STUDIES IN THE ANATOMY OF SUGARCANE STALK

III. Fission and Pseudo-Fission

BY S. L. SHARMA, M.SC., AND K. L. KHANNA, F.A.SC.
(*Central Sugarcane Research Station, Pusa, Bihar*)

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I. INTRODUCTION

WHILE harvesting B. O. 17 (a variety bred at the Station) the authors came across an abnormal case of bifurcation of stalk in which the two arms, after having grown independently for some distance, appeared to have coalesced to form a single stalk again.

Normally once a fission had taken place, the two resulting stems maintained their separate existence to the end.

With a view to study this abnormal case, search for normally bifurcated stalks yielded one stalk of Co 213 and two of *Saraitha*, a variety of indigenous canes of the province, belonging to the group of the same name.

All the four stalks were described in detail both from morphological and anatomical points of view, and an effort was made to explain the phenomenon.

II. MATERIAL AND METHODS

The four stalks were numbered as follows:

B.O. 17	..	I
Co 213	..	II
Saraitha	..	III and IV (Plate III).

The internodes were counted upwards and downwards respectively as + 1, + 2 and so on, and − 1, − 2 from the node above which the two arms existed as independant entities and which was, therefore, designated as Node 0. The nodes were similarly numbered as + i, + ii and so on upwards and − i, − ii.... downwards from Node 0. The two halves or arms of a stalk to the left and right of the median diameter* were respectively known as A and B. In the following account the number of a stalk is

* A stalk of sugarcane has two principal diameters, namely, (i) the median passing from front to back through the bud and (ii) the lateral from side to side at right angles to the median. If median diameter is greater than the lateral, the cross-section is said to be oval; if reverse is the case, it is known as flattened.

followed by that of an internode or a node; thus I/ + 2B would mean second internode of the right arm above Node 0 of stalk I. After morphological description of the stalks, their hand sections were taken from different internodes and at different levels of the same internode when necessary, were stained with 1% solution of safranin in 50% of alcohol, and mounted permanently.

III. Morphology

(*a*) *Normal fission.*—The two stalks of *Saraitha* were similar in that they did not bear within three or four internodes any outward indication of the agency causing the fission, and that the resultant arms of the fork were more or less equal in length and girth at least for a couple of internodes above the node 0 where actual rupture had taken place. In both the cases the process of splitting was slow and spread over 2–3 internodes below the node 0.

III/ − 4 had no signs of the oncoming split, as it was more or less circular in cross-section having only one bud groove and a cavity in the centre. At III/ − iii there appeared three buds of which the central one was much smaller than those, situated laterally and more or less equal in size. The left bud had a distinct furrow above it while there was no indication of a bud groove on the right, the central bud being too small to have any groove. III/ − 3 was somewhat flattened in cross-section, but the cavity inside maintained its central position. At III/ − ii there were two buds more or less equal in size but only the right one had a bud groove. III/ − 2 above it showed further flattening and the central cavity was pushed to the right and a small cavity was found to develop slowly in the left portion. Still there was no indication of any fissure on the surface. On III/ − i however, the buds were situated on either side of a cleft, and had their own grooves. III/ − 1 showed well developed fissures at both the ends of the median diameter and the cavities inside were more or less equally well formed in both the portions (Plate IV, Fig. 1) but it was enclosed by a single leafsheath. At III/0 bifurcation was over and the two resultant arms were complete in all details and grew independently of each other to the end. The nodes and internodes henceforward were encased in distinct leaf-sheaths without any organic connection between them, and were smoothly reniform in outline for some distance. In the case of IV, the process of splitting was more or less the same except that it was shortened by one internode and that there was some modification of details. IV/ − 3 and IV/ − ii were normal in all respects while IV/ − 2 had a shallow depression on the side of the bud and was somewhat flattened on the other side. The main cavity was pushed to one side and another, smaller in size, was making its appearance.

At IV/ – i the bud doubled itself and a cleft appeared on the front side of the internode IV/ – 1 while that from IV/ – 2 was continued at the other end of the median diameter and the two cavities became more or less equal in size (Plate IV, Fig. 2). At IV/0 the rupture was complete and henceforward the two shoots so formed maintained their separate identities, remaining reniform for some distance as already mentioned for III.

In the case of II belonging to Co 213 it appeared that its bifurcation had been brought about by an injury probably caused by an insect at II/ – i and II/ – 1. The major portion of the injury (not shown in the photograph) was situated in A on the other side of the internode. On the bud side also the internode was slightly damaged in B (Plate III *a*). As a result, probably of unequal damage to the two halves of the internode, its cross-section, normally oval in outline, was flattened and became pyriform, the narrow and corresponding to the more injured half, *i.e.*, A. At II/0 there was a single bud situated in A and the root zone and the growth ring did not show any cleft and both II/ + 1A and II/ + 1B were enclosed in a single sheath. In the internodal region just above the growth ring, the stalk bifurcated abruptly into two arms, without any inkling of the ensuing split such as a fissure or cleft on the surface of the lower internodes or of development of two cavities inside them. The two resultant arms were unequal to start with, the thinner arm A corresponding to the more injured left half and the initial difference in the size was maintained throughout.

From the foregoing description of the three stalks, it would appear that the proximity and potency of exciting factor would determine the relative size of the arms. If the disturbing influence was slow to act and situated at considerable distance, the two arms would be equal in length and girth of their internodes as was the case in the two stalks of *Saraitha*. If on the other hand, the causative agency was nearby as in Co 213 and violently active, division would be abrupt and the resulting arms of different sizes.

