not among the tufted asci at the base. The ascospores are thread-like and in many species break into fragments after they are released, each fragment behaving as a spore.

All species in this order are grouped in the single family Clavicipitaceae which some authors (Bessey, 1950; Martin, 1961) classify in the Hypocreales and others (Miller, 1949; Luttrell, 1951) in the Sphaeriales (Xylariales). In recognizing the order Clavicipitales I am following Nannfeldt (1932), Gäumann (1952), and Dennis (1960). Representative genera of the Clavicipitaceae are *Claviceps*, parasitic on grasses, and *Cordyceps*, parasitic on insects, spiders, and on the fruiting bodies of some fungi.

family CLAVICIPITACEAE

Claviceps purpurea (Fr.) Tul.

Claviceps purpurea, the cause of ergot of rye, will be used as an example of the family Clavicipitaceae. The thread-like ascospores are forcibly discharged from the perithecia in the spring about the time that certain susceptible grasses, such as rye, are in bloom. If the ascospores, which are wind-disseminated, happen to reach the flowers of the rye plant or other susceptible host, they germinate (Figure 117*L*), send germ tubes into the ovary, and cause infection. As the mycelium develops, it destroys the ovary tissues and replaces them in the flower by a soft, white, cottony, mycelial mat which soon becomes covered by acervulus-like layers of short conidiophores bearing minute, oval conidia at their tips (Figure 117*B*). These conidia are mixed with a sticky, sweet, nectar-like secretion, the origin of which is obscure. Attracted by this nectar, insects visit the infected ovaries and distribute the conidia to uninfected flowers, spreading the fungus in this way.

In the meantime, the mycelial mat, which has produced the conidiophores, continues to develop, begins to harden, and is eventually transformed into a hard pink or purplish, pseudoparenchymatous sclerotium. In shape the sclerotium resembles the grain of rye whose position it occupies, but it exceeds the rye grain in length. This sclerotium is the "ergot" of commerce. Thus, the mature heads of rye bear sclerotia of *Claviceps purpurea* together with rye grains on their spikelets (Figure 117*E*), the uninfected ovaries developing normally, the infected ones being destroyed and replaced by the sclerotia of the fungus as described. During the harvesting operations, many of the sclerotia are knocked off the spikelets, and fall to the ground,

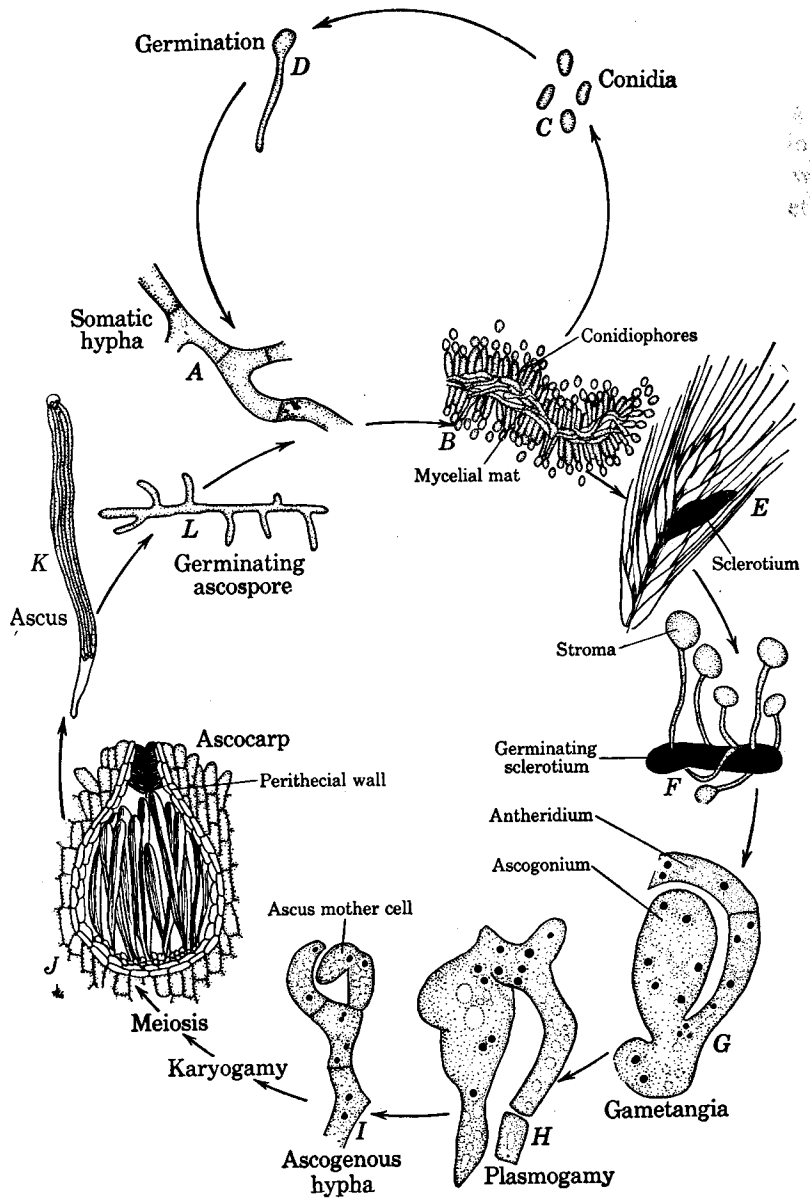

Figure 117. Life cycle of *Claviceps purpurea*. *A*, *D*, constructed; *G–I* redrawn from Brefeld, in Engler and Prantl, 1897, *Die natürlichen Pflanzenfamilien*, Teil I, Abt. 1**, Wilhelm Engelmann, Leipzig.

