other approaches.

One enlightening study was that by Dobkins and Folk[6] of pebbles on beaches in Tahiti. Among the advantages of studying beaches in Tahiti is that all the pebbles are of essentially one rock type, basalt, which has no bedding or crystal orientation and so tends to abrade uniformly. Dobkins and Folk found that the pebbles on the beaches are systematically flatter than those in the streams that originally carried them to the shore, and suggested that this difference results predominantly from pebbles' sliding motion back and forth in the wave swash and from sand blasting. On beaches composed of mixtures of pebbles and sand, slightly flattened pebbles tend to lie on the beachface with their sides upward. The sand carried by the wave swash mainly hits the pebbles on their exposed sides, chipping out minute pits and slowly increasing the degree of flatness. At the same time, spherical pebbles are easily rolled down the beach slope by the backwash of waves. This tends to carry the spherical pebbles offshore, leaving the flatter pebbles on the upper beach where they are more likely to be observed.

Clearly, fragmentation along planar structures in the original rock material can yield flattened pebbles. Equally apparent is that wave-induced abrasion is important in producing the marked symmetry and flat shapes of beach pebbles.

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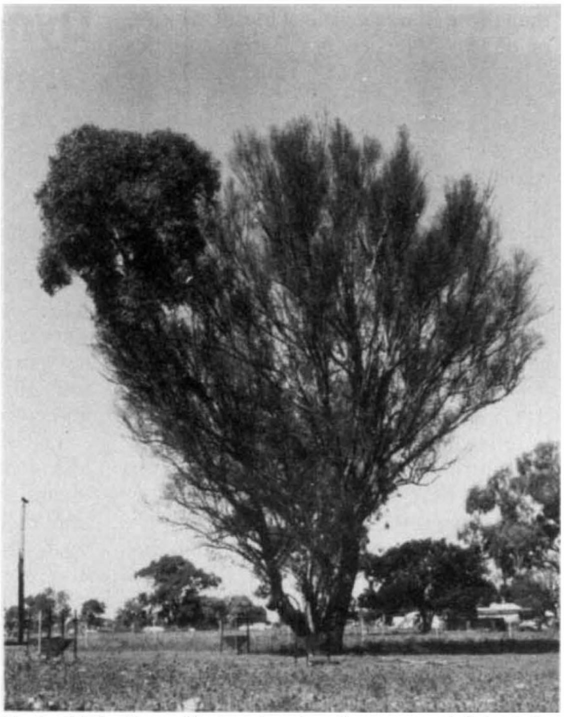
Mosaic resistance in plants

SIR—The existence of genetic variation between different parts of individual plants has long been exploited by plant breeders. This variation could be the basis for an adaptive response by plants to environmental change via the proliferation of tissues expressing newly arisen mutations. Such a process would lead to changes in the phenotype of individual trees over time as well as to the production of seed from genetically different branches. We have obtained the first direct evidence of an adaptive role for genetic variation within plants by measuring the composition of volatile oils among branches of eucalypt trees, the variation of which confers differential resistance to a defoliating insect.

Christmas beetles inflict heavy damage on trees of the genus *Eucalyptus* in south-east Australia, particularly in areas disturbed by agriculture (see ref. 1 for a review). Tree clearance and increased areas of improved pastures provide ideal habitat for soil-dwelling Christmas beetle larvae and this has resulted in a high level of herbivore pressure on the remaining trees when the adults emerge from the soil. During a beetle outbreak near Yeoval, New South Wales, we found a specimen of yellow box (*Eucalyptus melliodora*) which had a conspicuous branch immune to attack by a species of Christmas beetle (*Anoplognathus montanus*). By contrast, other branches were infested with beetles which completely defoliated the rest of the tree (see figure). This observation was supported by feeding trials in the laboratory where beetles were fed exclusively with leaves from resistant or susceptible branches.



Most of this *E. melliodora* tree has been completely defoliated by *A. montanus*, but one branch (on the left) remains virtually untouched.

A comparison of the volatile oil content of leaves from resistant and susceptible branches using gas chromatography showed major differences in the proportions of the main oil components, and these were consistent within each foliage type. The generality of the phenomenon observed in this single specimen of *E. melliodora* was supported by an examination of other trees of the same species in the same area. Of 20 nearby trees, two were uniformly susceptible to attack by *A. montanus* whereas the rest were uniformly resistant. The biochemical differences between these trees were similar to the differences between the susceptible and resistant branches of the mosaic tree.

We found no other mosaic *E. melliodora* at Yeoval, but examples have been discovered at other sites, and again similar differences in oil composition between resistant and susceptible branches were recorded. Furthermore, examples of within-tree variability involving similar biochemical differences have now been found in three other species of *Eucalyptus*.

The pattern of within-tree variation observed in *E. melliodora*, involving entire branches, strongly suggests that the resistant plant tissue has developed from meristematic cells containing newly arisen somatic mutations. Indeed, the biosynthesis of volatile oils is known to be under genetic control (see, for example, refs 2,3), although environmental and developmental factors can also influence the expression of various components (for example refs 3,4).

The occurrence of mosaic *E. melliodora* may be a specific response in susceptible trees to the increase in insect activity brought about by habitat disturbance, and could thus provide a mechanism for long-lived species such as trees to persist in the face of herbivore pressure. In addition, resistant branches will produce seed-containing genes for resistance which will be subject to selection among seedlings. We are raising seedlings from seed obtained from the resistant and susceptible branches to examine their oil content.

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Scientific Correspondence

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