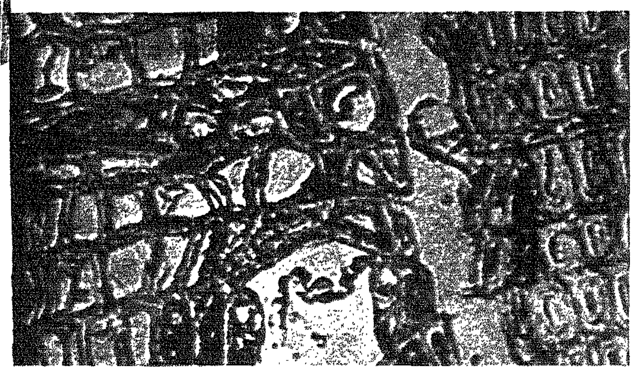
# Anatomy of Hemlock Ring Shake Associated with Sapsucker Injury



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# A New Look at Shake

SHAKE — a defect of standing trees in which the wood separates along the grain, the greater part between and parallel to the growth rings — has long been considered uncontrollable. It is a serious defect. The utilization of some species — such as hemlock, which is especially susceptible to shake — is severely limited by the frequent occurrence of this defect.

Various theories have been advanced in attempts to explain shake. Koehler (1933), as a result of wood-technology studies at the U. S. Forest Products Laboratory, suggested three probable causes of internal stresses in trees, which may contribute to the formation of ring shakes: (1) greater circumferential growth than radial growth; (2) reduction in turgidity of the older tissues; and (3) chemical shrinkage of the older wood.

He emphasized that the presence of parenchyma cells in the tree stem would be most effective in setting up such stresses. These cells remain alive and turgid for years after they are formed, and become well embedded in the wood before they die and lose their turgidity. As they die, he postulated, tension stresses would be set up in the heartwood, and this would throw the sapwood, which still has turgid cells, into compression.

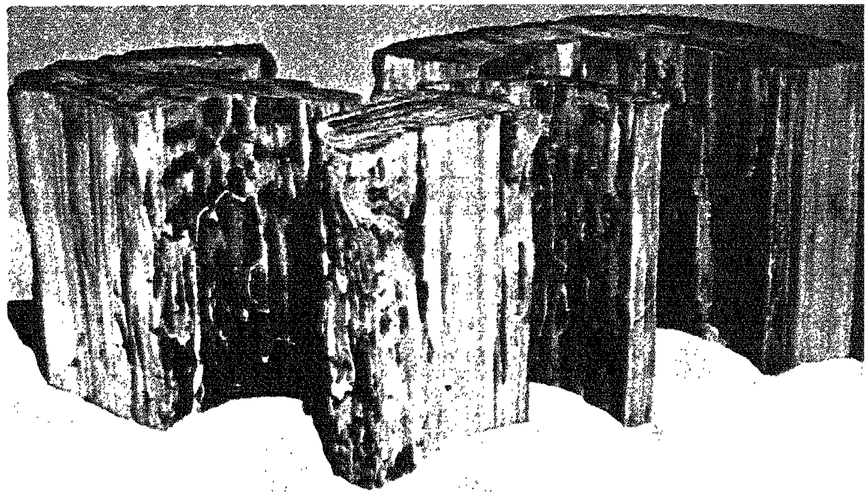


**Figure 1. — This section from a hemlock tree pulled apart along several ring-shake cracks. The scars from old sapsucker wounds line the separated surfaces. (From Shigo 1963.)**

Mergen (1958) postulated that the formation of compression wood in the flexible leaders of hemlock trees results eventually in the formation of shake because of the variations in strength and shrinkage properties of this reaction wood.

A number of other explanations have been offered (Wilson 1962), but none has gained wide acceptance. Shake has been attributed to weather conditions, especially wind; but research on the subject indicates that these theories probably are not correct.

In some of the research on the subject, shake has been related to age of the tree. Wilson reported that ring shake in eastern hemlock is statistically related to tree age: he found that shakes were formed between the ages of 60 and 125 years. The relationship was not influenced by the diameter of the tree nor by site.

