CONCERNING THE "BLOOD-TISSUE" OF THE INSECTA.—III.

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RHYNCHOTA. As representative of the Phytophthires the just-born young of a wax-secreting Aphid, which infests the alder, were studied. In sections the whole body-cavity was found to be filled with a reticulate fat-body, the nuclei of which measure only 3.5 μ. The oenocytes are scattered here and there throughout the reticulum apparently without any definite arrangement. They are large, brownish, opaque cells with sharp contour. The cytoplasm measures 12-18 μ; the nucleus 5-55 μ. They seem to have no morphological connection with the fat-body but to be merely slung in its meshes. The nuclei stain deeply and present the typical finely wound chromatin skein. Some of the scattered cells were found in the three thoracic segments, whither they had probably migrated during embryonic life from the pleural walls of the abdomen. In the prothorax only two oenocytes were found and these were placed symmetrically one on either side in the pleurae.

In the mature embryo of *Ranatra fusca* oenocyte-clusters occur in five of the abdominal segments. They are huge yellow cells with nuclei rich in chromatin and are lodged in niche-like depressions of the pleural hypodermis.

My observations on the oenocytes of *Zaitha fluminea* are limited to a stage of the embryo immediately preceding revolution. I find in the abdomen, just outside the appendages and stigmata, a series of thickenings which foreshadow the compressed pleural rim of the larva and imago. The pair of these thickenings in the first abdominal segment develop excessively, bulging out conspicuously beyond the niveau of the other thickenings, so that, had I not observed that the pleuropodia are invaginate in this form and did not their tufted secretion show clearly in the very same segment, I should have supposed that I had found a pair of evaginate knob-like appendages. Sections show that the greater development of the first pair of abdominal thickenings is due to excessive proliferation of the hypodermal cells to form a solid succulent mass—the oenocytes. So many of the hypodermal elements are here converted into oenocytes, that only a few flattened and attenuated cells remain to cover the mass externally. From the surface the oenocytes may be seen shining through this thin covering and this heightens the resemblance of the two swellings to the pleuropodia of such forms as Blatta and Xiphidium. The pleural thickenings of the second abdominal segment are also more pronounced than those of the succeeding segments but much smaller than the first pair. I could not make out that they gave rise to oenocytes. As I had no material of the later stages I was prevented from following the development of these organs further. It is possible that there are in the adult several pairs of oenocyte clusters as in other insects and that they develop from before backwards so that the stage which I studied may have shown only the formation of the first pair of anlagen. It seems to me more probable, however, that Zaitha develops only one pair of clusters and that the others have atrophied to such an extent as no longer to appear during ontogeny.

NEUROPTERA. In the just-hatched larvae of *Sialis infumata* a few oenocytes were found as large clear cells sticking in the pleural hypodermis between the insertions of the tergo-sternal muscles.

TRICHOPTERA. Specimens of the larvae of an unidentified Phryganeid were torn open in normal salt-solution and examined fresh or after treatment with methyl-green osmo-acetic mixture. In fresh preparations the gigantic oenocytes (Fig. 1.) are yellow, more or less rounded, and often provided with delicate processes which are attached to the tracheal hypodermis. The cytoplasm is usually finely granular; the chromatic skein of the nucleus is distinctly discernible in the unstained cell. Methyl green stains both cytoplasm and nucleus deeply and of about the same hue. This reagent, of course, accentuates the chromatic skein. There are no nucleoli.

In some of the larvae all the oenocytes contain vacuoles. These are arranged in a broad band surrounding the nucleus midway between the nuclear and cytoplasmic walls. These vacuoles are but slightly refractive and are not fat-globules. This condition of the oenocytes was found in a number of larvae and, I believe, represents a normal physiological state. Wielowiejski has made a similar observation. One is reminded of certain gland-cells which store up vacuoles of a specific substance in their cytoplasm, preparatory to secretion.

One of the facts brought out by measurements of Xiphidium, viz: the gradual growth of the oenocytes with the growth of the insect, was again clearly shown in the larvae of this Phryganeid. Different stages gave the following measurements.

	Cytoplasm.	*Nucleus.*
1. Larva just hatched,	12.0 μ	4.6 μ
2. Larva 13 mm. long,	40.8 μ	15.6 μ
3. Larva 17 mm. long,	62.8 μ	20.3 μ
4. Larva 25 mm. long,	103.7 μ	29.5 μ
5. Larva 30 mm. long,	137.– 166.8 μ	55.2 – 74. μ

Here the cytoplasm increases from 12. – 166.8 μ, while the nucleus grows from 4.6 – 74 μ, so that the latter undergoes a slightly greater relative increase in size. In Xiphidium we found the converse to hold good.

