T H E S I S.

INTERNAL STRUCTURE OF SOME APPLE VARIETIES.

Submitted by -

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To the Horticultural Department of the Michigan Agricultural College as a part requirement for the M. S. Degree.

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F O R E W O R D.

Acknowledgements are due to Mr. W. C. Dutton, Assistant Horticulturist of the Experiment Station, and to Associate Professor R. deZeeuw of the Botany Department, for invaluable assistance rendered in the photographic and microphotographic work.

J. G.

INTERNAL STRUCTURE OF SOME APPLE VARIETIES.

O B J E C T.

A comparison of core-lines and cells from different regions of the apple.

M A T E R I A L.

The apples for the work were obtained from the following state agricultural stations: Storrs, Connecticut; Perdue, Indiana; Urbana, Illinois; Lexington, Kentucky; Amherst, Massachusetts; Wooster, Ohio; Corvallis, Oregon; State College, Pennsylvania; Blacksburg, Virginia; Durham, New Hampshire; Geneva, New York; Pullman, Washington; Morgantown, West Virginia.

M E T H O D S.

The method of cutting the fruit for ordinary photographic work was similar to that employed by Professor E. J. Kraus of the Oregon Station with but few exceptions. A simple scheme or plan for cutting the fruit was devised as shown in the accompanying illustrations No. 1 and No. 2

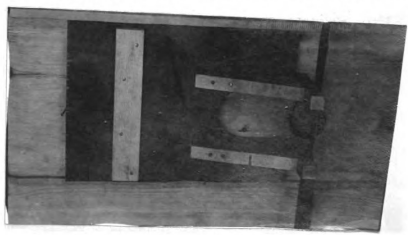


Illustration No. 1.

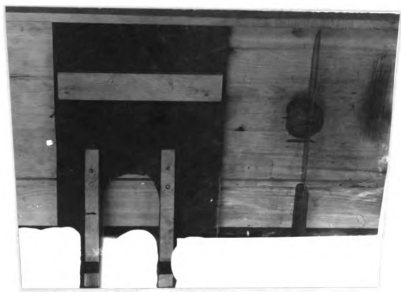


Illustration No. 2.

Mature fruit was used and cross sections studied exclusively. In making the cut it has been found better to have it anterior to the center of the core, since in this way you can gradually work up to the center of the core, and it is in the latter regions that the greater possibility for study offers itself. After making the first cut just above the center in most cases it was found advisable to remove the seeds with a needle or some other like instrument. In this work a needle of a dissecting set was used. In this way the carpels remained intact, i. e. were not so apt to be broken down. After the seeds had been removed, a uniform slice 1/16" - 1/8" thick was cut off. These sections or slices were cut by means of a sharp medium-sized cheese-knife, and with a quick drawing out of the knife (see illustration No. 2). Care was taken not to cut the sections too thin, in such cases, since they do not show as detailed a vascular

system as do those cut the proper thickness. As soon as the sections were cut they were labeled by means of small tags on which, such data as were deemed necessary, were written and in pencil. These tags were fastened to the sections by strings forced thru the edge of the sections and near the circumference with the dissecting needle already described.

After this had been done the sections were placed in the following per cents of grain alcohol and left for the indicated lengths of time:

50% . . . . . 2 - 4 days.
70% . . . . . 2 - 5 "
85% . . . . . 4 - 6 "
95% . . . . . 4 - 6 "
Absolute. . . . . 2 - 4 "

Between each change of alcohol and before adding another, the alcohol of the preceding grade, i. e. per cent, was drained off as thoroughly as possible and the sections then pressed lightly against filter paper, but as Professor Kraus suggests in his bulletin on "Variation of Internal Structure of Apple Varieties" they should not be allowed to become dry. After the sections had been thoroughly dehydrated they were removed from the absolute alcohol and placed in xylol and left for a period of two or three days. No definite rule can be laid down as to the proper length of time for each of the different steps described above in the dehydration and clearing process, as this depends in a large extent upon the variety being treated. For some varieties, as for example, Fameuse, the xylol and absolute alcohol may be omitted and the sections

placed directly into a clearer made up of equal parts of turpentine and carbolic acid (crystals). In the latter case it is better to place a glass plate over the sections in the carbolic acid clearer as this prevents any shrivelling or shrinking of the tissue which might otherwise occur since the sections in this manner are held in a flat position in the receptacle. On the other hand certain varieties, as the Ben Davis and Northern Spy, would not clear up in this clearer but had to be, in some cases, placed a second time in absolute alcohol and xylol in order that they should be properly cleared. After the sections had been properly cleared they were photographed as shown in Illustration No. 3.

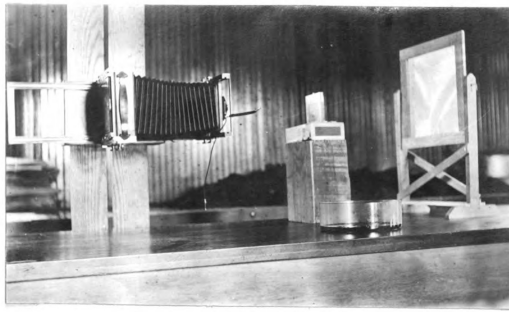


Illustration No. 3.

For the photo-micrographic work the following plan of proceedure was followed: Small blocks of apple 1/8" square were cut from the Ben Davis apple and in duplicate from the following regions: (a) primary vascular bundle region; (b) cortical region; (c) cambial region; and (d)

pith region. The apples used were from the following states: Connecticut, Indiana, Illinois, Oregon, Kentucky, Massachusetts, Pennsylvania, West Virginia, Virginia, and Michigan.

After the cutting had been made the section (in duplicate) were placed in small cheese cloth sacks with the necessary data for identification on them. It was found better not to use ink or pencil as these are very apt to be washed off in the process of clearing, especially is this true of ink. A better and safer scheme was to punch small holes in the tags used above, e. g. so many holes indicating a certain region from which the section had been taken. These cheese-cloth bags were next tied up with thread and dropped into the following fixing solution and left for a period of twenty-four hours.

Chrome-Acetic Fixer (Chromic acid - - - - - .8 grams.
Glacial acetic acid- - .5 c.c.
Water (distilled)- - 99.0 c.c.

The above process was to kill and fix the material in place after killing. The material was next removed from the fixing fluid and placed into a washing trough with running water and allowed it to wash for another twenty-four hour period.

After washing, the material was placed in the following grades or per cents of grain alcohol and left for the indicated lengths of time.

25% . . . . . 1 - 2 hours.
35% . . . . . 1 - 2 hours.
50% . . . . . 1 - 2 hours.
70% . . . . . 2 - 3 days.

The object of leaving them for a longer period in the 70% alcohol was to bring about a hardening of the apple tissue. Next the following grades of grain alcohol were used in the dehydration process:

85% . . . . . .2 hours.

95% . . . . . .8 hours or over night.

Absolute alcohol. . . . .2 - 6 hours.

At the end of the period, the absolute alcohol was changed and the material left for the same length of time before clearing. The material was next gradually brought into pure xylol as follows:

Absolute alcohol, 2 parts, and xylol, 1 part - 2 hrs.

" " 1 " " " 2 " - 2 "

Pure xylol - - - - - - - - 2 "

At the end of the final period, the old xylol was poured off and fresh xylol poured over the material.

After the above operation, a block of paraffin 1/2" X 1/2" X 3/4" was taken and 1/3 of it added to the xylol, one section in duplicate being placed in a vial. The material was then set aside for a period of 24 hours at room temperature, and then a second 1/3 of a paraffin block added to each vial and the material set on top of the paraffin bath, see Illustration No. 4 (on following page). At the end of this period the remainder of a block of paraffin was added to each vial and the material placed in the paraffin bath, see Illustration No. 4. After a period of 24 hours the corks of the vials were removed. After removing the corks the vials were left for a period of 4 - 6 days in

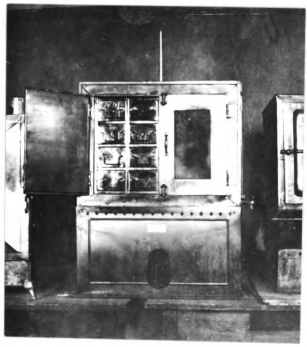


Illustration No. 4.

the bath. This is to allow the xylol to evaporate from the paraffin.

The blocks of paraffin used were made as follows: Papers measuring $1\frac{1}{4}$" X 2" were molded over little wooden blocks $\frac{1}{2}$" X $\frac{1}{2}$" X $\frac{3}{4}$". When the xylol had evaporated sufficiently from the vials, the material was embedded and the degree of success met with in this operation was or should be determined largely by the previous infiltration.

With warm needles from dissecting set, the material was arranged quickly and accurately in the paper boats, made as previously described. After arranging the material in the boats, a film was formed by drawing gently over the top of the paraffin in the boats. This kept the water from spoiling the blocks. These blocks of paraffin now containing the material were plunged into water as cold as it was possible to make it. In this water they were left for

15 - 20 minutes.

After removing from the water the blocks were dried and cemented with hot paraffin to blocks of wood $\frac{1}{2}$" X $\frac{1}{2}$" X $\frac{3}{4}$". The paraffin was allowed to thoroughly harden on the blocks before the work of cutting was begun. After the blocks had hardened sufficiently they were trimmed down to the required size, taking care to have the upper and lower edges exactly parallel with each other and with the edge of the knife.

The blocks containing the vascular systems were cut 15 microns in thickness, the blocks containing the rest of the material were cut both 15 microns and 20 microns in thickness, best results being obtained with the material containing the pith cells by cutting it 20 microns in thickness. A Bausch and Lomb simple rotary microtone and a special Torry razor were used to cut the material in the paraffin blocks.

