are particularly large and well developed in the root-cap cells and in developing cells of the vascular areas. They show no special features of distribution in mitosis. Each spherosome is disc-like, not spherical in shape. The body of the disc is yellowed somewhat but not blackened by osmic treatment. The rim of the disc is blackened intensely. Thus, when seen in plane view, the spherosomes appear essentially as black rings, while in profile view they appear as rods. It is these "rods" which apparently constitute the "inactive chondriome" of Guilliermond, the real morphology of which is here described for the first time.

(4) *Vacuome*—very finely demonstrated and particularly studied thus far only in Vicia faba. The general results are in remarkable agreement with the accounts heretofore given by the Dangeards using vital dyes. In my preparations, however, the vacuome is for the first time demonstrated in the finest detail and in a form adapted for permanent preservation and study. In the earliest meristem cells the vacuome consists of many roughly spherical masses scattered throughout the cytoplasm and blackened in a more or less complete way. Every step in the fusion of these vacuoles to form the large "cell-sap" areas of the plerome cells has been followed in detail. In the periblem cells, the history of the vacuoles is somewhat more complicated and is still being studied. In the periblem the networks early formed by fusion of the vacuoles often undergo a characteristic fragmentation during mitosis, reminiscent of the behavior of the Golgi apparatus in many animal cells.

The successful application of the methods here employed is as yet a matter largely of chance. The plastidome frequently blackens, but first-class results are only occasional. The spherome is almost always sharply impregnated, while the vacuome reacts very capriciously (frequently not at all). Furthermore, these elements may be impregnated singly or in any combination in a given cell. In general, an extensive series of serial preparations must be made in order to yield a few with really excellent fixation and impregnation.

The rather astonishing result has thus come out that methods of unusual selectivity for the Golgi material in animal cells, in plant cells will give positive results on a range of structural elements, including all known categories of cytoplasmic components (perhaps excepting central bodies). Thus all possible conclusions based on mere behavior toward osmic acid are seriously compromised from the very beginning.

The most pressing matter still remains of establishing the homologies presumably existent between the known series of cytoplasmic elements in plant and animal cells. My results incline me at present to accept the usual interpretation of the plastidome as equivalent to chondriosomes. I have followed all stages in the accumulation of starch (by the Benda and other methods) in the plastidome of root-cap, periblem and (less completely) plerome cells, and there can be no doubt as to the facts themselves. But as to interpretation, it appears that a definite conclusion must await some light on the actual functional significance of the chondriome in animal cells. The rôle of the presumed chondriome of plant cells as a center for carbohydrate synthesis suggests that in animal cells the chondriosomes may play a related part. Thus it becomes conceivable that the function of the chondriome may be found in carbohydrate metabolism, a hypothesis which might possibly be directly tested by a careful investigation of striated muscle fibers or liver cells.

With respect to the homologue of the vacuome in animal cells, it must be confessed that the pictures in periblem cells of Vicia are often astonishingly suggestive of the animal Golgi apparatus. Certain features of its behavior to technical treatment do not, however, tend to bear out the comparison. At present my results afford no critical demonstration one way or the other. But the capacity of the plant vacuome for staining with neutral red perhaps suggests some possible relation to structures similarly stainable in animal cells, and for which as yet no very satisfactory accounting has proved possible.

The spherome resembles in many ways the scattered Golgi bodies in certain animal cells. Further, the reaction to the osmic Golgi methods is usually positive, tends indeed to be fairly constant. Whether we can find in the spherome the homologue of the Golgi apparatus, as I suggested in my paper already referred to, must, however, remain uncertain pending the attainment of more critical criteria of judgment —possibilities of which I now have under investigation.

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THE USE OF SUBSCRIPT AND SUPERSCRIPT EXPONENTS IN MATHEMATICS AND IN CHEMISTRY[1]

SYSTEMS of notation are the tools of thought. A good workman is known by his tools, and to a greater extent than often is realized a good workman is such because of his tools. The extensive use of the abacus in countries, as ancient Rome or present-day China, whose people think in terms of symbols less convenient than the Hindu-Arabic notation, and the relatively great amount of time devoted to spelling in the schools of peoples whose writing is not phonetic,

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testify to the needless burden which an unsatisfactory notation imposes on thought.

Notations, like tools, may be so cumbersome as to make the best workman awkward; they may be inadequate to the work they are intended to perform, or they may be so built that they will do much that they were intended not to do and work more harm than service. Notations can no more be absolutely protected against misconstruction than tools can be made entirely "fool-proof," yet in neither case is there any warrant for assuming unnecessary risks. The symbolism of related branches of knowledge should be as nearly uniform as the differences in content permit.