COLEOPTERA. The oenocytes of *Photuris pennsylvanica* (imago) are of huge dimensions like those of the Trichopteran described above; their cytoplasm measuring 118.5 – 185. μ across, while their nuclei range from 33.5 – 60. μ. The cells are disposed in loose clusters in the pleural region of the abdomen and resemble their homologues in European Lampyrids.

In some Malacodermata Wielowiejski distinguished three different varieties of oenocytes according to size. In the Lampyrids he found only those of medium size — corresponding to the second variety of other Malacodermata, and suggests that in the fire-flies the "kleine oenocyten" (third variety) may be converted into the photogenetic organ. It is clear that if the "kleine oenocyten" are true oenocytes and if, moreover, Wielowiejski's suggestion is well founded, the photogenetic organs of the Lampyridae must be ectodermal structures. If on the other hand these interesting structures originate from the fat-body, as is usually maintained, they must be mesodermal.

In *Photuris pennsylvanica* the two layers of the light-organ consist of cells which closely resemble the elements of the fat-body proper. The cells constituting the inner layer have the same size and much the same appearance; their nuclei do not differ from those of the fat-body; in the outer layer, which is more especially concerned with the photogenetic function, the cytoplasm is, of course, considerably altered, but the nuclei are indistinguishable in every particular from those of the fat-cells. The resemblance between the fat-body and the light-organ is so great that I do not doubt their genetic relationship though I have not studied the development.

LEPIDOPTERA. Few insects appear to be better adapted for tracing out the origin of the oenocytes than the Lepidoptera. This is especially true of the larger Bombycid moths. That the segmental cell-clusters arise by delamination from the ectoderm was conclusively made out in the embryos of *Platysamia cecropia* and *Telea polyphemus*. Each cluster is several cell-layers in thickness and lies just behind and a little ventrad to an abdominal stigma. The succulent cells constituting the cluster are at first polygonal from mutual pressure, but as the time for hatching approaches, they become rounder and more loosely united. I have not traced them through the larval stages and merely record these fragmentary observations because they completely confirm Tichomiroff's and Graber's observations on the origin of the oenocytes from the ectoderm.

DIPTERA. Oenocytes probably occur throughout this order. To the families in which they were found by Wielowiejski (Chironomidae, Tipulidae, Culicidae, Tabanidae, Syrphidae, Muscidae, Pupipara) I would add two others (Cecidomyidae and Simulidae).

In the larvae of *Cecidomyia antennariae* beautiful large oenocytes occur in metameric clusters, each of which consists of about five cells. These seem not to be so regularly arranged as the oenocytes of Chironomus (Wielowiejski). One cell of each cluster is situated at some distance from the others but dorsad and not cephalad as in Chironomus. The cells measure 45.–75. µ; their nuclei 15. µ. They are round or slightly oval, and flattened in the same direction as the hypodermis, in niche-like excavations of which they lie.

In the young pupa they lose their connection with the hypodermis, become spheroidal and vacuolated and their nuclei decrease in size. I have failed to find any traces of oenocytes in the mature pupa and imago.

In the larva of Simulia the oenocytes resemble those of Cecidomyia.

The above insects belonging to many of the natural orders were also studied with a view to establishing the origin of the blood-corpuscles but my results were purely negative. I saw nothing to support Schaeffer's view* that the corpuscles arise from the fat-body. Such an origin is improbable *à priori* inasmuch as the cells composing the corpus adiposum are specialized for storing up fat and urates. That fat-globules and urates in the blood-corpuscles do not prove a genetic but only a physiological relationship between the fat-body and the blood is obvious if we stop to ask the question: How do the fat and urate inclusions reach the fat-body? It is most natural to suppose that they are transported thither by the blood-corpuscles. That the reverse may frequently be the case, viz: that the blood-phagocytes may receive their fat-globules from the fat-body and carry them to other parts of the organism to be utilized in the metabolic processes which are continually taking place, is, I admit, quite as probable. But neither of these processes throws any light on the origin of the blood-corpuscles themselves.

In the embryo the blood-corpuscles probably arise from undifferentiated mesodermic tissue. They are often found in different stages of caryokinesis and I can see nothing improbable in the supposition that they may continue to multiply throughout postembryonic life. It is also probable that mesodermic cell-masses of an undifferentiated nature, associated for obvious physiological reasons with the fat-body, may function as haematogenic centres during the larval stages. For all his figures and descriptions prove to the contrary, Schaeffer's "blutbildungsheerde" may be such undifferentiated mesoderm-masses and not portions of the true fat-body at all.

