraterrestrial origin for a disease. In the case of SARS the development of the pandemic can be traced almost on a day-by-day basis.

Evolutionary analysis of several protein-coding features of the sequences of the SARS-associated virus has provided clear evidence of its phylogenetic affinities with other mammalian and avian coronaviruses.[5] Reconstruction of viral evolution can be notoriously complicated, but the evidence suggests that the SARS-associated coronavirus jumped into the human population from felines, which are considered a delicacy by many Asiatic gourmets.

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1 Wickramasinghe C, Wainwright M, Narlikar J. SARS—a clue to its origins? *Lancet* 2003; **361:** 1832.
2 Hoyle F, Wickramasinghe NC. Astronomical origins of life. Dordrecht: Kluwer Academic Publishers, 2000.
3 Miller SL, Lazcano A. Formation of the building blocks of life. In: Schopf JW (ed). Life's origin: the beginning of biological evolution. Berkeley: California University Press, 2002: 77–111.
4 Hamilton WD, Lenton TM. Spora and Gaia: how microbes fly with their clouds. *Ethol Ecol Evol* 1998; **10:** 1–16.
5 Holmes KV, Enjuanes L. The SARS coronavirus: a postgenomic era. *Science* 2003; **300:** 1377–78.

Sir—I and my former colleagues at the Centre for Cellular and Molecular Biology (CCMB) worked with Chandra Wickramasinghe and colleagues on the experiment they describe.[1] We helped to design the cryosampler experiment and, unlike the authors of the above-mentioned letter, were present at the time of the balloon flight from Hyderabad. On that day, 16 samples were collected, of which eight were kept in Hyderabad for analysis at the CCMB; the remaining samples were sent to Wickramasinghe's group in Cardiff, UK.

The CCMB's expertise in working with exotic microorganisms, such as those from Antarctica and glacial regions, is widely recognised. The basic method for analysis of cryosampler samples collected at various altitudes was developed at the CCMB by Shivaji, who also established its validity with help from his colleagues through analysis of samples collected at lower altitudes (10–20 km); as expected at this altitude, Shivaji's group isolated various clones of an organism *(Pseudomonous stutzeri)* commonly found on Earth (Shivaji S, personal communication). However, using the same method, the CCMB group was unable to detect any microorganisms in any of the cryosampler samples from the experiment referred to by Wickramasinghe and colleagues.

Shivaji and I have asked the Cardiff group many times to repeat the work in the CCMB, but they declined to do so, leading us to believe that their results might not be reproducible. For this reason, we declined to be co-authors on the article they published in *FEMS Microbiology Letters*. In fact, the organisms that the Cardiff group isolated from the samples, which they claim came from space, are all normal residents of the surface of our planet.

If SARS came from space, cases of the disease should have occurred independently and concurrently in more than one location on our planet. The fact is that all cases (without exception) can be traced to a single location of an extremely small size in China. Furthermore, if Wickramasinghe and colleagues were correct, new foci of SARS should have appeared by now; on the basis of what we know about the virus, this possibility would decrease exponentially with every passing day.

Finally, SARS is a coronavirus. No such virus—or for that matter any RNA virus—unlike bacteria, is known to be resistant to the kind of radiation present in space.

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1 Wickramasinghe C, Wainwright M, Narlikar J. SARS—a clue to its origins? *Lancet* 2003; **361:** 1832.

Author's reply

Sir—All of the points your correspondents raise have been answered elsewhere.[1–3] In particular, a full explanation of the view that viral diseases could have a non-terrestrial origin can be found in *Diseases from Space*.[4]

Eske Willerslev and colleagues claim that NASA scientists have, since the late 1980s, shown that non-volcanic dust can reach, and remain in, the stratosphere. If this statement is true, then an Earth origin for our bacteria becomes likely. However, the dust referred to was sampled at between 17 km and 19 km above the Earth's surface[5]—that is barely, if at all, into the stratosphere—whereas our sampling height was 41 km.

Willerslev and co-workers, and Samuel Ponce de Leon and Antonio Lazcano maintain that since the bacteria we found in the stratosphere have the same 16s rRNA sequence as bacteria found on Earth they must originate from Earth, simply because bacteria from space would be expected to have evolved at different rates from those on Earth. We have commented elsewhere[3] that bacteria with the same sequences as their modern counterparts have also been found in Oligocene amber and Permian salt crystals. These independent findings suggest our understanding of bacterial evolution and phylogeny might be erroneous and that criticisms based on it might yet prove wide of the mark.

In his letter, Pushpa Bhargava does not mention that the pseudomonas work he refers to was offered for publication as evidence for life in the stratosphere, yet remains unpublished. Our work, by contrast, has been printed in an international, peer-reviewed journal.[3] We cannot explain why Bhargava's group are unable to replicate the isolation of viable, but non-cultureable, bacteria achieved independently by microbiologists here and in Cardiff.

All the correspondents seem determined to attack panspermia. The evidence will eventually accumulate to show who is right.

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1 Hoyle F, Wickramasinghe NC. Astronomical origins of life. Dordrecht: Kluwer, 2000.
2 Wickramasinghe C. Cosmic dragons. London: Souvenir Press, 2001.
3 Wainwright M, Wickramasinghe NC, Narlikar JV, Rajaratnam P. Microorganisms cultured from stratospheric air samples obtained at 41km. *FEMS Microbiol Lett* 2003; **218:** 161–65.