draw tube and so be raised to a level at which it may be focused. In this case the nose-piece must be removed.

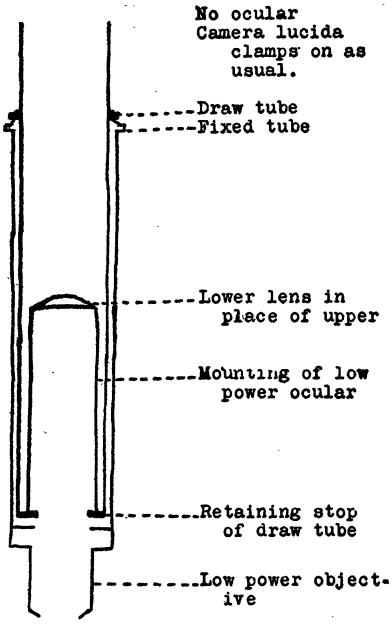

Diagram of a modification of a compound microscope for projecting low power images with the camera lucida. The stand and rack and pinion are not figured.

These methods lack firmness or adaptability and were always makeshifts.

I found an ingenious student last year using a combination which enabled him to get any magnification from ten to thirty diameters he pleased. I do not give the make of the microscope he was using, for I think any instrument with a draw tube can be used.

He took the long (low power) ocular and unscrewed the lenses, replacing the upper lens by the lower and discarding the upper lens. Then he unscrewed the draw tube, removed the retaining stop at the lower end of the draw tube, placed the modified ocular, lens upward, in the draw tube, screwed back the stop and replaced the draw tube in the microscope. He used no upper ocular but focused the instrument in the usual way. When the image was distinct he was able to increase its size by pulling out the draw tube and focusing again. I think a microscope that is constructed for 160 mm tube length will not be clear until that length is reached, but beyond that the image will be increased in size as the draw tube is lengthened.

With a camera lucida he was able to project section after section of a 10 mm pig series at sizes of ten and thirty diameters and all between.

This method may not be sound optically, but it gives clear images, increases the range of effective use of the compound microscope, and I wish I had known of it forty years ago.

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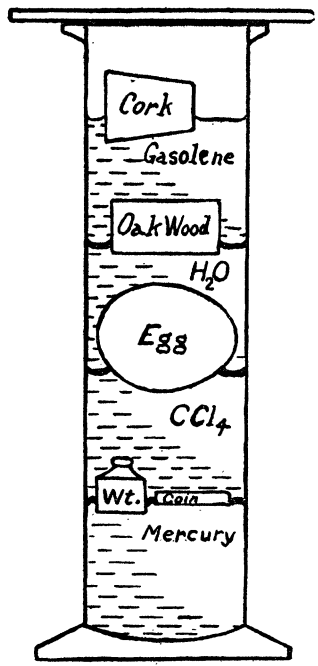
A PRACTICAL DENSITY DEMONSTRATION

THE differences in density of various liquids, the non-miscibility of these liquids and their buoyancy as expressed by Archimedes can be rather vividly demonstrated by use of the simple apparatus illustrated herewith. The liquids contained in an ordinary



hydrometer jar are mercury, carbon tetrachloride, water and gasolene, each added carefully in turn to the vessel. Objects are added as each layer of liquid is introduced. These may include a brass weight and coin, egg, piece of oak wood and cork which will float on the several layers of liquid, respectively. Gold or platinum articles will also sink in the mercury if added. When once this piece of apparatus has been arranged, it may be preserved for months, with the possible exception of the egg.

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SPECIAL ARTICLES

THE MATURATION AND SOMATIC DIVISIONS IN HYBRIDS, VARIABLES AND SO-CALLED MUTANTS

AN important feature in hybrids, which obviously has not attracted the attention which its significance demands, is the striking difference between the conduct of the chromosomes in the meiotic and somatic

(sporophytic) divisions. The present writer in his own work and that of his students has passed under review an enormous amount of material of hybrids, extremely variable species and so-called mutants. The technique of the mass method makes it possible to multiply almost indefinitely the material for observation, since many stages of the same material may be sectioned and stained simultaneously.

