

Topic 06: **Primary Plant Body: Embryogenesis and the Seedling**

(Photo Atlas: Figures 1.29, 9.147, 9.148, 9.149, 9.150, 9.1, 9.2)

A. Introduction

Plants are composed of fewer cell types, fewer tissues, and fewer organs than animals, yet they exhibit a remarkable variety of forms which are adapted to an equally wide variety of environments. Unlike animals, plants exhibit much flexibility in their structure, have modular organization, and have indeterminate growth (post-embryonic development of organs and tissues, etc.) due to the presence of meristems.

All of the cells of the plant body are derived from the meristematic regions in the shoot and the root. Following fertilization, the **EMBRYO** is formed during **EMBRYOGENESIS** and all of the primary organ regions are established. Following embryogenesis, **GERMINATION**, which is the resumption of growth in the seed ensues and the **RADICLE** or primary root emerges first.

The beginning of the plant, as with most organism starts from the **ZYGOTE** which rapidly develops first into an **EMBRYO** with the **SEED**. In many seeds the embryo, once formed, stops growing and moves into a state of **DORMANCY**. Later, if the seed is in favorable conditions, it **GERMINATES** during which the embryo resumes rapid growth and development and becomes the mature plant. Development follows a fairly standard pattern. The embryo can be divided into to main regions, the **HYPOCOTYL** that develops into the root and the **EPICOTYL** that develops into the shoot system.

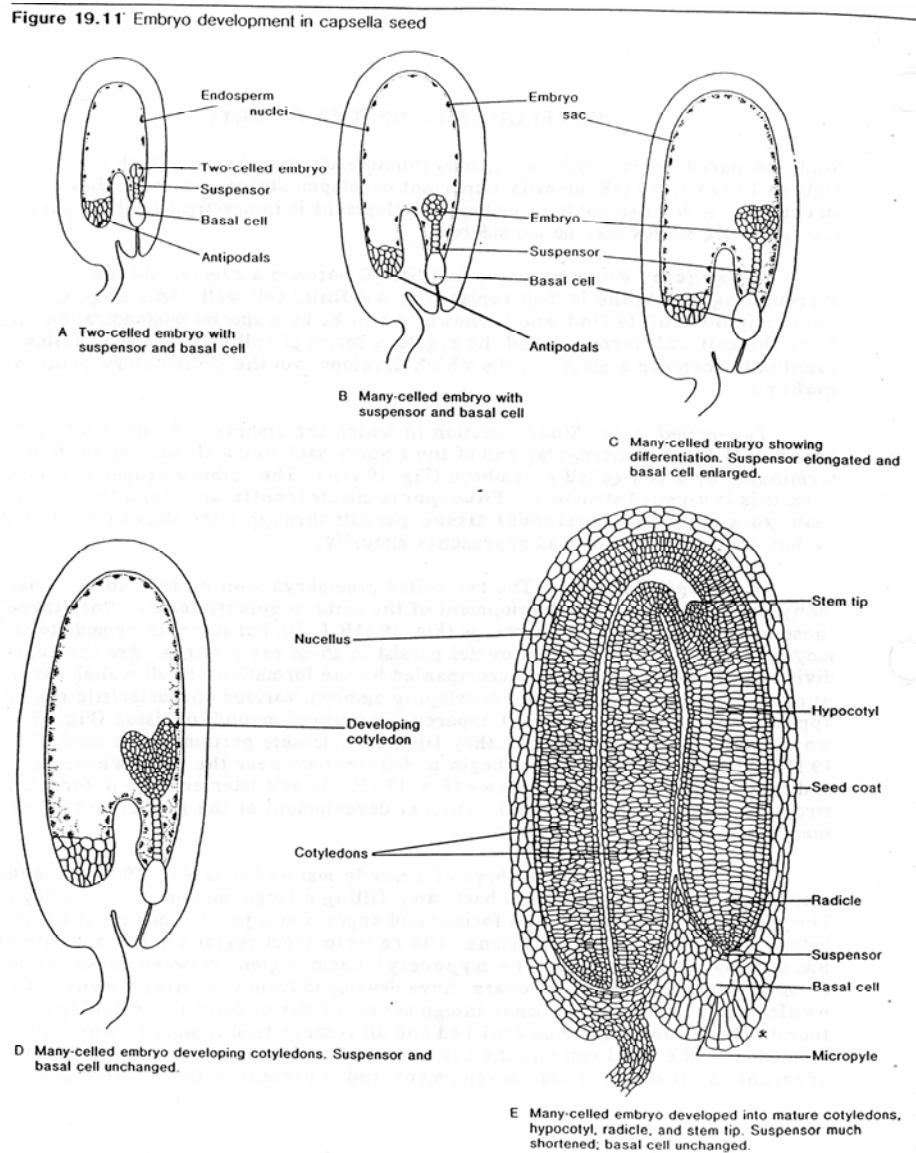
Plants differ from animals in their mechanisms of growth. Unlike animals, plants continue to grow as long as they live. They exhibit open growth by retaining localized areas of embryonic cells called **MERISTEMS**. Animals also have meristems but they are more or less diffuse throughout the organ. Meristem tissue consists of cells which do two things: produce cells and produce hormones. The cells produced by meristems **DIFFERENTIATE** to become tissues which have certain functions such as photosynthesis, support, conduction, protection and specialized structures. Meristems found at the tips of root and stems are called **APICAL MERISTEMS**.