After the material had been cut in paraffin ribbons it was arranged in a cardboard box or tray, a very thin film of albumen fixative was rubbed evenly over perfectly clean slides. After this, the pieces of ribbon were arranged on slides so that cover-glasses used would easily cover them. Next the sections were floated on water and warmed gently until all the wrinkles had been smoothed out. This was accomplished by placing the slides on top of the paraffin bath for about a half to one minute or more. After this operation the slides were set aside for about 24 hours, or until perfectly dry. When the slides were thoroughly dry, the sections were covered with xylol from a dropper bottle,

and not allowed to run-off for about one-half minute, then it was drained off and the operation repeated. The xylol was next rinsed off the sections with absolute alcohol, and this operation followed by rinsings with 95% alcohol and then 70% alcohol.

The slides were next run down from paraffin to 70% alcohol and then transferred to 50% alcoholic safranin stain and left for a period of 24 hours. After this operation the slides were dehydrated by flooding successively for one-half minute each with 70%, 95% and absolute alcohols. Then they were cleared in xylol for about one minute. The xylol on the under side and upper side as near to the sections as possible was wiped off with a clean cloth, and then the sections were mounted in balsam. When the balsam had hardened sufficiently the sections were photographed with photomicrograph as shown in Illustration No. 5.(on following page).

R E S U L T S.

From a study of sections of fruit and photographs, the internal structure for the same variety of apple, but grown in different regions of the country, was in the main nearly identical. This was true regardless of the size or form of the fruit studied.

CELL MEASUREMENTS.

	Average Size of Cells. (Microns)
Ind. Ben Davis - P. V. B. cross-section	18.75 X 22.5
Mich. Ben Davis- P. V. B. " "	16.875 X 18.75
Va. Ben Davis - P. V. B. " "	17.25 X 22.5

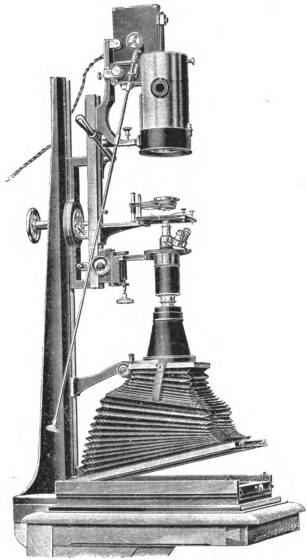


Fig. 14.

Illustration No. 5.

Photomicroscophic Apparatus.

(Cut taken from E. Leitz Company's Catalog)

	Average Size of Cells (Microns)
W. Va. Ben Davis - P. V. B. cross-section	15.00 X 16.875
Pa. Ben Davis - P. V. B. " "	16.875 X 20.625
Conn. Ben Davis - P. V. B. " "	19.50 X 23.25
Ill. Ben Davis - P. V. B. " "	15.75 X 18.75
Ore. Ben Davis - P. V. B. " "	13.50 X 18.00
Ky. Ben Davis - P. V. B. " "	18.00 X 19.50
Mass. Ben Davis - P. V. B. " "	15.75 X 15.75
Ky. Ben Davis - Co. cross section	71.25 X 90.00
Mich. Ben Davis - Co. " "	101.25 X 121.875
Conn. Ben Davis - Co. " "	78.75 X 101.25
Ore. Ben Davis - Co. " "	84.375 X 95.625
Penn. Ben Davis - Co. " "	90.00 X 108.75
Va. Ben Davis - Co. " "	88.125 X 131.25
Ill. Ben Davis - Co. " "	116.25 X 138.75
W. Va. Ben Davis - Co. " "	118.125 X 150.00
Ind. Ben Davis - Co. " "	112.50 X 142.50
Mich. Ben Davis - Ca. cross section	91.875 X 140.625
Penn. Ben Davis - Ca. " "	65.625 X 84.375
Va. Ben Davis - Ca. " "	103.125 X 168.75
Mass. Ben Davis - Ca. " "	76.875 X 129.375
Conn. Ben Davis - Ca. " "	88.125 X 151.875
Ore. Ben Davis - Ca. " "	67.50 X 121.875
Ind. Ben Davis - Ca. " "	99.375 X 159.375
Ill. Ben Davis - Ca. " "	75.00 X 106.875
Ky. Ben Davis - Ca. " "	73.125 X 148.125
Penn. Ben Davis - P. cross section	88.125 X 241.875
Mich. Ben Davis - P. " "	78.75 X 225.00

	Average Size of Cells (Microns)
Va. Ben Davis - P. cross section	88.125 X 234.375
Conn. Ben Davis - P. " "	93.75 X 271.875
Mass. Ben Davis - P. " "	88.125 X 225.00
Ind. Ben Davis - P. " "	84.375 X 234.375

Abreviations Defined.

P. V. B. . . . . .Primary Vascular System.

Co.. . . . . .Cortical Region.

Ca.. . . . . .Cambial Region.

P. . . . . .Pith Region.

Owing to a disintegration of cell structure from some of the apple material it was impossible to obtain photo-micrographs of all of the regions intended. This disintegration seemed to effect the pith cells worst of all and the vascular cells least of all. This may have been due to the large size of the pith cells, having a greater tendency to disintegrate, and the small vascular cells with a tendency to be of a woody texture remained intact for a longer period of time. Better results may have been obtained from apples in an earlier stage of maturity. Each region studied presented its peculiar type cell, the vascular cell being almost round and the smallest of all, the cortical being round to spherical and much larger than the vascular-system cells. The cambial cells were much like the cortical cells in size and shape but had a greater tendency toward the spherical or elliptical. The pith cells were the largest of any of the other cells being oblong in shape and 2½ - 3 or more times as long as they were broad. The cells for each region of the

apple studied seemed to be quite uniform thruout in size and shape for the same variety, but from different regions of the country.

L I T E R A T U R E C I T E D.

Kraus, E. J.
1916.
Variation of Internal Structure of Apple Varieties.
Oregon Agricultural Experiment Station.
Station Bulletin No. 135.

deZeeuw, R.
Laboratory Guide for Botanical Microtechnique.
Michigan Agricultural College.
Department of Botany.

D E S C R I P T I O N O F P L A T E S.

Plate I.
Fig. 1. Illinois Ben Davis.
Fig. 2. Pennsylvania Ben Davis.
Fig. 3. Virginia Ben Davis.
Fig. 4. Kentucky Ben Davis.

Plate II.
Fig. 1. Connecticut Ben Davis.
Fig. 2. Indiana Ben Davis.
Fig. 3. Oregon Ben Davis.
Fig. 4. West Virginia Ben Davis.

Plate III.
Fig. 1. Massachusetts Ben Davis.
Fig. 2. Michigan Ben Davis.
Fig. 3. Oregon York.
Fig. 4. Virginia York.

Plate IV.
Fig. 1. Kentucky York.
Fig. 2. Ohio York.
Fig. 3. Massachusetts York.
Fig. 4. Pennsylvania York.

Plate V.
Fig. 1. Washington York.
Fig. 2. Washington York.
Fig. 3. Indiana York.
Fig. 4. Massachusetts York.

Plate VI.
Fig. 1. Virginia Rome.
Fig. 2. New Hampshire Rome.
Fig. 3. New York Rome.
Fig. 4. Kentucky Rome.

Plate VII.
Fig. 1. Washington Grimes.
Fig. 2. Illinois Grimes.
Fig. 3. Kentucky Grimes.
Fig. 4. Oregon Grimes.

Plate VIII.
Fig. 1. Massachusetts Grimes.
Fig. 2. Indiana Grimes.
Fig. 3. Oregon Maiden Blush.
Fig. 4. Washington Rome.

Plate IX.
Fig. 1. Massachusetts Maiden Blush.
Fig. 2. Michigan Maiden Blush.
Fig. 3. New York Maiden Blush.
Fig. 4. New Hampshire McIntosh.

Plate X.
Fig. 1. New Hampshire McIntosh.
Fig. 2. Michigan McIntosh.
Fig. 3. New York McIntosh.
Fig. 4. Massachusetts McIntosh.

Plate XI.
Fig. 1. Washington McIntosh.
Fig. 2. Massachusetts Tolman.
Fig. 3. New Hampshire Tolman.
Fig. 4. New York Tolman.

Plate XII.
Fig. 1. Virginia Tolman.
Fig. 2. Washington Jonathan.
Fig. 3. Virginia Jonathan.
Fig. 4. Oregon Jonathan.

Plate XIII.
Fig. 1. New Hampshire Jonathan.
Fig. 2. Massachusetts Jonathan.
Fig. 3. Ohio Baldwin.
Fig. 4. Massachusetts Baldwin.

Plate XIV.
Fig. 1. Massachusetts Winter Banana.
Fig. 2. Ohio Winter Banana.
Fig. 3. Oregon Winter Banana.
Fig. 4. New York Winter Banana.

Plate XV.
Fig. 1. New York Baldwin.
Fig. 2. New Hampshire Baldwin.
Fig. 3. Pennsylvania Rhode Island Greening.
Fig. 4. Connecticut Rhode Island Greening.

Plate XVI.
Fig. 1. West Virginia Hubbardston.
Fig. 2. Massachusetts Hubbardston.

Fig. 3. Ohio Hubbardston.

Plate XVII.
Indiana Ben Davis - cross-section primary vascular bundle - 150X.

Plate XVIII.
Virginia Ben Davis - cross-section primary vascular buncle - 150X.

Plate XIX.
Kentucky Ben Davis - cross-section primary vascular bundle - 150X.

Plate XX.
Michigan Ben Davis - cross-section primary vascular bundle - 150X.

Plate XXI.
Illinois Ben Davis - cross-section primary vascular bundle - 150X.

Plate XXII.
Pennsylvania Ben Davis - cross-section primary vascular bundle - 150X.

