ways available in quantity. It should be pointed out that although the legumes used are unusual in yielding opalescent solutions, they resemble other plants in having chloroplasts about the size of red blood corpuscles.

The chlorophyll in the Lubimenko extracts I prepared was partially sedimented on long centrifugation in the cold in a Swedish angle centrifuge operating at top speed, and almost completely sedimented on 4 minutes centrifugation in the cold in an ultra-centrifuge operating at 20,000 r.p.m. under conditions under which tobacco mosaic virus is not sedimented to any significant extent. Thus the green particles in Lubimenko extracts are much smaller than chloroplasts, but larger than tobacco mosaic virus molecules. The exact size of the green particles, the extent of their homogeneity in size, and their rôle in photosynthesis remain to be studied.

High molecular weight particles with some color have previously been obtained from cow pea and cucumber leaves.[5] Unlike the green particles in the present extracts they represented only a very small part of the chlorophyll of the leaves and they sedimented more slowly than tobacco mosaic virus. It is possible that the green particles previously observed were decomposition products of the particles as they exist in cold aqueous extracts. It is also possible that the larger particles in the present extracts represent aggregates of the original material.

In summary, it has been shown that aqueous extracts of chlorophyll-protein can be obtained from constantly and readily available plants, that these extracts can be stabilized by cold, and that the green particles in these extracts are larger than tobacco mosaic virus.

I am indebted to Dr. F. O. Holmes and Dr. W. C. Price for advice in botanical matters.

M. L. ANSON

THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH,
PRINCETON, N. J.

[5] W. C. Price and W. G. Wyckoff, *Nature*, 141: 685, 1938; *Phytopath.*, 29: 83, 1939.

THE H-ION CONCENTRATION AND THE ORIGIN OF THE HEART BEAT

IT has been suggested that the H-ion concentration is intimately concerned with the fundamental process orginating the heart beat.[1] This suggestion was supported by experimental data which indicated that the H-ion concentration (within limits close to normal) was reciprocally related to the heart rate.[1, 2]

Recent investigators have stressed the necessity of distinguishing between the early, and often transient effects, and the later, more permanent effects which may be found in such studies.[3, 4] The results of these latter investigations throw some doubt on the value of the experimental procedures used to obtain evidence in support of the theory mentioned above.

The present experiments were carried out (*a*) on the excised sinus venosus of the frog heart suspended in aerated Ringer's solution and (*b*) on the right atrium of the guinea pig heart perfused by the method which I have recently described.[5]

In the experiments on the frog sinus venosus, the heart rate was counted at 10- to 15-minute intervals for at least 45 minutes or until the heart rate had become constant. The heart was then transferred to the experimental Ringer's solution and the heart rate was counted at the same intervals for 1 hour; the heart was then transferred back to normal Ringer's solution and the heart rate counted at intervals for at least 45 minutes. By observing the heart for such long periods of time, it is possible to distinguish between the transient and variable response which often occurs when the heart is transferred from one solution to another, even though the second solution may be of the same composition as the first, and the later, more permanent response.

The procedure with the guinea pig atrium was similar; however, 3 readings taken over a period of 30 minutes were found sufficient to determine the heart rate with each solution.

The results are given in the tables. The heart rate in each case is expressed as a decimal fraction of the heart rate in normal Ringer's solution. For the frog sinus venosus, the pH of the normal Ringer's solution was 7.7; for the guinea pig atrium, the pH was 7.52. The experimental solutions differ from the normal solution only in their pH values. The experimental values for the frog Ringer's solution were attained

[1] E. Cowles Andrus and Edward P. Carter, *Heart*, 11: 97, 1924.
[2] E. Cowles Andrus, *Jour. Physiol.*, 59: 361, 1924.
[3] J. J. Izquierdo, *Jour. Physiol.*, 68: 363, 1930.
[4] C. R. Spealman, *Am. Jour. Physiol.*, 124: 185, 1938.

TABLE 1

RELATIVE HEART RATE VALUES OF THE FROG SINUS VENOSUS AT DIFFERENT pH'S*

pH														
2.9	3.5	4.8	5.7	6.1	6.8	7.1	7.4	7.7	7.8	8.6	8.8	9.4	9.7	10.2
S	S	0.98	0.93	1.10	1.06	0.89	1.00	1.00	0.96	0.89	0.95	1.00	S	S
S	0.95	1.00	0.90	1.00	0.98	1.02	1.06	1.00	–	1.02	1.00	–	S	S

* Each value represents a determination on one heart. The pH was adjusted with 0.1 N HCl or NaOH. 24 hearts were used in the experiments. S indicates the heart stopped beating in the experimental solution; – indicates no experiment was made.

by adding the necessary quantities of 0.1 N acid or base to normal Ringer's solution; those for the modified Locke's solution used with the guinea pig atrium, by adjusting the ration of acid phosphate to basic phosphate.

