and to $N = 6.0594 \times 10^{23}$, is 2.166 gm/cm^3 or only a little lower than the lowest value quoted by Davey.[14]

The value $N = 6.0594 \times 10^{23}$ is equivalent to a factor 1.65033×10^{-24} ($\log^{-1} \overline{24}.2175704$ for converting atomic or molecular weights to grams.

The second method, depending upon the value of h, requires in addition a determination of the potential applied to an X-ray tube. The work of Blake and Duane[15] may be considered as a determination of d in terms of h. The values of h collected by Birge[16] vary somewhat among themselves but 6.560×10^{-27} seems a reasonable mean value of the results not depending upon X-ray wave-lengths, and this gives $d_{CaCO_3} = 3.0303 \times 10^{-8}$ or 0.058 per cent. higher than the value given above. This is within the range permitted by the probable error in the value of h just taken.

The following constants are therefore recommended to be used until other values are agreed upon, to the accuracy indicated by the logarithms.

Grating space of calcite:
3.028×10^{-8} cm. ($\log^{-1} \overline{8}.48116$)
Number of molecules per mol:
6.0594×10^{23} ($\log^{-1} 23.78243$)
Molybdenum K-radiation wave-lengths:
α_1 0.70783×10^{-8} cm. ($\log^{-1} \overline{9}.84993$)
α_2 0.71212×10^{-8} cm. ($\log^{-1} \overline{9}.85255$)

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PERIPHERAL MIGRATION OF A CENTRIOLE DERIVATIVE IN THE SPERMATOGENESIS OF ŒCANTHUS

In 1920 Mr. Chas. S. Driver began at Columbia University a study of the male germ cells of a common tree-cricket, *Œcanthus nigricornis* Walker, an Orthopteron insect of the family *Gryllidæ*. His preliminary study convinced him that, during the changes undergone by the spermatid as it begins to lengthen into the mature sperm, the entire distal centrole migrates posteriorly along the axial thread, eventually forming a terminal "plug" for the caudal sheath at its distal extremity. While a peripheral migration of part of the central apparatus in the spermatids of invertebrates was not hitherto entirely unknown, previous accounts are few in number and somewhat conflicting in substance. A reexamination of this phenomenon was, therefore, of considerable interest. The untimely death of Mr. Driver left his work incomplete and his material was delivered to me for further study. Driver deserves much credit for the excellence of the preparations, which are remarkably well fixed and stained. The method of Benda was used for fixation, and the sections were stained according to the alizarin-crystal violet technique. My observations were made at a magnification of 1,100 to 1,650 diameters, somewhat higher than that used by Driver in his survey of the material.

After a careful study I have reached a different conclusion in regard to the migrating "centriole" from those of Driver and earlier observers. Although there is in the spermatids of Œcanthus a peripheral migration of a body which appears much like a centriole and stains in a similar manner, I am able to demonstrate that the migrating body is not an entire centriole, but only a portion or derivative of the distal centriole.

In early spermatids of Œcanthus the central apparatus appears as a bar which lies perpendicularly to the nuclear membrane. The axial thread has already appeared at this early stage. The bar constricts in the center, dividing into a proximal and a distal centriole. Almost immediately a small portion of the latter, encircling the axial thread, is budded off and begins a migration along the thread. As it moves distally it increases rapidly in size, and eventually becomes as large as both proximal and distal centrioles combined. It reaches a permanent position at the distal extremity of the caudal (mitochondrial) sheath. The remainder of the distal centriole continues to lie

[14] *Loc. cit.*,[13] assuming the value attributed to Retgers is 2.167 and not 1.167 as printed.

[15] F. C. Blake, W. Duane, *Phys. Rev.*, (2), 10, 624-637 (December, 1917).

[16] *Loc. cit.*[1]

in close proximity to the proximal one at the nuclear wall; and in cells too heavily stained with crystal violet they appear as a single body, a fact which may account for Driver's view that only the proximal centriole remains near the nucleus. A full account of the circumstances connected with the origin and migration of the distal centriole derivative will be incorporated in a later paper.

Accounts of a distal migration of a centriole or its derivatives in the spermatogenesis of invertebrates are, as already indicated, rare. Only among insects have such cases been recorded. Perhaps the clearest and most convincing statement is that of Otte ('07)[1] for *Locusta viridissima*. Some of his figures, notably No. 87 and No. 92, bear a strong superficial resemblance to certain cells to be found in the Œcanthus preparations. Otte, like most of the other observers of similar phenomena, considers the migrating body to be an entire distal centriole. My observations upon the origin of the migrating body in *Œcanthus* caused me to become skeptical of similar reports in other cases; and through the kindness of Dr. O. L. Mohr of the University of Kristiania, who has sent me testes of *Locusta viridissima* fixed in Benda's solution, I was enabled to make a re-examinaion of the spermatids of this insect. A preliminary survey of the material, while not entirely conclusive, indicates that the centrioles of the "neck-region" of young spermatids are two in number prior to, and throughout, the period in which the centriole-like body performs its migration to the posterior pole of the cell. This body, therefore, appears to be a centriole derivative and not the distal centriole itself.

The discovery in *Œcanthus* of a centriole derivative which migrates along the axial thread to a position remote from the nucleus is of interest because it presents certain transitional features between two previously known and common types of spermatid metamorphosis. The first of these types has been reported by numerous observers upon the spermatogenesis of various invertebrates, including most of the insects. In the early spermatids of these animals two centrioles lie together in the neck-region of the young spermatid. One of these, the distal centriole or blepharoplast, spins out an axial thread. The two centrioles remain practically unchanged in the same region throughout the metamorphosis of the spermatid, and no peripheral migration of centriole derivatives occurs. The second type is characteristic of certain vertebrates, notably the mammals, and has been described by various authors for man, rat, guinea-pig, *Phalangista*, etc. In the spermatids of these forms two centrioles also remain in the neck-region, but the distal, after spinning out the axial thread, cuts off a ring-shaped body which encircles the thread and migrates distally, at least as far as the terminus of the middle-piece. There is no well-defined middle-piece in the insect sperm, and, as already stated, the migrating body, closely analogous to that of the mammal sperm, passes to the posterior margin of the caudal sheath.

This study also has a bearing upon certain phases of the problem of fertilization, notably the origin of the first cleavage spindle. Many observers hold that the first cleavage centers arise from, or in the immediate neighborhood of, the neck-region of the sperm as it enters the egg. It is possible that the proximal and distal centrioles maintain their individuality and form each a pole of the spindle, but this must remain a matter of conjecture. It is noteworthy, however, that in practically every animal that has been critically studied,[2] portions of both proximal and distal centrioles pass into the neck-region of the mature sperm. In this respect Œcanthus falls directly into line with the vast majority, and probably also *Locusta*.

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[1] Otte, Heinrich: "Samenreifung und Samenbildung bei Locusta viridissima," *Zool. Jahrb.*, Bd. 24, Heft 3, S. 431-521, 1907.

[2] Apparently an exception obtains in certain Mollusca; *vide* Gatenby ('18): "The Cytoplasmic Inclusions of the Germ-Cells. Part III—The Spermatogenesis of Some Other Pulmonates." *Quart. Jour. Mic. Sci.*, N. S., Vol. 63, No. 250, pp. 197-258.