trons from Wehnelt cathodes is due to a similar mechanism to that causing the emission from heated pure metals.

Daily variations of water and dry matter in the leaves of corn and the sorghums: Edwin C. Miller, Kansas Agricultural Experiment Station. Under the conditions of these experiments the sorghums, and more particularly milo, absorb water from the soil and transport it to the leaves more rapidly in proportion to the loss of water from the plant than does corn; and thus the sorghums can produce more dry matter for each unit of leaf area under severe climatic conditions than can the corn plant.

Note on complementary fresnellian fringes: Carl Barus, Department of Physics, Brown University.

The displacement interferometry of long distances: Carl Barus, Department of Physics, Brown University. In preceding notes two methods for measuring small angles have been suggested. Application is here made to the determination of distances and is shown that an object at about a mile should be located to about thirty feet.

National Research Council: Meetings of the Executive Committeee and the Joint Meeting of the Executive, Military, and Engineering Committees. Report of the Astronomy Committee.

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SPECIAL ARTICLES

INTRA-VITAM COLOR REACTIONS

We have slowly come to have great confidence in the specificity of certain physiological actions. We introduce into an organism certain substances, and definite results follow; but about the only thing we know in the matter is that the results follow with certainty. In such cases, if only we could see what it is that happens while it is happening, it seems certain that important advances would be made in our knowledge of nutrition, growth and decay—of physiology, pathology and medicine.

If substances giving color reactions in living tissues could be applied to small, transparent, varied and highly complex living organisms, under circumstances that would permit microscopic examination while the reactions are in progress, we might hope for more light on this exceedingly important subject. Experiments I have made lead to the belief that many of the conditions requisite for success in this line of investigation can be much more fully realized than hitherto by feeding colored substances, notably coal-tar dyes, to free-living nematodes.

These minute, transparent animals are comparatively highly organized; not only this, but also extremely varied in their mode of life. Some are exclusively vegetarian, others exclusively carnivorous, and others omnivorous. They constitute a group composed probably of hundreds of thousands of species, embodying an almost inconceivable number of kinds of physiological action. Their organs are enclosed in a thin transparent cuticle, and are strung out so as to make them unusually suitable for *intra-vitam* examination. Under slight pressure the nema flattens out more or less without losing its vitality sufficiently to preclude satisfactory *intra-vitam* examination under the highest powers of the microscope.

Observing certain precautions, I find that a great variety of coal-tar compounds and other colored compounds can be fed to nemas, apparently without interfering materially with their normal metabolism. I have had the best results by cumulative action, using small quantities of color dissolved in the medium in which the nema lived, and allowing the dye to act for days or weeks.

Not infrequently the dyes prove to be highly specific in their action. Only certain cells, or only definite parts of certain cells, exhibit visible reactions in the form of colorations. The results obtained by the use of any given dye may be quite varied. It is evident in many cases that the dye is digested and assimilated, thereby undergoing molecular changes by which it is converted into new compounds in a manner analogous to the processes exemplified in chemical laboratories devoted to the production of aniline dyes. Thus, a dye may give rise to several different colors, none of them like that of the dye itself, and all of them very likely due to new compounds. Often I have seen considerable evidence pointing to the conclusion that in some cases the dyes fed are converted into colorless compounds during the process of digestion (a reduction phenomenon), and these colorless compounds reconverted into colored substances after they arrive at certain destinations or conditions. The number of changes these "living laboratories" can ring on the molecular structure of a given dye must in some cases be very considerable. Two or more dyes fed simultaneously sometimes produce results more or less independent of each other. The spectacles are very brilliant.

Using these methods I have been able to demonstrate within the confines of a single cell the existence of an unsuspected number of kinds of "granules," manifestly playing different rôles. After the differences among these bodies have been shown in this way, it is sometimes possible to perceive corresponding morphological differences; but without the aid of the color reactions the differences would never have been suspected.

The main thing to bear in mind is that on the basis of our present more complete knowledge of the chemical and physical properties of coal-tar-derivatives these color reactions in living nemas may be made the index of physiological characters possessed by cells and their components. In view of the great variety of the known coal-tar derivatives, and the great variety of physiological activities exemplified in the free-living nemas, it seems to me a very reasonable hope that researches directed along this line will lead to important results, and that the nemas may become classical objects in cell and general physiology, as they have already become in sex physiology.

A new and rather extensive nomenclature will become necessary. It will be needful to distinguish between the results of *intra-vitam, intra-mortem* and *post-mortem* staining; for these three terms represent as many different phases in the chemical reactions that take place during the course of the experiments. As the cells lose vitality, new color reactions occur, and the death of the cell is followed by further equally marked changes in the reactions.