A plant composed of cells originating from apical meristems is **HERBACIOUS** and makes up the **PRIMARY PLANT BODY**. Cells produced by **LATERAL MERISTEMS** add girth to stems and roots. Cells produced by lateral meristems are called **SECONDARY TISSUES** and make up the **SECONDARY PLANT BODY**. In complex land plants various plant cell types combine in characteristic ways to produce simple and complex tissues. These in turn form organs such as leaves, flowers and modified organs including thorns, spines, tendrils, and tubers.

B. Embryogenesis

Embryogenesis transitions a fertilized **ZYGOTE** into a mature **EMBRYO**. **POLARITY** illustrated by the development of an **APICAL** and **BASAL** cell is established early during embryogenesis. Five distinct stages can be observed during embryogenesis: the **TWO-CELL** stage, the **GLOBULAR** stage, the **HEART** stage, the **TORPEDO** stage and finally the **MATURE** stage. Upon completion of embryogenesis, the embryo is formed in the seed and consists of all the cells and tissues required for development of the plant body.

Figure 2. Illustration depicting early and final stages of embryogenesis in Shepard's Purse (*Capsella bursa-pastoris*).



1. Obtain prepared slides from the *Capsella* embryogenesis series. Four slides are displayed. Make observations of each slide and Draw a representative developing embryo from each slide. You will notice that each slide contains several developing embryos that appear to be at varying developmental stages OR have been sectioned such that the entire embryo is not apparent. If unsure of which embryo to reference confer with the instructor or refer to the text for assistance.

Draw and Label the embryos including the following:

For each drawing, label the structures present using the following terms: two-celled proembryo, basal cell, suspensor, protoderm, procambium, ground meristem, endosperm, cotyledons, hypocotyl, shoot apical meristem, seed coat, root tip, and radicle (note, not all structures will be visible in all stages). Also label the stage each drawing best fits:

1. Globular stage
2. Heart stage
3. Torpedo stage
4. Bending cotyledons stage
5. Mature embryo stage.

a) PRECOTYLEDON

Is the basal cell apparent at this stage?

How many cells are in the suspensor?

Approximately how many cells are in the embryo?

b) EARLY COTYLEDONS

Is the basal cell present?

Is the suspensor present?

Is this a dicot or monocot?

How do you know?

c) BENDING COTYLEDONS

Can you find evidence of a basal cell?

Can you recognize the primary meristems?

Is a root or shoot apex apparent?

Why do the cotyledons bend?

d) MATURE EMBRYO

How has the embryo changed?

Is the basal cell connected to the embryo?

Is the suspensor present?

If not, WHY not?

