

quite fully matured; a^3 is the foliar trace of the cotyledon, which is just being separated by a layer of decidual periderm; x is the central cylinder of a , with the trace of the second leaf just making its appearance; b^* is the still embryonic second root of the smaller embryo b ; b^3 is the young cotyledon and y is the central cylinder. Figure 58 represents a lower section in the same series with the same lettering as before; a^* is the primary root of the better developed embryo, and b^* is that of the smaller embryo. At a^* is a prominence indicating the point of origin of the second root of the larger embryo. Figure 59 is of a section still lower down and passes through the common foot of the geminal sporophytes. The staining alone indicates the boundary between the two plants. Their central cylinders are separate throughout, but the fundamental tissues appear to be in textural continuity. A quite sharp demarcation, however, is produced by the different condition of nutrition of their cells; those on the side of a being loaded with starch; those of b , on the other hand, containing only a very small amount. Unwillingness to sacrifice the series prevented the use of the ordinary methods of demonstrating protoplasmic continuity for the purpose of discovering whether the protoplasm of the two was in reality continuous. The phenomena of nutrition would seem to negative such a supposition. Figures 57, 58 and 59 have been lithographed from photomicrographs.

The first root of the young sporophyte is sometimes diarchous, but just as often triarchous. There seems to be no relation between the vigor of the root and the number of protoxylem-strands; as depauperate plants sometimes have three strands, and, on the other hand, robust individuals often have only two. I have not found a single example of a monarchous root in the large number of specimens which I have examined. Figure 60 is a drawing of a section of a diarchous primary root in aqueous analinsulphate. The endodermis a is quite distinct, and shows plainly the characteristic radial lignified zones. Between it and the vascular tissue are one or more layers of pericycle cells. The protoxylem tracheides, x , are reticulate in their sculpture and not ringed or spiral as is generally the case. The metaxylem elements almost always meet in the centre. The bast, y , is made up of thick-walled elements, some of which are sieve-tubes and the rest elongated parenchyma cells. Between the bast and the vessels, is a considerable amount of wood parenchyma. Often two or three diarchous roots are formed, but sooner or later triarchous, and finally tetrarchous ones are produced.

The central cylinder of the stem becomes fully differentiated below the point of origin of the cotyledon. From the very first it has a well-