In this connection I may mention a very interesting organ which I have recently found in embryos of Blatta and Xiphidium and which appears to have some physiological connection with the other members of the "blutgewebe." This is a large v-shaped mass of cells situated just beneath and attached to the inner end of the oesophagus (stomodaeum) where the two entodermic strands diverge. This cell mass lies almost wholly in the trito-cerebral (second antennary?) segment and, I believe, represents a modification of the

*Beiträge zur histologie der insekten. II. Ueber blutbildungsheerde bei insectenlarven. Sprengel's Zool. Jahrb., 3 bd. heft 4. 1889.

greater portion of the mesoderm of the segment, though this is difficult to decide. It is apparently the earliest organ to differentiate from the walls of the coelomic sacs. Its cells, at first wedge-shaped, gradually increase in size, become rounded and highly vacuolated and resemble the fat-body elements, from which they may, nevertheless, always be distinguished by their peculiar yellow tint. I have traced the organ, which is a definite circumscribed structure, and which I call, for the present, the suboesophageal body, through the embryo into the larva, where it disintegrates and finally disappears. I regard it therefore, as a truly embryonic and early larval structure, quite distinct, at least physiologically, from the fat-body. Its function is very doubtful. If the trito-cerebral segment is homologous with the second antennary segment of the Crustacea and if, moreover, the suboesophageal body really develops from the mesoderm, it may be the homologue of the "green-gland" and consequently nephridial in its nature.

Reserving a general consideration of the "blood-tissue" for future publication, I here conclude with a brief summary of the points brought out in the foregoing paragraphs: —

(1) The fat-body of the Insecta is derived from the mesoderm—being a differentiation of portions of the coelomic walls and therefore metameric in origin.

(2) The oenocytes are derived by delamination or immigration from the ectoderm, just caudad to the tracheal involutions. They are also metameric organs.

(3) They are limited to the eight trachigerous abdominal segments.

(4) They appear to be restricted to the Pterygota, in all the members of which group they probably occur.

(5) They give rise neither to the fat-body nor to the blood but represent organs *sui generis*.

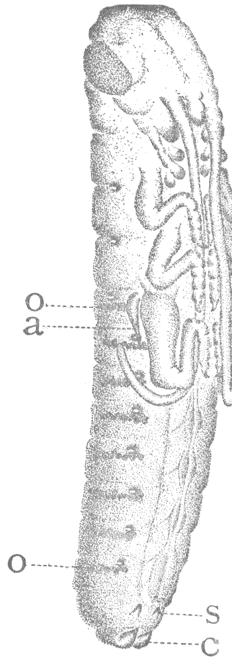
(6) After their differentiation from the primitive ectoderm they never divide but gradually increase in size.

(7) The blood-corpuscles of these insecta appear to arise early in embryonic life and perhaps also in post-embryonic life from undifferentiated mesoderm cells. The evidence of the derivation of the blood-corpuscles from the fat-body as such is unsatisfactory.

(8) The suboesophageal body arises in the trito-cerebral segment apparently from the mesoderm. Though it resembles the fat-body it must be regarded as a distinct organ. It disappears during larval life.

Clark University, Dec. 22, 1891.*

*Since the above article was written and sent to "Psyche," I have received two publications bearing on the origin of the fat-body in the insect embryo. The first is an account published in the second part of Korschelt and Heider's Lehrbuch der vergleichenden entwicklungsgeschichte der wirbellosen thiere, of Heymons' studies on *Phyllodromia germanica*. Soon afterwards Dr. Heymons kindly sent me a copy of his interesting paper (Die entwicklung der weiblichen geschlechtsorgane von Phyllodromia (Blatta) germanica L. Zeitschr. f. wiss. zoöl. LIII. 3. 1891, p. 434–536) the lucid illustrations of which show essentially the same method of origin for the fat-body as fig. 3 in my plate. He finds, also, that other portions of the coelomic wall may contribute to the formation of the corpus adiposum.)