Recent work by Shigo (1963) in New England has drawn attention to a new aspect of shake: he found a 100-percent correlation between occurrence of ring shake in eastern hemlock and damage caused by the feeding activities of the yellow-bellied sapsucker (*Sphyrapicus varius varius* L.), a bird of the woodpecker order. In dissecting trees in the course of forest-disease studies, Shigo found that shake invariably occurred in zones of old injuries caused by sapsuckers (fig. 1). He found a similar association between shake and sapsucker damage in some hardwoods.

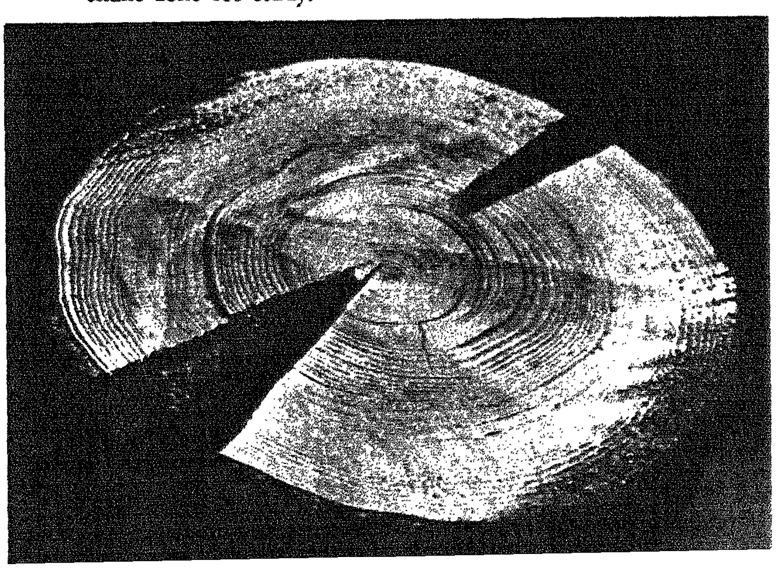
In the light of these findings, the anatomy of shake areas associated with sapsucker damage was investigated in an effort to obtain further information about the causes of shake defects.

## Procedure

Eight eastern hemlock trees (*Tsuga canadensis* L. Carr.) growing in the Bartlett Experimental Forest at Bartlett, New Hampshire, were selected for study. These trees, ranging in diameter breast high from 8 to 19 inches, were selected because the bark showed evidence of old sapsucker attack.

The trees were felled in May 1963. After felling, each tree was cut through at the area of sapsucker attack, and a 2-inch-thick

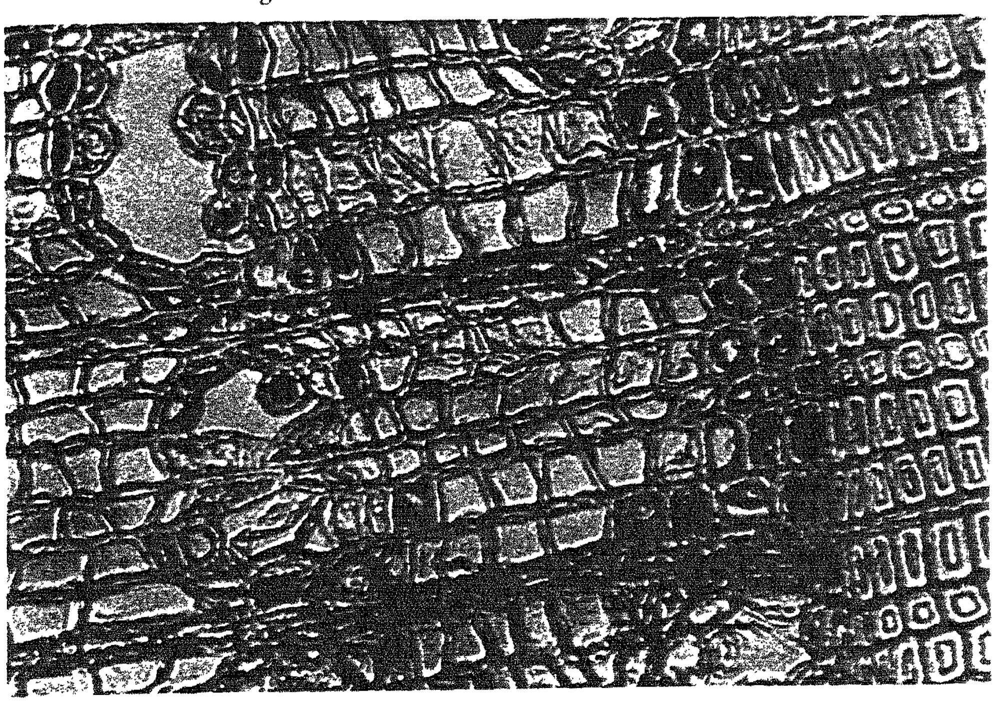
Figure 2. — Cross-section of one of the sample trees. Wedges have been cut out to obtain samples of the shake zone for study.