(*b*) *Pseudo-fission.*—The splitting of the stalk of B.O. 17 was the slowest of all. It took four internodes to complete the fission and that too not for good, because after three internodes the two arms appeared to have coalesced to form a single stalk. If the actual length required to effect the rupture was taken into consideration, it was about 21 cm. in this case as against 14 cm. in stalk III. No injury or any other disturbing factor was found to exist on nodes and internodes even as far down as I/ – 5. The earliest external indication of the ensuing bifurcation appeared on internode I/ – 4 in which a fissure was found to have developed to the right of the bud on I/ – iv, there being no sign whatsoever on the other side. In I/ – 3 a similar cleft was formed again on the right of the bud, while the one of I/ – 4 was continued, in this internode as well and became more pronounced. At I/ – ii and I/ – i there was only one bud having been pushed further to the left of the cleavage. In the I/ – 2, both the furrows deepened but not much. It was I/ – 1 in which actual splitting took place though not completely because the two arms A and B remained organically connected by a thin parenchymatous strip (Plate VI, Figs. 1 and 2) which was absent at I/0. At this node a rudimentary bud was represented by a few scales on A, there being no corresponding structure on B. The two arms were independent of each other above I/0 and although they were encased henceforward in sheaths of their own, they were not identical, which fact would be discussed later in detail. A formed three distinct internodes and developed, at I/ + iiA, a small bud situated in a plane more or less at right angles to that in which the bud at I/ – iv was formed. B consisted of only two internodes and was without any bud. Internode corresponding to I/ + 3A was represented at the upper end of I/ + 2B by a slight swelling, which was not demarcated into various parts of node and internode, there being no leaf and leaf scar corresponding to those of arm A at I/ + iiA.

Apparent coalescence of the two arms which started at approximately half the length of I/ +3A, was over in about 3/4 cm. and resulted in the formation of a single node I/ + iii complete in all details and with a bud on B side. It was formed more or less in the same plane in which I/ + iiA developed it, or in other words at right angles to that of the bud at I/ – iv. I/ + 4 did not bear any sign of having undergone a bifurcation except that it had a long shallow furrow (not shown in the photograph) situated laterally with respect to its own orientation. The furrow when considered in conjunction with the original axes of the stalk prevailing before splitting, would appear in its median plane. The axes of the stalk had therefore, rotated by about a right angle during bifurcation.

It would thus appear that the splitting of the stalk of B.O. 17 was abnormal not only because the two arms appeared to have coalesced after having maintained their independent identities for about 9 cm. but also because the two arms were not structurally identical with each other as was the case in the two stalks of *Saraitha* and one of Co 213. The adjacent surface of the two arms in B.O. 17 stalk did not develop root eyes and were like two pieces of jigsaw puzzle in broad outline the projections of one fitting into the depressions of the other, whereas in normal bifurcation the two arms were smoothly flattened on the adjacent sides on which root eyes were present as usual.

IV. Anatomy

(*a*) *Normal bifurcation*: (i) *Without any visible injury*.—This type of bifurcation did not interfere with the internal structure of the stalk to any great extent. The anatomical make up of IV/ — 3 and III/ — 4, III/ — 3 and III/ — 2 was perfectly normal except that another cavity had appeared in the last named internode (Plate IV, Fig. 1). Although none of the malformations associated with top borer attacks (Khanna and Sharma, 1948) or any other kind of disturbance in the internal structure was noticeable, the parenchymatous cells in the peripheral zone at the two ends of the median diameter along which fission would take place, were found to contain varying amounts of the brown substance apparently similar to that noted before (*loc. cit.*). The vascular bundles however, even in this portion of matrix were not clogged. In IV/ — 2 at one end of the plane of fission having a groove, an equilaterally triangular patch of comparatively thin-walled parenchyma (Plate IV, Fig. 3 *p*) appeared in between the outermost vascular bundles and a highly lignified zone of small celled parenchyma (called henceforward the hypodermal zone) and was continued taperingly on either side of the depression. It was covered over by epidermis except in the depression where it having atrophied, the outermost cells of hypodermal zone also showed necrosis. The parenchymatous ground tissues in the neighbourhood had heavy deposit of the brown substance and although xylem vessels of the vascular bundles embedded in this matrix were not choked, phlœm was sometimes affected. This variation in the anatomical make-up was continued in IV/ — 1 as well without any change in size or structure. In the case of III/ — 1 the parenchymatous patch was cresentiform instead of being triangular and was continued on either side of the depression in which another layer of this tissue (Plate IV, Fig. 5 *p'*) was present above the hypodermal zone showing necrosis.

The other end of the median plane of IV/ — 2 did not show any depression although the parenchymatous cells forming the matrix contained the same brown substance. Higher up in IV/ — 1, a comparatively thin hypodermal zone (similar to that shown in Plate IV, Fig. 4) was present in the depression, where necrosis having set in, epidermis was absent. But the triangular patch of parenchyma was absent at this end. The hypodermal zone was continued as mentioned before taperingly on either side of the depression beyond which it was covered over by epidermis. In the case of III/ — 1 (Plate IV, Fig. 4), the depression being shallow, the epidermis was intact but the structure otherwise was the same as that described above. The brown substance also was present in the matrix but the vascular bundles were mostly free of it. It would, therefore, appear that although the plane of fission was clearly laid down in III/ − 1 and IV/ − 1 it did not disturb the internal structure to any appreciable extent except that both of them had two cavities each. In the case of III/ − 1, however, lignification of parenchyma along the plane of fission was comparatively poor for some distance from both the ends (Plate IV, Fig. 5 *l*).

Above the node 0, the structure of the two arms was in both the stalks normal in all respects but for very light deposit of the brown substance in parenchymatous cells in the peripheral zone in adjacent flattened portions of the internodes. Since these and internodes above them did not show any outward sign of disturbed anatomy, they were not studied any further.