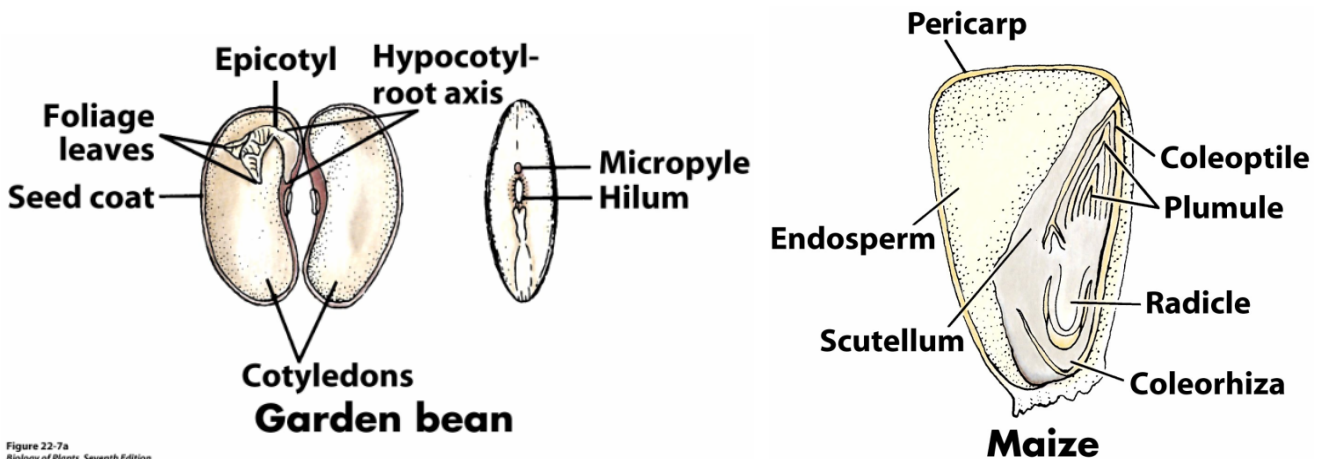
C1. Primary Plant Body: Embryo Structure

At maturity the embryo often consists of an **EPICOTYL**, **COTYLEDONS**, and a **HYPOCOTYL**. The epicotyl, together with its juvenile leaves, is called the **PLUMULE**. If the tip of the hypocotyl is distinctly root-like, it is termed the **RADICLE**.

In monocotyledonous plants such as the grasses, specialized terms are used to describe the embryonic parts: the single massive cotyledon is termed the **SCUTELLUM**, while the plumule and radicle are enclosed by protective structures termed the **COLEOPTILE** and the **COLEORHIZA** respectively.

You will be expected to know all of the structures that are characteristic of both a dicot and a monocot seed and seedling.

Figure 3. Illustration representing the cross section through a mature dicot (garden bean) and monocot (maize) seed.



1. Using a **PEANUT**, carefully break the seed open (you will have to remove the outer shell first) and examine the embryo with the naked eye AND with the dissecting scope.

Draw and label the parts of the embryo and the seed.

Is this an example of a dicot or a monocot?

How do you know?

Is a radicle apparent?

What is the food source?

Is this different from the maize?

In figure 3 above, be able to identify the ANALOGOUS structures for monocots and dicots.

2. Using a dry **MAIZE** kernel, cut the kernel in half lengthwise to view the internal seed and embryo structures. Make a thin section of the kernel for use with the dissecting scope. ADD a drop of Potassium Iodine onto the cut section. This will stain the starch and improve viewing.

Draw and label the parts of the embryo and the seed.

Is this an example of a dicot or a monocot?

How do you know?

Is a radicle apparent?

What is the food source?

Is this different from the maize?

Does the maize kernel contain an embryonic plant?

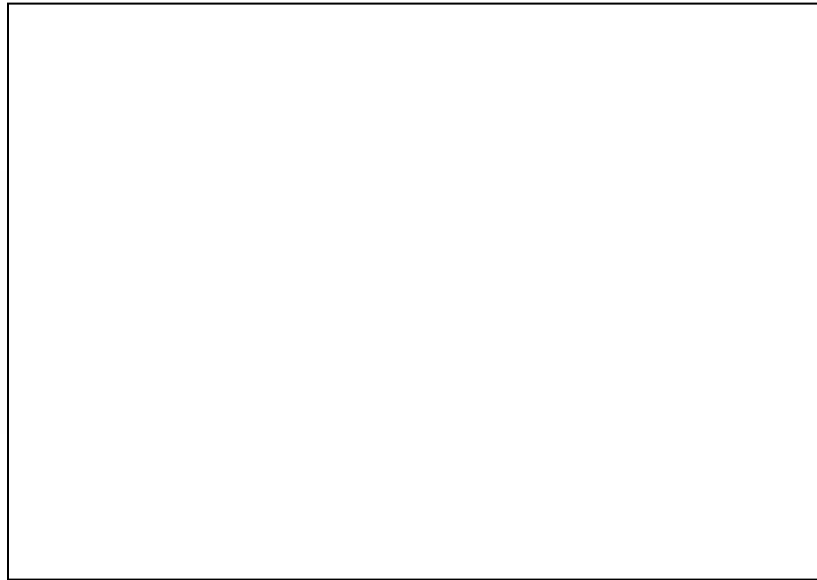
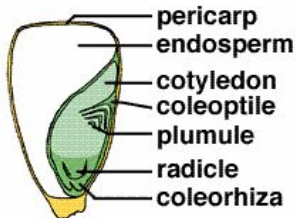
3. Now obtain a **maize kernel** and **bean seed** that have been imbibed for at least 3 days and appears to be germinating as recognized by the emergence of the radicle (primary root).