Subscripts and superscripts are used in logic, in algebra and in higher mathematics in a manner consistent enough to permit the generalization that subscripts are used to designate the various members of a series or group of related symbols; a_1, a_2, a_3; k_{12}, k_{14}, k_{23}, ∇_{124}, ∇_{123}, etc., while superscripts denote the same operation as would be represented by the repetition of the symbol to which the superscript (exponent) belongs a number of times indicated by the superscript:

$$a^2 \equiv aa,\ b^3 \equiv bbb,\ d^3(y) \equiv d(d(d(y))),$$
$$dx^3 \equiv dx\ dx\ dx,\ \nabla^2(\varphi) \equiv (\nabla \cdot \nabla)\ \varphi.$$

It would conduce to clearness of thought and ease of expression to preserve this distinction in the notations of arithmetic and of chemistry.

In arithmetic the value of a given digit depends on its position relative to units place, commonly indicated by the decimal point. The possible values of the digit then form an infinite geometric series of numbers, the ratio between successive terms being the base of numeration, that is, ten. If it be desired to designate a particular value of a digit, the principle stated above calls for the use of a subscript indicative of its position in the series. The logical starting point is units place, so that, *e.g.*, $3_0 \equiv 3.$, $4_1 \equiv 40.$, $6_3 \equiv 6000.$, $2_{-2} \equiv 0.02$. It is, of course, not necessary to indicate the position of every digit in a number expressed in the decimal notation, *e.g.*,

$$\pi \equiv 3_0 1_{-1} 4_{-2} 1_{-3} 6_{-4} \ldots,$$

since, if any one be indicated, the others are determined by position. Not only is it not necessary that units place be the one indicated, but in the many cases in which the units figure is not one of the significant figures, it is inconvenient, and even impractical, to indicate it. Thus to indicate units figure in a wave length of visible light, expressed in centimeters, would require the writing of four, or five, non-significant zeros; and the velocity of light, in centimeters per second, lacks six significant figures of reaching the decimal point, with the present experimental error of measurement.

The convention that a superscript is a shorthand way of indicating the repetition of a symbol would give, in arithmetic: $10^3 \equiv 1000$, $7^4 \equiv 7777$, $0.9^3 57 \equiv 0.99957$, $1/3 \equiv 0.3^\infty$. Only in the first case is the value the same as that given by an algebraic exponent, but *e.g.*, $10x \neq 107$ when $x = 7$. The use of a subscript to indicate repeated digits is fairly common, at least for the digits 0 and 9, but reasons for preferring the superscript for this meaning have already been given.

Comparing the proposed notation with that commonly used, *e.g.*, $c = 2_{10}9986 \equiv 2.9986 \times 10^{10}$, it can be seen that the latter requires the meaningless symbols, ., ×, and 10, meaningless because the first is the sign of units place, which the first significant figure in that number is not, the second of the multiplication of two numbers, in order to express one, and 10 is the symbol for *any* base of numeration.

In the case of temperature,[2] units place is ordinarily a significant figure, and, on the other hand, it is necessary to indicate in some manner which of several systems of stating temperatures is being used. This may be done by attaching to the units figure a subscript letter appropriate to the system: K for Kelvin (Centigrade absolute), C for Centigrade (Celsius), F for Fahrenheit, A for Fahrenheit absolute and R for Réaumur. Thus $310_K 1 \equiv 37_C 0 \equiv 98_F 6 \equiv 558_A 18 \equiv 29_R 6$ would all represent the same temperature.[3] This mode of representation has the incidental advantage of obviating the possibility of confusion between a temperature and an angle, for example, of 60°.

In chemical symbols the suggested use of sub- and superscripts would give $H^2O \equiv HHO$, and would make Li_6 and Li_7 represent two different atomic species of the element lithium, the subscripts being, in this case, the atomic weights of the two known isotopes of lithium. The first usage is that of French chemists and of the German Chemiker Kalender, and the second has already been used to a considerable extent in spite of the obvious danger of confusion with the present subscript exponents. As an example of the notation proposed, consider a molecule of phosphorus pentachloride containing three atoms of the chlorine isotope of atomic weight 35, and two of the isotope of atomic weight 37. Its formula would be $PCl_{35}{}^3\,Cl_{37}{}^2$. It is becoming increasingly apparent that formulas for such compounds must be written, and the sooner the convention for such is established the less confusion there will be.

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[2] This paragraph has been inserted since the paper was read.

[3] "Normal" human mouth temperature.