(ii) *With visible injury.*—In the case of Co 213 stalk, II/ − 2 and II/ − 1 were normal in their anatomical structure although the latter along with the node II/ − i having been injured, deformed out of its normal oval cross-section. The injured tissue of II/ − 1 showed strructure resembling Plate III, Figs. 3 and 4 (Khanna and Sharma, 1948) which indicated that the internode was fairly well advanced towards maturation when it was attacked (Plate IV, Fig. 6). II/ − 1 had no signs of the ensuing split as the plane of splitting was not demarcated by the formation of grooves externally or internally by the appearance of hypodermal zone or the presence of parenchymatous proliferation or necrosis of the epidermis. The ground tissue also was uniformly lignified throughout the whole cross-section. In the front fissure above II/0 there was no necrosis but an outgrowth consisting of hypodermal zone and a layer of morbid parenchymatous tissue was present (Plate III, Fig. 7). Both of them were continued on the either side and were covered over by the epidermis. Parenchymatous cells of general ground tissue contained granular substance which stained deeply, and was different from the brown substance referred to before. The intensity of deposit in cells decreased as one moved farther away both horizontally towards the centre or sideways and vertically from the node. Very light deposit of the brown substance was present in cells on the fringe of parenchyma having this granular substance. None of the elements of vascular bundles was clogged. The plane of fission was demarcated along the median diameter by parenchymatous cells in appearance squarish or oblong in cross-section, and by vascular bundles having been cut slatingly. At the other end of the diameter there was no structural variation.

In II/ + 1A and II/ + 1B, the injured portions resembled Plate IV, Fig. 6, while other portions of II/ + 1A had a thin layer of hypodermal zone and broad layer of morbid parenchyma in which sparsely scattered vascular bundles were found (Plate IV, Fig. 8). Parenchyma forming the ground tissue had brown deposit but the vascular bundles embedded in it were free of it. The rind was normally constituted in uninjured portions of II/+ 1B.

Internodes higher up namely II/+ 2A and II/+ 2B were normal in all respects. Even the brown deposit so characteristic of recently disturbed anatomy was absent in their adjacent areas.

(*b*) *Pseudo-fission.*—Abnormal bifurcation in the B.O. 17 stalk was totally different from the other three cases so for described. Apart from the morphological differences already given in the preceding section, the antomy of this stalk was very much affected and over a considerable distance. I/ — 5 which had no external indication such as a cleft and in which the rind was normally constituted, had one big and two small patches of small-celled parenchyma arranged along the median diameter near the natural cavity of the cane (Plate V, Fig. 1). The vascular bundles in the neighbourhood of these patches were sometimes deformed but were not clogged. Brown substance was present only towards the periphery. It was quite probable that the disturbance in the storage tissue started in I/ — 6 or in still lower internodes. But where it actually began could not be stated definitely as internodes below I/ — 5 were not preserved and were, therefore, not available for study. In I/ — 4 the disturbed area increased in size and progressed towards the rind where a cleft and a hypodermal zone had appeared. Within the disturbed area, small-celled parenchyma contained a patch consisting of dead cells (Plate V, Fig. 2) or a cavity partly full of decaying cells (Plate III, Fig. 3). Phlœm of some vascular bundles was affected and parenchymatous cells were full of the brown substance. In I/ — 3 the plane of fission which had been fixed externally by the presence of fissures in front and back, was discernible in the internal structure also, as small patches of small-celled parenchyma were present in the distal half in which a new and somewhat shallow cleft had appeared (Plate V, Fig. 4). The natural cavity was absent and that formed by the disorganisation of diseased tissue though well defined in the lower half of the internode, was slowly obliterated by the squeezing of small-celled parenchyma brought about by the growth of cells on its periphery. Phlœm of neighbouring vascular bundles and parenchymatous cells below the hypodermal zone contained varying quantities of the brown substance. The plane of longitudinal fission in I/ — 2 was well defined by a chain of patches of small- and elongated-celled parenchyma, and small cavities enclosed in them and was slowly perfected as one approached I/ — i (Plate V, Figs. 5 and 6). The rind was interrupted only in the fissures. At one end of the median plane a wedge of thin-walled parenchyma full of protoplasmic substance was present and was continued on either side of the depression between the hypodermal zone and vascular bundles. The intensity of the cell contents decreased as one moved away from the depression. At places cavities surrounded by necrosis were found in the longitudinal depression. A and B arms of I/− 1 were connected by a narrow strip formed by thin-walled elongated parenchymatous cells (Plate VI, Figs. 1 and 2). Epidermis and vascular bundles typically peripheral* in their organization were present up to the points marked *a*, *b*, *c* and *d* in Plate VI, Fig. 1. The tissues between these points were covered over by heavily lignified cells, and the vascular bundles were central in structure. Necrosis and variations in the structure of parenchymatous ground tissues did not follow any particular plan or pattern. Curiously enough the vascular bundles and cells of the ground tissue near the fissure were mostly free of all foreign substances. Only near the origin of the fissures the latter contained brown substance.

Above I/0, the two arms on adjacent sides had no properly constituted rind (Plate VI, Figs. 3 and 4). There was no epidermis and the vascular bundles were practically absent. The outermost tissue mostly consisted of lignified small-celled parenchyma. An island of seven vascular bundles along with a thick band of highly lignified small-celled parenchyma (Plate VI, Fig. 3) appeared to be a crude attempt on the part of I/+ 1A to form a rind. The outlines of both the arms on adjacent sides were not smooth as was the case of in the three stalks already described. In higher internodes I/+ 2A and 1/+ 2B more typically in the latter (Plate VI, Figs. 5 and 6), a rind consisting of epidermis, a broad highly lignified hypodermal zone and peripherally constituted vascular bundles, was formed over the greater part of the adjacent sides. The upper swollen portion of I/+ 2B had vascular bundles characteristic of a node (Plate VI, Fig. 7) while in I/+ 3A they were internodal in structure. In the region of pseudo-coalescence (Plate VII, Figs. 1–5) vascular bundles of the two arms maintained their respective nature, *i.e.*, in the portion corresponding to A, they were internodal and interspersed all over the ground tissue while in that corresponding to B they were nodal in structure and were crowded together right up to the edge of the connecting tissue. Vascular bundles from the nodal half of the cross-section appeared to pass into the internodal half and were cut longitudinally (Plate VII, Figs. 2–4). The parenchymatous cells forming the connecting tissue were also squarish or oblong in transverse section indicating thereby that their longitudinal axis was more or less at right angles to that of the

* The sheath at its xylem end in vascular bundles of the peripheral region is much more massive than at the phlœm end. In the vascular bundles of the central region the sheath is equally thick at both the ends.