Plate XXIII.
Connecticut Ben Davis - cross-section primary vascular bundle - 150X.

Plate XXIV.
Oregon Ben Davis - cross-section primary vascular buncle - 150X.

Plate XXV.
Massachusetts Ben Davis - cross-section primary vascular bundle - 150X.

Plate XXVI.
West Virginia Ben Davis-cross-section primary vascular bundle - 150X.

Plate XXVII.
Virginia Ben Davis - longitudinal section primary vascular bundle - 150X.

Plate XXVIII.
Illinois Ben Davis - longitudinal section primary vascular bundle - 150X.

Plate XXIX.
Indiana Ben Davis - longitudinal section primary vascular bundle - 150X.

Plate XXX.
Connecticut Ben Davis - longitudinal section primary vascular bundle - 150X.

Plate XXXI.
Michigan Ben Davis - longitudinal section primary vascular bundle - 150X.

Plate XXXII.
Kentucky Ben Davis - cross-section cortical region - 150X.

Plate XXXIII.
Kentucky Ben Davis - longitudinal section cortical region - 150X.

Plate XXXIV.
Michigan Ben Davis - cross-section cortical region - 150X.

Plate XXXV.
Michigan Ben Davis - longitudinal section cortical region - 150X.

Plate XXXVI:
Connecticut Ben Davis - cross-section cortical region - 150X.

Plate XXXVII.
Oregon Ben Davis - cross-section cortical region - 150X.

Plate XXXVIII.
Oregon Ben Davis - longitudinal section cortical region - 150X.

Plate XXXIX.
Pennsylvania Ben Davis - cross-section cortical region - 150X.

Plate XL.
Pennsylvania Ben Davis - longitudinal section cortical region - 150X.

Plate XLI.
Virginia Ben Davis - cross-section cortical region - 150X.

Plate XLII.
Virginia Ben Davis - longitudinal section cortical region - 150X.

Plate XLIII.
Illinois Ben Davis - cross-section cortical region - 150X.

Plate XLIV.
Illinois Ben Davis - longitudinal section cortical region - 150X.

Plate XLV.
Indiana Ben Davis - longitudinal section cortical region - 150X.

Plate XLVI.
Michigan Ben Davis - cross-section cambial region - 150X.

Plate XLVII.
Pennsylvania Ben Davis - cross-section cambial region - 150X.

Plate XLVIII.
Pennsylvania Ben Davis - longitudinal section cambial region - 150X.

Plate XLIX.
Virginia Ben Davis - longitudinal section cambial region - 150X.

Plate L.
Massachusetts Ben Davis - cross-section cambial region - 150X.

Plate LI.
Massachusetts Ben Davis - longitudinal section cambial region - 150X.

Plate LII.
Connecticut Ben Davis - cross-section cambial region - 150X.

Plate LIII.
Indiana Ben Davis - cross-section cambial region - 150X.

Plate LIV.
Indiana Ben Davis - longitudinal section cambial region - 150X.

Plate LV.
Kentucky Ben Davis - longitudinal section cambial region - 150X.

Plate LVI.
Illinois Ben Davis - cross-section cambial region - 150X.

Plate LVII.
Illinois Ben Davis - longitudinal section cambial region - 150X.

Plate LVIII.
Michigan Ben Davis - longitudinal section pith region - 150X.

Plate LIX.
Virginia Ben Davis - longitudinal section pith region - 150X.

Plate LX.
Indiana Ben Davis - longitudinal section pith region - 150X.

PLATE I.

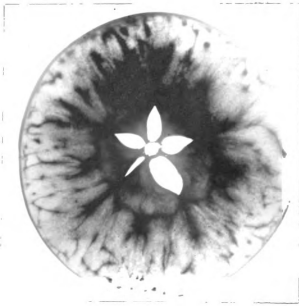
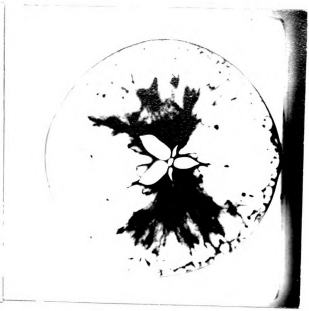


Fig. 1.



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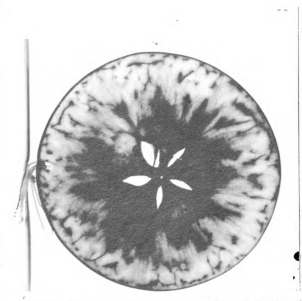


Fig. 3.

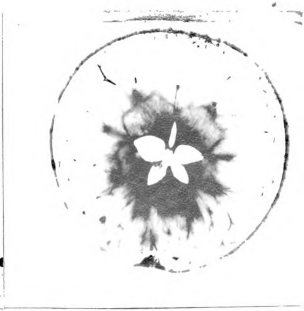


Fig. 4.

PLATE I.

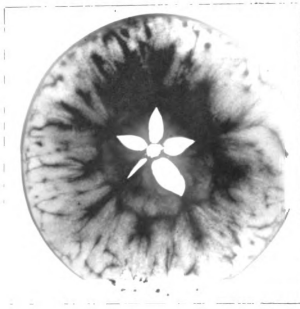
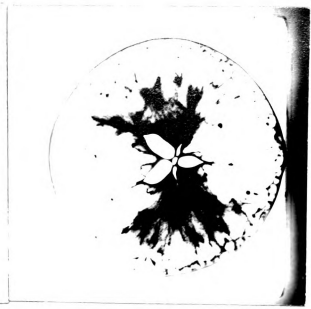


Fig. 1.



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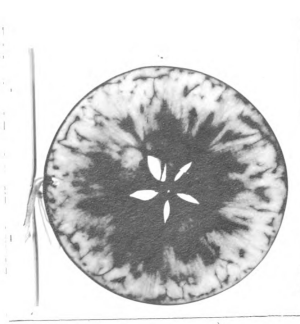


Fig. 3.

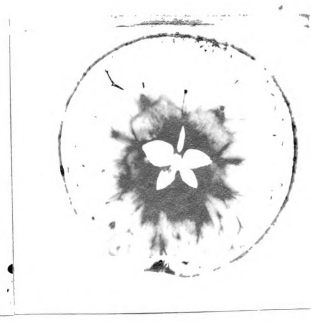


Fig. 4.

PLATE II.

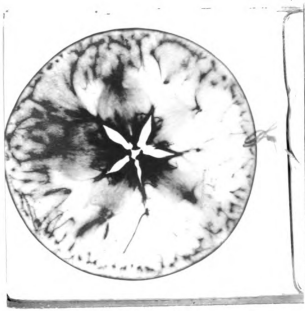


Fig. 1.

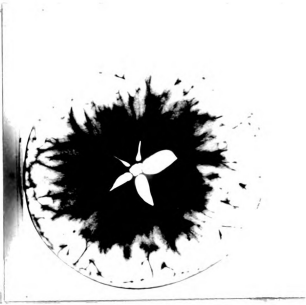


Fig. 2.

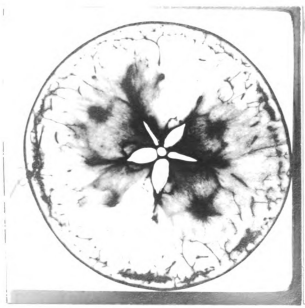


Fig. 3.

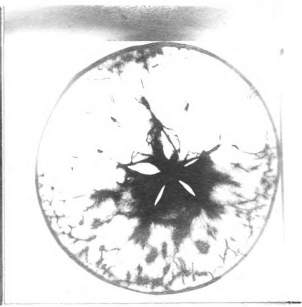


Fig. 4.

PLATE III.

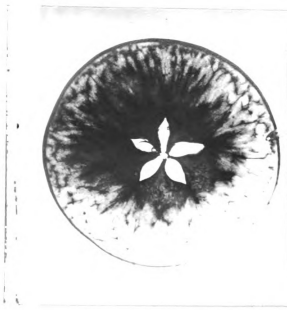


Fig. 1.

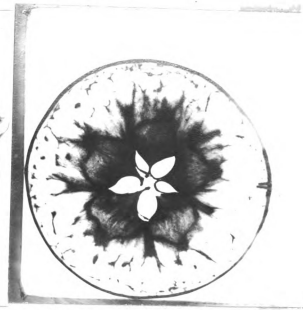


Fig. 2.

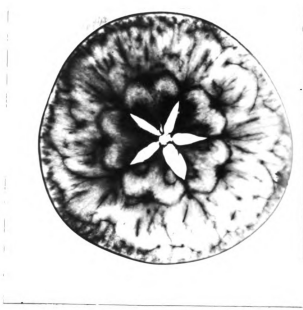


Fig. 3.

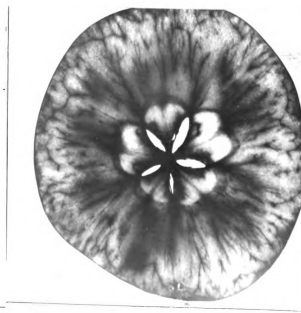


Fig. 4.

PLATE IV.

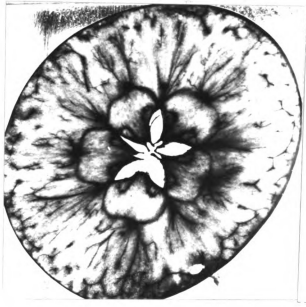


Fig. 1.

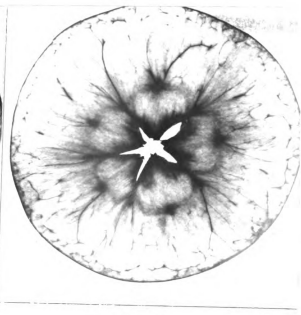


Fig. 2.

