THE DEVELOPMENT AND ANATOMY OF THE COWPEA SEEDLING

(VIGNA SINENSIS)

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(VIGNA SINENSIS)

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Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

1938

Submitted to the Department of Botany and Plant Pathology

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

For the degree of

MASTER OF SCIENCE

1939

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ACKNOWLEDGMENT

I wish to acknowledge with gratitude the encouragement given me in the preparation of this paper by Professor Robert Stratton of the Department of Botany and Plant Pathology and by Professor Orville C. Schultz of the same department. I also wish to thank Dr. W. B. Gernert of the Department of Agronomy for donating the seed used in this investigation.

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INTRODUCTION

The literature on the cowpea is not at all extensive although the plant has been cultivated since prehistoric times. Previous studies have been confined to methods of culture, utilization, variety testing, and disease resistance. The present study was undertaken to describe the developmental anatomy of the cowpea seedling and especially to determine the region of root-stem transition.

There are about sixty known species of Vigna, three of which are cultivated, namely: the Asparagus bean, Vigna sesquipedalis (L) W. F. Wight; the catjung, Vigna catjung (Burm.) Walp.; and the cowpea, Vigna sinensis (Stickman) Enlicher. Of these three species the cowpea is by far the most important.

According to Piper (3) the correct name for the cowpea is Vigna sinensis (Stickman) Enlicher. Piper found that the specimen described by Linnaeus as Dolichos unguiculatus is actually Phaseolus antillanus. The name applied by Stickman in 1759 is therefore the correct one.

Wight (6) states that the cowpea originally came from India, but Piper (5) concludes that the original home was Central Africa where the wild prototype, Vigna triloba, is still found growing.

In either event the cowpea

> "seems to have been first cultivated in India and to have spread in prehistoric times to China, the whole of the Malayan region, and probably much of Africa. It was known in Europe at least as early as the beginning of the Christian Era." (3)

The cowpea was introduced early into the West Indies and by 1775 it was well known in Carolina. (3) It is now the most important legume grown in the area where cotton is cultivated. (4)

METHODS AND MATERIALS

Material from five different varieties of cowpeas was used in this study. The seed was obtained from the Oklahoma Experiment Station Farm where the varieties have been grown and tested for a number of years. The plants were grown in sand in the College greenhouse. The following varieties were used: Brabham, Early Buff, Groit, Iron, and New Era.

Entire plants of each variety varying from one to twenty-one days in age were killed and fixed in formalin-acetic alcohol. Each seedling was cut into segments approximately ten millimeters long and fixed for at least ten days before dehydration. The material was cleared in xylol, imbedded in paraffin and sectioned serially at fifteen microns. The sections were stained in an alcoholic solution of safranin and light green in clove oil. Free-hand sections were used as an aid in determining the transition region and the leaf traces.

Plate III was prepared by Naylor's (2) method. Briefly this consists of photographing the sections, enlarging the photograph and tracing with India ink. The photograph is then faded out with a potassium iodide-iodine solution and the iodine is removed with a sodium hyposulphite solution.

EXPLANATION OF TERMS

Hypocotyl - In this paper the term hypocotyl refers to that portion of of the stem between the cotyledonary node and the root.

Epicotyl - That portion of the axis above the cotyledonary node is called the epicotyl.

Collet - The swelling at the ground level which occurs just above the root is the collet.

THE SEEDLING

The seeds germinate in about two days at a temperature of 80 to 85 degrees Fahrenheit. The radicle breaks through the seed coat at the micropyle and elongates rapidly establishing a permanent, primary root system. The hypocotyl also elongates rapidly arching and pulling the cotyledons out of the ground. The plumule remains between the folded cotyledons until the hypocotyl is approximately five and one-half centimeters long. The hard seed coat often adheres to the cotyledons for a day or two so that the plumule has great difficulty in escaping. The cotyledons never become leaf-like, but fall from the plant soon after the first true leaves begin to function. The first true leaves stand at right angles to the cotyledons and are opposite and unifoliate. The first trifoliate leaf develops in about fourteen days. At the same node another trifoliate leaf develops somewhat later. There are two stipules at the base of each leaf and two stipels at the base of each leaflet. Buds develop early in the axils of the cotyledons, unifoliate leaves and trifoliate leaves. Ordinarily, the buds in the axils of the cotyledons do not function.

