ELECTRON MICROSCOPE STUDIES ON THE DICTYOSOMES AND ACROBLASTS IN THE MALE GERM CELLS OF THE CRICKET*

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Few cellular structures have provoked more discussion than the Golgi apparatus. This is due in part to the fact that the Golgi material cannot be readily observed in the living cell by means of the light microscope. However, since the advent of the phase-contrast and electron microscopes, evidence has been rapidly accumulating in support of the view that the Golgi apparatus is a real cellular structure. Much credit is due Dalton and Felix (9) for demonstrating by use of the electron microscope that in vertebrate cells the Golgi apparatus is composed of (*a*) a system of parallel double-membraned lamellae and (*b*) a closely associated group of vacuoles often extending in a chain-like fashion along the sides of the lamellar mass. In some cells small granules (400 A in diameter) are also seen within the Golgi region. Several other authors have also described a similar ultramicroscopic structure for the Golgi apparatus in vertebrate cells (7, 11, 14, 15, 18, 19, 20, 24, 25, 26).

We undertook the present investigation partly because of the repeated claim by Shafiq (21, 22, 23) that the dictyosome form of the Golgi material in insects (nerve cells of the grasshopper) is an artifact, contrary to the observations of Beams and King (3) and Beams, Sedar, and Evans (4). In addition, it seemed of interest to compare the basic ultramicroscopic structure of the dictyosomes of an insect with that of the published accounts of the Golgi apparatus of vertebrates.

Materials and Methods

The germ cells of the field cricket (*Nemobius sp.*) were fixed for 30 minutes in 1 per cent buffered osmium tetroxide (pH 7.25). They were quickly washed, dehydrated, infiltrated, and embedded in a mixture consisting of 72 per cent *n*-butyl-methacrylate and 28 per cent methyl methacrylate. To this was added 0.2 gm. of luperco per 10 cc. of mixture. Polymeriza-

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tion was accomplished in an oven at 45°C. for 12 to 24 hours. Sectioning was done with an International Minot rotary type thin-sectioning microtome. The sections were studied without removal of the plastic with the aid of an RCA model EMU electron microscope.

OBSERVATIONS

Dictyosomes.—For a detailed description of the number, distribution, behavior, and literature pertaining to the dictyosomes in the germ cells of the cricket the reader is referred to Johnson (16).

It will suffice to point out here that the dictyosomes in the secondary spermatocytes are discrete crescent-shaped bodies. Their ultramicroscopic structure is of a duplex nature consisting of a compact series of parallel double-membraned lamellae (Figs. 1 and 2 (*L*)) and vacuoles which are often arranged in a chain-like fashion along the boundary of the lamellar mass (Figs. 1 and 2 (*V*)). The width of the lamellae is approximately 400 A. The profiles of the membranes in the lamellae of the dictyosomes appear relatively more dense than does the space between them. In some preparations, depending upon the plane of section, the vacuoles are seen concentrated at the ends of the lamellar mass (Fig. 2). In this position, the lamellar mass seems to spread out with the individual lamellae expanding and surrounding the relatively large vacuoles (Fig. 2). Associatied with the dictyosome complex a special region is often seen which, in some preparations, appears to be limited by a double-membraned lamella and to contain vacuoles of varying size (Fig. 1 (*PA*)). This is thought to constitute the pro-acrosome region described in light microscope studies (16). A further discussion of this point will appear elsewhere.

The Acroblast.—It is well known that the young spermatid contains a number of scattered dictyosomes which, by successive fusion, give rise to a single cup-shaped body, the acroblast (Figs. 3 and 4). During this period also, the mitochondria fuse giving rise to the mitochondrial nebenkern (6).

The ultramicroscopic structure of the acroblast is basically similar to that of the dictyosomes. Profiles of 15 to 20 compact lamellae may be seen arranged in a crescent-shaped mass located toward the base of the cup-shaped body (Fig. 3 (*L*)). At the upper margin of the acroblast the individual lamellae either open up to enclose vacuoles, or they extend for some distance where they appear to break up into rows of small vesicles (Fig. 3). Possibly this behavior of the lamellae is associated with the formation of new vacuoles.