The cell elements I have mentioned vary in size, but most of them are exceedingly small, many so small that they are on the limits of visibility, using the very best instruments with the greatest skill and under the most favorable conditions. On the other hand, some of them are large enough so that they can be examined in considerable detail and their structures made out. Among them are the bodies currently referred to under the name mitochondria and other more or less synonymous words.

As it will be some time before we can establish a rational nomenclature for these numerous intracellular structures, it is desirable meanwhile to adopt terms that will permit intelligent discussion of our discoveries as they are made. While the principles underlying such a nomenclature are easily defined, it is by no means easy, in the present condition of things, to suggest suitable short and expressive roots to be used as a basis. There will be less liability of confusion if the names first employed relate to form, size and position rather than to function.

Investigations of this character are not unlikely to stimulate further research in connection with aniline derivatives. Present efforts are directed toward the discovery of dyes of greater or less permanency. Permanency, however, is of little moment in these investigations; what is of moment is the chemical composition and physical properties of the dyes. No doubt dyes of a greater range of composition can be produced if permanency be disregarded. Furthermore, as already hinted, colorless compounds may be used in intravitam work if in the course of the metabolism they are converted into colored compounds. The results of recent studies of dies as chemical indicators come into play, and give valuable evidence in determining acidity and alkalinity.

I am almost ready to express the opinion that a small army of investigators should be engaged on the problems opened up in this way. The equipment needed by the investigator is as follows: He must be a very good microscopist, versed in physiology, cytology and histology. He should be conversant with the chemistry of the coal-tar compounds, not so much from the viewpoint of the maker of dyes as from that of the broad-minded chemist, freed from the economic domination of the dye industry, for, as before remarked, fugitive dyes, and even colorless compounds, are possible factors in such investigations as are here under discussion. He should have a working knowledge of nemas.

ILLUMINATION

In order to distinguish with accuracy among *intra-vitam* color reactions it is necessary to be very particular about illumination. The most perfectly corrected lenses must be used, both as condenser and objective, and the light used must be as nearly white as possible. The best source of light known to me for these researches is bright sunlight reflected from a plane matte white reflector. The reflector should be several feet across, and placed at a distance from the microscope several times its own diameter. It should be universally adjustable, so that it can be set to reflect a maximum of light to the mirror of the microscope —all the better if heliostatic. A good surface for the screen is made by whitewashing a rather finely woven cotton cloth.

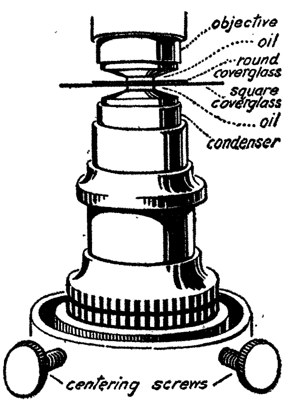

FIG. 1.

The best optical arrangement I have tried is the use of one apochromatic objective as a condenser for another apochromatic objective. I have been using with success a 2 mm. apochromatic as a condenser for a 2 mm. or 1.5 mm. apochromatic objective. These precautions are necessary if fine color distinctions are to be made with the greatest possible accuracy. If these precautions are taken it will be found that fine distinctions can be made with such precision as to dispel all doubt as to the existence, side by side, in the same cell of definite structures of varying character that it would otherwise be impossible or exceedingly difficult to distinguish from each other.

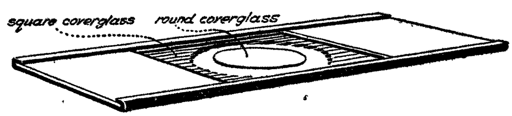

FIG. 2.

The use of an ordinary apochromatic objective as a condenser necessitates the use of a special object slide, consisting essentially of a carrier and two cover glasses. The object is mounted between the cover glasses. Such a slide is shown in the accompanying illustration. The substage of the microscope should have a centering arrangement and a rack and pinion or screw focusing adjustment. A little experience with an apparatus of this sort, in which all known precautions are taken to remove color from the optical system, leads one to distrust the ordinary Abbé substage condenser where fine distinctions are to be made between colors, especially if the colors are of similar character.

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THE AMERICAN CHEMICAL SOCIETY

DIVISION OF PHYSICAL AND INORGANIC CHEMISTRY

H. P. Talbot, *Chairman*

E. B. Millard, *Secretary*

The positive and negative specific heat of saturated vapors: F. P. SIEBEL. A vapor expanding from a temperature T to the temperature $T-1$ reversibly, yields the maximal work W due to the latent heat of vaporization H introduced at the higher temperature in accordance with the second law expressible in equivalent calories as

$$W = H\frac{T-(T-1)}{T} = \frac{H}{T}\text{ calories.}$$

This amount of work is in many cases greater than