

Capsicum manifested a brownish red finely punctate surface as a result of the fungal culture. A yellowish buff layer supported the sporangia. This substratum was thick but brittle to the touch.

The purplish brown tiny globular masses of sporangia completely covered the hyphal surface growth on Cascara. The vegetative portion of *Aspergillus* on this drug formed a thin but tenacious pellicle.

The Ginger culture appeared as an irregularly lobed structure. The entire powder formed into a thick layer. The upper surface, with abundant sporangia, was dark reddish brown in color, having a granular texture. The undersurface of the culture was moist and sticky.

Small, regularly punctate spherical bodies of a reddish brown color characterize this growth on Licorice. The culture is only slightly moist.

On Rhubarb this fungus is light brown in color, small, yellowish papillose elevations appearing on the surface.

The alliaceous odor prominent on the Mustard culture of *Aspergillus*, differentiates this growth from the other cultures on Mustard as a medium. A small number of sporangia were present.

Sarsaparilla developed a dry, dark brown powdery mass of sporangia. No hyphae were apparent on this drug.

It is my belief that the medicinal substances and particularly drug powders may be utilized to differentiate the cultural characteristics of the fungi.

The possible change in structure and composition brought about through mold contamination is at present under investigation.

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## A HISTOLOGICAL STUDY OF HORSERADISH ROOT AND SOME COMMON ADULTERANTS.\*

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Horseradish Root (*Radicula Armoracia* L.) Rob. is a much-used condiment. Commercially, it occurs as the entire root, or it may be obtained in the grated and pickled condition. The authors recently had occasion to examine several samples of the grated root, purchased in the open market, and found that not all of the supposedly genuine roots were identical when seen under the compound microscope. Hence, a general study of the genuine Horseradish Root was initiated, along with certain other substances suspected as adulterants. These were the ordinary red beet, *Beta vulgaris* L.; turnip, *Brassica rapa* L.; and parsnip root, *Pastinaca sativa* L.

### MORPHOLOGY OF HORSERADISH ROOT.

The genuine root occurs as a conical tap root, from one to two and a half feet in length, branched at the lower end; the roots sold commercially are usually one foot long and from one to two inches thick. The main root is cylindraceous, tapers very slightly and is divided at the apex into three or more crowns, or stem bases, bearing annular leaf scars. The summit of each branch may bear a number of young leaves, pale green, or nearly white in color. Externally, the root is of light

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yellowish brown color, and divides at its lower end into three or four vertical rows of fibrous secondary roots. Internally, the root is white and fleshy, the fracture is short and sharp; the transverse section shows a thin corky layer, and a thin, watery-looking line denotes the cambium, within which the xylem is indicated by a fine radiation. When broken or bruised, the root exhales a very pungent odor, and has a sharply biting acrid taste.