Plate VII, Figs. 1–5 and 6). The connecting tissue slowly increased dth and the character of vascular bundles in B portion changed from .o internodal (Plate VII, *cf.* Figs. 1 and 5) as one approached I/ + iii. 4 there was no sign of the stalk having undergone a fission except ear the depression, the cells of the ground tissue contained heavy s of brown substance (Plate VII, Fig. 7).

V. Discussion

om the foregoing morphological description and anatomical details four stalks, it would appear that they fell into two distinct groups, :

Co 213 and *Saraitha* (both the stalks) in which as a result of longi- fission, the resulting arms grew independently thenceforward and entical and complete in themselves, each node in both the arms having In all the three cases the adjoining surfaces of the two arms were and with root eyes in root zone and the internal structure was quite . That the two arms in Co 213 stalk were different from each other size of the internodes was clearly due to the position of the injury.

B.O. 17 stalk in which the longitudinal fission was not permanent two arms appeared to have coalesced after remaining separate for) cm. In arm A there were three distinct internodes with buds on the nodes, *i.e.*, I/0A and I/ + iiA. The other arm B had only two des with a swelling, nodal in structure at its upper end. There was at its nodes. The adjoining surfaces of the two arms were not smooth thout root eyes in root zone and there was no properly constituted those portions. The epidermis was replaced by lignified parenchy- tissue having very few vascular bundles.

e reason for the splitting of Co 213 stalk was evident because in there was a distinct insect-injury in causing which some of the growth- ing substances called auxins were incidentally introduced into plant and the growing point being very near, it broke up into two. Martin oy artificially inoculating the extract of green leaf-hopper of sugarcane, *acephala mollipes* (family Jassidæ) was able to break up the apical o several buds in two out of 21 stalks of P.O.J. 2878.

e case of stalks of *Saraitha* was slightly on a different footing. gh no injury or any other kind of disturbing agency was present within ernodes below the node of actual division, some factor must be work- bring about the doubling of buds, the appearance and development ther cavity, and retarding the lignification of parenchymatous cells a particular plane. Evidently it was slow in action as compared to that of Co 213, but was fast enough to overtake the growing point and of sufficient intensity to split it into two more or less equal arms. The mode and stages of bifurcation along with the concurrent teratological condition and the final outcome of the whole process therefore pointed to the presence of a disturbing agency at a considerable distance from the actual seat of growth activity. From the resultant effect of this substance, it might be taken to be similar or very much allied to that of Co 213.

In the stalk of B.O. 17 the disturbance in the internal structure appeared to have been brought about by a substance of a totally different nature, because instead of inciting the cells to proliferate, it arrested their growth in the first instance and then brought about their death. The dead cells disintegrated yielding their place to a cavity to fill which surrounding parenchymatous cells in certain cases elongated to form a kind of palisade-like tissue.

In I/ − 5 the affected area being very small, it appeared that the growth arresting substance was just beginning to manifest its presence. In higher internodes, progressively greater area of parenchymatous ground tissue along the median diameter was brought under its influence till in I/ − 1 necrosis along that diameter was widespread, and more or less continuous from front to back resulting in complete rupture at I/0, and the presence of elongated cells in I/ − 1 was due to a subsequent reaction of the surrounding tissues. The presence of two arms higher up with their jig-saw-like adjoining surfaces without properly constituted rind in these portions in internodal region, and without root eyes in the nodal region, pointed to a splitting totally different from that undergone by the other three stalks. The appearance of a bud on alternate nodes (I/0A and I/ + iiA) further strengthened this view. It seems that the bud at I/ + iB and the internode I/ + 3B could not be formed probably due to too much physiological strain though there seemed to be an attempt at the formation of the latter as was apparent from the change of character of vascular bundles from nodal to internodal in the pseudo-joint. The disturbing agency ceased to function abruptly and the I/ + 4 showed no sign of any stress except that it was flattened very much with respect to the original orientation of the stalk. Whether the disturbing element exhausted itself or a change took place in environment could not be stated definitely. But this much might be said that the stalk did not react so as to stop the rot.

It would, therefore, appear that B.O. 17 stalk was a case of pseudo-fission brought about by the arrest of growth of and later on the death of parenchymatous cells along the median plane while in Co 213 and *Saraitha* stalks, fission was brought about by the splitting of the growing point and that the agency causing fission and pseudo-fission were fundamentally different in nature. It is however, interesting to note that both of them worked in the same plane, *i.e.*, along the median diameter which seemed to occupy a position unique in itself which view was further supported by the fact that once it was laid down, buds would always be formed in that and in no other plane. The shifting of bud slowly through nearly a right angle in B.O. 17 might be interpreted as an attempt on the part of the stalk to preserve this unique diameter the fundamental use of which to the stalk is still to be fully comprehended.

VI. Summary

1. Of the four stalks described from morphological and anatomical points of view, two of *Saraitha* and one of Co 213 showed fission and that of B.O. 17 pseudo-fission.

2. In Co 213 in which the internode just below the node of bifurcation bore signs of insect-injury, had unequal arms and the reaction of tissues was similar to that described elsewhere. As fission was violent and swift in this case, the arms were unequal in dimensions.

3. In the stalks of *Saraitha* there was no visible injury or any other disturbance 3 4 internodes below the node of actual fission. Slow changes such as appearance of two cavities, poor lignification of parenchyma along the median plane, doubling of buds and formation of more or less equal arms appeared to indicate the presence of a disturbing factor at considerable distance from the seat of growth activity.

4. In Co 213 and the *Saraitha*, bifurcation of stem was brought about by the fission of growing point itself, by the action of auxins or similar growth-promoting substances.

5. In B.O. 17 splitting was brought about by the necrosis of parenchymatous cells along the median plane after their growth had been arrested by a slow acting factor. The absence of properly constituted rind in the adjoining portions of the two arms and presence of a bud on alternate nodes on one of the arms supported this view. B.O. 17 was therefore, a case of pseudofission.

