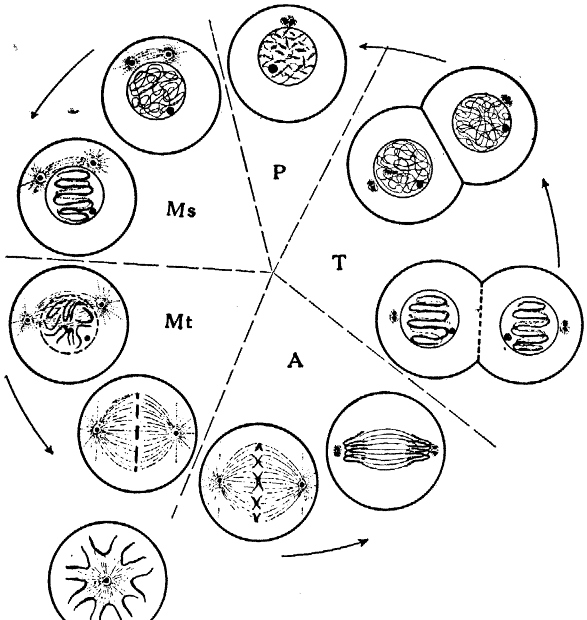
that it seems worth while to pass it on to others. The following comments will give the essential features of the diagram. The process of cell division is represented as a cycle. The cycle is represented by five phases; each phase, excepting the prophase, is represented by two stages which are intended to represent an early stage and a late stage in each phase.

The prophase, *P*, is limited to the resting (mitotically speaking) nucleus; enclosed in a nuclear membrane with its chromatin material in the form of granules as usually described; with a large nucleolus; and a centrosphere containing two centrosomes. Emphasis is always placed upon the facts that while we speak of this as a resting nucleus we are speaking mitotically and that metabolically this is the active phase of the cell and that as far as the life of the cell is concerned it is a very long period and further that it is really the end of the cell's existence as a cell and not its beginning.

The term mesophase, *Ms*, is introduced to designate that phase of the process of mitosis described as spireme thread formation. The other characteristic thing in this phase is that the centrosomes have commenced to separate. The mesophase is divided into two stages. In the first stage the spireme thread is long, slender and much coiled. In the second stage the thread has shortened and thickened and has been thrown into a definite number of loops, each loop corresponding to a future chromosome.



The metaphase, *Mt*, is characterized by the chromosomes. The chromosomes are represented as the broken loops of the short looped spireme thread. Another character is the disappearance of the nuclear membrane. In the first stage the chromosomes are represented as being scattered in the cell, while the centrosomes are about 90° from each other. In the second stage the centrosomes have reached their polar positions, 180° from each other, and the chromosomes have arranged themselves at the equator. Both equatorial and polar views, *p*, of this stage are shown for the sake of clearness. Attention is usually called to the disappearance of the nucleolus during this stage. Mitosis may be said to have reached its climax with this stage and all the rest of the process may be described as a process of reconstruction of the chromatin material.

The anaphase, *A*, means that time during mitosis when there are daughter chromosomes in the cell. It starts with the first indications of the splitting of the chromosomes and ends with them arranged at the poles. The first stage shows the beginning of the splitting and the second stage shows the chromosomes pulled to the poles and the division of the cytoplasm started. The centrosomes have usually divided by this time in preparation for the next mitosis, and the nucleolus has usually reappeared.

The telophase, *T*, may be described as the daughter spireme phase. In the first stage we have short thick looped daughter spireme threads formed apparently by the growing together of the ends of the looped chromosomes. This stage is exactly comparable with the second stage of the mesophase save that we are now "back-tracking" and have daughter spireme threads instead of a single thread. The nuclear membrane has reformed and the cytoplasmic division is usually complete. In the second stage we have long daughter spireme threads which are comparable to the first stage of the mesophase and the interesting process of mitosis is all but finished for there remains but the single step, the transformation of the thread into scattered granules and we are back with daughter prophase stages ready to start the whole process over again. And while in the minds of the older students who have learned the old nomenclature we may have appeared to add to the confusion by introducing new terms and by limiting old terms in a new way, and to have simply run round in a circle and arrived nowhere, yet my experience with beginning students leads me to believe that there is some little merit in it.