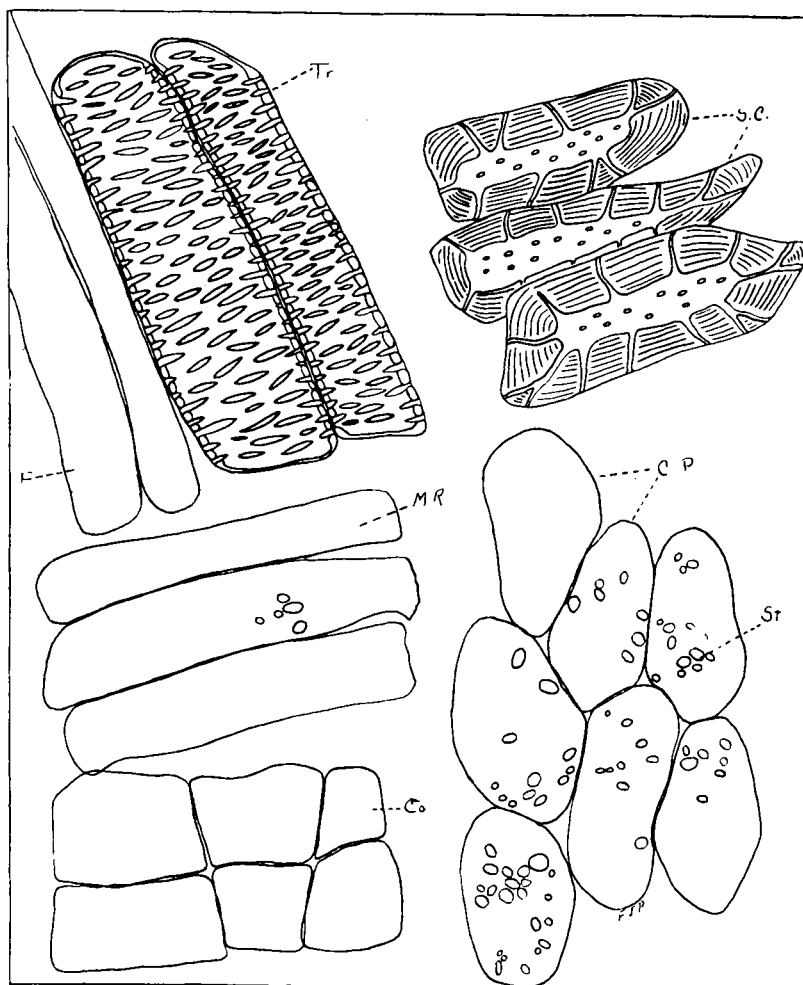


Fig. 1.—Horseradish Root (*Radicula Armoracia*). C. P., cortical parenchyma; F., fibers; M. R., medullary ray cells; St., starch; S. C., stone cells; Tr., reticulate tracheids. Camera lucida sketch (660 X).

#### MICROSCOPY OF HORSERADISH ROOT.

Under the microscope, the cork consists of several layers of elongated, very thin-walled cells. These vary from 30 to 40 microns in width, 26 to 29 microns in length and 5 to 6 microns in thickness. Two to three layers of well-defined phelloderm cells are located under the cork. These cells are larger and slightly thicker-walled than the cork cells and are laid down in a very regular manner. The

cortical parenchyma consists of typical iso-diametric cells, measuring 48 microns in diameter. Large, isolated masses of stone cells occur in this region, the individual cells being thick-walled ( $8\mu$ ), pale amber in color, striated and porous. These cells vary in shape, from round to elongated rectangular, ranging in size from 58 microns long by 26 microns wide, to 107 microns long by 23 microns wide. These stone cells