6. The disturbing element in B.O. 17 was different from that working in the other two varieties. The former arrested the growth of cells and ultimately brought about their disintegration while the latter incited the cells to proliferation.

7. That both the kinds of substances worked along the median diameter showed that it was different from all other diameters and occupied a unique

position in the organisation of sugarcane stalk the full significance of which is still imperfectly understood.

VII. Acknowledgements

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References

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Explanation of Plates

Plate III

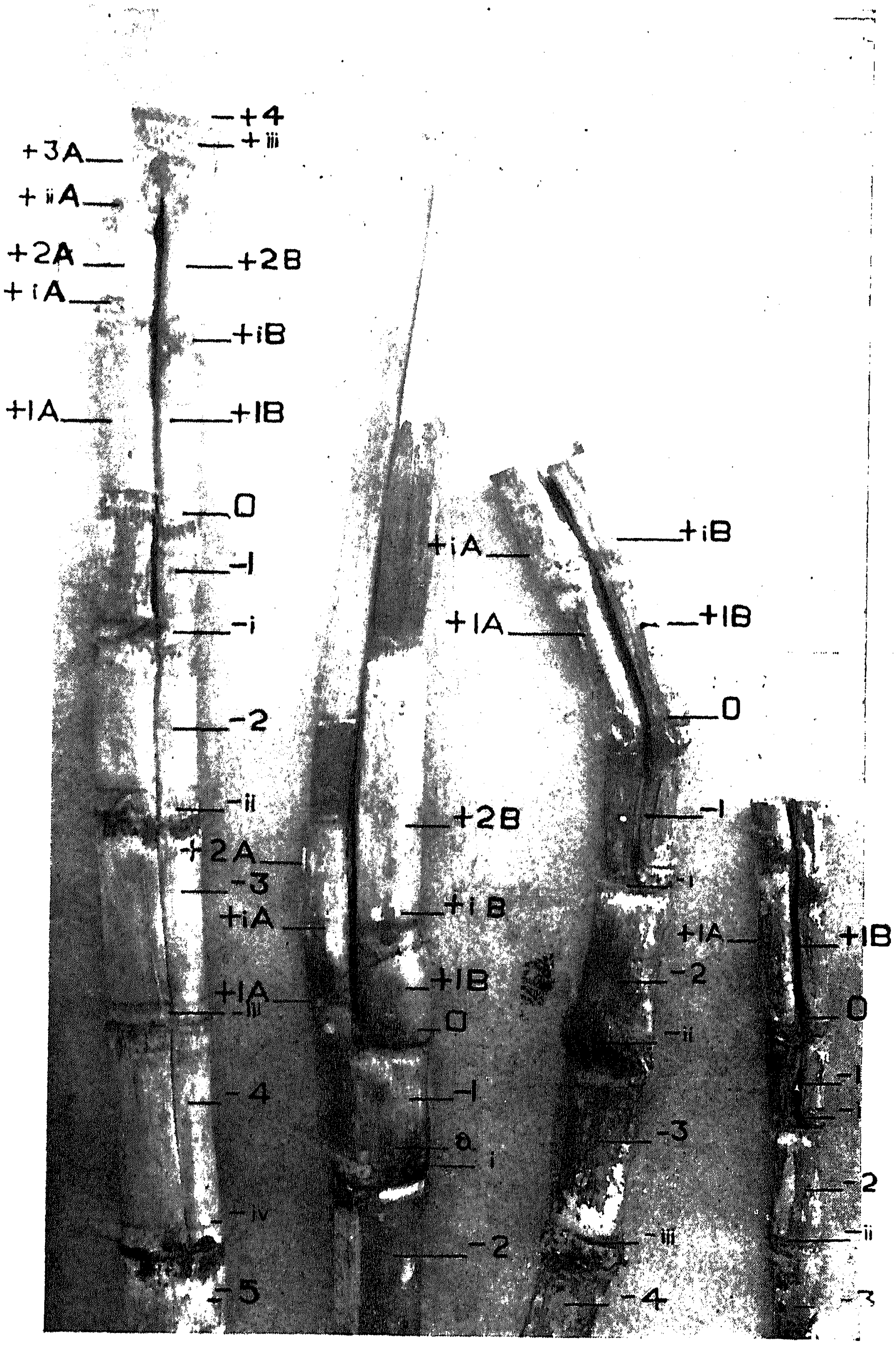
Photograph of the four stems belonging to, from left to right, B. 0·17 (I), Co 213 (II) and *Saraitha* (III and IV). The initial difference in the size of internodes forming the two arms in II was maintained while those of III and IV were equal for considerable distance. There was doubling of buds in the latter two stalks before fission while the bud on II/−i was destroyed by injury (*a*). All nodes in the three stalks (II–IV) had a bud each after splitting. But in I it was formed on alternate nodes (I/0A and I/+iiA) on arm A only (5/6 natural size).

Plate IV

Transverse sections of stalks II, III and IV, showing normal fission. Figs. 1, 4 and 5, III/−1; Figs. 2 and 3, IV/−1 ; Fig. 6, II/−1 ; Fig. 7, just above II/0 ; Fig. 8, II/+1A. Figs. 1 and 2 show two cavities (C) formed prior to bifurcation. In Figs. 3 and 5 patches of small-celled parenchyma (*p*) covered over by hypodermal zone (*h*) are illustrated ; in Fig. 5, there is another layer of the former (*p′*) over the latter. The hypodermal layer (*h*) in Fig. 4 is narrow. That the plane of fission has already been decided upon is indicated by the poor lignification of ground tissue (*l*). Fig. 6 shows insect-injury to tissues fairly well advanced towards maturation. In Fig. 7 there is no necrosis in the fissure which is occupied by an outgrowth, consisting of small-celled parenchyma and hypodermal zone. A broad zone of morbid parenchyma having sparsely scattered vascular bundles is shown in Fig. 8 (Figs. 1 and 6, ×10 ; Figs. 2 and 5, ×15 ; Fig. 3, ×50 ; Fig. 4, ×100 ; Figs. 7 and 8, ×25. Opaque areas in this plate and in subsequent ones are due to either sections being very thick or air bubbles getting into them).