Z. P. METCALF
NORTH CAROLINA STATE COLLEGE AND EXPERIMENT STATION

SPECIAL ARTICLES

OSCILLATIONS IN THE LOW VOLTAGE HELIUM ARC

R. BÄR, M. v Laue and E. Meyer have recently published a paper[1] explaining the apparent main-

[1] *Zs. f. Phys.*, 20, p. 83 (1923).

tenance of the helium arc at voltages below the first radiating potential.[2] They find that the voltage across the arc is not constant, but fluctuates periodically between a value above the first radiating potential (19.8 v.) and a much lower value. The apparent voltage as read on a direct current meter is a time average of the actual variable voltage. They conclude that the oscillations can be maintained only when the circuit contains inductance in series with the arc.

The writers had independently noticed these oscillations, and come to the same conclusion, that the arc is only possible provided the voltage in part of the cycle rises above the lowest critical potential of the gas. Similar oscillations were also found in mercury vapor arcs, where the peak voltage always exceeded the first resonance potential 4.9 volts. In the diatomic gases hydrogen and nitrogen, no oscillations of this kind were detected. The results of the investigation have led us to an interpretation of the essential features of these oscillations, as described briefly in the following paragraphs.

The arcs are maintained between a hot filament cathode and a cold anode distant about 5 mm in the gas at an optimum pressure of 3 or 4 mm. In the simplest circuit a control resistance is placed in series with the arc and source of e. m. f. Contrary to the conclusions of Bär, von Laue and Meyer, we have not found inductance in the circuit to be essential, although the presence of inductance or capacity has an effect (smaller than might be expected) on the frequency of the oscillations and their wave form. These authors used a source of current whose electromotive force was 12 volts, *i.e.*, less than the first radiating potential. As the principal characteristic of these oscillations is that the maximum voltage attained is greater than the first radiating potential, the necessity of inductance with so low an electromotive force does not establish its fundamental relation to the phenomenon.

We have succeeded in maintaining the oscillations in a circuit whose inductance is as nearly as possible eliminated, but whose battery electromotive force was larger than 20 volts, usually 120 volts, and whose series resistance was quite high. In a typical case the minimum of the current voltage curve[3] as determined with direct current instruments was, at 306 ma., 17.6 volts. The corresponding maximum and minimum voltages, measured with a peak voltmeter, were 22.8 and 15.9 volts, respectively.

The writers have also found two distinct types of oscillation in the arc.

[2] K. T. Compton, E. G. Lilly and P. S. Olmstead, *Phys. Rev.*, 16, p. 282 (1920). A. C. Davies, *Proc. Roy. Soc.* (A) 100, p. 599 (1922).

[3] *Cf.* Compton, Lilly and Olmstead, *loc. cit.*, p. 286.

I. A type of oscillation which appeared when the direct current voltage across the tube first began to diminish with increasing current. This type was characterized by the following: (a) The maximum voltage (ca. 28 v) was above the ionizing potential; (b) The minimum voltage (ca. 16 v) was below the first radiating potential; (c) The direct current voltage was much nearer the maximum voltage than the minimum; (d) The amplitude of oscillation showed no marked variation as the resistance in the circuit was changed.

When the direct current voltmeter reading was reduced below about 25 volts, these oscillations stopped suddenly, and the arc was maintained without noticeable oscillations at about 20 volts. On decreasing the series resistance farther, the voltage dropped a few tenths of a volt, and the current rose, but no oscillations were detectable.

II. On further decreasing the series resistance, oscillations again set in. In this type: (a) The maximum voltage was above the first radiating potential, and below the ionizing potential; (b) The minimum voltage was below the first radiating potential; (c) The reading of the direct current voltmeter was usually nearer the minimum than the maximum voltage; (d) The amplitude showed a marked maximum at the minimum of the direct current-voltage curve.

We believe that some insight into the mechanism of these phenomena is obtained from the following considerations: Suppose the tube to be connected to a battery of, say 50 volts, through a non-inductive series resistance, so that the complicating effects of inductance will disappear. If the series resistance is very large, the current through the tube will be low, limited by a negative charge about the cathode. As the resistance is decreased, the voltage across the tube will increase, until ionization takes place. The positive ions will neutralize a portion of the negative space charge, allowing the current to increase. Finally the amount of ionization becomes so great that the charges must rearrange themselves in such a way that a positive space charge surrounds the cathode. This rearrangement allows the current to increase considerably, and the arc may be said to have "struck."

