The mature dried fiber is the most economically relevant part of the cotton plant. The production of fiber with appropriate physical properties requires a very specific sequence of developmental steps, each controlled by a number of as yet poorly defined biological processes. Fiber development requires fertilization of the ovule and growth of the embryo within. Each of the three stages of fiber development (initiation, elongation and secondary wall synthesis) directly impacts the final physical properties of the mature fiber. Fiber maturation refers to the natural drying and collapse of the fiber that occurs when the boll opens. Exposure of the mature fibers to air results in the drying of the fibers. The physical and chemical processes involved in maturation are closely related to the structure and chemical composition of the fiber. This section describes the growth and development of cotton fibers, emphasizing the biological processes required for each stage of development and the changes that occur in the fiber once the boll opens and the living fiber cell dies.

Fiber growth and development is rather unique among plant cells. Only a few plant cells in nature (fiber cells from flax and ramie) can reach the final length and volume of a cotton fiber. From its inception as an immature epidermal cell on the ovule to its death upon the opening of the boll, fiber cells increase in length some 4,000 - 5,000 times. The fiber increases in diameter by two to three times and volume some 10,000 - 15,000 fold. From epidermal cell to mature fiber, the cell undergoes a three step developmental sequence (initiation, elongation and secondary wall synthesis) followed by maturation. These first three steps occur in the living fiber and are controlled by the biological processes that regulate cell growth and development. The final step occurs upon opening of the boll and includes the death of the fiber cell. In addition to the long fibers, most commercial cultivars (excluding Pima or Gossypium barbadense) have very short white or colored fibers on the seed called linters or fuzz fibers. Fuzz fibers are of less commercial value. Cotton fiber quality,
as defined by length, maturity, strength, and micronaire, is primarily determined by the genetic makeup of the plant, but is also influenced by climatic conditions experienced by the crop.

**FIBER INITIATION**

Fiber development begins when the flower is about to open. As the ovule grows, immature epidermal (protoderm) cells of the future seed coat divide to accommodate the increase in volume of the ovule. Non-fiber epidermal cells divide and expand in a manner so as to increase the surface area of the seed. By a process that is still not understood, some epidermal cells dramatically change their pattern of growth to become fiber cells. Surface cells destined to become fibers stop dividing and dramatically change their growth direction, producing extremely long, single cells that extend perpendicularly above the surface of the ovule (Figure 30, 31).

**Figure 30.** On the day of anthesis numerous fiber initials develop primarily at the chalazal end of the ovule. (J. McD. Stewart)
Figure 31. Using SEM, fiber initials first appear as hemispherical swellings or bumps on the surface of the ovule. (J. M'D. Stewart)
The change in growth direction occurs near the day of anthesis. Depending on the cotton species and environmental conditions, fiber initials are first observed between -1 and 0 DPA (days post anthesis). While originally believed to be signaled by ovule fertilization, fiber initiation before fertilization clearly indicates that the two processes (fertilization and fiber initiation) are not mutually dependent on each other.

Estimates vary, but between 10 and 25% of immature protodermal (immature epidermal) cells develop into cotton fibers. Fiber initiation is first detected by a swelling of the protodermal cell above the surface of the ovule (Figure 32). The

![Figure 32](image)

**Figure 32.** Using LM, sections of the ovule and developing fibers reveal that as fiber initials swell above the surface of the ovule, cell diameter increases so that fiber cells (f) are much wider than neighboring protodermal cells (e) and over-spread them. (P. Lu and J. Jernstedt)
initial swelling of the protodermal cell is isodiametric (equal in all directions). However, within a day or two, the swelling is specifically directed toward cell elongation.

Several waves of fiber initiation occur on the ovule. Initiation is observed first at the crest and chalazal end of the ovule (Figure 33). Fiber initiation proceeds down the ovule such that by 24 to 48 hours, fiber initials are observed at the micropylar (pointed) end of the ovule (Figures 33 and 34).

Figure 33. The wave of fiber initiation is observed along the length of the ovule, using SEM. Longer (older) fibers are observed at the chalazal end of the ovule. As one proceeds towards the micropyle end of the ovule (arrow), shorter and shorter fibers are observed. (J. McD. Stewart)
Although reports vary, recent evidence indicates that fiber initials continue to be produced for four to five days. These initials develop into the lint fibers used for textiles. Subsequent waves of fiber initiation result in the production of fuzz fiber. Fuzz fiber appears to be initiated about 10 DPA.
Figure 35. As fibers enter the phase of rapid elongation (3 DPA) variability in shape of fibers is observed. Using SEM, fibers form different shapes, with some exhibiting long narrow tips (a) while others have broader, more blunted tips (b). (P. Lu and J. Jernstedt)