Enclosing the compact lamellar mass near the base of the acroblast is a layer of more or less vacuolated ground substance (Figs. 3 and 4 (*G*)). Distal to this layer, which is best seen at the base of the acroblast, is a lamella-like layer composed of double membranes (Figs. 3 and 4 (*B*)). In some preparations it seems to be structurally like and closely associated with the endoplasmic reticulum (Fig. 2 (*E*)). However, such an apparent close morphological relationship between the two may be only fortuitous. The region in which the acrosome vacuole and granule develop is seen in Fig. 4. In the young acroblast this

region appears to contain many small vesicles (Fig. 3 (*AR*)). However, in more mature ones a single large vacuole appears (*AV*), within which is seen the developing acrosome (Fig. 4 (*AG*)).

DISCUSSION

Johnson (16) states that the dictyosomes in the male germ cells of the cricket are easily seen in the living unstained cell. In all species studied by him the dictyosomes have exactly the same shape and form in both fixed and living cells (cf. Gatenby (10) for a general discussion of dictyosomes in invertebrates).

Electron microscope studies reveal the dictyosomes of the cricket germ cells to have a structure comparable to the Golgi apparatus of vertebrates. This close similarity is considered strong evidence in support of the view that the two are homologous structures. As has long been known, the Golgi material has a similar function in the germ cells of both vertebrates and invertebrates, namely, the formation of the acrosome.

It should also be pointed out that the dictyosomes and acroblasts have a structure distinct from that of the mitochondria. In some cells the Golgi material appears to bear a close relationship to the endoplasmic reticulum (9, 19).

We agree with Baker (2) that there is no evidence for thinking that the dictyosomes of germ cells are of a different category from those of somatic cells. This is further substantiated by the fact that the dictyosomes of *Helix* germ cells (5, 13), earthworm germ cells (8), eggs of echinoderms (1), nerve cells of *Patella vulgata* (17), choanocytes of *Grantia*, and the contractile vacuole of certain Protozoa (12) display structures comparable to the Golgi apparatus of vertebrates and the dictyosomes of the germ cells of the cricket.

It is suggested from the relative positions of the lamellar and vacuolar components of the dictyosomes and acroblasts that the lamellar portion is probably comparable to the osmiophilic and the vacuolar portion to the osmiophobic components of the classical description.

SUMMARY

The dictyosome (Golgi body) in the secondary spermatocyte of the cricket appears in electron micrographs as a duplex structure composed of (*a*) a group of parallel double-membraned lamellae and (*b*) a group of associated vacuoles arranged along the compact lamellae in a chain-like fashion. This arrangement of ultramicroscopic structure for the dictyosomes is strikingly comparable to that described for the Golgi apparatus of vertebrates. Accordingly, the two are considered homologous structures. Associated with the duplex structure of the dictyosomes is a differentiated region composed of small vacuoles. This is thought to represent the pro-acrosome region described in light microscope preparations.

In the spermatid the dictyosomes fuse, giving rise to the acroblast. Like the dictyosomes, the acroblasts are made up of double-membraned lamellae and associated vacuoles. In addition, a differentiated acrosome region is present which, in some preparations, may display the acrosome vacuole and granule.

Both the dictyosomes and acroblasts are distinct from mitochondria.