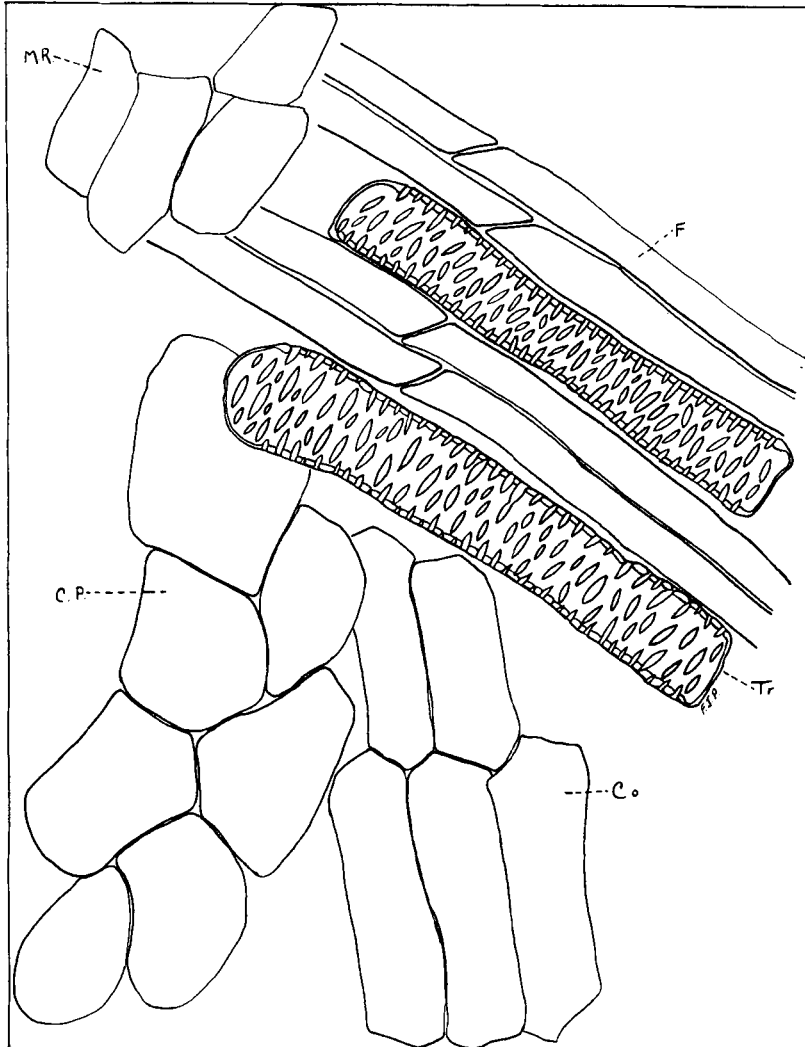


Fig. 2.—Beet Root (*Beta vulgaris*). Co., cork; F., fibers; C. P., cortical parenchyma; M. R., medullary ray cells; Tr., reticulate tracheids. Camera lucida sketch (660 X).

are very characteristic and could well serve as a diagnostic element. The phloem and cambium are very obscure in the grated product; medullary rays extend throughout the central region in a very regular and finely radiate arrangement. The ray cells average 26 microns in length, 98 microns in width and 26 microns wide in sectional view. In the grated condition bands of ray cells appear in long

fragments, and two or three cells in width. The inter-radial parenchyma cells are somewhat smaller than those of the cortex; otherwise, they show the typical isodiametric structure. Bast fibers are quite numerous in the cortex and occur as groups, the individual cells averaging 107 microns in length and 20 microns in width. The tracheids are very numerous and occur in groups of one to five or more, surrounded by the inter-radial parenchyma and the thin-walled elongated wood