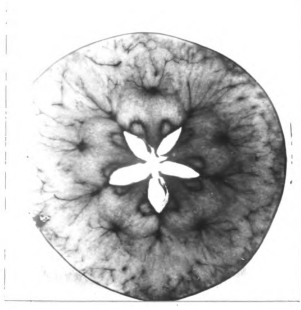


Fig. 3.

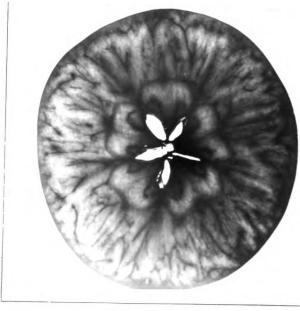


Fig. 4.

PLATE V.

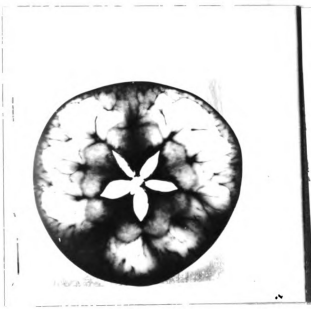


Fig. 1.

Fig. 2.

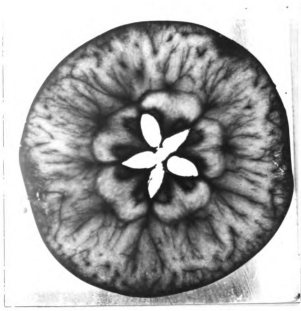


Fig. 3.

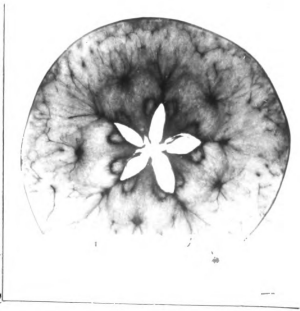


Fig. 4.

P L A T E VI.

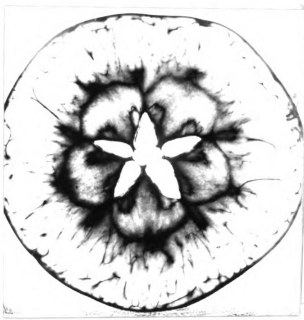
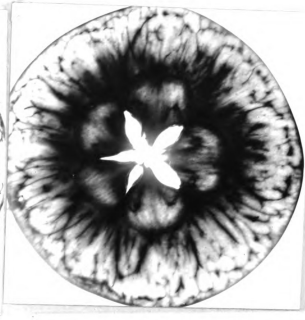


Fig. 1.



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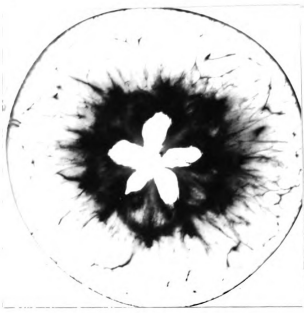


Fig. 3.

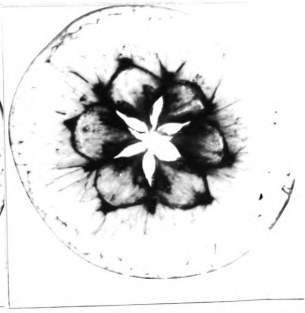


Fig. 4.

PLATE VII.

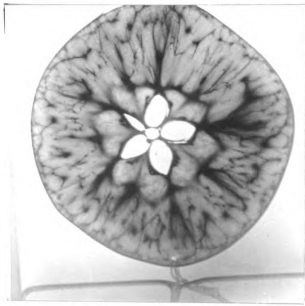


Fig. 1.

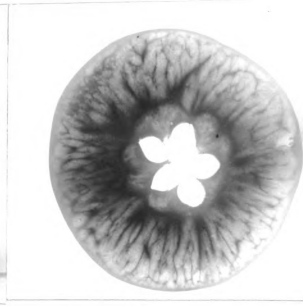


Fig. 2.

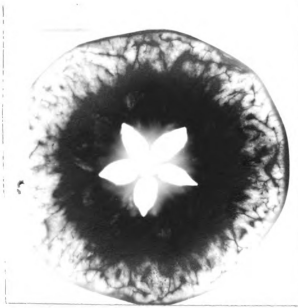


Fig. 3.

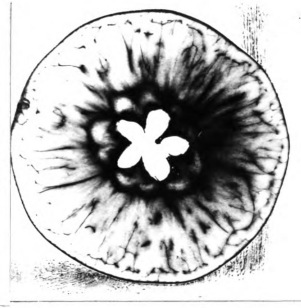


Fig. 4.

PLATE VIII.

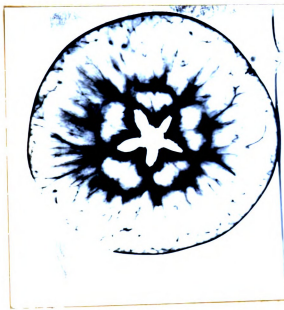


Fig. 1.

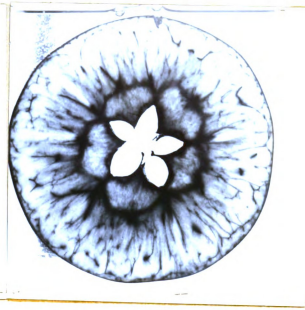


Fig. 2.

Fig. 3.

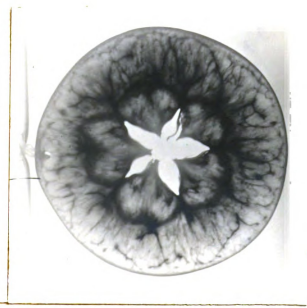


Fig. 4.

PLATE IX.

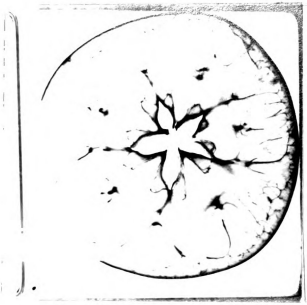


Fig. 1.

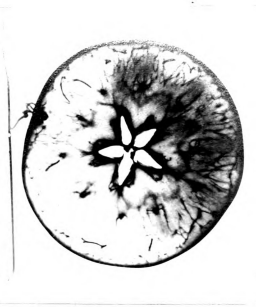


Fig. 2.

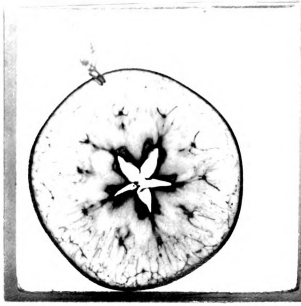


Fig. 3.

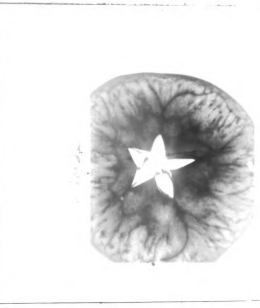


Fig. 4.

PLATE X.

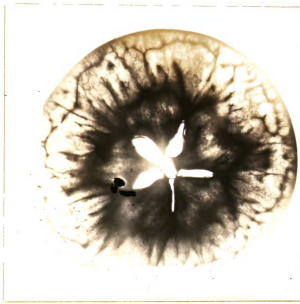


Fig. 1.

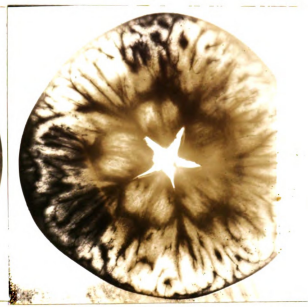


Fig. 2.

Fig. 3.

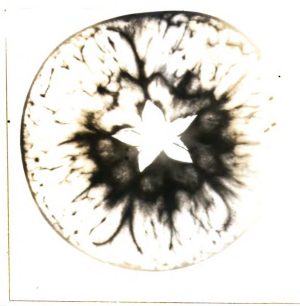


Fig. 4.

PLATE XI.

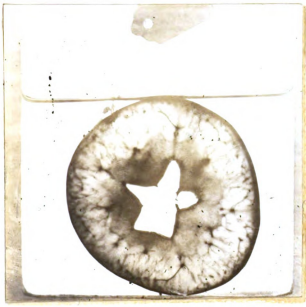


Fig. 1.

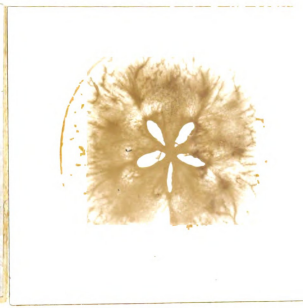


Fig. 2.

Fig. 3.

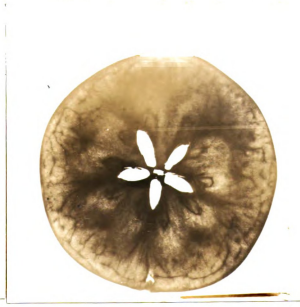


Fig. 4.

PLATE XII.

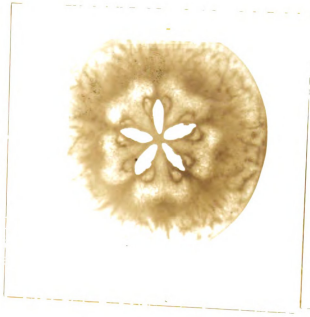


Fig. 1.

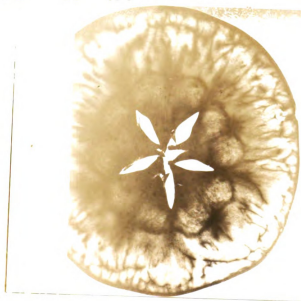


Fig. 2.

Fig. 3.