But this increase in the current must increase the voltage-drop across the series resistance, so that the voltage across the tube may drop below the lowest voltage at which ions are formed by *any* process. If this happens, the positive space charge must disappear. It will be replaced by a negative space charge, which will again reduce the current through the tube. This will allow the voltage across it to rise, whereupon the cycle will be repeated. It is the time required for the rearrangement of the space charge that determines the period and wave form of the oscillations.

This investigation is being continued.

Carl H. Eckart,
K. T. Compton

Princeton University

ON WALDEN-INVERSION

In connection with the problem of Walden-Inversion, it is important to know whether the change in the polarity of a group attached to the asymmetric carbon atom is accompanied with a change of direction of optical rotation when the change of polarity is accomplished without resorting to substitution. It is realized that the result may depend on the polarity of the other elements attached to the asymmetric carbon atom. A systematic study in this direction is possible on substances of two groups; first on derivatives of secondary carbinols of the type R_1CHOHR_2 and second, on the derivatives of the primary alcohols of the type $\begin{matrix} R_1 \\ R_2 \end{matrix} > \overset{H}{C}—CH_2OH$. In both groups of substances the radicles R_1 and R_2 may be varied infinitely and in both of them, the polarity of one group may be changed without substitution. Both these groups of substances are now under investigation in our laboratory. Results have already been obtained on a derivative of the first group of substances.

Laevo-methylhexylcarbinol was converted by substitution into dextro bromide; this, in its turn, again by substitution into laevo-mercaptan and the latter by oxidation (without substitution) into dextro-sulfonic acid.

$$\underset{\text{laevo}}{C_6H_{13}CHOHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHBrCH_3}$$

$$\rightarrow \underset{\text{laevo}}{C_6H_{13}CHSHCH_3} \rightarrow \underset{\text{dextro}}{C_6H_{13}CHSO_3HCH_3}.$$

Thus, in this group of substances, the change in polarity, brought about with or without substitution on the asymmetric carbon atom, leads to a change in the direction of rotation.

P. A. Levene,
L. A. Mikeska

THE RELATION OF CLIMATIC CONDITIONS TO THE SALT-PROPORTION REQUIREMENTS OF PLANTS IN SOLUTION CULTURES

Although it has been known for more than sixty years that many forms of higher green plants may be grown to maturity with their roots in an aqueous solution of a few inorganic salts, it is only in the last decade that attention has been seriously directed to the study of the relations that prevail between the nature of the solution thus used (kinds of salts, salt proportions and total salt concentration) and the amount and kind of growth exhibited by the plants. Since the publication of the earlier work in this field by Schreiner and Skinner, Tottingham, and Shive, many experimental studies have been made, by different investigators, with the aim of throwing light on this complex relation. Great difficulty has thus far been encountered, however, in obtaining satisfactory agreement or consistency, even by the same experimenter, between the results of two or more experiments planned and executed so as to be as nearly alike as possible with respect to the plants and solutions used. Similar difficulty is frequently encountered in many other lines of biological experimentation, whether with plants or animals.

In experimentation dealing with the influence of external conditions on the growth of any kind of plant, it is of course essential that all the individual plants of the same experiment should be as nearly alike as possible (in variety, race and physiological condition) at the outset of the experiment, and also that this same degree of similarity should obtain among all the plants of several experiments that are planned to give comparable results. But we can not be at all sure that variability among the plants with which the experiments are set up is satisfactorily cared for by employing seeds of a pure line, selecting them for uniformity of weight, germinating all seeds in the same way, and selecting the seedlings for likeness in size, robustness, and so forth. Even after taking all feasible precautions in this respect, internal variability is generally found to be far from negligible. The difficulty can of course be largely overcome by employing a great number of duplicates in every test. The number of duplicates needed naturally depends on the degree of precision required in the results and on the degree of internal variability that persists in the plants after care has been exercised in selection, and other experimental details. By using a sufficient number of duplicates, all cultures in a comparable series, whether in the same or in several experiments, may be made to represent the same quality and range of internal variability in the plants. It may be added that the plants at the beginning of an experiment should be adequately described. This is necessary in order that it may be known for just what sets of original internal conditions the experimental results may be considered as applicable, in order that the experiment may be repeated later, and in order that subsequent experimentation in general may be carried out so as to be comparable with earlier tests. Statistical methods are requisite for finding and stating what kinds and ranges of variability persist in the original plants. Also, statistical treatment of the experimental results