physics and chemistry, as well as to other branches of mathematics. The general methods and results of the newer algebra were first made available to professional mathematicians as a whole by van der Waerden's now classic "Moderne Algebra." However, besides being written in a foreign language, this book was far too advanced and compendious to be a suitable text for a standard graduate course in this country.

MacDuffee's new volume is the second noteworthy attempt to provide such a text, the first being Albert's "Modern Higher Algebra." Although it covers much less ground than Albert's book and contains no original material, MacDuffee's book, as its title suggests, affords an easier introduction to abstract algebra than Albert's. By emphasizing the most basic theorems and making no attempt at completeness, MacDuffee drives home the fundamental ideas of modern algebra. And by illustrating each definition with carefully chosen examples, he gives "concrete" significance to them—a difficult feat in so-called "abstract" algebra.

The book is not designed for purposes of reference or for use in advanced seminars. However, considerable ground is covered in the theory of algebraic numbers, including the Kronecker program of developing the real and complex number systems from the rational integers, finite fields, valuations and p-adic numbers. This emphasis gives the book an arithmetic bias, especially in the first 200 pages. The last third is devoted to matrices, concerning which the author has already written a standard reference work, and to linear associative algebras. Like van der Waerden and Albert, the author has in effect presupposed "the traditional" course in the theory of equations, and has not dealt with applications outside the domain of pure algebra.

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SPECIAL ARTICLES

ON LUBIMENKO EXTRACTS OF CHLOROPHYLL-PROTEIN

IT has often been suggested that chlorophyll in the living plant is the prosthetic group of a conjugated protein and that when chlorophyll is extracted with an organic solvent it is separated from the protein to which it was originally attached. When, however, one avoids organic solvents and extracts ground leaves with water or salt solution, one usually obtains not a water-soluble chlorophyll-protein but a suspension of chloroplasts from which the chloroplasts are separated by filtration or centrifugation. A little water-soluble chlorophyll can be extracted from chloroplasts by bile salts[1] and much more by the modern synthetic detergents.[2] But it is not safe to use these reagents for the extraction of native, unmodified protein because they are known to denature proteins.[2]

Probably the most interesting and promising observations concerning water-soluble chlorophyll-protein compounds have been made by Lubimenko,[3] whose paper has never received the attention it merits. In the course of a very extensive survey of the chemical natural history of chloroplasts and their pigments, Lubimenko found that a few plants, in particular the lilies, *Aspidistra elatior* and *Funkia,* yielded on extraction of their leaves with water at his unspecified Russian room temperature not suspensions of chloroplasts but opalescent solutions from which the green pigment was not removed by filtration. Lubimenko gave good evidence that the chlorophyll in his opalescent extracts was bound to protein. His evidence was similar to the evidence that visual purple in the eye is bound to protein.[4]

Following Lubimenko, I ground leaves of a species of *Funkia* found in a local garden with sand, extracted the ground leaves with dilute sodium chloride, removed insoluble material by centrifugation with a Swedish angle centrifuge or filtration through Hyflo Super-Cel (Johns-Manville), and obtained a green opalescent solution in which no particles could be seen with an oil-immersion lens. The chlorophyll in the extract was much more unstable than I had expected from reading Lubimenko's paper. At 20–25° C. an appreciable amount of the chlorophyll in the extract went over into an insoluble form within an hour. This process was greatly speeded up by raising the temperature to 37° C., greatly slowed down by lowering the temperature to 0° C. All operations with Lubimenko extracts should, therefore, be carried out in the cold. Freezing, however, should be avoided, since it makes the chlorophyll-protein insoluble.

I have investigated many plants available in the neighborhood and in the Institute greenhouses and found that opalescent Lubimenko extracts can be prepared from a number of legumes, in particular the Early Golden Cluster variety of bean, *Phaseolus vulgaris* L., and the Black variety of cow pea, *Vigna sinensis* Endl., as well as from the lilies used by Lubimenko. These legumes have the great advantage that they can be grown readily and rapidly in the greenhouse throughout the year from seeds which are al-

[1] E. Smith, SCIENCE, 88: 170, 1938.
[2] M. L. Anson, SCIENCE, 90: 142, 1939: *Jour. Gen. Physiol.*, 23: 239, 1939.
[3] V. N. Lubimenko, *Rev. Gen. Bot.*, 39: 619, 1927.
[4] W. Kühne, in L. Hermann, "Handbuch der Physiologie," pt. 2, Leipzig; F. C. W. Vogel, 3: 264, 1879; G. Wald, *Jour. Gen. Physiol.*, 19: 351, 1935.

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.

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[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.