In known hybrids the contrast between the conduct of the chromosomes in the reduction division and in the divisions of the body cells is very marked. In the latter, the chromosomes invariably, so far as we have been able to observe in a huge amount of material, conduct themselves quite normally. The chromosomes move regularly to form the equatorial plate and with the same degree of uniformity pass later to the poles of the spindle. In the case of the reduction divisions of hybrids, however, the situation is very different. If the parent species of the hybrid have diverse numbers of chromosomes the irregularities in the reduction division are usually very marked. A common occurrence is the presence of univalent chromosomes, in addition to the bivalents which are exclusively found in the meiotic mitoses of normal species. These univalents, and frequently also the bivalents as well, lag both in the metaphases and anaphases of nuclear division with corresponding abnormalities in the development of the sex cells. Very little is known at the present time about the cytology of hybrids among animals, but the case of the mule corresponds exactly with that described for plant hybrids.

In the case of extremely variable species such as are found frequently in large genera of plants, the divisions of the body cells and the reproductive cells in general present the same features as are found in known hybrids, whether plants or animals. The genus Rosa has been widely investigated in regard to its reduction divisions and a number of striking abnormalities have been described in the various species of the Canina section and to a less extent in other sections. Although these abnormalities appear strikingly where the number of chromosomes is an uneven multiple of the seven characteristics of the genus they are also found to a less extent in the case of even-multipled polyploid species. It does not, however, seem to have been noted that the sporophytic divisions in these highly variable roses are quite normal, even when the reduction divisions present extreme departures from the usual type. Investigations in this laboratory on the genus Crataegus, on the Rubi of the Eubatus section, etc., show that this contrast in the conduct of the chromosomes in the sexual and sporophytic cells is found equally in other large and variable rosaceous genera. Extensive investigations on grasses, sedges, Betulaceae, Eucalypts, acacias, Proteaceae, etc., show that this is the usual state of affairs in highly variable species.

In the case of the so-called mutable species similar conditions are observed, although since those as at present studied do not usually present highly complex equipments of chromosomes, the conditions are slightly less clear than in the case of many mutable species and known hybrids. We may take the Boston fern as a recognized mutating form. Investigations carried on in these laboratories which will shortly be published show that in this fern the reduction divisions and the sporophytic divisions present the same contrast as in hybrids and variables. In the reduction division of the Boston fern there are many lagging chromosomes both in the metaphase and the anaphase. In spite of the high degree of clonal or bud variation found in this type, the sporophytic divisions so far as they have been observed in a large amount of material and in different clones, are entirely normal. In *Nephrolepsis exaltata,* one of the known parent species of the Boston fern, by contrast both the meiotic and sporophytic mitoses are entirely normal. It is an interesting fact that in one clone of the Boston fern Benedict was able to secure a small number of viable spores. When these germinated they gave rise to an extremely varied progeny, thus presenting further reason for regarding the Boston fern as a hybrid derivative of *N. exaltata.*

In *Oenothera Lamarckiana* and other variable Oenotheras the same situation presents itself. On account of the relatively infrequent multiplication of the chromosome numbers in so-called mutating Oenotheras the abnormalities in the reduction division are less frequent, although they have been described by nearly all those who have worked on the cytology of Oenothera. The most marked abnormalities in the sexual divisions are apparently found in those individuals which present in the highest degree the sterility which is more or less characteristic of all species of Oenothera. The Daturas also appear to be characterized by similar abnormalities, especially in the case of individuals with uneven multiples of chromosome equipment.

