A periderm-color chimera in *Abies*

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A chimera of red and yellow periderm color is described from a population intermediate between *Abies concolor* and *A. grandis*. Its formation probably followed changes in properties of apical initials, rather than in cells produced later in development. Apparently only a single genetic change can control this red–yellow periderm color difference.

Introduction

Periderm color is one characteristic separating the closely related white fir (*Abies concolor* [Gordon and Glend.] Lindl. ex Hildebr.) and grand fir (*A. grandis* [Dougl. ex D. Don] Lindl.). Grand fir periderm is reddish-purple while that of white fir, at least var. *lowiana*, the California variety, is yellowish (Chang 1954; Daniels 1969). Recent studies of *Abies* periderm (Mullick 1971; Mullick and Jensen 1973*a*, 1973*b*) indicate that the reddish-purple pigmentation is in the periderms which develop adjacent to dead cells, called necrophylactic periderms. These include the "usual sequent" and "wound" periderms of earlier descriptions. *Abies* species also develop a sequent periderm equivalent to their first periderm, which is brown in both grand and white fir. These brown periderms are referred to as exophylactic. The color difference separating white and grand fir almost certainly resides in the necrophylactic periderm, although detailed histological examination would be necessary to prove this.

The color difference between the periderms of the two species is easily recognized and has been used to determine the structure of populations intermediate between the two species. In intermediate populations, variation in red pigmenta-

tion occurs, from the intense color characteristic of grand fir to a very light pink (Daniels 1969; Zobel 1973). However, no difference in pigment intensity within a single tree has been reported, except for changes due to weathering of the peripheral layer of bark. This note describes a periderm-color chimera in *Abies*.

Observations

The tree to be described is located in the canyon of Strawberry Creek, about 14 km SSE of Prairie City, Grant Co., Oregon, in a population of predominantly yellow-barked trees. It is about 30 cm dbh (diameter at breast height) and is one of three trees that have grown together at the base.

The periderm-color pattern of the exposed part of the base of the tree is fairly complex (Fig. 1). The red zone R2 continues upwards, at least to 3 m. The ends of the red and partial yellow bands (Fig. 1, R1 and Y2) are hidden under either the soil or the adjacent tree. The color changes are rather sharp (Fig. 2) and the corners of the yellow stripe (Y2) are approximately right angles. The color difference appears to extend throughout the depth of the rhytidome (outer bark). The pigmentation of the red periderm of this tree is quite intense, not the lighter color sometimes found in the area of intergradation of grand and white firs.

How common this phenomenon may be is uncertain. Many hundreds of trees have been examined for periderm color but usually only with a single cut. The chimera was discovered only while we were examining the interface between this tree and one of its yellow-barked neighbors. Over 350 trees within the populations sampled by Zobel (1973) have been reexamined for the presence of this phenomenon; it has not been found again.

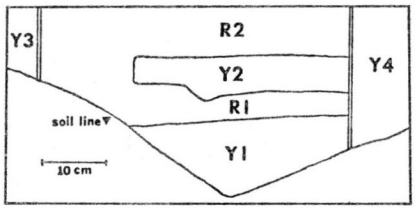

FIG. 1. A diagrammatic representation of the periderm-color chimera. R1 and R2 represent red periderm and Y1 and Y2 represent yellow periderm in the chimera. Y3 and Y4 are the adjacent trees which obscure about half the circumference of the base of the chimera tree.

Interpretation

From the location of the lower yellow band in Fig. 1 (Y1), it may be descended ultimately from either the root or shoot meristem of the seedling; if it is from the root, the two meristems produced cells differing in their pigment-producing potential, the root yellow and the stem red. However, the extent of Y1 is uncertain because of the position of the soil line, and it may occupy only a sector of the stem, as does Y2. In any case, the upper yellow band (Y2) was probably produced as a sectorial chimera, such as those described by Stewart and Derman (1970) and Bain and Derman (1944). Even though periderm is secondary tissue, its origin is directly traceable to the apical meristematic activity, which produced the cortical tissues in which the phellogen originated. The development of such a pattern as this (Fig. 1) seems explicable on the basis of described phenomena associated with the apical meristem, which must have occurred during the early seedling stage of this tree.