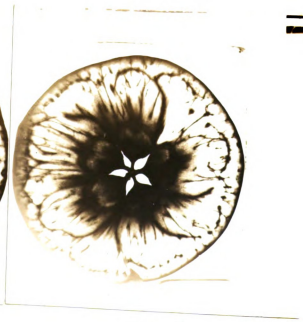


Fig. 4.

PLATE XIII.

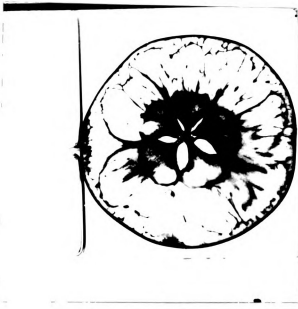


Fig. 1.

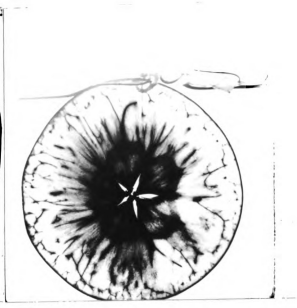


Fig. 2.

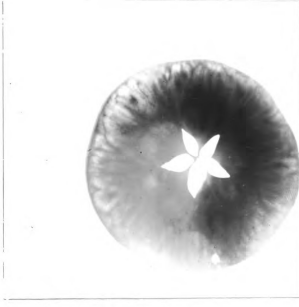


Fig. 3.

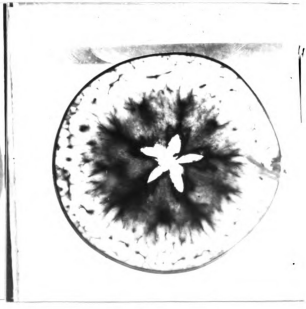


Fig. 4.

P L A T E XIV.

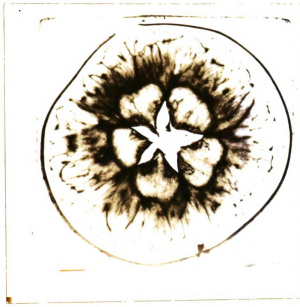


Fig. 1.

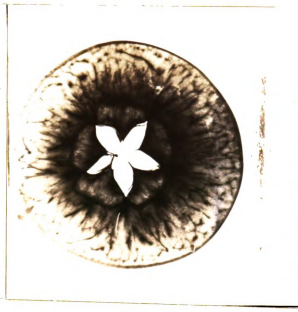


Fig. 2.

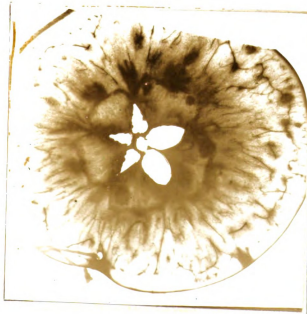


Fig. 3.

Fig. 4.

PLATE XV.

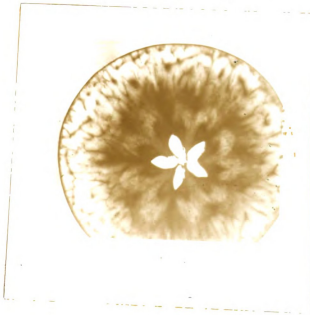


Fig. 1.

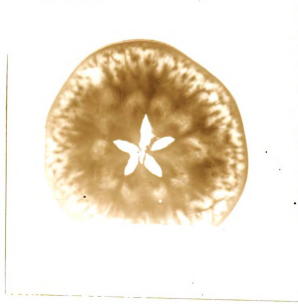


Fig. 2.

Fig. 3.

Fig. 4.

PLATE XVI.

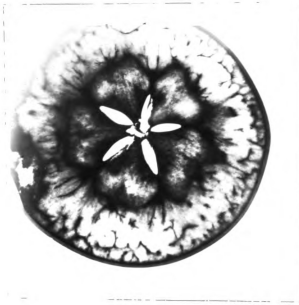


Fig. 1.

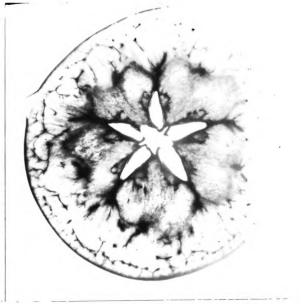


Fig. 2.

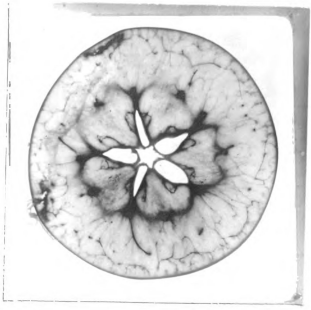


Fig. 3.

P L A T E XVII.

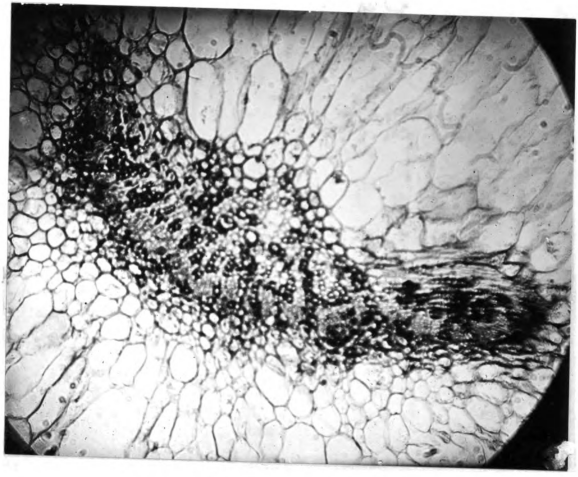
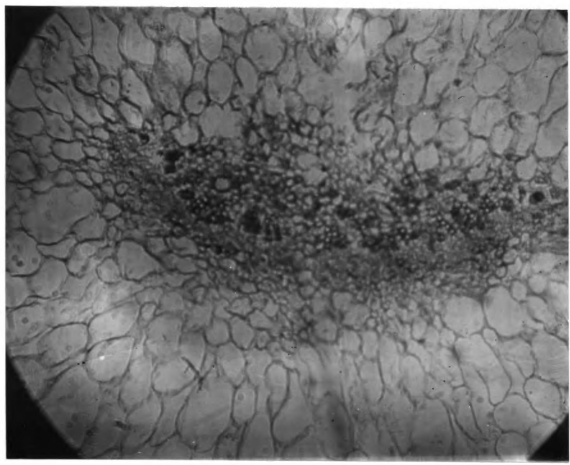


PLATE XVIII.



P L A T E XIX.

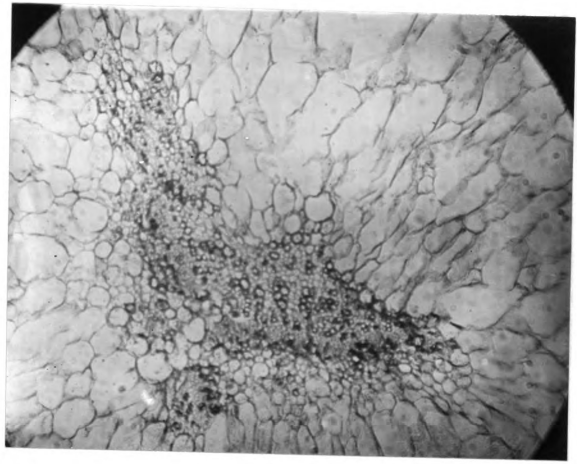
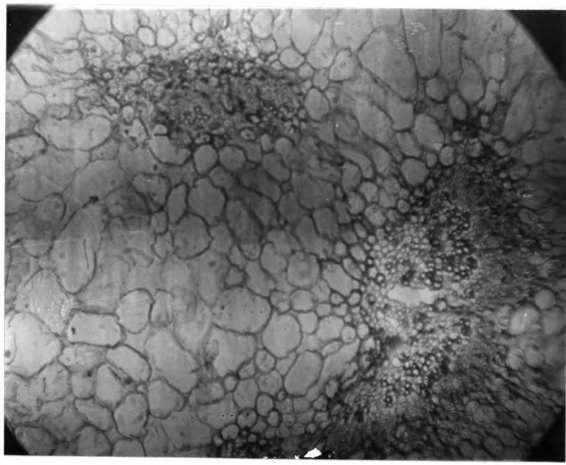
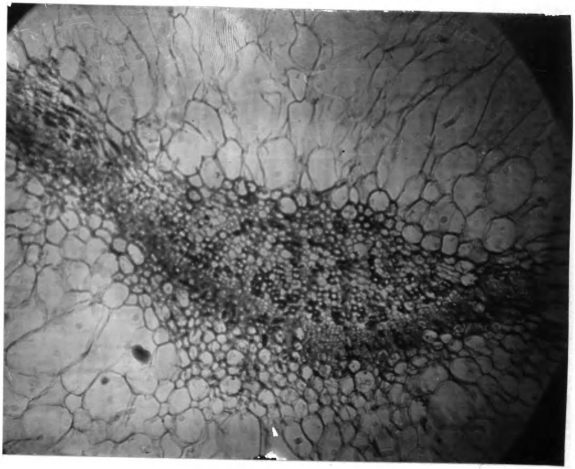


PLATE XX.

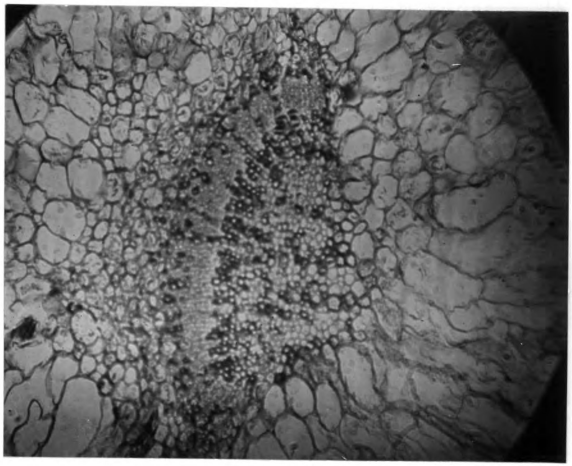


P L A T E XXI.

