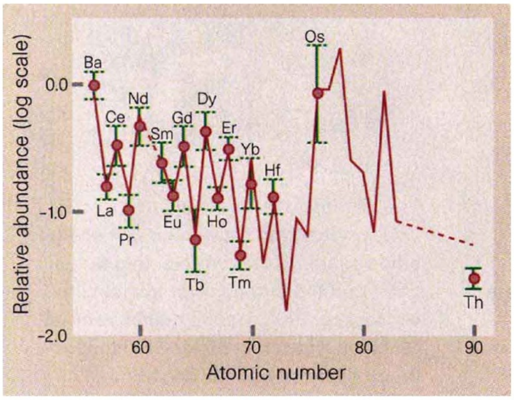

Thorium loss. The pattern of heavy-element abundances in the star CS22892–052 (green) matches that in the Sun (yellow line), except in the case of ^{235}Th, which has a radioactive half-life of about 14 billion years. CS22892–052 is probably between 13 and 21 billion years old. (From ref. 1.)

prediction requires models for the chemical evolution of the Galaxy and for the complicated chains of element synthesis in stars and supernovae. Although there have been careful investigations along these lines before, the results have been considered slightly dubious because of the strong dependence on modelling complicated processes. To see how the new work bypasses these uncertainties requires a little background.

The bulk of every element heavier than boron has been formed by nuclear reactions in stars, becoming recycled into the interstellar medium and incorporated into new stars. That is why the oldest stars in the Galaxy are much poorer in these elements than is the Sun. Equilibrium nuclear fusion produces elements up to iron; the heavier elements are mostly formed by non-equilibrium reactions, where neutrons are added to nuclei to build heavy, unstable atoms which then decay into stable atoms. One such route is the 'r-process', in which many neutrons are added between decays.

Nearly all the potential 'nucleochronometers' — elements that have half-lives in the region of one to ten Gyr — are produced via the r-process. But there is an astronomical catch-22 involved in measuring the abundances of most r-process elements. Their generally weak absorption lines can be overwhelmed by a forest of other line blends — iron is the biggest culprit — and attempting to minimize the iron confusion by observing more chemically deficient stars doesn't necessarily work, because the lines from the elements of interest are likely to be weaker too.

Fortunately, there is a way out. The chemically poor stars of the Galactic halo can have iron abundances as small as 1/10,000 of the solar value, but the ratio of r-process elements to iron is usually higher than it is in the Sun. Why? The r-process is thought to occur in very massive stars, which explode as supernovae after a short life. In contrast, much of the iron in the Galaxy is thought to be produced in supernovae of a different type, with much longer-lived progenitor stars; so the old halo stars were formed before there was much iron around.

This is where CS22892–052 enters the story. It is one of the 'ultra-metal-deficient' stars in the halo, with the highest-known ratio of r-process elements to iron — so high that it is possible to measure the abundances of 17 such elements, from barium to thorium. As first reported in Sneden *et al.*[2] and discussed more fully by Cowan *et al.*[1], when the abundances of stable r-process elements in CS22892–052 are plotted against scaled Solar System abundances, the patterns match almost perfectly (see figure). The only exception is ^{235}Th, which in CS22892–052 sits a factor of two below the scaled solar value (corrected for decay over the past 4.6 Gyr).

Based on the pattern of stable elements, it seems inescapable that the r-process synthesis that preceded the formation of CS22892–052 was essentially identical to the one that preceded the formation of the Sun. Given the factor of two deficiency in thorium, and its half-life of 14.2 Gyr, it is trivial to derive an age of about 15 Gyr. This estimate is independent of Galactic chemical evolution and of stellar-model-based ages of globular clusters.

But this is actually a lower limit to the age of CS22892–052, as it assumes that the thorium in the Solar System was synthesized just before the formation of the Sun. In fact, much of it is bound to be older, so the initial thorium abundance was higher and the age of CS22892–052 must be greater. The authors' preferred evolution model corrects the age of this star to 17±4 Gyr.

Does this prove the stellar modellers correct? With only this single measurement in one star, and the single line of thorium, it is premature to consider the age of the oldest stars a solved problem. Observations with improved signal-to-noise ratio and higher spectral resolution are possible, however, and will decrease the large uncertainty. There are many additional candidate stars, and in the next few years this will be a hotly pursued line of research. But this is already an ominous discovery for conventional cosmology. It is rare to have such a clean result with bearing on such an important problem.

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Daedalus

Youth in age

Spare-part surgery is a demanding business. Organs such as hearts, livers, kidneys, and so on, can often be implanted successfully into patients whose own organs have failed. But nervous and glandular tissue is very hard to replace, and rejection is always a problem. Daedalus now has a new approach.

Every part of our bodies is formed by the differentiation of fetal cells, guided by the environment around them. By the time a part is finally formed, its cells have more or less exhausted their regenerative capacity, and can seldom repair serious damage. But imagine, says Daedalus, that a small amount of (e.g.) brain tissue were removed from a newborn baby, and stored in liquid nitrogen. Many decades later, its owner might begin to suffer brain trouble: perhaps Alzheimer's or Parkinson's disease. The long-stored sample of tissue could be warmed up, and cultured in a suitable medium (even brain cells can be cultured these days). The result would be a useful quantity of the patient's own brain cells. They could be injected into the site of damage without fear of rejection. And these new cells would still have all the plasticity of youth. They would differentiate in the normal youthful way, taking their clues from the cells around them. They would make the right sort of connections to the rest of the brain, and form a splendid 'hardware patch' for the failing region.

This scheme can clearly be generalized. Small samples of many crucial tissues — liver, nerve, bone marrow, thyroid, gonad, and so on — could be taken from each newborn baby, and stored in liquid nitrogen as an insurance against future trouble.

Accident and old age would lose many of their terrors. No longer would their victims have to wait for some donor of a new part to become available. Their own repair material would be always at hand, ready to grow spontaneously into the required form on simple injection. Even the normal but still resented features of advancing age, such as sexual decline, might be alleviated. At the age of perhaps 35 or 40, one might have a stored sample of one's own neonatal gonadal tissue reinjected. Nothing much would happen; but ten or twelve years later, the injected tissue would start its own private pubertal development. Its owner would enjoy a surge of new youthful vigour and enterprise, countering the normal decline. He or she would probably not live any longer, but would enjoy a much livelier old age. And governments would be delighted. They would be able to reset pensionable age to about 95. **David Jones**