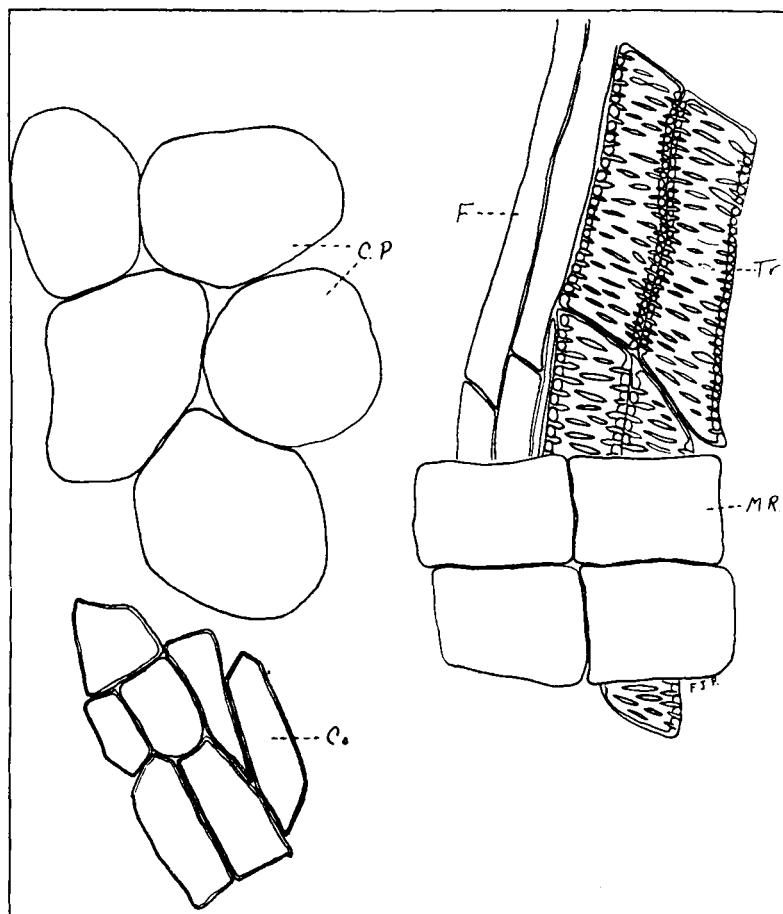


Fig. 3.—Turnip Root (*Brassica rapa*). *Co.*, cork; *C. P.*, cortical parenchyma; *F.*, fibers; *M. R.*, medullary ray cells; *Tr.*, reticulate tracheids. Camera lucida sketch (660 X).

fibers. The tracheids vary from 65 to 85 microns in length and from 35 to 65 microns in width. The end walls are blunt or truncate, to slightly oblique. The markings on the walls are characteristically reticulate. Starch is found throughout the parenchyma and ray cells of the root. The starch grains are single, rounded to oval in shape and very small in size. The largest grains are rarely more than 7 microns in diameter, or along their longest axis, while the great majority are much smaller than this. A well-defined hilum is not apparent.

## MICROSCOPY OF BEET ROOT.

The root of the beet, *Beta vulgaris* L., can be readily identified as an adulterant by the presence of large masses of parenchyma cells, showing no starch. Ramifying through these masses of cells are the reticulate tracheids. The parenchyma cells vary from 87 (or slightly less) to 130 microns in diameter. These are from two to three times the size of the horseradish cells. The reticulate tracheids occur in