Plate V

Transverse sections of the stem of B. 0·17 showing progress of pseudo-fission. Figs. 1, 2 and 3 illustrate small-celled parenchymatous patches showing the arrest of growth. Secondary cavities (*c*) are enclosed within them. In Fig. 2 one of them (*c′*) is full of dead-cells which have disintegrated to some extent in Fig. 3. Formation of a fissure and the interruption of the rind are illustrated in Fig. 4. Small-celled ground tissue at the bottom of the cleft may be noted. Figs. 5 and 6 when joined together at X and X' give the entire plane of fission as it appears near I/−i. There is lateral inversion in Fig. 6 : that is why X′ is upside down image of X. Along the plane of fission are situated patches of morbid parenchyma and secondary cavities (Fig. 1, ×20 ; Figs. 2, 4, 5 and 6, ×10 ; and Fig. 3, ×15).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-3
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+1A
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S. L. Sharma and
K. L. Khanna

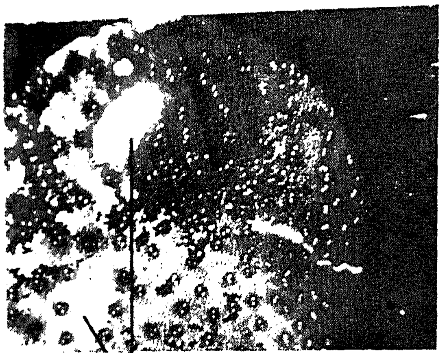

FIG. 1

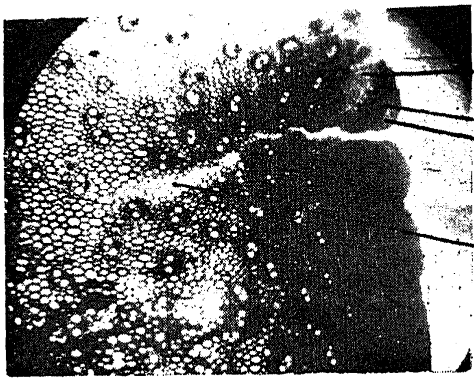

FIG. 5

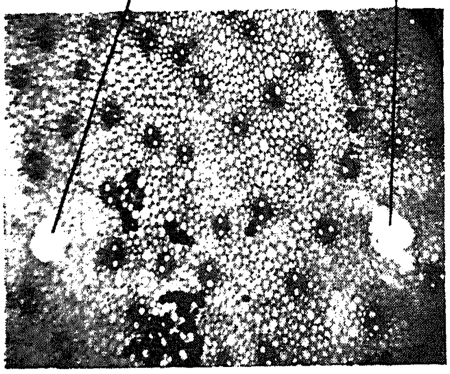

FIG. 2

