Experimental Anatomy of Plant Development
Laboratory 4

Plant Growth - Seed Structure and Embryogeny

Introduction

Growth in vascular plants is among the most complex for all organisms. It begins with development of the embryo (embryonic growth), and then continues with meristematic growth. All plants have primary meristematic growth (usually termed primary growth) that produces new organs and leads to the increase in length of stems and roots. This provides a mechanism for the open, indeterminate, modular growth pattern that characterizes vascular plants. Large and/or long-lived plants also have secondary growth that leads to increase in the girth of organs. Metistematic growth will be covered in Laboratory 5. In this exercise we will familiarize ourselves with the embryonic growth of cells and tissues in polycotyledons, dicotyledons and monocotyledons.

In the early stages of development, the embryos of dicotyledons and monocotyledons undergo similar sequences of cell divisions, both becoming cylindrical bodies. It is with the formation of the cotyledon(s) that a distinction first appears, for the dicotyledonous embryo begins to assume a bilobed shape, whereas the monocotyledonous embryo remains cylindrical. This growth occurs throughout the embryo (i.e., embryonic growth), with primary meristems becoming organized at the tip of the epicotyl and radicle as the remainder of the embryonic tissues mature. In monocots these meristems are covered by structures called the coleoptile (shoot apex) and coleorhiza (root apex).

Endosperm formation (in flowering plants only) begins with the mitotic division of the primary endosperm nucleus. Despite the existence of different modes of development of endosperm, its function is clear-cut: to provide essential food materials for the developing embryo and, in many cases, the young seedling. In some angiosperms the endosperm is completely digested by the developing embryo. The embryos of such seeds (known as exalbuminous seeds) commonly develop thick food-storing cotyledons. In other angiosperms variable amounts of endosperm tissue are present (albuninous seeds) and are utilized at the time of germination by the embryo, which has resumed growth.

A. Embryo and Seed of Gymnosperms and Dicotyledonous Flowering Plants

Dissect embryos from partly germinated seeds with straight (e.g., Ginkgo and, Lactuca, Pholistoma, Xanthium, Daucus, Linum, or Ricinus; See Fig. 16-14, p. 397 in Gifford and Foster for Ginkgo; Fig. 20-27, p. 482 in Raven, et al for Pinus; Fig. 20.1, p. 416 in Mauseth for Pholistoma) and curved or bent (e.g., Capsella, Lycopersicon, Beta, Spinacia, Datura, Melilotus, Phaseolus, or Pisum; See Figs. 20-10 and 20-11, p. 426-427 in Mauseth for Capsella; ) embryos.. Note their shape and structure. When
the embryo is curved, cut it in half longitudinally using the protruding radicle as a guide. Note presence or absence of endosperm in seed.

Study demonstration slides showing Capsella embryos in different stages of development. Identify endosperm in all slides. Compare with stages of development shown in Figs. 24.5, 24.6, pp. 480, 481, respectively.

1. Zygote surrounded by endosperm. Note that, although the zygote has not yet divided, endosperm development is well underway.

2. Two-celled proembryo, consisting of basal and distal cells.

3. Beginning of differentiation of proembryo into suspensor and embryo proper. The distal, vertically elongate cells, through division, will eventually give rise to the stem and cotyledons of the embryo. The remaining cells will give rise to the suspensor and apical meristem of root (plus the root cap).

4. Embryo before the emergence of cotyledons. The protoderm (precursor of epidermis) is present, but no other tissue differentiation is discernible. No apical meristems are present. The embryo proper is attached to the ovule by the suspensor. Note the large basal cell.

5. Embryo after emergence of cotyledons. Tissue systems precursors—protoderm, ground meristem, and procambium—are blocked out. They will become epidermis, cortex, and vascular system, respectively. The apical meristem of root is partly organized. The suspensor is still intact.


B. Monocotyledonous Embryo and Seed

1. Liliaceae

Examine seeds of either Iris or Amaryllis.

Study demonstration slides of Lilium or Sagittaria embryos in different stages of development. Compare with embryo development in Allium, (look at the appropriate figures of embryogeny in Mauseth or Raven, et al.) respectively.

1. Zygote and primary endosperm nucleus.
(2) Two_celled proembryo. Note endosperm development is well underway.

(3) Four_celled proembryo (only three cells are in focus at one time).

(4) Six_celled proembryo.

(5) Beginning of differentiation of proembryo into suspensor and embryo proper.

(6) Embryo before emergence of cotyledon. At this stage the *Lilium* embryo resembles a dicotyledonous embryo, consisting of a suspensor and spherical embryo proper. Note abundant, cellular endosperm.

(7) Upward growth of the embryo is initiating the single cotyledon. The suspensor is still present.

(8) Notch below cotyledon designates developing epicotyl meristem. Note suspensor and basal cell.

(9) Further development of epicotyl meristem and cotyledon. Procambial strand extends from developing apical meristem of root through cotyledon.


(11) *Lilium* seed showing transection of hypocotyl_root axis. Note abundant endosperm.

2. Poaceae

   Study a germinated caryopsis of *Zea* and also one or more other cereals such as *Triticum, Secale, Hordeum*, and *Avena*, (if available).

   Examine the slide of a *Zea* embryo. Grass embryos reach a relatively high degree of development during maturation of the caryopsis. As you study these embryos, familiarize yourself with the special terms used to designate parts of the grass embryo. Figs. 23-7 and 23-8, p. 562 & 564 of Raven, et al. will be helpful.
C. Seed Germination, Dormancy, and Relation of Embryo to Mature Plant - *Ginkgo biloba*

Examine the seeds of *Ginkgo* that we planted earlier. After three weeks we expect that those without sarcotesta will be germinating. Are those with sarcotesta germinating? Why, or why not. The paper by Holt and Rothwell on demonstration may help you answer this question.

Now examine the seedlings of *Ginkgo* that were germinated in the greenhouse several weeks ago. Upon germination, the apical meristem of the shoot forms leaves, nodes, and internodes—i.e., increments of the shoot—in regular sequence. This is the vegetative stage of growth. At an appropriate time the vegetative apical meristem is changed into a fertile meristem (floral apical meristem in flowering plants. Apical meristems in the axils of leaves may produce axillary shoots. These in turn may have axillary shoots. As a result of such development the plant bears a system of branches upon the main, or the primary, stem. The radicle forms the taproot. In some plants the taproot forms branches and these, in turn, also produce branches. The process is repeated several times and results in the development of a much branched root system. In other plants (e.g., grasses) the main root system is formed by adventitious roots arising in connection with axillary shoots.

LABORATORY 3 – Checklist

By the end of the lab, your notebook should contain drawings of the following

A.  

[ ] *Ginkgo* embryo  
[ ] *Phaseolus* (bean)/*Pisum* (pea) embryo from germinated seeds  
[ ] Series of drawings showing *Capsella* embryogeny

B.  

[ ] *Amaryllis* seed with embryo  
[ ] Series of drawings showing *Lilium* embryogeny  
[ ] *Zea* (corn) embryo from germinated seed  
[ ] *Hordeum* (barley) embryo from germinated seed  
[ ] *Zea* (corn) embryo longitudinal section (slide)