region were similar: temperatures were low before the heating events (below 700 K) and chondrules cooled quickly after formation. The data of Misawa and Nakamura[2] contribute to a better characterization of the precursor material of chondrules which contained refractory lithophile elements. The earlier authors cited above concluded that an epoch of condensation or fractional condensation of hot gases in the nebula produced an assortment of refractory and other dust before the chondrules formed. The refractory components of most chondrules contain elements such as rare-earth elements (REE), calcium, aluminium and less-refractory elements such as magnesium, nearly in their solar proportions.

CAIs are less abundant than chondrules and are much richer in refractory elements. Although some CAIs seem to have been melted, many do not. The origins of the many types of CAIs are even more controversial than those of chondrules. Some, like chondrules, are thought to be the products of high-temperature processing of pre-existing solids in the nebula. Others could be the direct products of condensation. Isotope evidence indicates that many CAIs incorporate presolar components not found in chondrules. The conditions that many CAIs formed under seem to have been different from those of chondrule formation: cooling rates were slower, and there is little evidence of low ambient temperatures before their formation.

Several types of CAIs have extraordinary fractionated abundance patterns of REE and other refractory elements. The abundances of refractories can be uniform or monotonic functions of elemental volatility or even hump-shaped functions of volatility as in the group-II CAIs discussed by Misawa and Nakamura. The only processes that can produce Group-II patterns are fractional condensation or evaporation at very high temperatures. Most chondrules previously studied, and presumably the others in Misawa and Nakamura's study, have REE abundances that are uniform or vary smoothly with ionic radius, not with volatility as in group-II patterns.

Misawa and Nakamura now report in this issue[2] that some chondrules do have group-II fractionated REE and refractory element patterns similar to those previously found only in CAIs. In fact, chondrules with fractionated REE and other refractory elements had been found previously, but were, for the most part, ignored because they were so different from other chondrules. Chondrules nearly identical in composition and texture with Misawa and Nakamura's Felix-8 were found in Ornans (CO) and Allende (CV)[5,6]. It now seems likely that several per cent of all chondrules in carbonaceous chondrites have fractionated REE patterns. In ordinary and enstatite chondrites, which contain far fewer CAIs, no samples with group-II REE patterns have been found among several hundred chondrules studied.

These observations imply that at least some CAIs formed earlier than chondrules, but in the same or a nearby nebular location. Although the origin of CAIs, including those with group-II patterns, is disputed, the chondrules with group-II patterns must have been formed by the melting of an assemblage of grains including lower-temperature components and an already-formed group-II refractory component. As Misawa and Nakamura show[2], very high-temperature processing must have occurred before chondrule melting. Perhaps small CAIs occasionally mixed with more normal, lower-temperature chondrule precursors. If so, models of the solar nebula must allow for a gradual change in conditions from those inferred for CAIs to those inferred for chondrules.

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Did the prey predate the parasite?

OVER evolutionary time it is not altogether a rare event for prey to survive being eaten. Some may pass through the predator's digestive system unharmed, others might profit from the gut environment and reproduce there, while in extreme cases the prey might find a new niche after passing through the gut wall. These are probably the most usual evolutionary routes from a free-living to a parasitic lifestyle, but a recent study on the ciliate *Lambornella clarki* reveals a novel twist to the evolution of parasitism among prey species (Washburn, J.O. *et al. Science* 240, 1193; 1988).

***L. clarki* is often found in pools in tree-holes where it feeds on bacteria and other microorganisms. Occasionally, larvae of the mosquito *Aedes sierrensis* develop in the same treeholes where they prey upon the free-living ciliates. All is not lost, however, if the ciliates get sufficient advance warning of the presence of a potential predator. Shortly after detecting the mosquito larvae, the ciliate population undergoes a dramatic transformation. The potential prey are able to transform into very effective parasites: the free-living pear-shaped ciliates divide and their offspring transform into spherical cells termed theronts. The theronts make small holes in the cuticle of the mosquito larvae through which they enter the haemocoel. Once ensconced within the body of their would-be predators, the theronts are able to absorb sufficient nutrients to reproduce and ultimately kill their hosts. As they die, the parasitized mosquito larvae release numerous free living ciliates, some of which may transform into parasitic theronts and attack surviving mosquito larvae.**

The carefully controlled experiments of Washburn *et al.* reveal that water previously conditioned by the presence of mosquito larvae is sufficient to produce a high level of parasite production. Transformation starts after about 40 hours which is, significantly, just short of the time taken for non-feeding first-instar mosquito larvae to develop into efficient predators. The rate of transformation seems not to depend on whether the mosquito larvae had been feeding on a ciliate population.

IMAGE UNAVAILABLE FOR COPYRIGHT REASONS

Courtesy of Jan Washburn/*Science*.

Above, three free-living trophonts and one parasite theront of L. clarki. *Below, invasive cysts formed by theronts on the cuticle of* A. sierrensis *larva.*

Nevertheless, under controlled conditions, water that has not been conditioned by mosquito larvae also results in the production of a few potentially parasitic theronts. In the wild, such theronts would die within 24 hours if mosquito larvae did not appear. But if they did, the theronts would be at a marked selective advantage over their free-living conspecifics. Unfortunately, it is not yet clear whether the parasitic or free-living ciliate is the ancestral morph. It is not uncommon for the parasitic ciliates to exterminate mosquito populations from naturally occurring treeholes. Whatever further work is done on this fascinating system, the identification of a potential biological control agent for one species of mosquito perhaps holds hope for others.

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