

ROOT AND SHOOT SYSTEM

The root and shoot of vascular plants may be positionally and developmentally related in various ways. However, botanical teaching and research are strongly influenced by the paradigmatic annual dicotyledon, whose bipolar embryo develops into a plant with root and shoot meeting only at the hypocotyl. A plant has many complicated and complex systems that keep it living and growing, including the shoot system. When referring to the shoot system in a plant, we generally refer to the leaves, buds, flowering stems and flowering buds, as well as the main stem itself. The word 'shoot' generally is used when talking about the main stem (Fig.1).

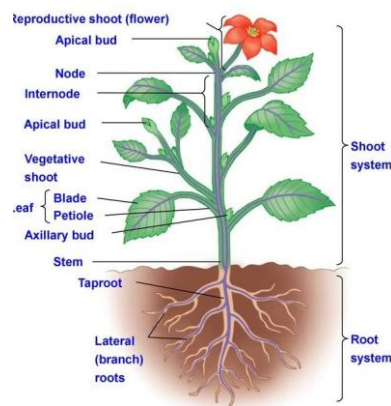


Fig.1. A typical dicot plant

In 1930, Goebel criticized this example as a general model for plants, and proposed a new concept “allorhizy” (referring to plants whose root and shoot are related as above) and “homorhizy” (referring to plants without a bipolar embryo, all of whose roots are shoot-borne, e.g., pteridophytes). Goebel’s approach permeates the extensive German morphological literature, but has been virtually ignored in English-language literature. However, it suggests a correlation between embryo type and mature morphology that does not always hold. Furthermore, it does not take into account the root-borne shoots typical of many plant species. Finally, Goebel’s presentation of the terms

creates ambiguity as to whether they designate structural concepts or the attributes of evolutionary groups. The alternative, proposed here is a structural analysis of the possible topological relationships among root and shoot systems. Each structural class is then considered with regard to embryo types, potential for clonal growth and other ecological correlates, and phylogenetic distribution. This approach provides both a test of Goebel's concepts and a basis for further comparative study of whole plant form.

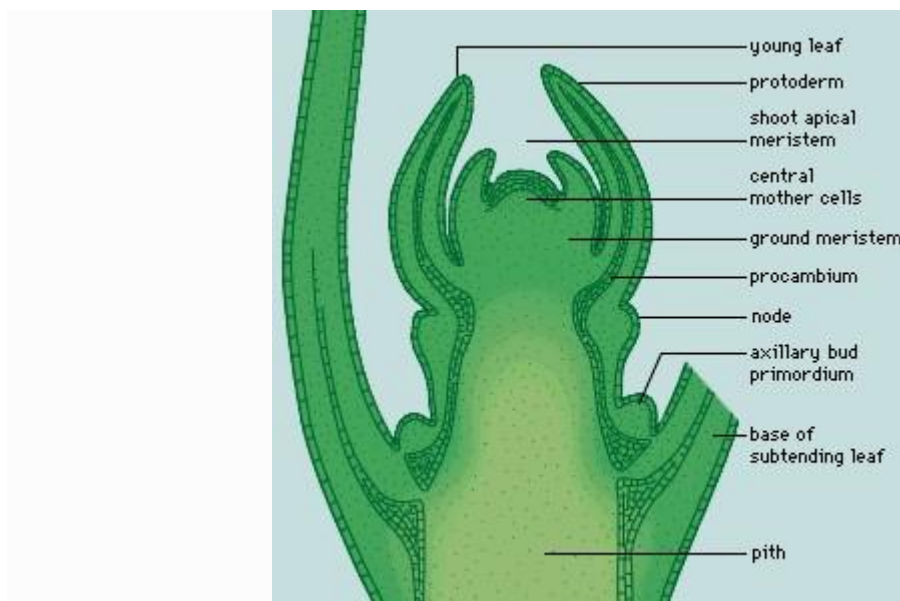


Fig.2. Meristematic tip of shoot apex

Many workers going through plant morphogenesis favor the view that the fate of a cell is determined by the position it occupies in the plant body rather than by its lineage (Fig.2). The critical evidence comes from analyses of genetic mosaics in shoot apices and developing leaves of maize, tobacco, and *Arabidopsis*. These analyses have revealed that cell lineages, although important, are not a reliable indicator of the eventual fate of a cell. The fate of a cell in plants is determined more by the position it occupies in the plant organ/body than by the manner in which it is derived. This conclusion implies that the commitment to a specific fate is flexible within limits; it is delayed until the position of the cell/organ in relation to its neighbors and the environment is

secure. This strategy makes intuitive sense for organisms where cells are fixed in space and cannot move about and where an error in lineage would be difficult to eradicate.

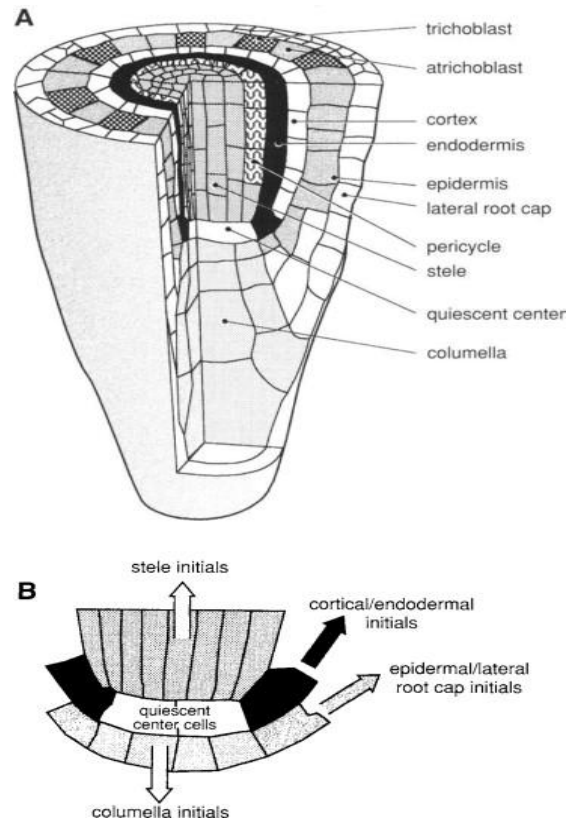


Fig.3. schematic representation of *Arabidopsis* root tip (A) and detail view of quiescent centre (B). Stem like initials surround the quiescent centre.

Positional cues imply that environmental factors, as well as existing tissues and organs, exert an influence on the determination/differentiation of new tissues and organs. There are many examples of effects of environmental factors on plant growth and development. In the following, some examples of interaction with existing cells and tissues are given first before discussing the nature of intercellular communication.

Cell lineage in roots, in contrast to that in shoots, is highly predictable. Anatomical and clonal analyses of embryonic root in *Arabidopsis* based on cell line-specific markers have been used to define the location of quiescent center

and origin of various tissue layers, such as cortex, endodermis, and pericycle (Fig.3).