disk was removed for examination. Each tree was found to contain some shake and to have the sapsucker damage in conjunction with it as described by Shigo.

Two additional disks were taken from the injured area of each tree and were taken to the Forestry School of The Pennsylvania State University for laboratory study. In the laboratory each disk was sectioned radially with a saw to obtain a wedge-shaped piece containing the shake and sapsucker damage (fig. 2). A small block was cut from the damage zone and mounted in celloidin, and a microtome was used to cut both radial and tangential sections 11 microns thick. These unstained sections, mounted on slides, were used for microscopic study.

Figure 3. — Sapsucker-damaged area, in cross-section at 100X. Latewood cells are at right, parenchyma cells at right center. Resin canals are at left center.



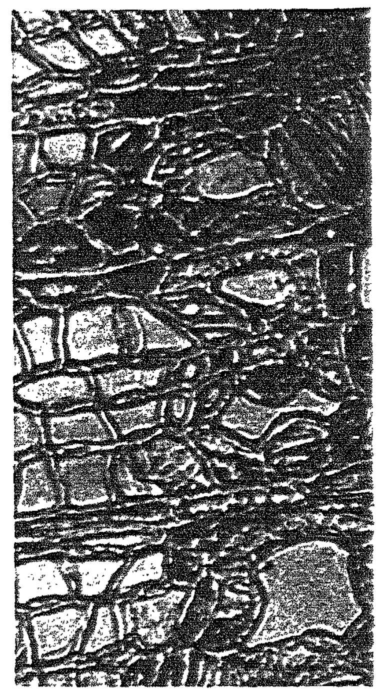


Figure 4. — Shake
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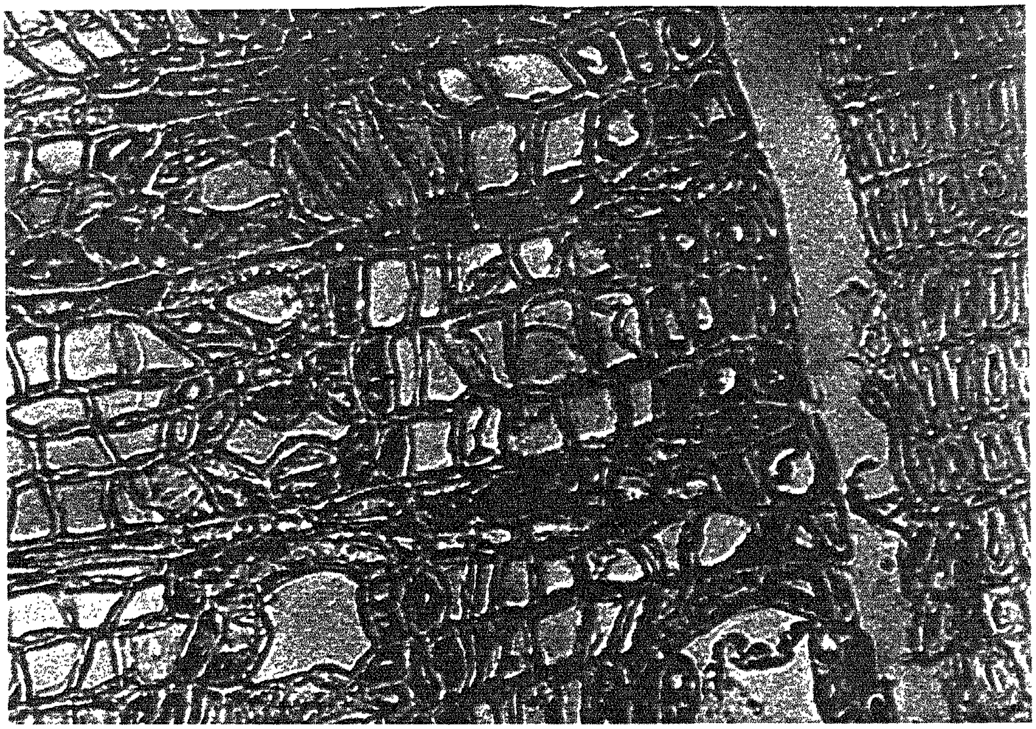