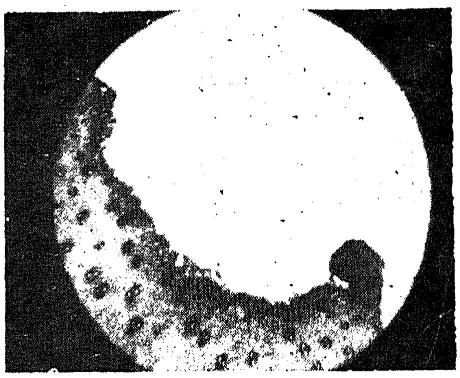

FIG. 6

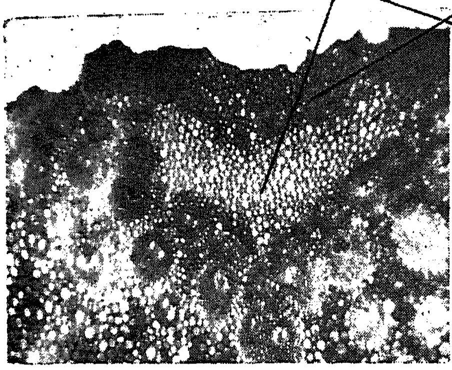

FIG. 3

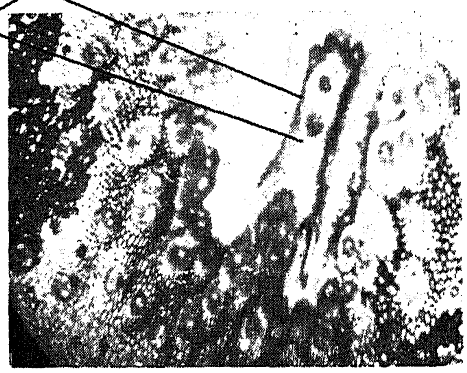

FIG. 7

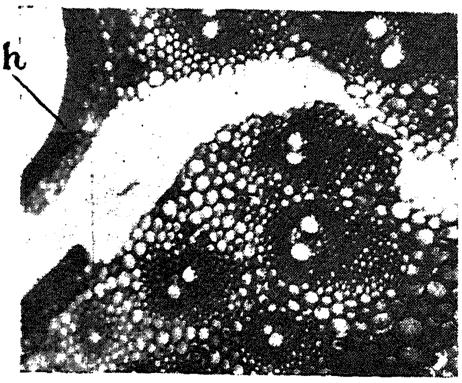

FIG. 4

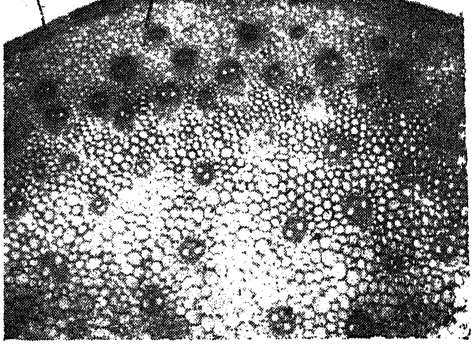

FIG. 8

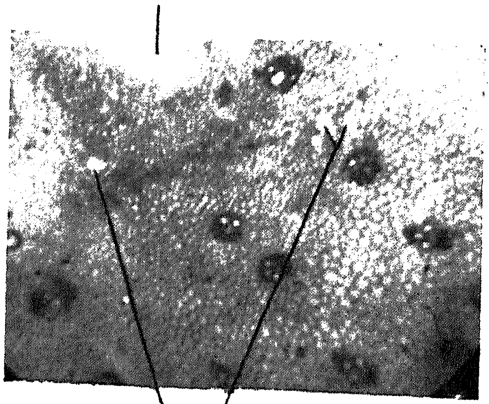

FIG. 1

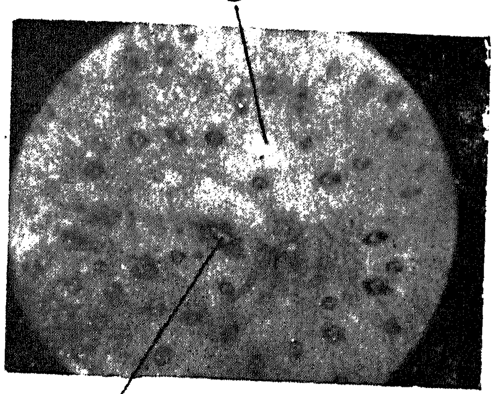

FIG. 2

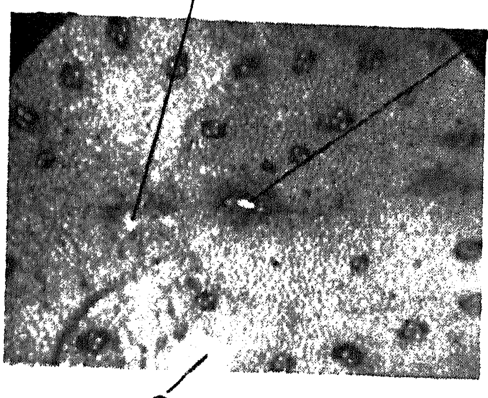

FIG. 3

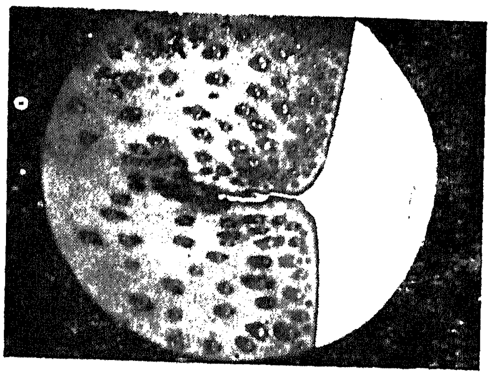

FIG. 4

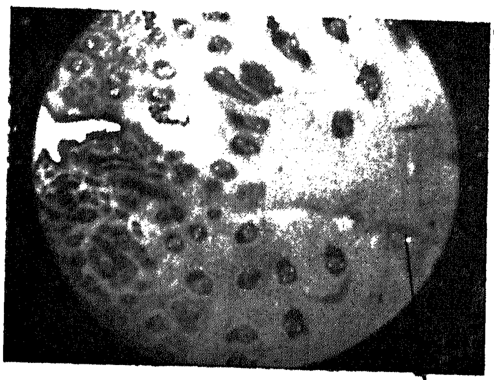

FIG. 5

FIG. 6

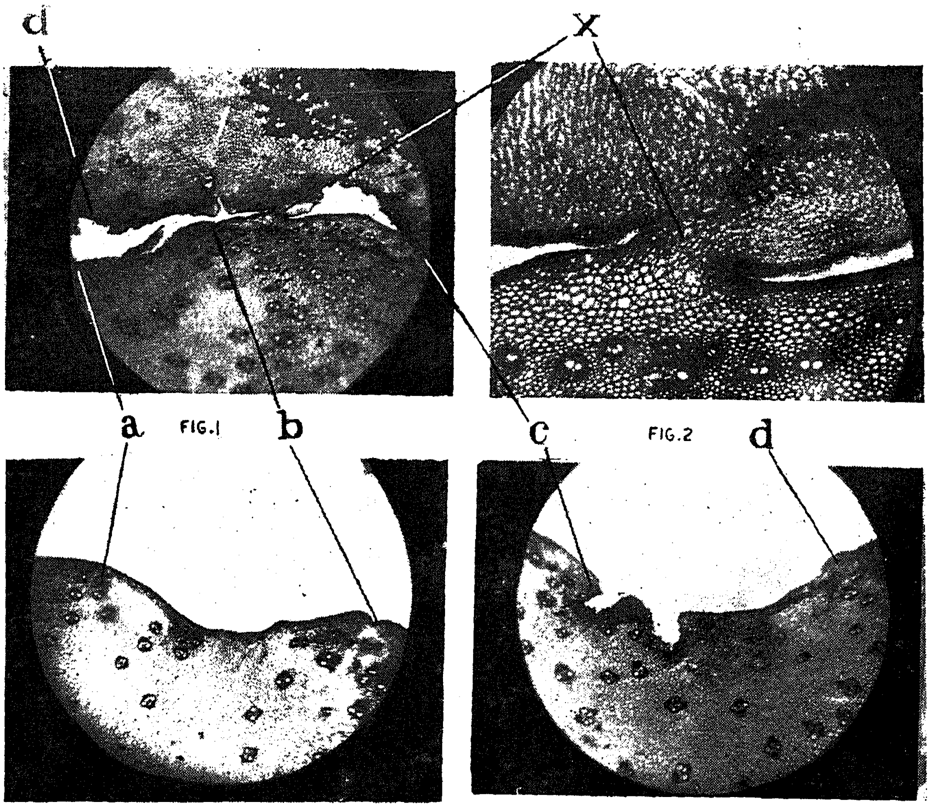

FIG. 1   FIG. 2

FIG. 3   FIG. 4

FIG. 5

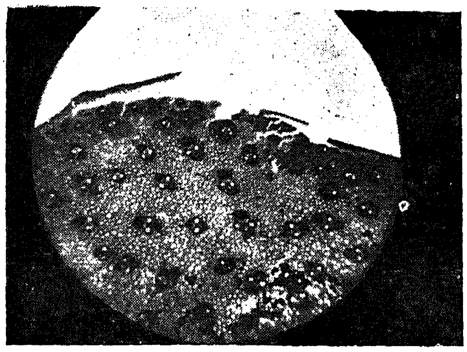

FIG. 6

FIG. 7

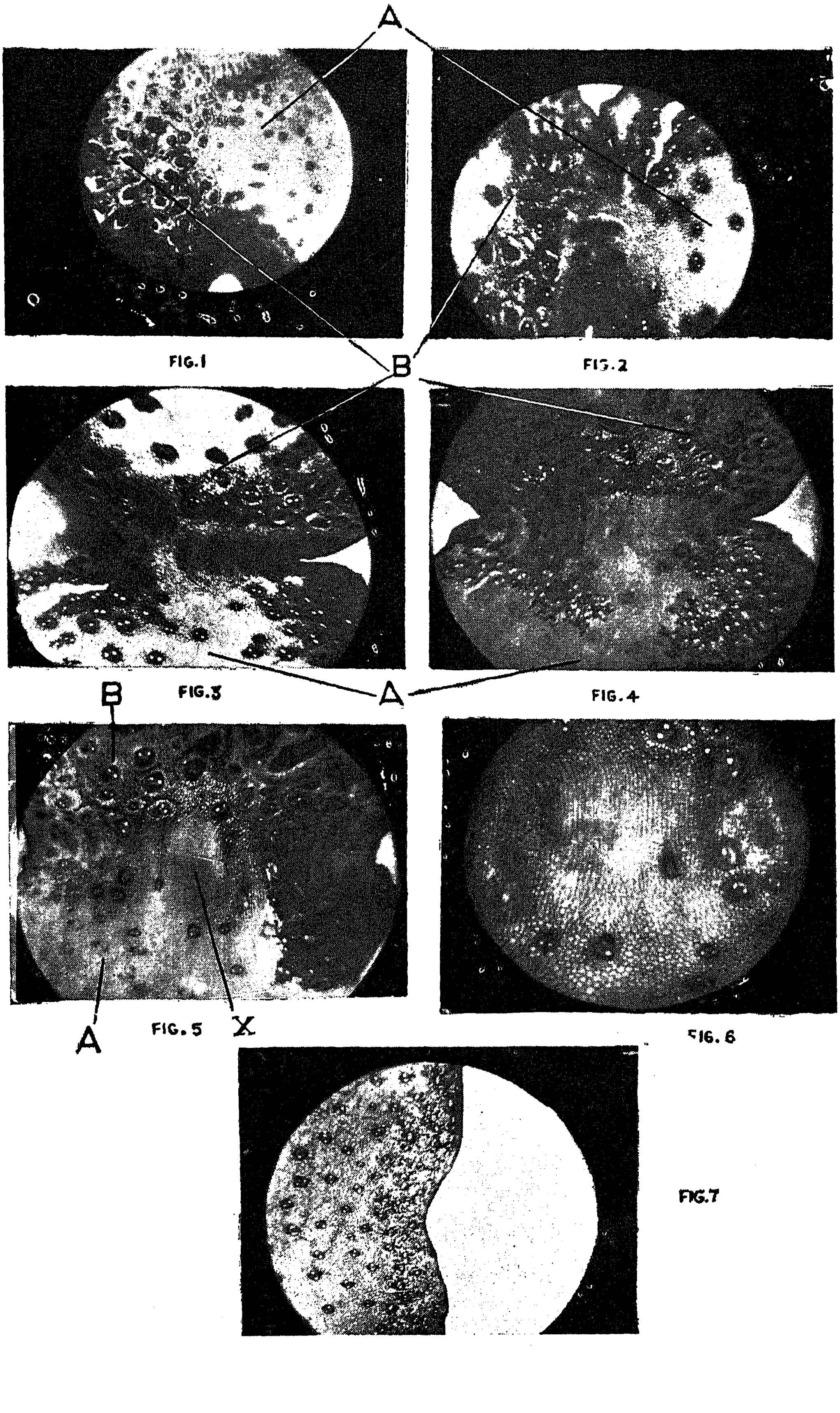

FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 6 FIG. 7

PLATE VI

Transverse sections of the two arms of B. O. 17 stem. The two arms of I/−1 are still connected with each other by a narrow strip of morbid parenchyma (X) in Figs. 1 and 2. Between *a* and *b*, *c* and *d* in Fig. 1, and Figs. 3 and 4, there is no properly constituted rind. The tissues are covered over by highly lignified zone of morbid parenchyma. Vascular bundles between these points are few and far between and are central in nature. Figs. 5 and 6 show attempts at the formation of rind which are more successful in the latter. The nodal character of the swollen upper end of I/+2B is apparent because vascular bundles are cut in all planes and the parenchymatous cells surrounding them are arranged stellate fashion (Figs. 1, 3, 4, 5 and 6, ×10; Fig. 2, ×65; Fig. 7, ×20).

PLATE VII

Transverse sections of the pseudo-joint at various levels from below upwards and I/+4. Figs. 1–5 illustrate the internodal and nodal character of the two portions corresponding to arms A and B. In portion A, the vascular bundles are scattered in the ground tissue while in B, they are crowded together right up to the edge of the connective tissue (X). Their dispersal and the change from nodal to internodal character are noteworthy in Fig. 5. They are cut longitudinally while passing through the connective tissue as shown in Figs. 2–4. The parenchymatous cells in this region are also cut in the same way. Fig. 6 is an enlargement of part of Fig. 5 to illustrate the point. Fig. 7 passes through I/+4 which is normal in structure (Figs. 1–5, ×5; Fig. 6, ×15; Fig. 7, ×10).