The so-called mutating species most in the eye of biologists at the present moment is *Drosophila melanogaster.* The somatic divisions of this species normal and polyploid have been admirably described by Professor Morgan and his associates. Unfortunately, however, they have furnished no descriptions of the obviously highly significant male meiotic mitoses of this species. As a result of the examination of a huge amount of material, investigated with the advantage of the mass method, it becomes obvious that the

male meiotic phenomena in the male gonads of *D. melanogaster* are strikingly similar to the reduction divisions in known hybrids, whether plants or animals. The abnormalities of the maturation division in this species, so much investigated by too purely experimental means, seem to show beyond any reasonable doubt that it is of hybrid origin. This is the more obvious because meiosis in certain other species of Drosophila to judge from the published descriptions is quite normal. It seems unfortunate that the experimentalists *pur sang* should in the main choose for investigation such freaks as the Boston fern, species of Oenothera and above all *Drosophila melanogaster*. The results of experimental work would apparently be much more permanent and convincing were the subject material less abnormal than in the cases mentioned above.

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HIGH AND LOW FREQUENCY MEASUREMENTS WITH LAMINARIA

AN interpretation of the resistance changes in *Laminaria* when bathed in solutions of NaCl, $CaCl_2$, etc., is of importance in the theory of permeability. Several possibilities exist beside alteration of the ionic permeability of the protoplasm.

(1) There may be a change in the specific resistance of the intercellular substance corresponding to its well-known hardening in calcium and the softening in sodium salts. (2) The specific resistance may remain constant while the cross section expands or contracts, as observed by Kotte in the walls of algae. Or (3) a change in the electrical capacitance of the cell surface might alter the effective impedance of the whole system.

None of these interpretations is clearly indicated by measurements taken at one frequency only, so that it seemed desirable to extend the readings made at 1,000 cycles by Osterhout,[1] both to zero frequency and to very high frequencies, in order better to locate the seat of change.

Direct current measurements were made by using magnesium metal ribbons dipping into the sea water of the electrode cups. (The Osterhout apparatus was used for holding the column of *Laminaria* discs. Sea water was kept in the end cups while the discs were bathed in various solutions.) These ribbons acted as reversible electrodes to the magnesium ions, which are present in the sea water in sufficient number to carry small currents without much polarization. They were likewise balanced by another pair of similar electrodes in the adjacent arm of the bridge.

The $CaCl_2$ curves of Osterhout were nicely duplicated with this apparatus and the direct current readings agreed exactly with 1,000 cycle ones taken alternately with the same electrodes. At 40,000 cycles the readings were about 20 per cent. lower, at the highest point, and nearly the same at death.

For very high frequencies a thermocouple ammeter-voltmeter apparatus was employed through the kindness of Dr. Kenneth S. Cole, who made the measurements. Values were obtained at the following frequencies: 6,000, 13,750, 45,500, 115,500, 375,000, 1,090,000, 10,800,000 cycles. Not enough points were obtained to construct good curves, but the essential fact was developed that while the low frequency readings rose and fell during injury, the high frequency readings showed much less change, and at 10^7 cycles the values were nearly constant through the whole run. Whether this constant value is actually that of the dead ohmic resistance must be answered by future research. It is nearly as low, however.

Meanwhile we may conclude from these results that:

(1) There is no change in the specific conductivity of either the inter- or intracellular material during treatment with $CaCl_2$ or NaCl, since the high frequency value remained constant.

(2) The changes in impedance are not due to changes of capacitance since the latter would not affect the direct current readings, which agree entirely with the 1,000 cycle values. What capacitance there is has little effect on the impedance except at much higher frequencies.

(3) Changes in cross section may occur but are not sufficient to explain the results.

We may therefore hold to the interpretation advanced by Osterhout that the observed resistance change is really a change in the permeability of protoplasm to ions. Since the resistance may rise 60 per cent. or more above the normal value in sea-water, it is evident that there must be considerable ionic exchange in the normal state. The reconcilement of this fact to the relatively low permeability of *Valonia* and *Nitella* to ions is a task toward which present experiments are directed.

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[1] Osterhout, W. J. V., "Injury, Recovery and Death, in Relation to Conductivity and Permeability," Philadelphia and London, 1922.

THE ABSOLUTE ZERO OF INTERNAL ENERGY AND ENTROPY, AND THE CORRESPONDING INERTNESS OF MATTER

THE controllable internal energy and entropy of a substance or mixture, which varies with the volume v and absolute temperature T, the writer has shown