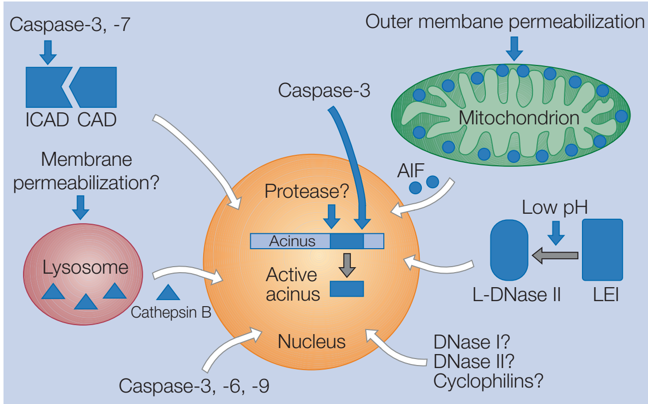

Figure 1 **Apoptotic effectors that act on the nucleus. Disruption of intracellular compartmentalization (which is well established for mitochondria but putative for lysosomes), or pH-driven conformational change, culminates in the nuclear import of effector proteins — such as caspase-activated DNase (CAD), apoptosis-inducing factor (AIF), cathepsin B, L-DNase II — or in the activation of Acinus, which is already present in the nucleus. Sahara *et al.*[1] report that cleavage of Acinus by caspase-3 and an unknown protease generates an active fragment that can cause chromatin condensation, despite lacking DNase activity. It is not clear which pathways co-activate and/or require Acinus for chromatin condensation. Other proteins with DNase activity, which are thought to be involved in apoptotic digestion of chromatin, are also listed.**

in the absence of caspase activation. Similarly, inactivation of the caspase-3 gene does not prevent chromatin condensation. Rather, it modifies the pattern of the process, or retards it according to different cell types or stimuli[6,7].

One of the proteins responsible for caspase-independent chromatin condensation has, in fact, been identified. Known as the apoptosis-inducing factor (AIF), it is a flavoprotein that is normally confined to the space between the outer and inner mitochondrial membranes[8]. Once apoptosis is induced, AIF translocates from the mitochondrion to the nucleus, where it causes partial chromatin condensation in the periphery of the nucleus[8]. This pattern of condensation is clearly distinct from those induced by CAD (ref. 3) or Acinus[1]. AIF causes degradation of DNA into fragments greater than around 50 kb in length[8] — a large-scale DNA fragmentation that precedes the more advanced internucleosomal degradation.

Another chromatin-condensation factor, which translocates from the cytoplasm to the nucleus, is L-DNase II (Fig. 1). This protein is derived from a serpin-like protease inhibitor, leukocyte elastase inhibitor, through a post-translational modification that may be triggered by cytosolic acidification[9], a metabolic change that often accompanies apoptosis. When added to purified nuclei, the L-DNase II causes a marked chromatin condensation and chops the chromatin into nucleosome-sized fragments[9]. Yet another protein that might contribute to chromatin condensation and internucleosomal DNA fragmentation is cathepsin B. This protein could be activated on its release from lysosomes of the apoptotic cell[10]. Alternatively, cathepsins might act as degradative enzymes in the phagolysosome.

Why are there so many chromatin-condensation factors? One possibility is sequential action. For example, AIF may act before the caspase-dependent chromatin-condensation factors[8]. Another idea is complementarity, which is evident from the many different effects of the distinct apoptosis-promoting molecules that act on the nucleus (Table 1). Finally, redundancy is suggested because apoptotic extracts can contain CAD and other chromatin-condensation factors[3], including Acinus[1]. Redundancy is underlined by the observation that, in Jurkat cells, overexpression of a caspase-3-resistant ICAD mutant prevents CAD-mediated DNA fragmentation, yet fails to abolish (Acinus-mediated?) chromatin condensation[11]. Some chromatin-condensation factors such as CAD are expressed in a strictly tissue-specific fashion[12], indicating that chromatin condensation may result from distinct molecular processes in different cell types. This means that, although they are morphologically uniform, pyknosis and karyorrhexis may result from highly specialized processes. Part of the mystery remains to be pierced. ■

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Daedalus

Weed insulation

Last week Daedalus proposed a ship coated with ice. Not only would it have the lowest possible skin-friction; fouling organisms could never grow on its hull. He now doubts this latter assertion. No marine plant is known to anchor itself to ice. But many specialized bacteria can live in ice, and tundra lichens can survive in an environment dominated by it. So perhaps a seaweed exists, or can be bred, to flourish on an icy surface.

Many seaweeds anchor themselves to solid surfaces, both naval and natural. They do so, not to draw nourishment from the surface, but to contact a large volume of water as it sweeps past their anchorage. A seaweed that could fasten itself to ice would gain the same benefit. DREADCO biologists are now trying to create one.

The trouble, of course, is that natural ice is usually melting. No plant can stick to its surface; it needs to carve out a cavity. Daedalus recalls that Arctic fish, like many other cold-adapted species, generate high internal concentrations of special anti-freeze compounds. If the genes for such a compound could be transferred to seaweed, and the plant could learn to exude it from its anchoring foot, it could melt out a secure root-cavity in the ice. As fast as the ice melted, it would deepen and renew its cavity. It could spread as a permanent coating on the submerged surface of an ice shelf, even colonizing the underneath. Enough light would penetrate the ice to sustain photosynthesis.

This challenging biological project has a bold ecological purpose — to reduce the melt-rate of the polar ice. During the Second World War, an artificial iceberg was proposed as an aircraft-carrier. To reduce its melt-rate, it was to be made from a dilute suspension of wood-pulp in water. This would give it a furry surface, which would be an excellent thermal insulator. Similarly, the Arctic and Antarctic polar ice shelves could be insulated by seeding them with Daedalus's ice-weed.

A menace of global warming would thus be countered. Released in the polar oceans, ice-weed would spread luxuriantly under the polar ice shelves and submarine glaciers, reducing their rate of melting. Their contribution to the rising sea-level would be cut right back. They would also release fewer free-floating icebergs to menace the world's shipping lanes. The bergs that were released would, of course, be thoroughly weed-insulated, and would last much longer. They might even be captured and towed into tropical ports for use as sources of fresh water. **David Jones**