INVESTIGATION

The root of the cowpea is a tetrarch, exarch protostele. The protoxylem groups are just distinguishable one centimeter back of the root tip. Four centimeters higher the metaxylem and a weak endodermis have differentiated. The phloem of the root remains parenchymatous in character except for a few peripheral fibers lying next to the pericycle and alternating with the protoxylem points. These fibers are differentiated when the seedling is nine days old. The pericycle is multiseriate and originates the lateral roots on the same radii as the

protoxylem points. The lateral roots are diarch exarch protosteles. Cambium initials differentiate very early in the root and at the collet a complete cambium ring has developed. The cortex of the root consists of several layers of parenchyma, an epidermis and an endodermis with weak Casparian strips. The root is of the third Angiospermous type of Janczewski (1). In this type a distinct plerome and pleriblem originate the stele and the cortex, respectively, while a third histogen, the dermatogen-calyptrogen, originates the root cap and the epidermis.

Each xylem strand of the root forks by radial division. As each strand forks it swings out laterally at the collet until the protoxylem assumes a mesarch position. (Plate II, C) The lateral development of the xylem continues in the hypocotyl to just below the cotyledons where the halves of two of the original strands become widely separated. The four bundles which result have passed through a 180° turn and are completely endarch at the cotyledonary node. The halves of the other two original bundles do not separate and the protoxylem remains in a mesarch position from the collet to the cotyledons (Plate II, E). These two mesarch bundles are the cotyledonary traces.

Two or three centimeters below the collet the metaxylem fails to lignify. This parenchymatous center soon breaks down completely so that the hypocotyl has a hollow center. Except for groups of fibers, the phloem of the hypocotyl remains parenchymatous and contains many large lacunae.

Above the cotyledonary node there are six bundles. Four of these represent halves of two of the original bundles and two are new traces. These six bundles are grouped in threes, the groups being separated by the gaps of the cotyledonary traces. Higher in the epicotyl six new traces appear, two above the cotyledonary plane and two in the groups

on either side. (Plate II, F) Just below the unifoliate leaves three veins leave the central stele on either side becoming the leaf traces. The three traces to each leaf unite into one bundle in the petiole of the leaf. Each stipule is supplied by one bundle.

In the petiole of the trifoliate leaf a new trace has appeared and two bundles move to the peripheral ridges to become stipel traces. The two lateral leaflets of the trifoliate leaf are supplied by branches of two traces. These branches unite in the petiolule. The end leaflet is supplied by three traces which also unite in the petiolule. The stipels of each leaflet are each supplied by one trace. (Plate II, H & I)

No cortical fibers developed in the seedlings studied, but pericyclic fibers cause the older stem and hypocotyl to become very hard. A complete cambium ring seems to function throughout the seedling above the collet. By the time the seedling is four weeks old a typical dictyostele with collateral endarch bundles is developed in the epicotyl.

SUMMARY

1. The root of the cowpea is a tetrarch, exarch protostele.
2. The center of the root becomes parenchymatous in nature, separating the metaxylem into four groups.
3. Cambium initials develop early between the protoxylem arms.
4. The pericycle is multiseriate and produces the lateral roots on the same radii as the protoxylem points.
5. The endodermis which extends only to the collet has very weak Casparian strips.
6. The first evidence of transition occurs at the collet when the radial development of the metaxylem causes the protoxylem to become mesarch.
7. Two of the original xylem groups fork and swing out laterally passing through a 180° turn in the hypocotyl. They become four endarch bundles just below the cotyledons.
8. The other two original bundles remain mesarch throughout the hypocotyl and become the cotyledonary traces.
9. Above the cotyledons other traces appear. The unifoliate leaves are supplied by three traces and their stipules by one each. The two lateral leaflets of the trifoliate leaves are each supplied by two traces while the end leaflet is supplied by three. Stipels are each supplied by one trace.
10. Pericyclic fibers develop in the stem and hypocotyl of four-week-old seedlings.
11. No anatomical differences between the varieties were noted.

EXPLANATION OF PLATE I

A. Germinating seed of the cowpea. The radicle is emerging.

B. Two day old seedling. The arch of the hypocotyl has almost been lost.

C. Four day old seedling. The hard seed coat adheres preventing the first leaves from emerging.

D. Six day old seedling. The epicotyl has elongated and the two unifoliate leaves are functioning.

E. Nine day old seedling. The cotyledons have fallen from the plant and the apical bud is developing.

F. Twelve day old seedling. Note that both of the trifoliate leaves have appeared at the second node above the cotyledons, but that one is much slower in developing than the other.