Figure 4. — Shake at sapsucker-damaged area, in cross-section at 100X. Middle lamella separation and torn cell separation are evident.

## Results

Earlywood parenchyma and traumatic resin canals (fig. 3) were found to occur at the point of sapsucker injury in all eight trees. Where the shake occurred, it was between the latewood cells and traumatic parenchyma (fig. 4 and fig. 5). The sapsucker damage shown in the photographs was done approximately 70 years ago.

The schizogenous traumatic resin canals observed, and the traumatic parenchyma in isolated spots in the springwood, are characteristic of wound formations. The large masses of cells (fig. 5) — irregular in size, shape, and arrangement, and with no strands as seen radially — identify wound parenchyma. The

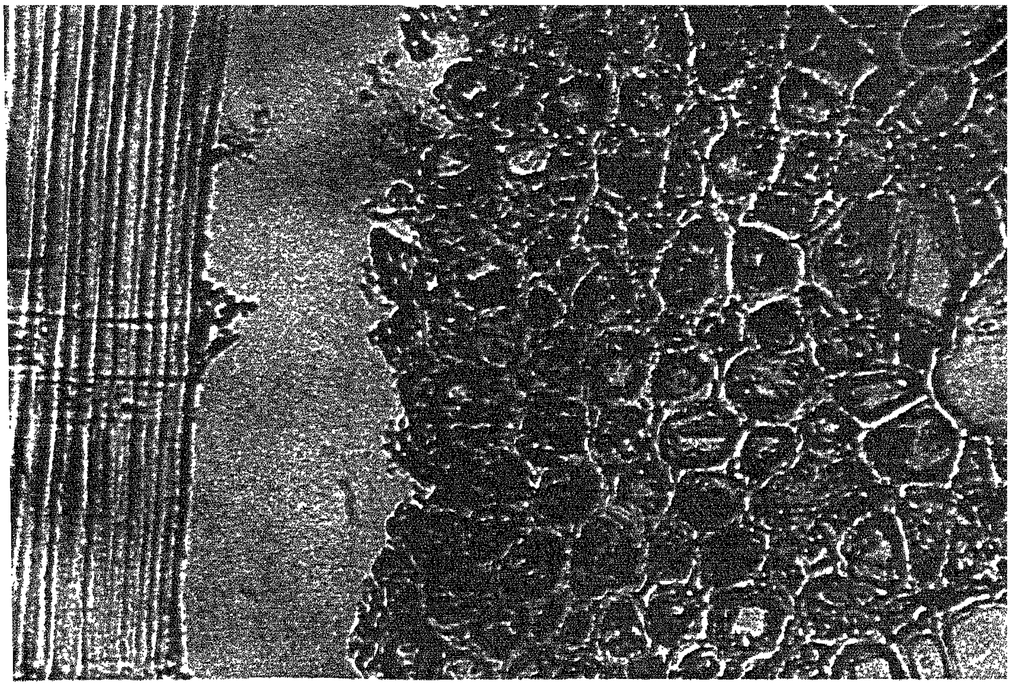


Figure 5. — Traumatic parenchyma at shake. Radial section at 100X.

cell walls are rather thick and abundantly pitted, and the cell contents are dark in color.

The shake found was a cell-wall type of failure in which the first row of springwood tracheids was torn across the cell wall from lumen to lumen, or a separation at the compound middle lamella (figures 4, 5, and 6). Separations at the middle lamella predominated. This form of ring shake is similar to two types of shelling failures in softwoods described by Kutsche and Ethington (1962).

In all the microtome sections studied, the traumatic parenchyma and resin canals appeared only in the early springwood. There was no evidence of parenchyma or resin canals in the later parts of any growth rings.

