the same is true of the flashes of light from dinoflagellates at Sanibel and at Woods Hole. In both localities the measurements were made at quite close range, the excitation of these minute organisms being apparently due to the swirl of water around piles and submerged timbers.

The colonies of hydroids, which were attached to the supporting timbers of the float at Woods Hole, were excited to momentary luminescence by rubbing with the fingers, a procedure suggested by Professor Harvey.

The finely luminescent jellyfish at the foot of the list (Mnemiopsis Leidyi), although rarely seen at Woods Hole, appeared in abundance during the writer's visit. When excited spontaneously by the swash of a quiet sea the brightness was quite uniformly .11 ml. to .12 ml. After lying at rest in a tub of sea water a sudden agitation of the organisms (as by strongly tapping the tub or stirring the water) produced an initial brightness of .30 ml., which could not be immediately repeated by the application of further excitation.

Even the dimmest of the intensities noted above, that of the faint glow observed in the wake of a steamer at sea, is about ten times what would result from the illumination of white objects by a clear but moonless sky. The foam of a breaking wave is not suitable for such a comparison, since one can not be sure of the complete absence of luminosity. A measurement of the very white shell-beach on Sanibel Island at night, which was probably comparable to sea-foam in reflecting power, was therefore selected. It was found to have a brightness of only .00008 millilamberts.

When one contemplates the vast range between such intensities and that, say, of the same beach under the noonday sun, one calls to mind Langley's classical memoir on the least quantity of light necessary to vision.

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EXPERIMENTS ON THE CULTIVATION OF THE ACTIVE AGENT OF MOSAIC DISEASE OF TOBACCO AND TOMATO

THE experiments here reported relate to the problem of the cultivation of the microbic agent of mosaic disease of tobacco (*Nicotiana tabacum*) and tomato (*Lycopersicum esculentum*).

It was determined as a preliminary that the active agent was readily filterable through Berkefeld filters, sizes "V" and "N." Also the disease was transmitted from the affected tobacco to previously normal tomato plants and similarly from the tomato to tobacco, thus effecting a cross-passage. Furthermore, the signs of the mosaic disease in the tobacco and tomato plants of the initial stock and in those to which the affection was transferred experimentally were identical with those described by other investigators, notably by Allard.

The medium employed in the cultivation tests consisted of an aqueous extract of carefully selected fresh young stems, leaves and shoots from tomato plants which were shown by experiments to be free of the disease. The extract was centrifuged at high speed and filtered twice through Berkefeld "N" filters. The filtrate was retained for use if its final pH was 5.3 — 6.0 (for no artificial adjustment was made by adding acid or alkali), if no evidence of contamination existed and if none of its contained albumins or globulins were precipitated.

Materials for culture were obtained from stout tomato stems or large tobacco leaves which were cut from the plant with a razor. The cut end of the stem or the leaf was sterilized by searing in a flame and a sterile capillary pipette, connected with a small rubber bulb, was inserted into the stem or into the midrib of the petiole of the leaf, in the direction of the long axis. About 0.01 cc of liquid containing the active agent was then aspirated directly into the pipette and inoculated into 3 to 5 cc of the medium, which was then placed in a dark cabinet in the greenhouse, at a temperature of 28 to 30° C.

After seven to ten days or longer, the medium containing mosaic materials showed as a rule a faint, uniform, translucent, almost imperceptible haze. In some instances, no changes could be made out by inspection with the naked eye on comparison with the controls. Stained specimens, however, revealed more granular material than in the latter. Nevertheless, by the available tinctorial methods, by darkfield examination, by supravital and unstained preparations studied with the ordinary microscope, we failed to differentiate formed elements as distinct from the granules or precipitate which were to be found in the uninoculated medium as well.

To determine whether the agent of mosaic disease had multiplied recourse was had to the inoculation of plants. Since the agent is known to be extremely active, even in high dilutions (Allard, Doolittle), careful attention was given to the possibility that a mere transfer of the original active material from tube to tube might be responsible for the results. As will be shown in a more detailed communication to appear shortly, our tests indicated that no interpretation could be made regarding the power of a subplant in artificial media to induce mosaic disease unless the original inoculum in this subplant is diluted at least one part to a million. Under the conditions of our

experiments, this point was reached by the fourth subplant, in which latter the original inoculum was present in an estimated dilution of one to ten million.