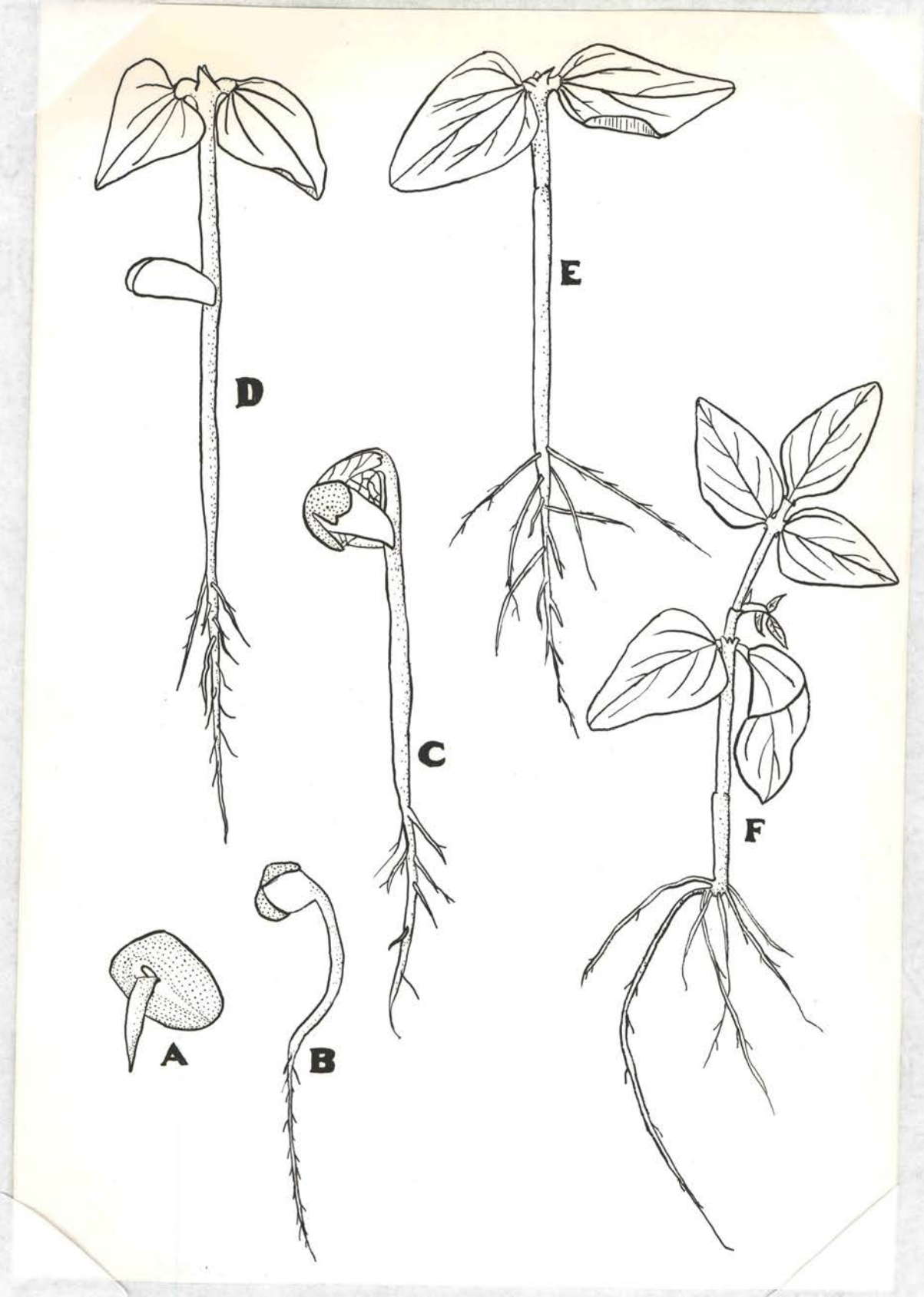

PLATE I

EXPLANATION OF PLATE II

In all diagrams, protoxylem is indicated by solid black, metaxylem by single hatching, phloem by shading and cambium by crosses. Only xylem is indicated in figures E to I inclusive.

A. Transverse section of root six cm. back of the root tip showing the four protoxylem groups.

B. Transverse section of root $1\frac{1}{2}$ cm. below the collet showing the four protoxylem groups between the four phloem areas. Note that the metaxylem in the center has failed to lignify.

C. Transverse section at the collet showing extensive lateral development of the sylem which causes the protoxylem to assume a mesarch position.

D. Transverse section of hypocotyl $2\frac{1}{2}$ cm. above the collet. Note the complete cambium ring. The parenchyma in the center has completely broken down.

E. Transverse section of the hypocotyl just below the cotyledons. The two bundles which have failed to become endarch are the cotyledonary traces.