The rate of beat of the frog sinus venosus is not significantly affected when the pH is varied over a wide range. This is true whether highly dissociated acids or bases are present (Table 1) or whether weakly dissociated acids or bases are present (Table 2). Outside of a certain pH range, the sinus venosus usually stopped beating during the period of 1 hour in which it was in these solutions. The rate of beat of the guinea pig heart was not significantly affected by the pH in the region studied.

TABLE 2

RELATIVE HEART RATE VALUES OF THE FROG SINUS VENOSUS AT DIFFERENT pH'S*

pH 6.2	6.7	7.2	7.7	8.2
1.00	0.94	0.97	1.00	1.03
1.00	1.05	0.95	1.00	1.05

* Each value represents a determination on one heart. The pH was adjusted with 0.1 N CH_3COOH or NH_4OH. 8 hearts were used in the experiments.

TABLE 3

RELATIVE HEART RATE VALUES OF THE GUINEA PIG RIGHT-ATRIUM AT DIFFERENT pH'S*

pH 7.03	7.30	7.38	7.52	7.60	7.65
1.01	0.95	1.04	1.00	1.08	1.04
–	0.89	0.99	1.00	–	1.05

* Each value represents a determination on one heart. The proper pH's were obtained by adjusting the ratio of acid to basic phosphate. 4 hearts were used in the experiments. – indicates no experiment was made.

SUMMARY

The rate of the frog or guinea pig heart preparation was not significantly influenced by the H-ion concentration when this was kept within limits which allowed the heart to continue beating. The theory that the H-ion concentration is intimately concerned with the origination of the heart beat is not supported by the results of this investigation.

C. R. SPEALMAN

MEDICAL COLLEGE OF VIRGINIA

SUSCEPTIBILITY TO DISEASE IN RELATION TO PLANT NUTRITION[1]

IF the severity of a plant disease is different under different fertilizer treatments or other environmental conditions affecting plant nutrition, it becomes important to know in what respects nutrition differs under the various conditions and in relation to the severity of the disease. The method of foliar diagnosis[2, 3] as the following example shows, enables the investigator to obtain this information.

In an experiment on greenhouse tomatoes grown on plots of which the cultural conditions, except the fertilizer treatment, were similar, certain plants on some of the plots began to show the characteristic symptoms of streak disease about 80 days after transplantation to the beds. This disease is known to be caused by a virus or a mixture of viruses; the symptoms are light yellow, elongated, irregular areas on young leaflets which later turn brown and die, and elongated brown lesions appearing longitudinally on stems. New growth may appear healthy from time to time during the season, and at other times may show the lesions just described. The latter characteristic serves to differentiate the disease symptoms from those of potash deficiency, in which new, healthy leaves do not develop after lesions appear.

Because the disease was wide-spread on certain plots and entirely absent from others, which were exposed equally to infection, but differed in manurial treatment, an examination was undertaken by the method of foliar diagnosis to compare the course of nutrition of low-yielding plants exhibiting symptoms of streak, grown on a plot fertilized with nitrogen only as commercial sodium nitrate, with that of high-yielding, healthy plants growing on a plot fertilized with rotted manure and complete commercial fertilizer.

In Fig. 1 are shown in trilinear coordinates the equilibrium between the dominant elements for the sixteenth leaf from the base as expressed by the composition of the *NPK-units,* which are derived by converting the percentage values of nitrogen, phosphoric acid and potash to milligram equivalents and finding the proportion which each of these bears to the milligram equivalent total. The samples were taken 85 days after the plants were placed in the beds.

The coordinates are shown for leaves from three types of plants on the plot having diseased plants, namely: plants showing no visible symptoms of disease at the time of sampling (II); plants showing slight symptoms (III); and plants severely diseased (IV). Comparison is made with morphologically homologous leaves from plants on a plot (No. 8L) on which no disease appeared (I). This latter received a complete fertilizer, together with well-rotted horse manure.

The coordinates (II, III and IV) of the leaves from the several types of plants from the plot No. 12L having diseased plants are displaced relative to those

[5] C. R. Spealman, *Proc. Soc. Exp. Biol. and Med.,* 45: 189, 1940.

[1] Authorized for publication as paper No. 978 of the Journal Series of the Pennsylvania Agricultural Experiment Station.

[2] Walter Thomas, *Plant Physiology,* 12: 571–600, 1937.

[3] Walter Thomas and Warren B. Mack, *Pa. Agr. Exp. Sta. Bull. No. 378,* pp. 1–33, 1939.