As soybean seed takes on water and swells, the radicle is the first part of the embryo to penetrate the seedcoat (figure 2.2). It develops rapidly into a root which must become firmly anchored for the seedling to develop enough leverage to force its way to the soil surface. Lateral roots are formed soon after the radicle or primary root begins to elongate (figure 2.3). Root hairs appear on the primary root within four or five days after germination and on the lateral roots soon after they are formed. These hairs are the main absorbing surface of the root system. They are very small — nearly invisible without a lens — and might be desc
extensions of single epidermal cells. They a
actively growing part of the root just behind the growing point. Many people incorrectly think of branch roots, which can be easily seen, as root hairs.

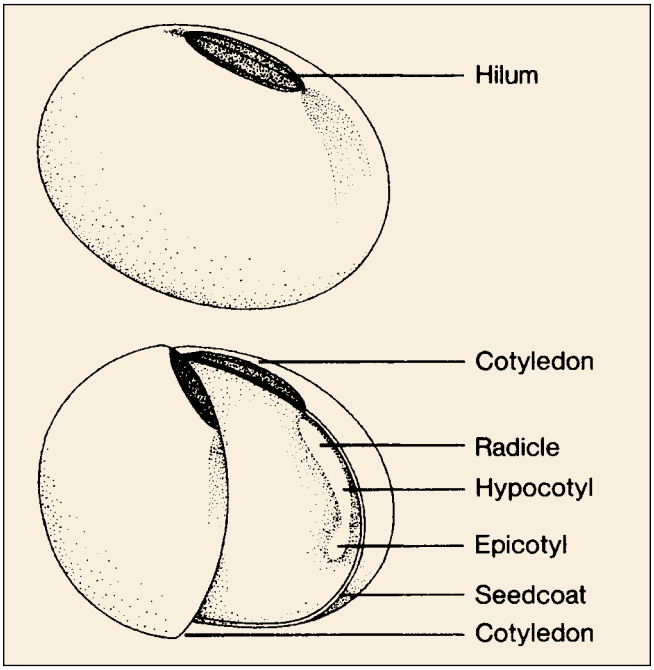


**Figure 2.1**. Drawing of an intact soybean seed and a cutaway showing seed parts.

**Figure 2.2**. The radicle, which becomes the primary root of the soybean seed, is the first part of the embryo to emerge once the seed has taken in enough water.

The taproot of the soybean plant is less pronounced than taproots of many other legumes, such as alfalfa. Soybean roots branch extensively. While the young roots appear to be a taproot system, the lateral roots soon make up most of the root mass. Within five to six weeks after planting, the lateral roots will reach the center of 30-inch rows. By the end of the growing season, the roots will penetrate to a depth of five feet or more in a well-drained soil. However, the bulk of the roots will be found in the upper 12 inches of soil, with a surprisingly large proportion of the root mass in the topmost 6 inches.

After the radicle emerges (figure 2.2), the hypocotyl begins to elongate. It forms an arch — the hypocotyl hook — which pushes upward through the soil (figure 2.4). As the arch breaks the soil surface, it straightens in response to light striking it on top, and pulls the cotyledons and epicotyl — the small leaves, buds, and growing point at the tip of the stem — upward and free of the soil, leaving the seed coat behind (figure 2.3). The uppermost cells of the hypocotyl stop growing as cells on its underside continue to grow until the arch is straightened, lifting the cotyledons into an upright position (figure 2.5). Because the hypocotyl arch is easily broken when pushing or pulling against a solid crust, soil crusting is a serious threat to the germinating soybean.

The epicotyl is exposed to sunlight when the cotyledons begin to open toward a more or less horizontal position (figure 2.6). At this stage, the plant is prepared for growth. The first three leaves begin expanding from the epicotyl by the time the cotyledons and epicotyl reach the soil surface (figure 2.6). These unfold and develop rapidly following exposure to the sunlight (figure 2.7). The first two leaves are unifoliolate — they each have only one leaf blade, and they are attached opposite each other at the same node (figure 2.8), which is located above the cotyledonary node. The next leaf and all those that follow are trifoliolate, meaning that they have three leaflets attached to a single petiole (figure 2.9). Each node above the cotyledonary node has one trifoliolate leaf attached, and petiole attachment points alternate from one side of the stem to the other on succeeding nodes (figure 2.10). A system of plant staging worked out by scientists at Iowa State University designates vegetative stages as "V" stages, with VE and VC referring to plant emergence and expansion of the unifoliolate leaves, respectively. After that, stage designations V1, V2,...V(n) are used to refer to the number of unrolled (with leaf edges no longer touching) trifoliolate leaves.

**Figure 2.3.** Lateral roots begin to form within a few days after emergence.

**Figure 2.4.** The hypocotyl hook appears above the soil surface as hypocotyl growth brings the cotyledons out of the soil.

**Figure 2.5**. After the hypocotyl has emerged from the soil, the hypocotyl hook straightens to lift the cotyledons.

**Figure 2.6**. Upon exposure to light, the upright cotyledons turn green in the light, and begin to open. The first leaves soon appear.

**Figure 2.7**. The two unifoliolate leaves expand above the unfolding cotyledons.

**Figure 2.8**. The first trifoliolate leaf appears above the unifoliolate, cotyledonary leaves.

**Figure 2.9**. The first trifoliolate leaf unfolding on the main stem. Succeeding leaves will unfold in the same manner at the tip of the growing stem.

**Figure 2.10**. A soybean plant with 3 trifoliolate leaves (growth stage V3).

Soon after exposure to sunlight the cotyledons and other plant parts develop active chlorophyll and turn green. However, the food material stored in the cotyledons remains the main source of nourishment for about a week after emergence. The cotyledons drop after most of their stored nutrients are used up; after this, the seedling is capable of supporting itself by photosynthesis. Photosynthesis by the cotyledons is useful for a short time after they turn green, but it is soon replaced by leaf photosynthesis.

Much of the soybean plant's nitrogen requirement is supplied by nitrogen-fixing bacteria that live in nodules on its roots. Nitrogen-fixing *Bradyrhizobium* bacteria "attack" root hairs, and the root produces a nodule in response to this attack. This results in a *symbiosis*, in which the bacteria that colonize the nodule receive their food supply from the plant, and the plant receives "in return" nitrogen fixed from the air. This process, due to the great difficulty in breaking the bonds that hold two nitrogen atoms together in the air, requires a great deal of energy and some complicated biochemistry on the part of the bacteria.

The first nodules appear within about one week after seedling emergence, and are easily visible as they increase in size (figure 2.11). Ten to 14 days later, the nodule bacteria are able to supply most of the plant's nitrogen requirements. Nitrate in the soil, however, reduces nodule formation and activity; thus fertilizer application or carryover from a previous crop will delay bacterial fixation. Active nodules have an internal pink color (figure 2.12) and remain active for six to seven weeks before they begin to break down. New nodules are formed during much of the life of the plant, normally ending at some point during the podfilling stages.

After emergence, the seedling is relatively tolerant of cold temperatures. This is surprising when one considers that the apical meristem — the main growing point — is above the soil surface in soybean, in contrast to that of corn, which is protected underground until the plant has about 6 leaves exposed. The cold tolerance of soybean tissue is high. Temperatures that kill young corn plants back to the soil line may damage no more than the uppermost parts of the young soybean plant.