F. Transverse section of the epicotyl one cm. above the cotyledonary node. Note that there are six large xylem areas and six secondary areas.

G. Transverse section of epicotyl just below the unifoliate leaves. Bundles 1, 2, and 3 are traces to one of these leaves.

H. Transverse section of petiole of trifoliate leaf just below the end leaflet.

I. Transverse section of petiole of trifoliate leaf. Bundles 1 and 2 are traces to one of the lateral leaflets. Bundle 3 is a stipel trace.

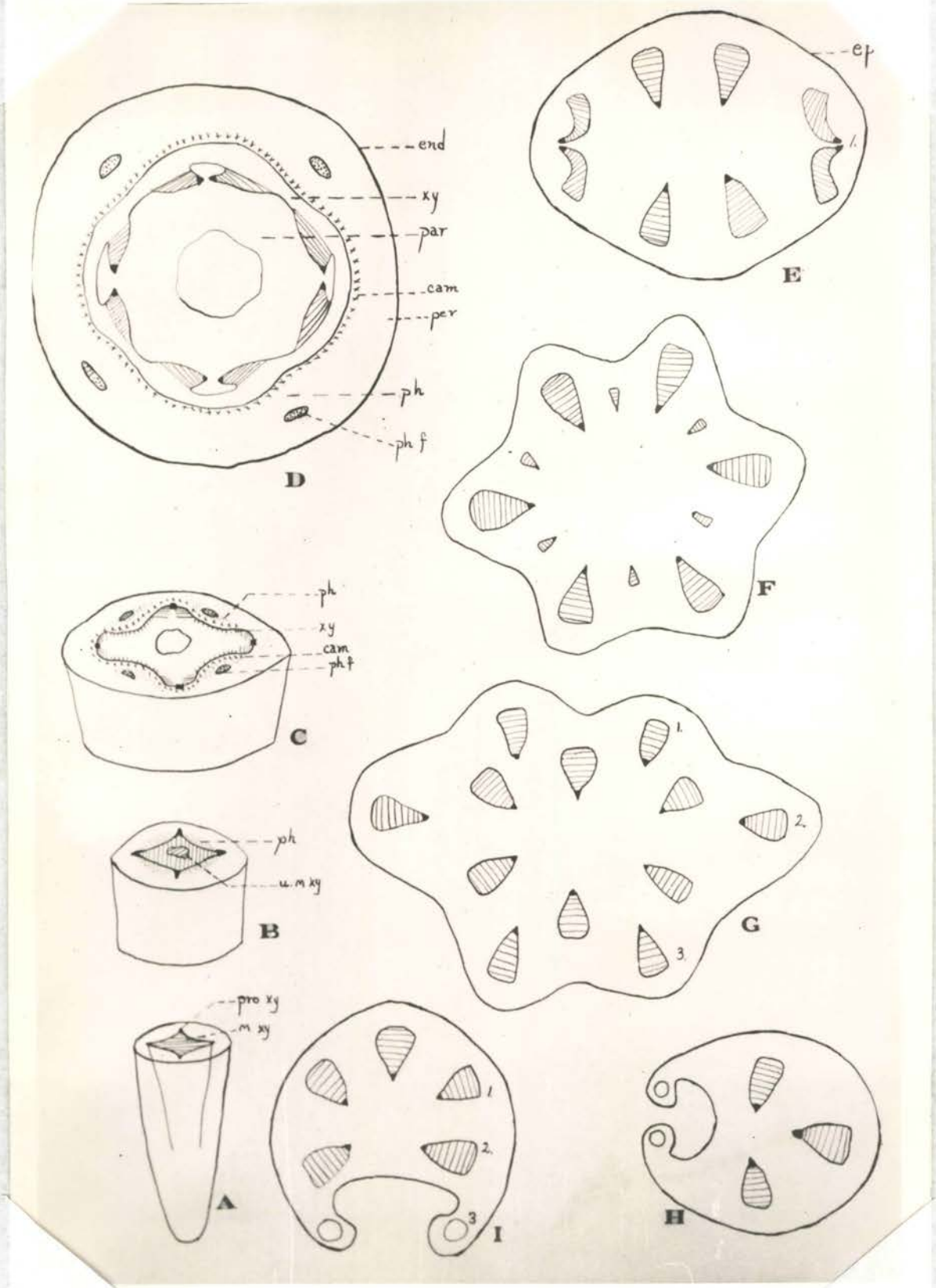
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PLATE II

EXPLANATION OF PLATE III

A. Transverse section of root $5\frac{1}{2}$ cm. below collet. Note the cambium initials and the groups of phloem fibers.