Prepare a section for use with the dissecting scope as in step 4. Be careful the seed so that the root (and any shoot) are bisected (cut in half). This will allow you to see the growth of the organs from the internal regions of the embryo.

Identify and Draw the organs and tissue recognizable:

C2. The Primary Plant Body: Connections Following Germination

1. Obtain a **germinated maize seedling** and examine it closely. In the box below, Draw and Label the structures visible.



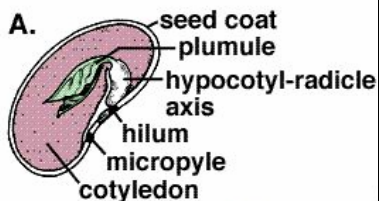
What structures have experienced the most growth?

Is the primary root present?

Are there any other types of roots present?

Label all of the seed structures on your drawing of the seedling.

2. Obtain a **germinated garden bean seedling** and examine it closely. In the box below, Draw and Label the structures visible.



Consider the questions from above and LABEL the structures in the picture.

C3. Comparative Analysis of Germination in Various Seedlings:

Analyze seeds and seedlings from the imbibition series provided. Each series represents a different plant species. Seeds have been imbibed on water for 0, 24, 48, 72, 120, and 168 hours. Carefully observe and dissect one representative seed/seedling for each species of plant. Make a sketch of the seed/seedling for each time point and LABEL as many of the structures introduced on pages 4 and 9. Be sure to make careful observations using the dissecting microscope. Use the space provided below for each species. Observe the barley and sunflower species first and then continue with the remaining species as time allows:

Monocot: Barley:

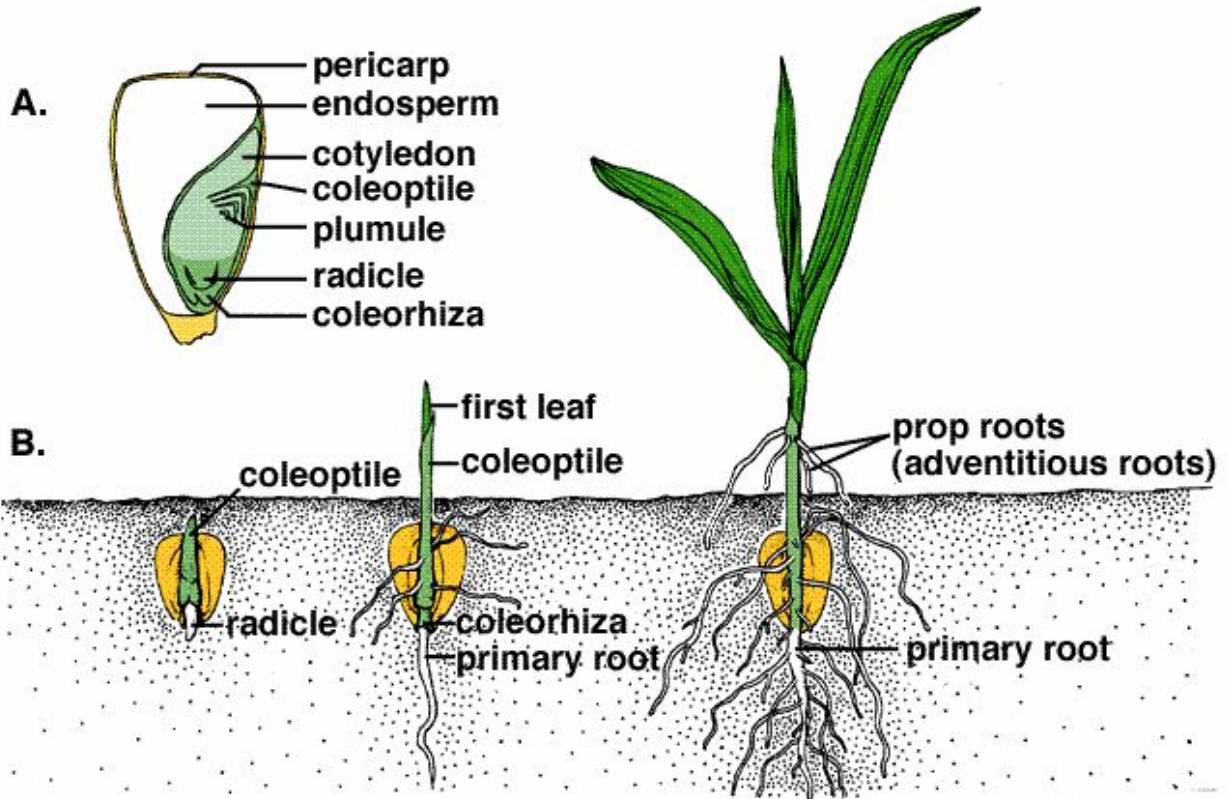
Eudicot: Sunflower:

Eudicot: Radish

Eudicot: Pea:

Eudicot: Arabidopsis:

Corn—Structure and Germination



Garden Bean—Structure and Germination

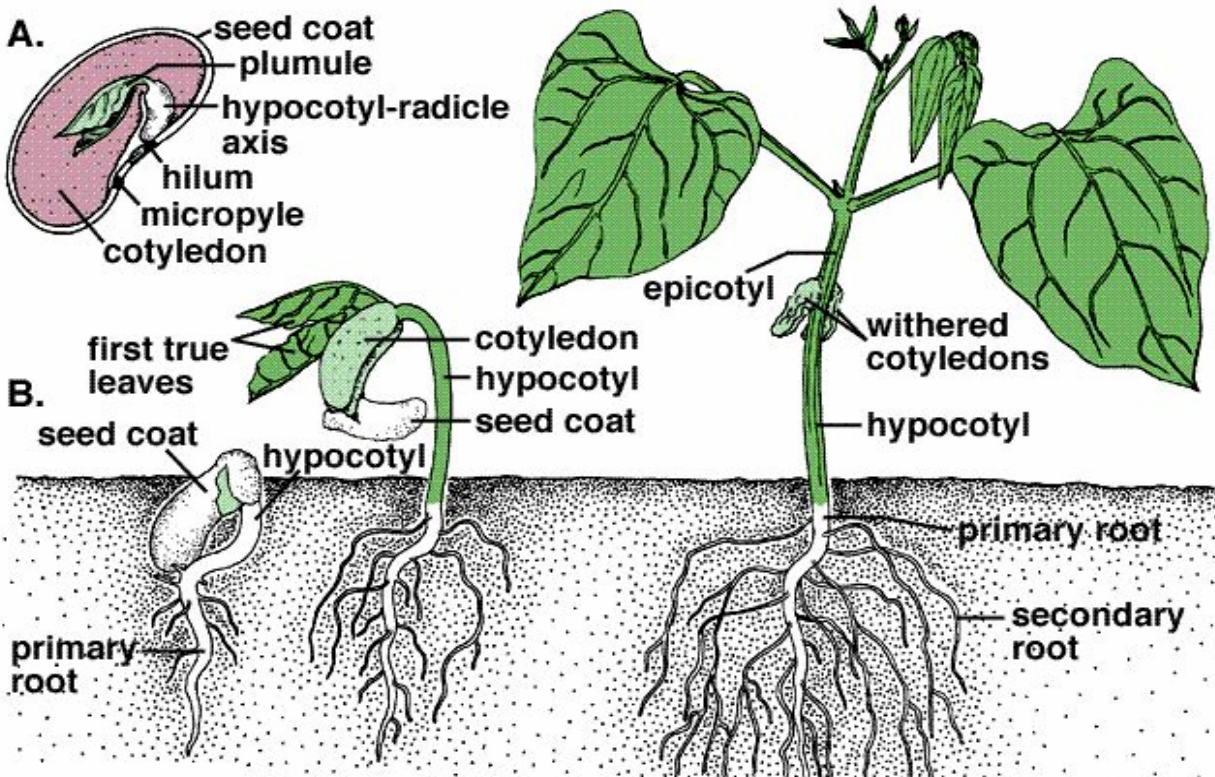


Figure 4: Basic organization of seed and vegetative plant organs and tissues in beans and maize.