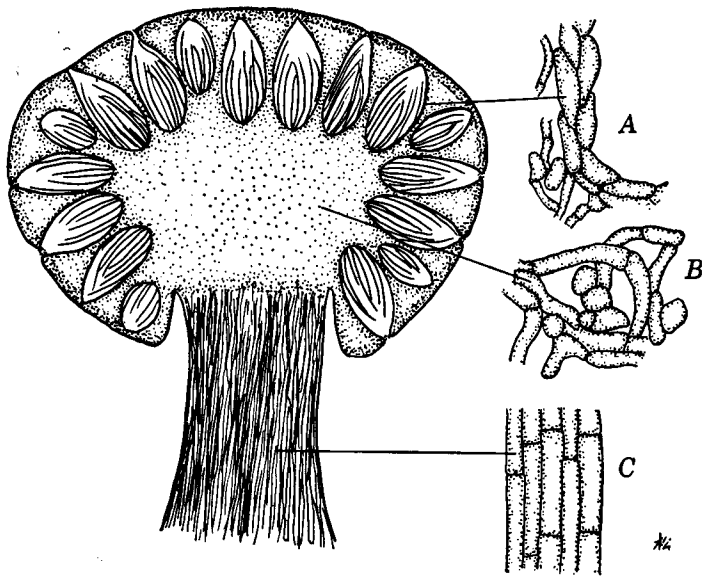

Figure 118. *Claviceps purpurea.* Stroma with embedded perithecia. *A.* Structure of perithecial wall. *B.* Structure of stromatal head. *C.* Structure of stalk.

where they pass the winter. The following spring, the sclerotia germinate and form several long-stalked, mushroom-like, dark purple stromata with globose heads. These stromata, which are about three-eighths of an inch tall, are easily visible (Figure 117*F*). Within these stromatal heads and just below their surface, arise a number of minute cavities surrounded by the pseudoparenchymatous stromatic tissue. Each of these cavities contains a single, multinucleate ascogonium at the base of which one or more multinucleate antheridia arise (Figure 117*G*). Plasmogamy now takes place between one of the antheridia and the ascogonium, the male nuclei migrating into the female organ (Figure 117*H*). The details of ascus formation have not been worked out, but we presume that they do not differ essentially from those of similar Ascomycetes. While the asci are forming, thin perithecial walls develop around the sexual apparatus within the stromatal heads, forming definite perithecia which open out on the surface of the stroma through a long, neck-like ostiole (Figures 117*J* and 118). Each mature perithecium bears several elongated, cylindrical asci, each containing eight thread-like ascospores (Figure 117*K*).

Whereas the mycelium of *Claviceps purpurea* parasitizing the rye plant is responsible for the plant disease known as ergot, the sclerotia of the fungus, which contain a number of poisonous alkaloids, are responsible for poisoning animals, including man, thus causing a condition known as **ergotism.** Cattle are often poisoned by grazing on grasses which carry the sclerotia of the fungus, or in fields in which the sclerotia are lying. In the past, because of improper methods used in cleaning flour, death of human beings from ergot poisoning was not uncommon in countries where the consumption of rye bread is high. With modern methods of milling, ergotism in human beings has been greatly reduced, but once in a while we read of a mass poisoning of people even today. In August 1951, for example, the American press [1] reported that a large number of people in the village of Pont-St. Esprit in France were suddenly attacked by what at first appeared to be a mysterious malady but which was soon diagnosed as ergotism. The symptoms were described in detail, and photographs of the suffering and the dead supplemented the gruesome reports.

Ergotism is much more common as a disease of domestic animals, however. Cattle which graze in infected fields are regularly poisoned by the sclerotia of this fungus.

The sclerotia of *Claviceps purpurea* are used in medicine for the preparation of a powerful abortifacient, which is also utilized in controlling hemorrhage during childbirth. So valuable is this drug that a number of studies have been conducted in an effort to discover a method for artificially infecting plants with *Claviceps purpurea* for the establishment of ergot farms. Pharmaceutical companies, however, are much more interested in a method for growing the fungus in liquid culture in vats, as they grow *Penicillium* for penicillin production. Although *Claviceps purpurea* grows easily in culture, no one has succeeded in inducing sclerotial formation outside the host plant.

orders CORONOPHORALES and CORYNELIALES

Too little is known about these orders to warrant discussion in an introductory book. The asci in both groups are said to be unitunicate, and the ascocarps to be ascostromata. If this is true, the correlation between unitunicate ascus and perithecium, and bitunicate ascus and ascostroma, appears to break down in these forms.

[1] *Life Magazine,* September 10, 1951; *New York Times,* August 29, 1951.