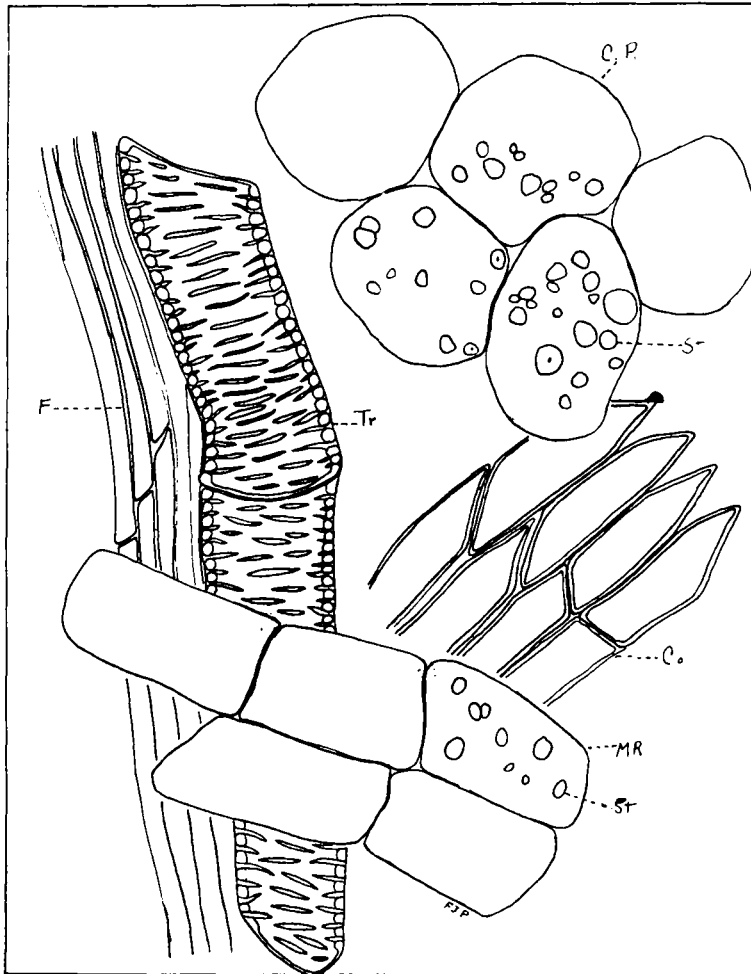


Fig. 4.—Parsnip Root (*Pastinaca sativa*). Co., cork; C. P., cortical parenchyma; F., fibers; M. R., medullary ray cells; St., starch; Tr., reticulate tracheids. Camera lucida sketch (660 X).

masses, the individual tracheid ranging from 136 to 290 microns in length and from 17 to 26 microns in width, somewhat longer and narrower than those of horseradish. Thin-walled masses of elongated fibers accompany these vessels; these are upward of 200 microns in length and 9 microns in width.

## MICROSCOPY OF WHITE TURNIP ROOT.

The white turnip, *Brassica rapa* L., if present in horseradish may be noted by its extremely large, thin-walled parenchyma cells devoid of starch. These cells

measure from 130 to 170 microns in diameter. The tracheids are shorter than either horseradish or beet, ranging from 80 to 120 microns in length and 30 to 50 microns wide. The markings are more rounded, of irregular size, giving the tracheid a very characteristic reticulate appearance. The vessels occur singly, or in small groups, in contrast with those of the beet and horseradish.

#### MICROSCOPY OF PARSNIP ROOT.

Parsnip root, *Pastinaca sativa* L., is characterized by the large numbers of single and compound starch grains present. The individual grains are rounded to slightly angular. The larger grains, 12 microns in diameter, show a centrally located cleft hilum. The compound grains occur in groups of two or three, with an occasional group of more than three. The angular grains are members of compound grains, separated during the grating process. The predominance of the larger grains, plus the presence of the compound grains, would serve to indicate the presence of parsnip in horseradish. The vessels of parsnip are of the usual reticulate tracheid type, ranging anywhere from 120 to 160 microns in length, and from 40 to 50 microns in width. The size would be midway between those of the horseradish and beet, and somewhat longer than those of the turnip. The vessels of parsnip are accompanied by extremely long, thin-walled fiber cells, averaging over 200 microns in length. The cortical parenchyma cells bear starch and measure about 64 microns in diameter. These cells are smaller than those of the beet and turnip, and larger than those of the true horseradish. Inter-radial parenchyma, medullary rays and tracheids occur combined in masses, in the grated state, both the ray cells and parenchyma cells bearing the above-mentioned starch.

Another added substance found in the commercial samples of horseradish was cornstarch.

| SUMMARY.     |  |  |  |   |
|--------------|--|--|--|---|
|              | Parenchyma.                              | Stone Cells.   | Tracheids.   | Starch.   |
| Horseradish  | Isodiametric<br>48 $\mu$ wide            | Porous, striated,<br>pale amber in<br>color, 58 to<br>107 $\mu$ long, 23<br>to 26 $\mu$ wide | Reticulate 65 to<br>85 $\mu$ long, 35 to<br>65 $\mu$ wide    | Simple 7 $\mu$<br>broad                                       |
| Beet         | Isodiametric<br>87 to 130 $\mu$<br>wide  | Absent   | Reticulate, 136 to<br>290 $\mu$ long, 17<br>to 26 $\mu$ wide | Absent  |
| White Turnip | Isodiametric<br>130 to<br>170 $\mu$ wide | Absent   | Reticulate, 80 to<br>120 $\mu$ long, 30<br>to 50 $\mu$ wide  | Absent  |
| Parsnip      | Isodiametric<br>64 $\mu$ wide            | Absent   | Reticulate 120 to<br>160 $\mu$ long, 40<br>to 50 $\mu$ wide  | Simple and<br>2 to 3<br>c o m-<br>p o u n d<br>12 $\mu$ broad |

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