If multiplication of the active agent be indicated by the capacity of the fourth and more remote subplants to induce mosaic disease in normal plants, then of 17 attempts to culture the active agent of tobacco and tomato mosaic, all must be considered as successful but one. It was found that normal tomato plants showed the disease on inoculation with early and remote subplants, up to the twelfth, which represented a diluted of the initial inoculum of one to 4×10^{-16}. Once the experimental disease gained a foothold, there was no difference in the severity of the affection following inoculation of the subplants from that induced by the original, undiluted active agent itself. All the characteristic signs regarded as criteria of the disease were present. The experimental mosaic disease induced by the cultural fluids could be transmitted from plant to plant in unlimited series both by direct application of the liquid of the affected plant to previously normal tomato leaves and by inoculation with the material from subplants of the liquid in the artificial medium.

In the course of the experiments a significant fact was noted, namely, that the agent present in remote subplants which can induce the disease was not readily filterable. The nature of the change thus indicated remains to be determined.

The conclusion seems justified that the incitant of mosaic disease of tobacco and tomatoes is a living, microbic body which can be cultivated in an artificial medium.

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THE AMERICAN CHEMICAL SOCIETY

DIVISION OF INORGANIC AND PHYSICAL CHEMISTRY

Graham Edgar, *chairman*
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A re-determination of the heats of oxidation of certain metals: S. W. PARR and J. E. MOOSE. (1) A direct method and apparatus have been perfected for the accurate determination of the heats of oxidation of certain metals. (2) Very pure aluminium, cadmium, cerium, lanthanum, magnesium, molybdenum, tantalum, tin, tungsten, and zinc have been completely oxidized inside a specially designed combustion crucible and the thermal effect of the oxidation measured. (3) Beryllium has been partially oxidized and the thermal effect measured. (4) Certain metals may be completely oxidized inside a Parr oxygen bomb when sized and arranged properly about a fuse wire within a combustion crucible and subjected to thirty atmospheres pressure of oxygen. (5) The values recorded for the same metal agree more closely than those that have been obtained by indirect methods.

The mechanism of acid catalysis of ester hydrolysis: JAMES KENDALL and CECIL V. KING. Freezing point determinations have been made upon dilute aqueous solutions of ethyl acetate; hydrochloric, trichloracetic, monochloracetic and acetic acids; and equimolecular mixtures of each of these acids with ethyl acetate, in concentrations up to the limit of solubility of ethyl acetate. Specific conductivities have been measured, at 0°, upon solutions of these acids and their equimolecular mixtures with ethyl acetate. The velocity of hydrolysis of ethyl acetate, at 0°, was measured, in the latter solutions. The approximate solubility of ethyl acetate, at 0°, in these solutions was noted. Experiments were carried out to determine the effect of the presence of ethyl acetate upon the velocity of inversion of cane sugar when catalyzed by hydrochloric acid. The collected data have been analyzed with the object of determining the state of molecular complexity in the acid-ester solutions, and the effect of water upon acid-ester compounds. The bearing of the results obtained upon the dual theory of acid catalysis and upon Rice's theory of catalysis by unhydrated hydrogen ion has also been considered.

A new energy relation governing liquids and vapors: J. E. MILLS. The author has previously shown in a long series of articles published mainly in the *Journal of Physical Chemistry* that molecular forces obey the law,

$$1. \qquad f = \frac{-m_1 E}{s^2}$$

where f is the force acting between two molecules, m_1 is the mass of a molecule, E is a constant

$$= 31414 \sqrt[3]{\frac{3}{4\pi}} \sqrt[3]{m_1 \mu^1}$$

and s is the distance through which the force acts.

It is now shown that under this law

$$2. \quad \mu^1 \sqrt[3]{d_o} - \left(\mu^1 \sqrt[3]{d} + \frac{Ej}{2} \right) = \text{energy given out on changing from the density at the absolute zero to any other density d (liquid) or D (vapor)} = C\ R\ T\ \ln \frac{d^o}{d}.$$

Ej is the temperature energy of the molecules. C is the constant of Dieterici's equation for the internal heat of vaporization, namely, $\lambda = C\ R\ T \ln \frac{d_o}{d}$

$$3. \quad \mu^1 \sqrt[3]{d_o} = \mu^1 \sqrt[3]{d} + \frac{Ej}{2} + C\ R\ T \ln \frac{d_o}{d} \text{ for liquid}$$

$$= \mu^1 \sqrt[3]{D} + \frac{Ej}{2} + C\ R\ T \ln \frac{d_o}{D} \text{ for vapor.}$$

This equation has been tested for ethyl oxide, di-isopropyl, di-isobutyl, isopentane, normal pentane, nor-