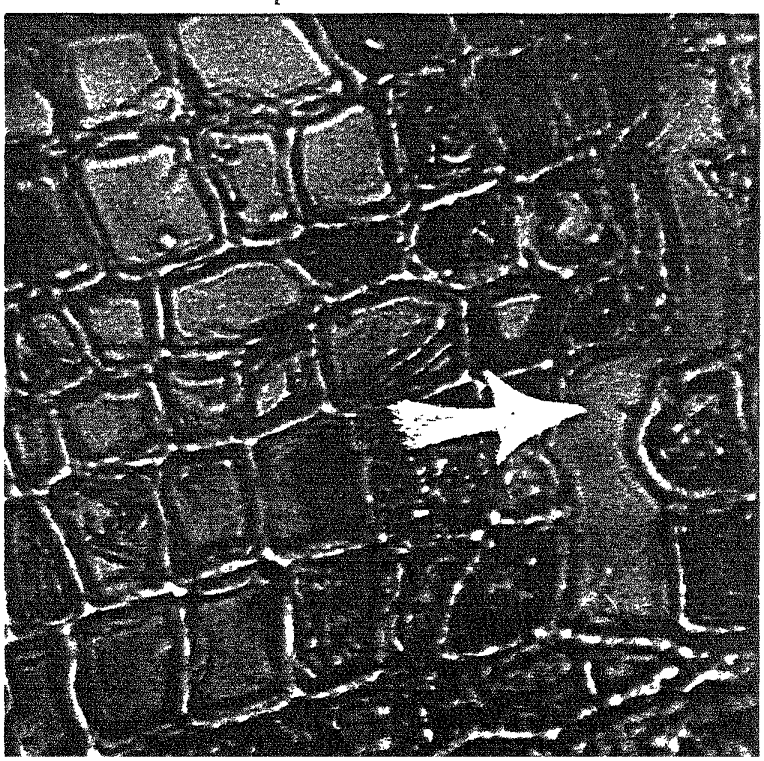
# Conclusions and Discussion

Laboratory study of the wood structure in the eight sample trees lends support to several theories and findings concerning shake. The formation of large amounts of traumatic parenchyma and traumatic resin canals at the site of sapsucker injury is typical of conifer wound tissue.

The cell structure of the wood in the areas of sapsucker damage tends to support the theory advanced by Koehler: that the dehydration of the parenchyma cells produces internal stresses that contribute to formation of shake defects.

No data are available on the life of the traumatic parenchyma in eastern hemlock, but the parenchyma will certainly die and dehydrate as the trees reach advanced age. This supports the findings of Wilson: that shakes do not form in hemlock until the trees reach an age of at least 60 years.

Figure 6. — Shake (arrow) at damaged area, showing a middle lamella separation. Cross-section at 450X.



Resin canals are not normal to hemlock, and if present are caused by injury. Thompson and Sifton (1925) showed that wounds caused rows of canals in more or less close tangential series and that scattered canals were numerous at short distances from the wound. Record (1934) reported that resin ducts originate in the cambial zone in response to a special stimulus or irritation, in this case physical damage by the sapsuckers.

The presence of a single row of traumatic canals in each ring of the trees studied is not easily explained. From the cellular evidence of the samples observed it must be concluded that, in the year when the ring was formed, these trees were subject to a single sapsucker attack that occurred during a limited time in the early growing season. In one tree, this early-season attack was sufficient to produce external scars that were visible after 70 years.

The feeding habits of the sapsuckers can be related to the cellular evidence found. Beal and McAtee (1922) have described the springtime sampling done by the sapsuckers in selecting certain "orchard" trees for heavy feeding later in the season. Such sampling would account for the single row of resin canals in the springwood areas of the sectioned trees.

It must be concluded that the springtime sampling of the sapsuckers produces scars visible on the bark of hemlock many years later. Continued attack during the entire growing season would undoubtedly result in large areas of killed cambium and scar overgrowth as noted by Shigo (1963) on some trees. Control of damage to hemlock as an effort to reduce the occurrence of shake would undoubtedly be difficult. If such control were attempted it ought to be directed not only at the intense feeding on orchard trees, but also against the springtime exploratory attacks.

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