TABLE 13.5 Advantages and Disadvantages of Organ Cultures

Advantages
Biosynthetic capacity often returns upon organogenesis.
Product spectrum for flavors and fragrances returns to that for parent plant.
Product secretion is enhanced in many cases (particularly root cultures).
Genetic stability under growth conditions is greatly improved over callus or suspension culture.
Self-immobilization; provides more optimal mix of cell types.
Disadvantages
Growth rates may be lower than suspension cultures in some, but not all cases.
Efficient, scalable reactors for organized tissues need to be developed.
Control of microenvironmental conditions is often more difficult.

The primary disadvantages for organ cultures have been their apparently slow growth rates and difficulties in designing effective bioreactors to handle organized tissues. Recent advances suggest that both limitations may be circumvented, and in several cases, organ cultures that grow more rapidly than their corresponding suspension cultures have been found.

Some plants (some dicots, but no monocots) will respond to infection by *Agrobacterium rhizogenes* with rapid root proliferation. This infection leads to *hairy roots*. The best doubling times for hairy root cultures approach or exceed typical values for many suspension cultures. Even in species not susceptible to *A. rhizogenes* infection, recent results indicate that proper control of hormone content can accelerate growth rates to acceptable levels (three- to five-day doubling times). The biggest difficulty with the large-scale culture of roots is the formation of root *mats*. These mats restrict internal mass transfer, can entrap gas and float, and present significant problems in maintaining a scalable uniform environment. However, large-scale units for root culture have been built (20000 l for ginseng roots in Japan). Laboratory-scale reactors using a mist or forced convection of liquid nutrients appear promising and provide much better mass transfer in the center of root mats.

One other advantage of using organ cultures over whole plants is the possibility of using precursor feeding and elicitors. For example, with species of onion and garlic, the use of precursors can greatly enhance the formation of flavor compounds. Different precursors give different levels of enhancement to particular components of the flavor spectrum. By using combinations of chemical precursors, it may be possible to custom-make flavors for specific applications.

Shoot cultures present additional problems. Light may be required for some shoot cultures, while roots can be grown easily in the dark. Shoot cultures may be *mixotrophic*, involving the exogenous supply of sugars as well as some photosynthesis. In some cases, control of the *photoperiod* (hours of exposure to light per day) is important. However, the most crucial need for light comes from the role that light often plays in cellular regulation. Exposure to light of certain wavelengths is essential to induce synthesis of some enzymes. In at least some cases, these enzymes play a crucial role in secondary metabolism. The maintenance of uniform light intensity in a large reactor is a challenging and partially unsolved problem.

One other perceived limitation on shoot cultures has been the belief that they could not be grown under totally submerged conditions. Recent experiments have shown that