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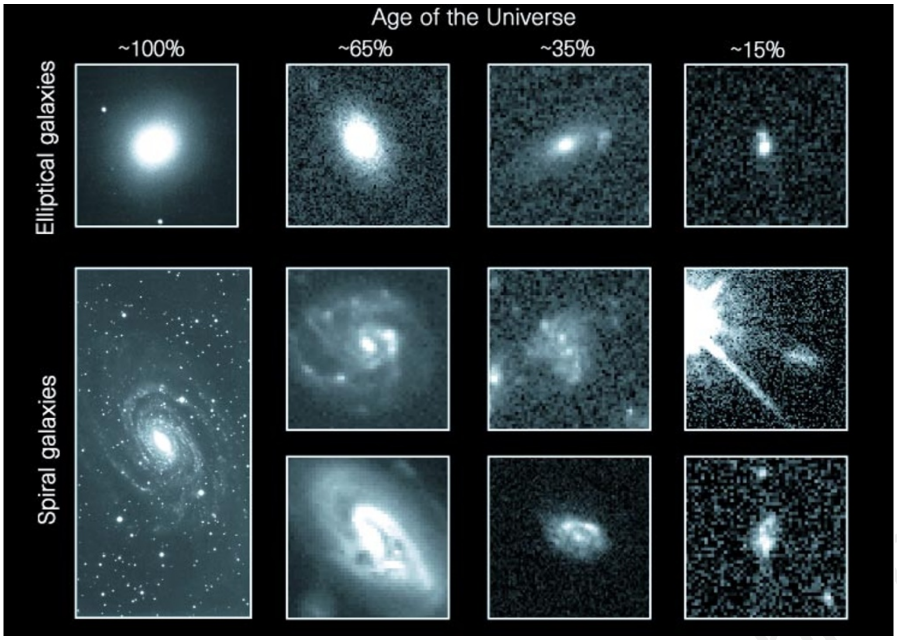

Figure 2 **The evolution of elliptical and spiral galaxies. Whereas ellipticals are easily recognized even in the early Universe, the distinctive structure of today's spiral galaxies appears increasingly disturbed at earlier times.**

probable spiral progenitors in the Hubble Deep Field are lumpy and twisted, at these redshifts Noguchi's disk is smooth.

However, in cosmological simulations that use our best guesses as to the state of the early Universe, galaxy formation proceeds hierarchically. Galaxies are built by mergers and fragile stellar disks are often destroyed when they combine to form hot, spheroidal objects at high redshifts[10]. Ummm, OK, let's invert our map again! Now we can account for ellipticals. But what road leads to the thin, rotating spirals we see today?

Clumps to the rescue. In Noguchi's isolated galaxy, clumps help form disks with surface density profiles similar to those of real spirals. But it is difficult to determine whether the bulge-to-disk mass ratio in the model is representative of spirals, and whether a thin disk still exists at the final time.

How can we distinguish between Noguchi's model and a hierarchical picture, in which clumpiness could be produced by merging among small companion galaxies? One difference is that, in Noguchi's model, the clumps should all rotate around a common centre, and observations may be able to detect such rotation.

What other phenomena might clumps cause? Noguchi suggests that they may be the seeds that produce active galactic nuclei, whose huge luminosities are attributed to gas being accreted onto a supermassive black hole. Mergers of orbiting clumps might feed active galactic nuclei, by inducing an inflow of gas. But neither in Noguchi's models nor in hierarchical models is the resolution high enough to explore this assertion in detail.

Noguchi's simulation is alluring in that it treats galaxy formation at a resolution not easily obtained by cosmological simulations. But such simple models both triumph and fail: because it does not rely on cosmology, the collapse need not be limited to a particular time in the Universe; but neither does it predict a cosmology that can be tested against the real Universe. Such models leave us with no map. □

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Ecology

Nipped in the bud

There are many examples of happy partnerships between plants and ants, in which, for instance, the plant gains protection from herbivores and in return the ants are housed. These symbiotic relationships can, however, be so one-sided that they verge on parasitism, and a striking example is described by Douglas Yu and Naomi Pierce in *Proceedings of the Royal Society of London B* (265, 375–382; 1998).

The plant involved is a member of the Boraginaceae family, *Cordia nodosa*, which grows to some 2 m in height and is a common constituent of lowland forest in southeast Amazonian Peru. The ant belongs to the genus *Allomerus*, and inhabits so-called domatia, specialized swellings in the stems of the host. Yu and Pierce found that almost 80% of the plants they sampled contained colonies of *Allomerus*.

The ant, however, manipulates the plant to its own ends by destroying the flower buds and flowers while energetically protecting the leaves from attack by other insects. The ants don't eat the buds or flowers — they just wilfully chew off the reproductive structures in what Yu and Pierce refer to as acts of 'castration'. The result is ravaged buds, such as those shown here, and a dramatic reduction in fruit production. Conversely, senescence of the plant's branches is delayed, thereby providing more domatia for the ants. There appears to be no gain for the plant in this, just the pain of severely impaired reproductive capacity. Nor, apparently, does the plant retaliate in any way.

The question then is why, given that the host's competitiveness must be adversely affected, does this ant–plant relationship seem to persist and be widespread? Yu and Pierce think that one explanation may lie in the truly mutualistic relationship that *C. nodosa* has with three species of another genus of ant, *Azteca*. These species — the

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good guys as far as the plant is concerned — inhabited only about one-tenth of the *C. nodosa* sampled. But these plants reproduce normally and may provide enough new recruits to keep the overall population stable.

Further twists lie in the observations that a few of the *C. nodosa* examined carried colonies of both genera of ant on separate trunks; the respective effects on plant reproduction were as expected from the main findings. More curiously, in fewer than 1% of cases the *Allomerus* ants left the buds alone, and the host fruited normally. That tantalizing finding defies explanation.

Tim Lincoln