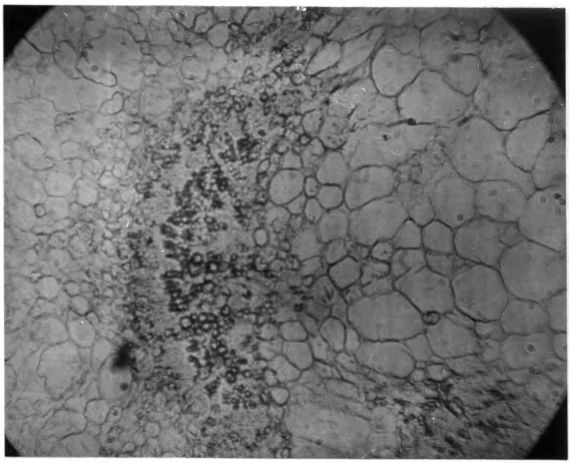


P L A T E XXII.

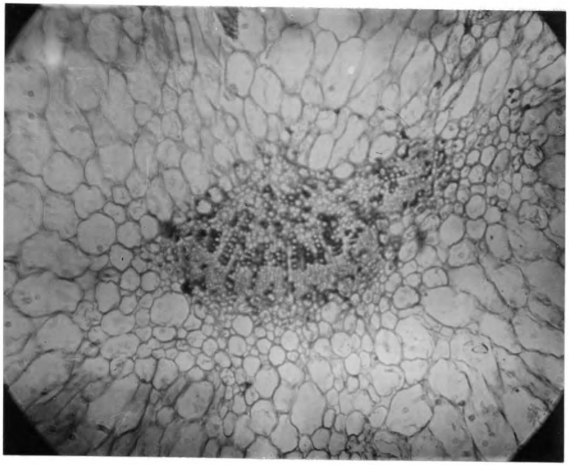
P L A T E XXIII.



P L A T E XXIV.



P L A T E XXV.



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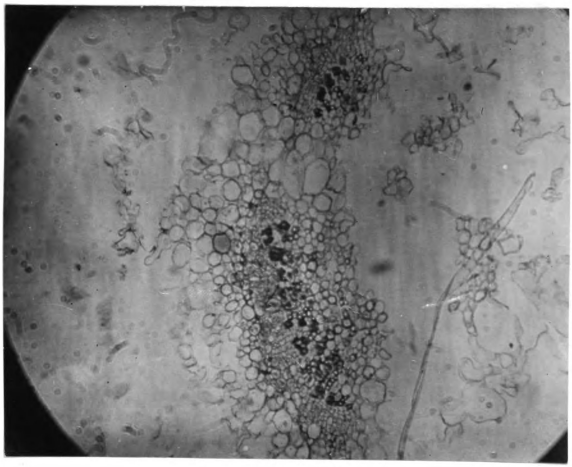
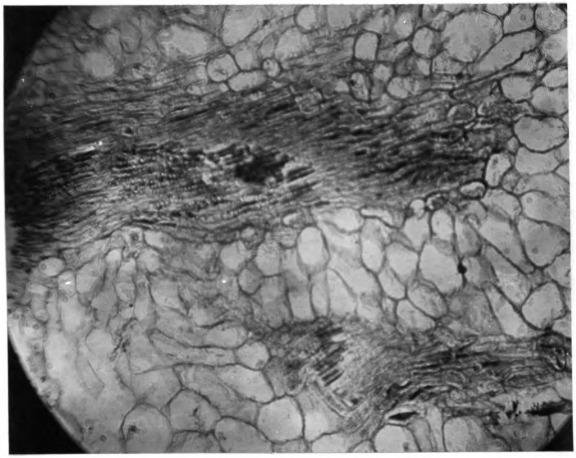


PLATE XXVII.



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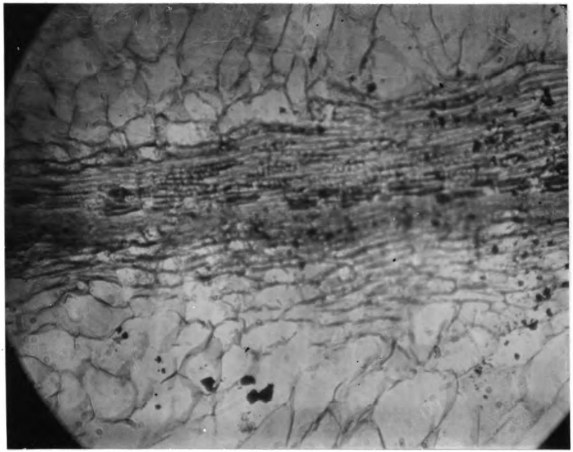


P L A T E XXIX.

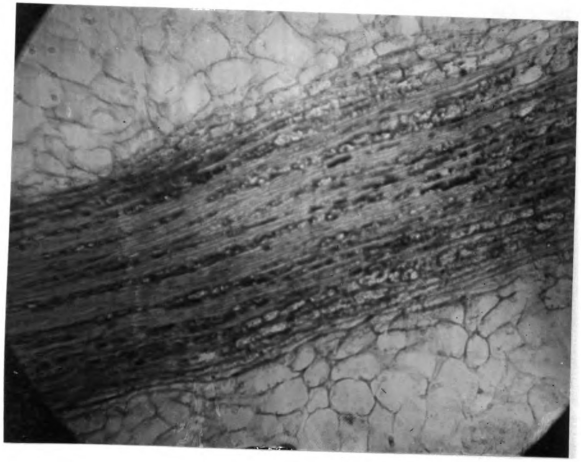
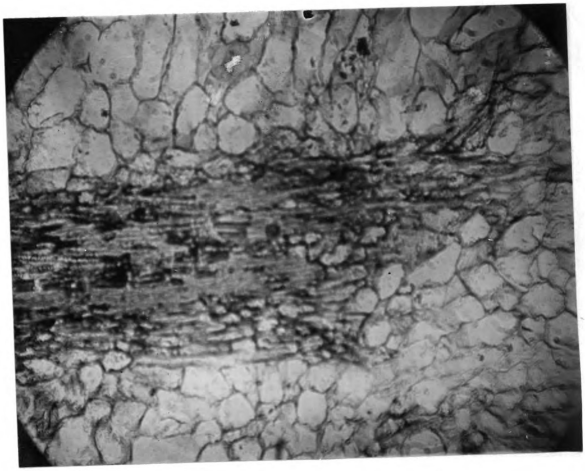


PLATE XXX.



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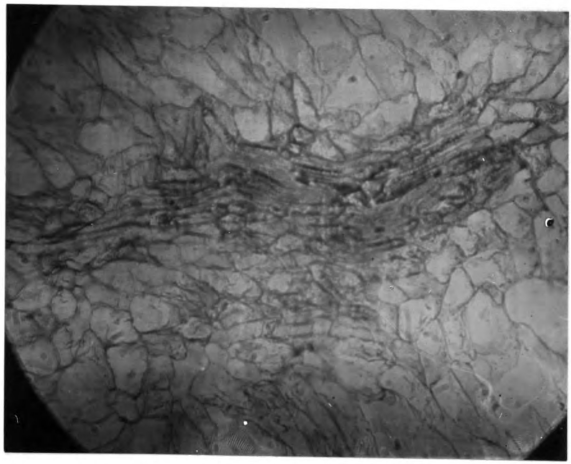

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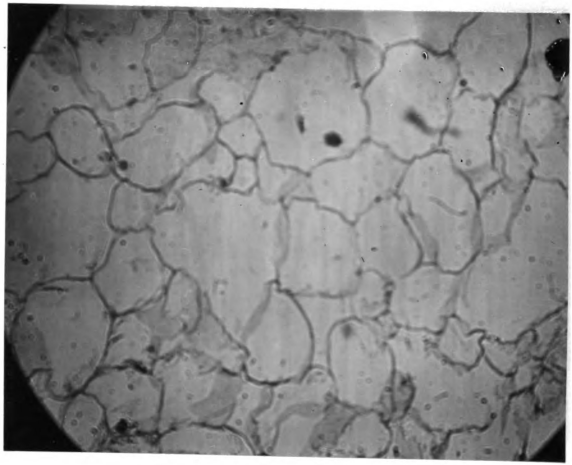

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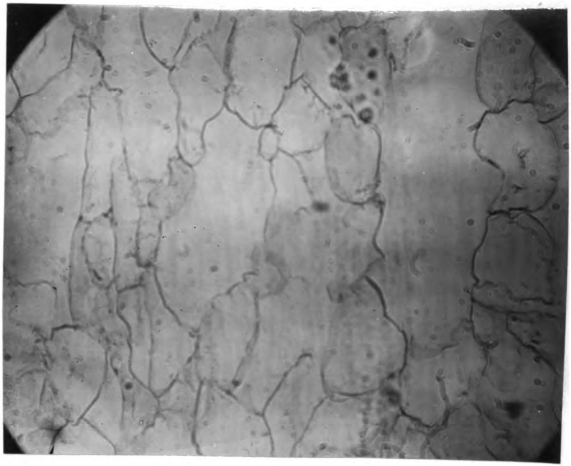