Since there are apparently relatively few cells acting, at any time, as the apical initials, from which all tissues are ultimately derived, a change in pigment-producing potential in one of them leads to a sectorial chimera (Stewart and Derman 1970; Bain and Derman 1944). Parke (1959) describes "perhaps 4 to 7" apical initials in white fir while Stewart and Derman (1970) suggest, from experimental evidence with sectorial chimeras, that 1 to 3 is the usual case in a variety of species. By this interpretation, if one of the two or three initials lacked some prerequisite for pigment production, one would expect a sectorial chimera like the upper yellow band.

If the above interpretation is accepted, the sharp boundaries in potential for pigment production which occurred as the seedling grew could be due to "displacement," in which one of the apical initials is replaced by a cell from a more interior position, having a different potential for pigment production (Stewart and Derman 1970). Once it is displaced, and the number of descendents from a particular cell has become fixed, a sharp horizontal boundary should result. The height of the yellow and red bands suggests that they represent the primary growth for 1 or 2 years for a young fir seedling. The displacement

PLATE I

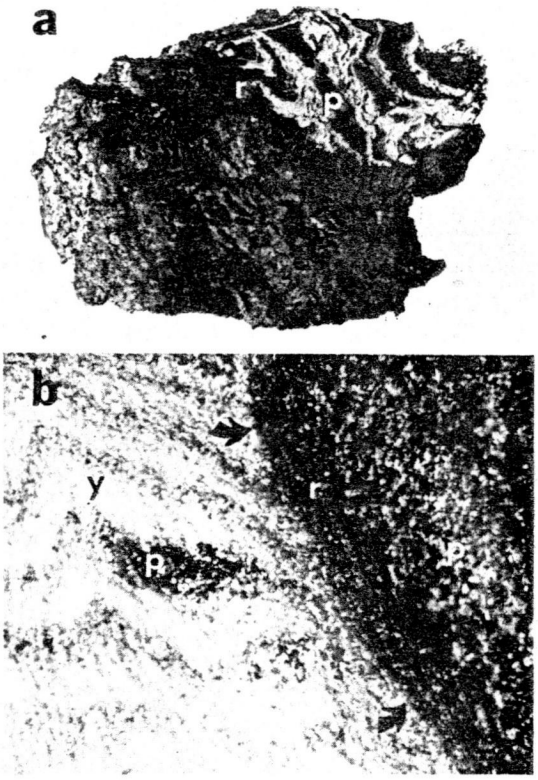

FIG. 2. The boundary between red and yellow periderm. (*a*) A chip of bark with both red and yellow periderm (68 × 48 mm). The difference between red periderm and old phloem is not very distinct in the photograph. The view is of the outside of the bark chip, which is from the end of the upper yellow band in Fig. 1. The top of the tree is toward the lower left. (*b*) An enlargement of a cross section across the red–yellow boundary (arrows). The distance between arrows is about 1.2 mm. *r* = red periderm, *y* = yellow periderm, and *p* = old phloem.

seems most likely to occur during the rapid enlargement of the shoot apex preceding formation of the new preformed shoot in the bud, as Parke (1959) describes for white fir. The boundary of a band may represent a mutation in an apical initial, although such an explanation seems unlikely for all the periderm color boundaries in this tree.

Another explanation would postulate a change in cells below the apical initials. The number of potential descendents of any cell decreases as that cell becomes further removed from the apex, and sectorial chimeras attributed to this origin are considerably shorter than those apparently due to apical origin (Stewart and Derman 1970). It seems unlikely that any cell but an apical initial would produce enough descendents to contribute to the 3–7 cm of height growth necessary to result in the banded patterns found here.

Alternative explanations for the development of this chimera must invoke simultaneous changes in many cells, which seem much more unlikely than the tentative explanation given above. No mechanism can be suggested for simultaneous changes in many cells.

The abrupt change from intense reddish-purple pigmentation to its absence also allows inferences about the control of this character. Daniels (1969, p. 186) suggested that the red–yellow periderm character was controlled by a single gene. The reddish-purple color of the necrophylactic periderm (Mullick and Jensen 1973*a*, 1973*b*) of conifers apparently results from several distinct pigments of different chemical types (Mullick 1969*a*, 1969*b*). At least three pigments occur in grand fir (Mullick 1969*b*). The occurrence of several pigments, rather than one as originally believed, makes single-gene control seem less likely. However, the chimera described here does suggest that a single gene may differentiate the deeply pigmented and non-pigmented periderm. Apparently this change alone is necessary to allow formation of all the pigments in red bark, perhaps via some precursor that is affected by a single gene, or to block their formation (or allow for their degradation) in yellow bark.

Acknowledgment

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