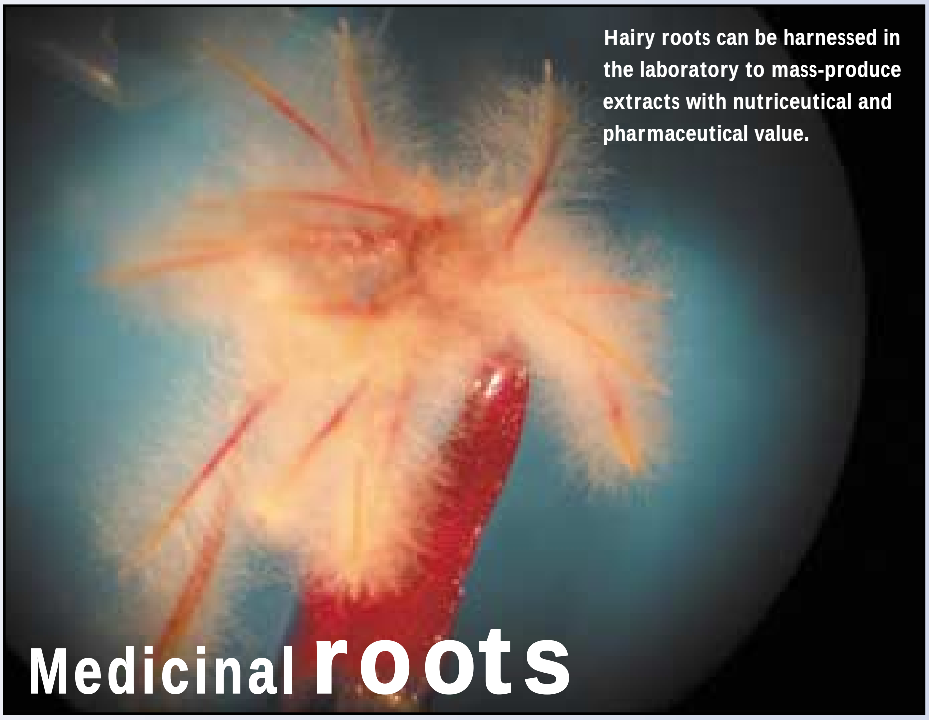
Medicinal roots



Hairy roots can be harnessed in the laboratory to mass-produce extracts with nutriceutical and pharmaceutical value.

A disease of plants could help scientists produce remedies for human ailments. 'Hairy root', occurs when the soil bacterium, *Agrobacterium rhizogenes*, infects wounded plant cells, triggering the production of a malignant mass of fine roots. In nature, this leads to stunted plants. But in the laboratory, hairy roots can be harnessed to produce plant extracts with nutriceutical and pharmaceutical value.

Dr Philip Franks of Food Science Australia, and his colleagues in the CRC for Bioproducts, are investigating the use of hairy roots to mass-produce the active ingredients found in herbal medicines such as echinacea, ginseng and gynostemma. By introducing *A. rhizogenes* into tissue cultures of the herbs that manufacture these compounds, they hope to produce large quantities of hairy roots – up to 10 000 litres – and commercial quantities of the target extracts.

'Some of the plants our herbal medicines are extracted from grow very slowly, and demand is greater than supply,' Franks says.

'So we're looking at ways to supply that demand by producing high concentrations of a standardised product through plant tissue culture in large scale fermenters. Typically you can get 10–100 times more product per mass of plant material in a fermenter than in the field.'

Plant tissue culture has been used to produce ginseng at a commercial scale and is used to manufacture commercial quantities of anti-cancer agents. The technology is also being investigated as a means of producing biopolymers (such as food emulsifiers) and pigments for foods.

The technology takes advantage of the fact that every cell in a plant contains the information it needs to produce a whole new plant. This 'totipotency' allows scientists to take a small piece of leaf, root or stem, and produce a clump of undifferentiated cells known as a 'callus'. Then, by manipulating the nutrient and growth hormone concentrations fed to the callus, they can produce shoots, roots, or a complete plant.

To produce compounds such as plant biopolymers, on a large scale, the callus is gradually introduced to larger and larger volumes of liquid culture. These 'apple-sauce' cultures consist of clumps of individual plant cells all manufacturing the compound of interest. To produce more complex chemicals such as herbal medicines, however, differentiated plant tissue may be needed. This is where hairy roots come in.

'While every plant cell is capable of producing the same thing, some chemicals are only produced by specialised tissue,' Franks says.

'With a differentiated tissue, such as hairy roots, you can have a degree of specialisation between the cells. So cells on the outside of a root might produce a chemical that is then modified by cells on the inside of the root to produce the bioactive chemical we're interested in.'

Franks says hairy roots also have a higher growth rate than normal roots. This means higher productivity per litre of fermenter volume, and cheaper production costs.

The research group has hairy root cultures for several different species of the medicinal herbs being studied. The next step is to get these cultures growing in larger volumes of liquid. Some technical challenges will also need to be addressed. For example, hairy roots are so fine that a fermenter could become root-bound, much like a plant that has outgrown its pot.

'There are many different types of hairy roots; some are like peach fuzz and others like maiden-hair ferns without the leaves,' Franks says

'We're still learning how to pick and choose and manipulate the roots to get one that's easy to use and suitable to scale up.'

Franks says that if the technical challenges are met, the technology could be used to produce more human medicines. 'With so much potential for drugs from rainforests, there are big biodiscovery programs everywhere,' he says.

'But it's difficult to produce complex drugs synthetically, and you can't go cutting down rainforests.

'Plant tissue culture will give us a way of doing something with those discoveries. And with our unique 10 000-litre pilot plant, Australia is well positioned to take advantage of them.'

Food Science Australia is a joint venture of CSIRO and the Australian Food Industry Science Centre (Afisc)

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The CRC for Bioproducts develops commercial products from plants and other organisms, such as natural colours, complementary medicines, nutri-ceuticals, pharmaceutical intermediates and biopolymers. The research is based on developing plant cell culture and fermentation techniques, as well as novel extraction and separation technologies. Partners in the CRC include Food Science Australia, the universities of Melbourne, Newcastle, New South Wales, and Flinders, the Australian Wine Research Institute and several industry participants.