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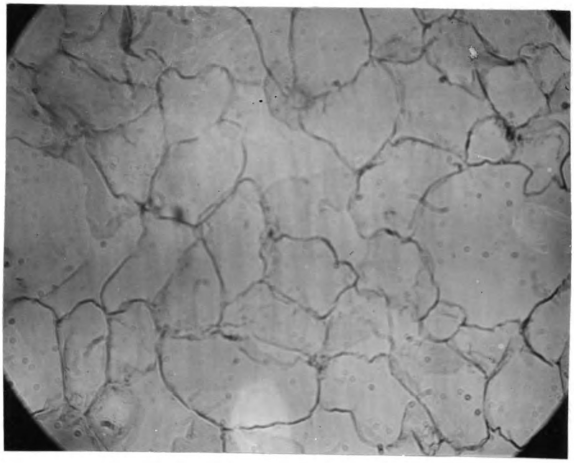

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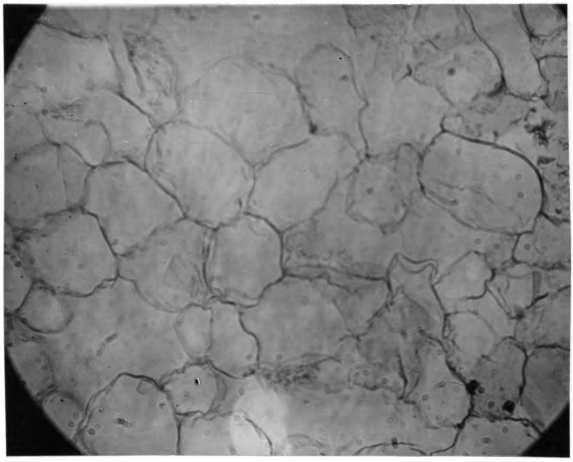

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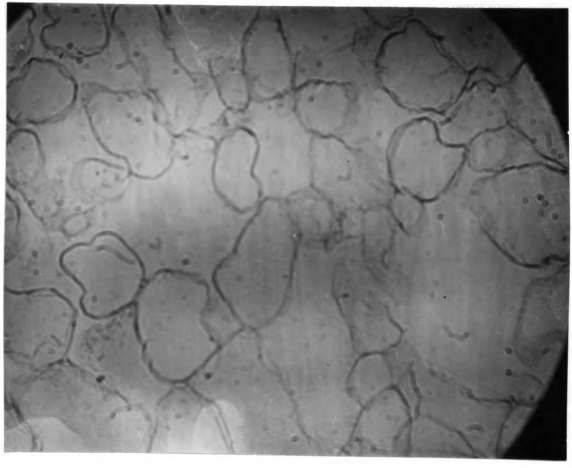

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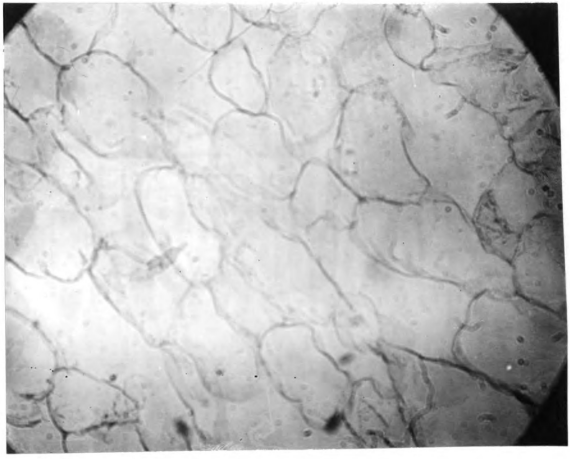

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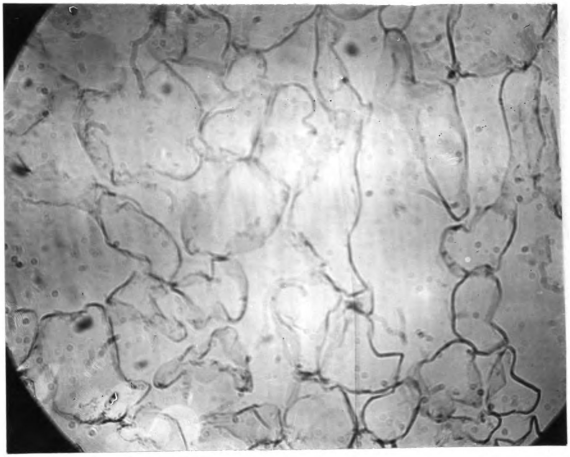

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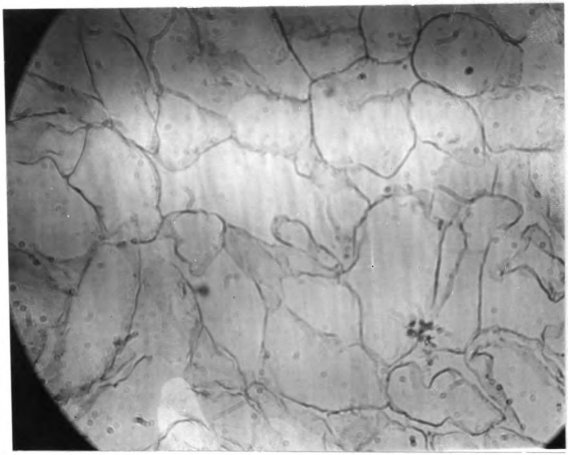


PLATE XL.

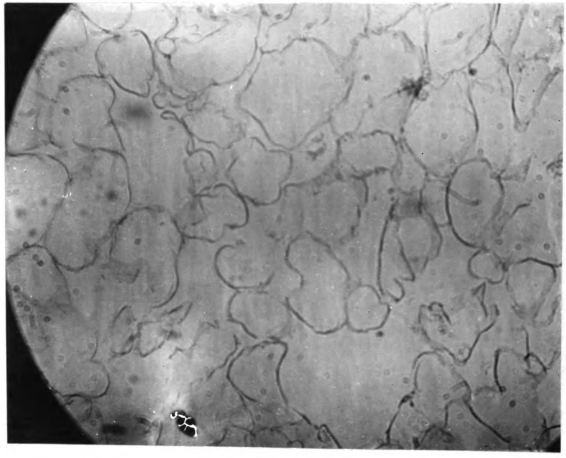
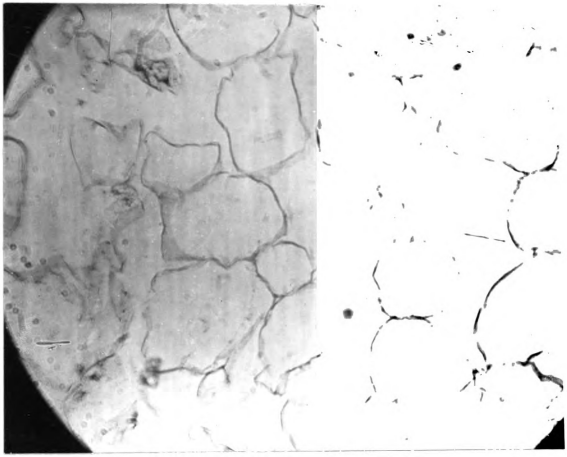


PLATE XLI.



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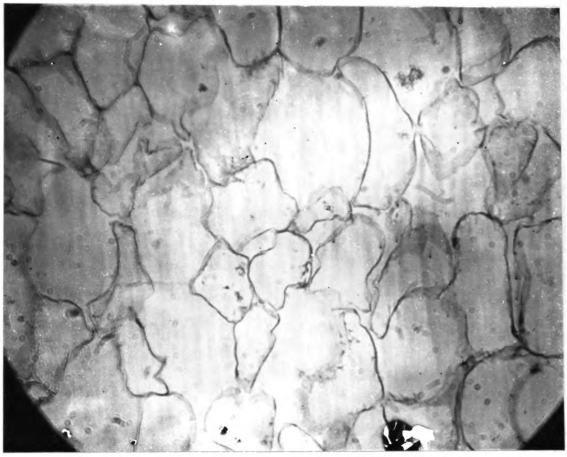

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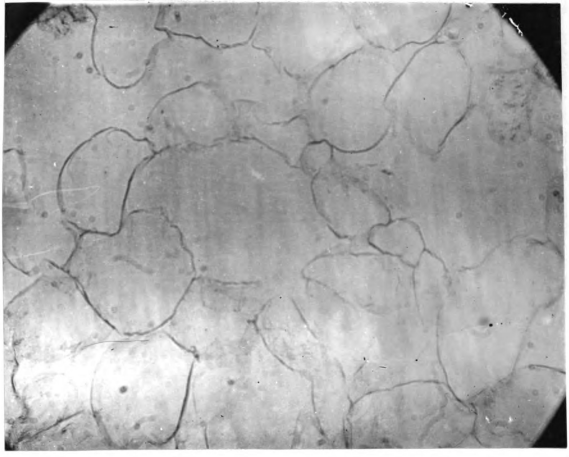

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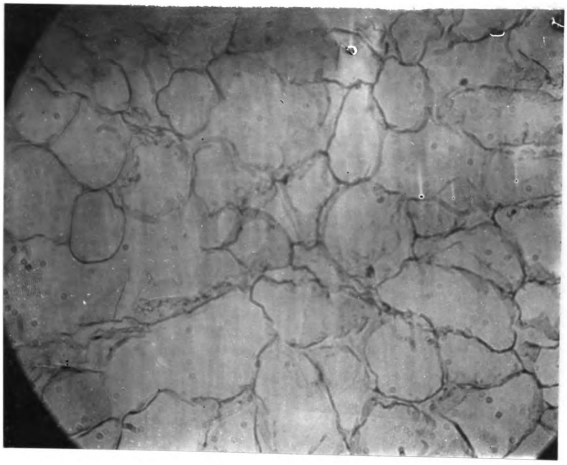