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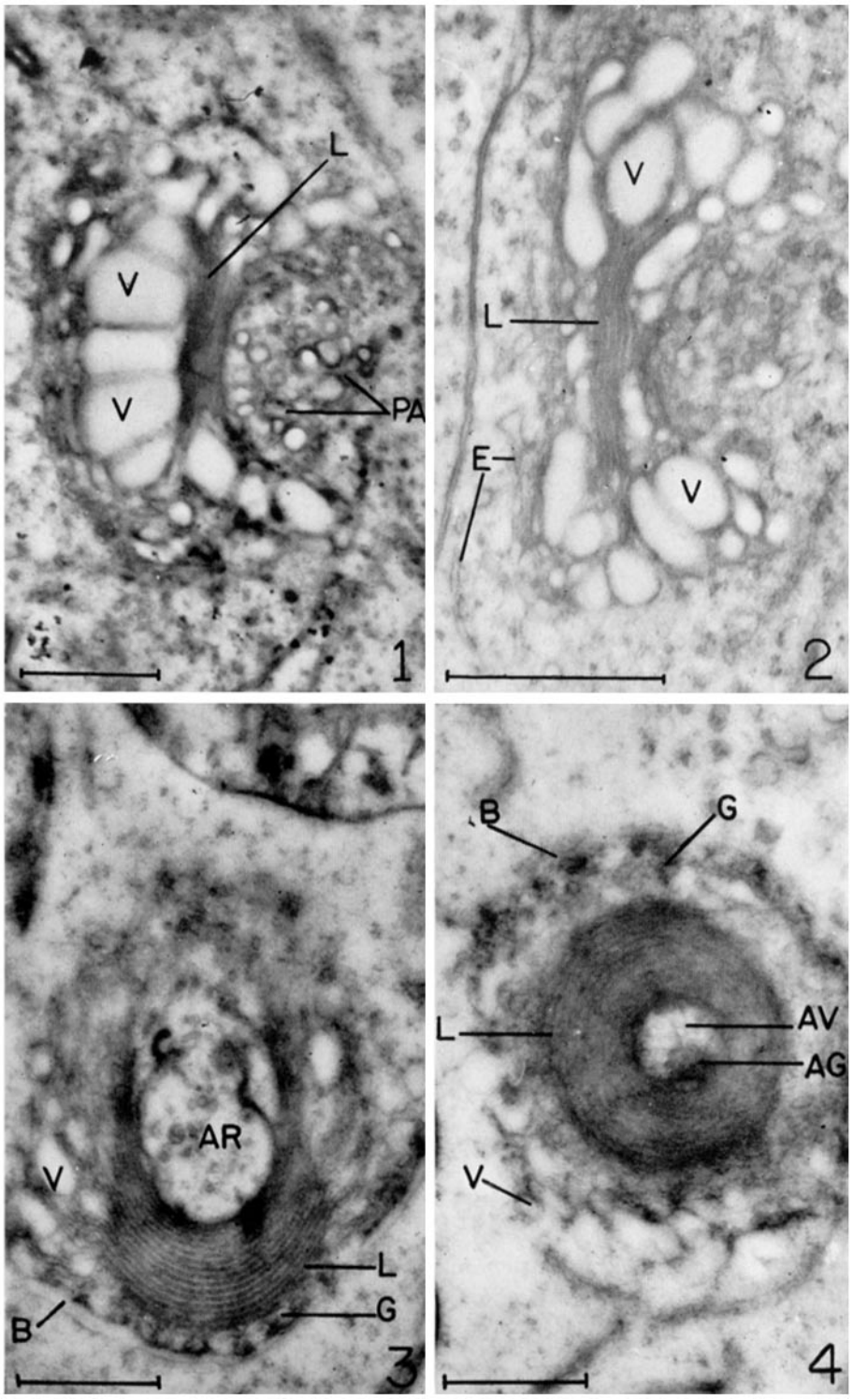
PLATE

EXPLANATION OF PLATE 45

FIGS. 1 and 2. Sections through secondary spermatocyte dictyosomes showing vacuoles (*V*) and lamellae (*L*). The region at *PA* contains many small vacuoles and is thought to be comparable to the pro-acrosome region of light microscopy. Portions of endoplasmic reticulum are shown in Fig. 2 (*E*).

FIG. 3. Section through long axis of acroblast of spermatid. Note lamellae (*L*), vacuoles (*V*), and acrosome region (*AR*). Portion of the ground substance of the acroblast is shown at *G*. At *B* is a layer which appears to separate the acroblast proper from the surrounding cytoplasm. This layer is structurally like and sometimes appears closely associated with the endoplasmic reticulum.

FIG. 4. Transverse section of acroblast showing acrosome granule (*AG*), acrosome vacuole (*AV*), lamellae (*L*), vacuoles (*V*), ground substance of acroblast (*G*), and limiting layer (*B*).



(Beams *et al.*: Male germ cells of cricket)