New Regulatory Mechanism of Parasitism

Parasites of certain red algae insert nuclei into the cells of their hosts and cause dramatic changes in metabolism and morphology

Parasites as a class deploy a wide and inventive range of methods for bending the activity of their hosts to support their own needs. But, until recently, none had been shown to perform the trick that certain red algal parasites are now known to do: they insert nuclei into the cells of their hosts. As a consequence, the morphology and metabolism of the invaded host cell alter dramatically as it shifts into high-gear food production, from which the parasite benefits.

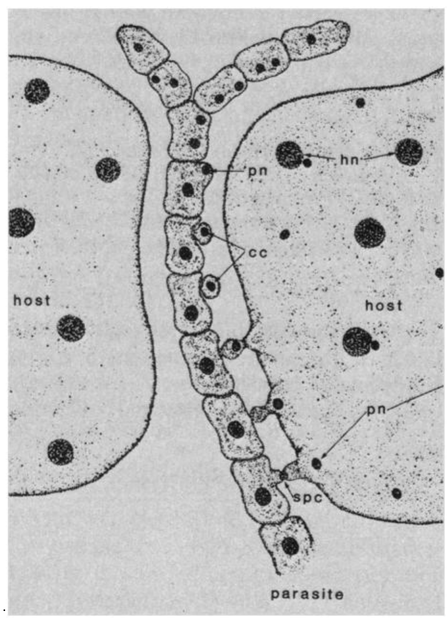
Lynda Goff, of the University of California, Santa Cruz, and Annette Coleman, Brown University, were able to demonstrate unequivocally the transfer of nuclei between the tiny red algal parasite *Choreocolax* and its distantly related red algal host *Polysiphonia* by the application of microspectrofluorometry (*1*). Conventional staining and microscopy techniques have previously proved inadequate in showing up nuclear locations and affinities in the somewhat impenetrable world of red algae and their parasites.

Goff and Coleman describe the system as "a new and remarkable regulatory mechanism of parasitism," but they are as yet unable to say whether the host cell's transformation is the result of activity of the parasite nucleus or is caused by cytoplasmic agents that are transferred with it. However, because the nuclei persist in their new environment for many weeks rather than being degraded as often happens in experimental cell fusions, the chances are that the nuclei are active. In any case, this aspect of red algal parasitism clearly raises some interesting questions about heterogenous nuclear-cytoplasmic interactions. And, as invaded host cells survive and function for long periods with foreign nuclei scattered about their cytoplasm, the concept of the "individual" is inevitably blurred.

Red algae (Rhodophyta) represent a somewhat bizarre branch of the biological world, for many reasons but particularly in their relationship with parasites. For a start, there is an extraordinarily large number of parasites in this group of eukaryotic plants. More than 15 percent of known genera of the major class Florideophyceae are parasitic. And all of these parasites have other, often closely related, red algae as their hosts. Moreover, host specificity can be extraordinarily narrow, sometimes down to the level of discrimination between different populations of the same species.

The most unusual property among the higher forms of the Florideophyceae, however, is the existence of extensive linkages—called, for somewhat arcane reasons, pit connections—between cells. It is this property that appears to underlie the abundance of parasitic forms in this group, all of which deploy nuclear transfer to their hosts.

Growth of organisms in this group usually follows the same pattern: apical growth of uninucleate cells. Following cell division the two daughter cells remain in intimate contact with each other, as the septum between them is incompletely formed, even though a glycoprotein plug later forms. The resulting linkage is known as a primary pit connection.



Nuclear invasion

A parasitic filament grows between host cells. A condensed parasite nucleus (pn) is enclosed in a conjunctor cell (cc) and then inserted into the host cell when a secondary pit connection (spc) forms.

A similar linkage—called a secondary pit connection—can be established between adjacent nonsister cells, but this usually involves the transfer of a nucleus from one cell to the other. Why this group of red algae sets up such an elaborate network of plugged connections is a topic of much discussion but little agreement among algologists. The obvious, and perhaps most popular, notion is that they form a system of conduits, but movement of anything through them remains to be consistently demonstrated.

The existence of secondary pit connections between *Polysiphonia*, the centimeter or so long filamentous turf so common on tropical and temperate intertidal zones, and *Choreocolax*, whose tiny filaments weave between the cells of its host, has been known for some time. But before Goff and Coleman applied microspectrofluorometry to this red algal pair, no one had been able to confirm or deny the reasonable inference that nuclei also passed between parasite and host.

What happens is that cells at the growing tip of the parasite undergo an asymmetric cell division and split off a small conjunctor cell, which contains a tiny condensed nucleus. The conjunctor cell makes contact with an adjacent host cell, a pit connection is formed, and the nucleus is inserted into the host (see diagram). The result is that the infected cell may enlarge to 20 times its normal size, the cell wall thickens, and various cytoplasmic alterations develop. The number of host nuclei increases, as does their DNA content. Mitochondria and chloroplasts multiply, and photosynthetic products accumulate. It is interesting that this constellation of changes is restricted to cells invaded by parasite nuclei: adjacent host cells are unaffected.

All the host/parasite interactions among the Florideophyceae apparently operate in this same manner. This, together with the very tight host/parasite specificity and the usually close (within family) relationship between the pairs, should offer interesting insights about the evolutionary affinities among the red algae. The taxonomy of this group is currently less than satisfactory, being based in the main on recondite events surrounding fertilization.

There are, of course, other possible interpretations of the apparently close taxonomic relationships between hosts and parasites among this group. When in speculative mood, Goff likes to contemplate the possibility of genetic exchange between host/parasite pairs. The highly unusual mechanism of parasitism clearly offers an opportunity for such exchange.—**Roger Lewin**

References and Notes

1. L. J. Goff and A. W. Coleman, *Proc. Natl. Acad. Sci. U.S.A.* **81**, 5420 (1984).