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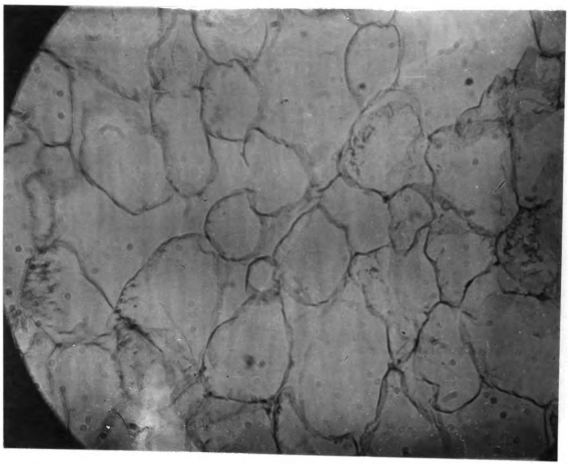

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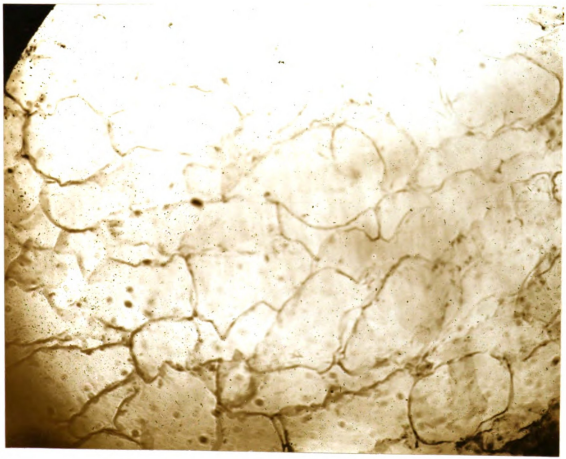
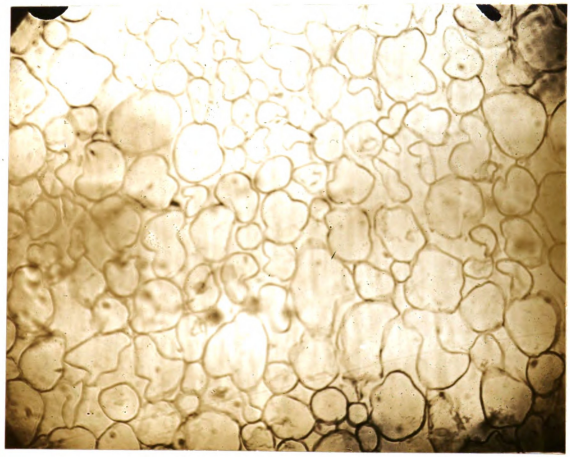


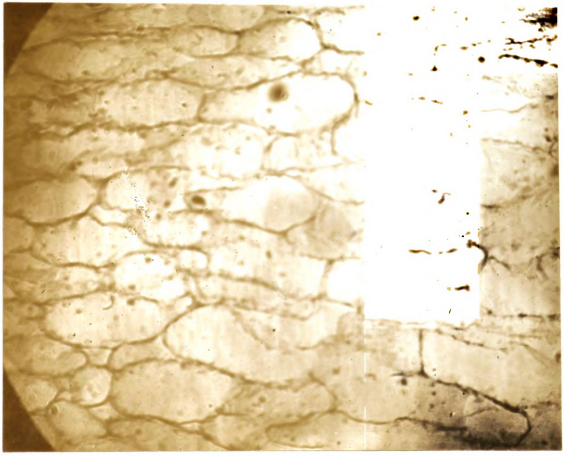
PLATE XLVII.

PLATE XLVIII.



P L A T E XLIX.

PLATE L.



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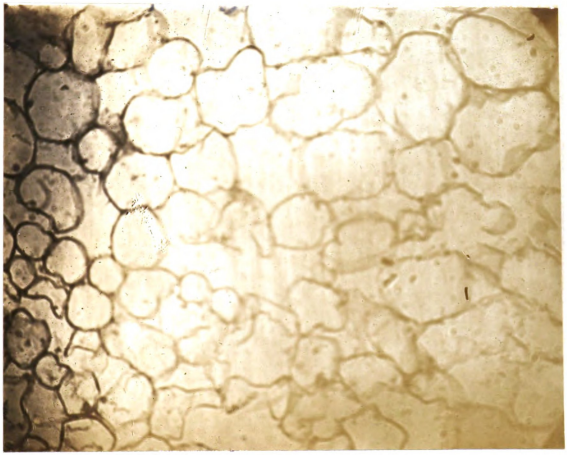

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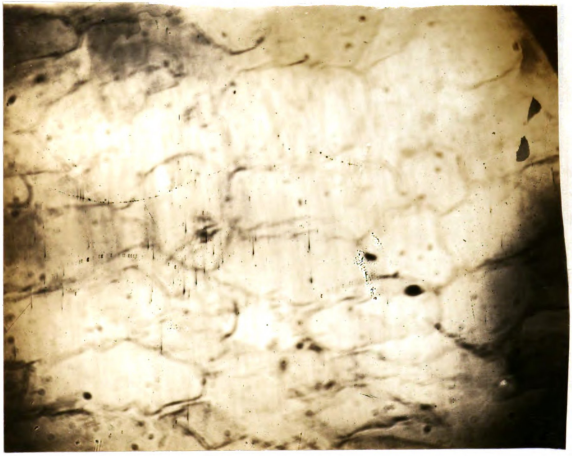

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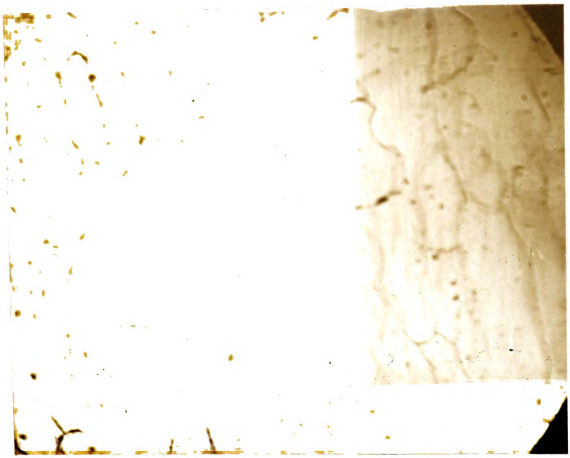
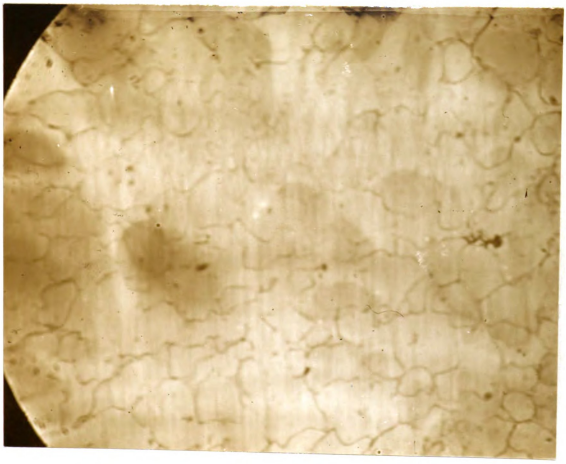


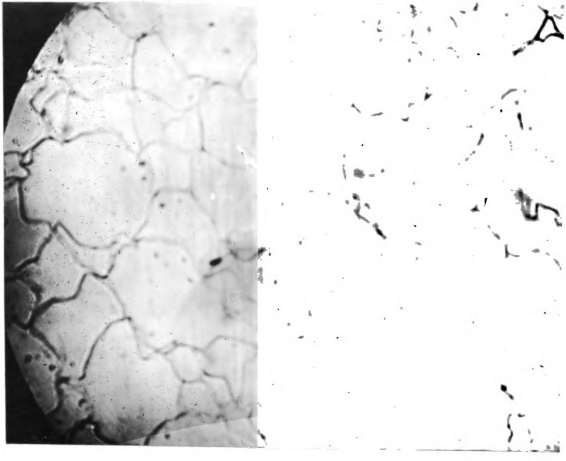
PLATE LIV.

PLATE LV.



P L A T E LVI.

PLATE LVII.



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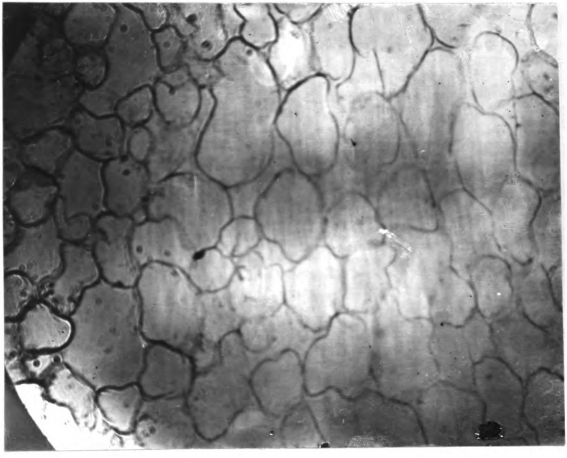

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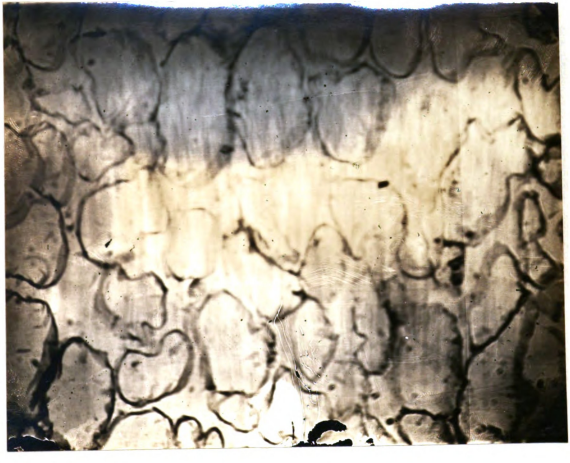

PLATE LX.