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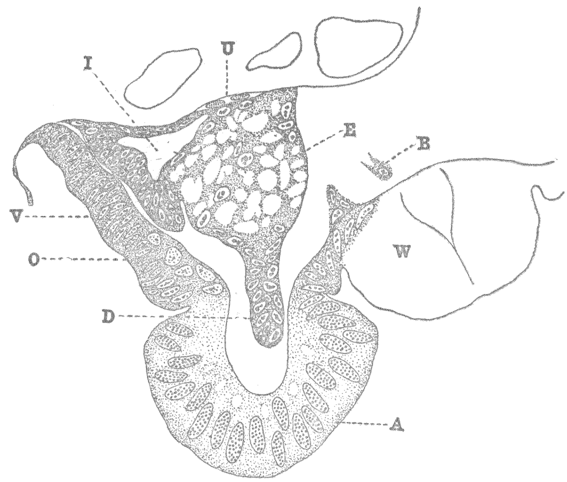

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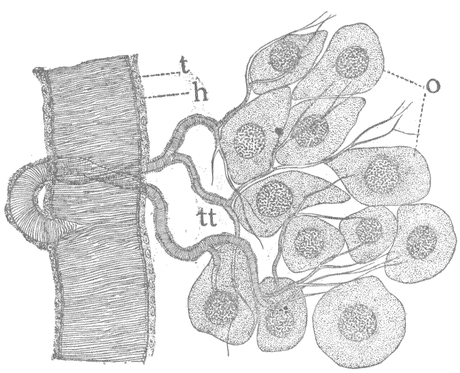

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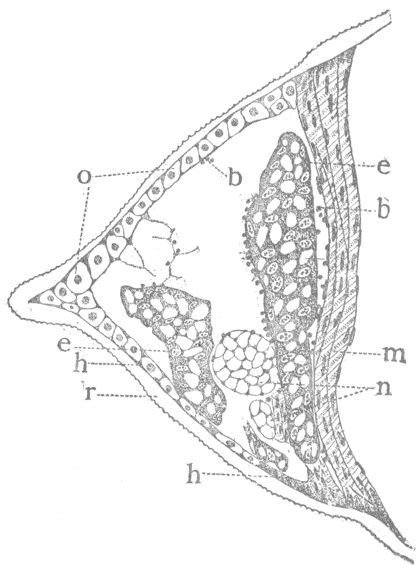

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EXPLANATION OF PLATE 7.

Fig. 1. Cluster of oenocytes from a nearly mature Phryganeid larva. *o*, oenocytes; *t*, large tracheal branch; *tt*, smaller tracheal ramifications; *h*, tracheal hypodermis.

Fig. 2. A nearly mature embryo of *Xiphidium ensiferum*. *oo*, oenocyte clusters seen from the surface through the integument; *a*, pleuropodium of the right side (appendage of the first abdominal segment); *s*, styli (belonging to the ninth abdominal segment; the specimen being a male); *c*, cerci.

Fig. 3. Part of a transverse section through the first abdominal segment of a young embryo of *Blatta* (*Phyllodromia*) *germanica*. *v*, pleural ectoderm; *o*, oenocytes; *a*, pleuropodium; *i*, coelomic cavity; *u*, entoderm; *w*, nerve-cord; *e*, fat-body; *b*, blood-corpuscle; *d*, diverticulum of the coelomic wall, which in appendage-bearing segments becomes converted into the limb-musculature but in this segment atrophies.

Fig. 4. Part of a transverse section through one of the abdominal segments of a *Blasturus* nymph; *o*, oenocytes; *hh*, hypodermal cells; *r*, chitinous cuticle; *ee*, fat-body; *bb*, blood-corpuscles; *m*, tergo-sternal muscles; *n*, muscles in cross-section.

TACHINID PARASITE OF EUCATERVA VARIARIA GROTE, AND OTHER NOTES.

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Along the arroyos on the mesa-lands, and near the bases of mountain ranges, in southern New Mexico, may be found growing large tree-like shrubs, with willow-like leaves, and bearing in spring numbers of rather large pink flowers, which are followed by catalpa-like seed-pods. This is known to botanists as *Chilopsis saligna*.* In August these shrubs are well stocked with the cocoons of a moth, *Eucaterva variaria* Grote, the larvae of which feed upon the leaves. The identification was made by Dr. Henry Skinner, to whom I sent a specimen of the moth. The cocoons are very lightly spun of silk, binding the leaves together to form a part of them, and are formed on the terminal shoots. From one of these cocoons, there issued, about the 4th or 5th of September, a ♂ specimen of a Tachinid, which I can in no way distinguish from the ♂ of *Hyphantrophaga hyphantriae* Twns. The parasite issued without going into earth, as there was none of the latter in the jar in which the cocoons were placed, but came directly from the cocoon of the moth, in which, if I remember rightly, the puparium of the Tachinid was found. This is quite a different habit from that possessed by those members of the same species which parasitize the Fall web-worm; perhaps the latter individuals

*I am indebted to Professor E. O. Wooton, of the New Mexico Agricultural College, for the name.