

Since most secondary products are not made in rapidly growing cultures, two-phase fermentations are employed. The first phase is used to promote growth, and a second phase is optimized for product formation. Liquid suspensions can be cultured analogously to fermenters for microbes, if the special characteristics of plant cells are taken into account. Alternatively, immobilized or entrapped cell systems can be used. In either case, *elicitors* can often be used to enhance product formation. A combination of immobilization and *in situ* separation techniques can often dramatically improve production.

Organized tissues (shoots, roots, and embryos) hold promise as techniques to improve yields. However, bioreactor designs that supply homogeneous environments for organ cultures are only now being developed.

## SUGGESTIONS FOR FURTHER READING

### *Overview on plant physiology*

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### *Overview on plant cell culture*

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## PROBLEMS

- 13.1.** The uptake of the auxin, indole acetic acid (or IAA), by suspension cultures of *Parthenocissus* sp. is nearly zero order at 1 nmol/mg dry cell weight-min. The diffusivity of IAA in water