B. Transverse section of root $1\frac{1}{2}$ cm. below collet. Note the parenchymatous center.

C. Transverse section of hypocotyl 3 mm. above the collet. Note the large lacunae and fibers in the phloem and the mesarch position of the protoxylem.

D. Transverse section of epicotyl one cm. above the cotyledonary node.

Abbreviations used: cam, cambium; end, endodermis; epi, epidermis; l root, lateral root; m xy, metaxylem; par, parenchyma; per, pericycle; ph, phloem; ph f, phloem fibers; pro xy, protoxylem; u m xy, unlignified metaxylem.

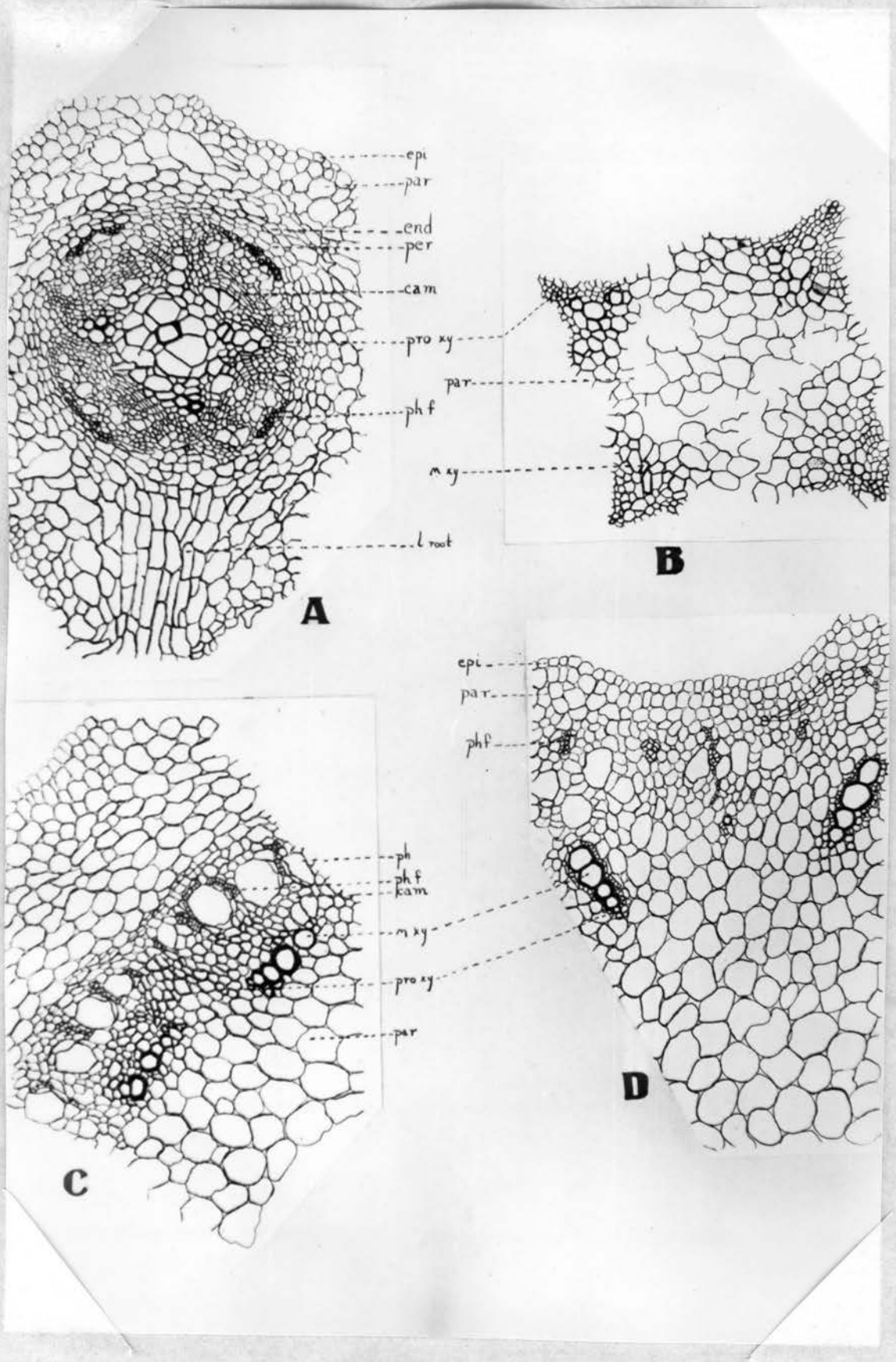
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PLATE III

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