ersetzt werden. Aber das ändert doch an dem Prinzip nichts, dass jeder Lebensvorgang in irgendwelchem Grade von der Außenwelt abhängen muss. Der Nachweis dafür lässt sich nicht theoretisch, auch nicht durch bloße Beschreibung der in der Natur zu beobachtenden Erscheinungen führen. Wir können vielmehr nur auf dem Wege experimenteller Forschung das fundamentale Problem angreifen, um dadurch allmählich einen wirklichen Einblick in die innere Struktur der Pflanzen zu gewinnen.

Heidelberg, den 12. März 1912.

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# A Laboratory-Course in Physiology Based on Daphnia and other Animalcules.

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In the course of the work in general elementary biology used as an introduction and orientation to the instruction in human medical physiology, it has become obvious that the time has come for broadening, and not little, the practical phases of such instruction. Especially clear is it that already we instructors have wasted too many months of our students' precious school-time in the study of isolated and thus unnourished and abnormal mechanisms. One thinks of course at once of the nerve-muscle preparation and of the isolated heart and of strips of cat's bladder. These have long-since served their day and now it is high time that we began to take the view-point of the more advanced physical educationists, and attempted to elaborate in our teaching the mode of working of normal organs and tissues *in normal animals.* The scientific, like the other, tendencies of the day is toward synthesis and unification, toward the study, more and more exact, of „things as they are" . . . inseparable parts of an animal whose ultimate essence is unique individuality, an everywhere mutually interdependent single mechanism, not a chest of independent tools. This synthetic tendency in physiology, and in biology in general, applies not alone to discussions of the parts of a single animal, but also to the pointing-out of the unification and inherent similarity of all that lives. The recent books by the plant-physiologists have taken us far toward this desirable goal, while the devotees of the new science of animal behaviour and the physiologic zoölogists, yes, even the protozoölogists, have taken us further yet. Today, then, as we never could before the days of these and of the physical chemists, do we realize how universal and how minute is the unification of parts into the unit of vitality, the animal, and how much alike, essentially, all animals are[1]).

The brief course in laboratory physiology suggested here (already worked out in detail for use by the student) has perfect theoretic sanction therefore as a new method in the teaching of physiologic science, — it is clearly a licentiate of evolutionary philosophy. In directer phrase, the fundamental doctrine and many of the facts of mammalian physiology can be demonstrated in animals far below the mammals in complexity and vastly smaller in size. Vital mechanics uses relatively few reall indifferent ways and means. The protozoa and especially the small crustacea and rotifers are for the purposes of elementary physiology far more similar to man than their size-contrast would imply. The course as arranged at present includes both physiology of a basal kind and a modicum of what we may term physiologic anatomy, and furthermore something of animal psychology, — ever closer to physiology, as is inevitable. With a wide choice and selection from the well-nigh infinite variety of material known to the professional zoölogist, there is no definable limit to its development in each of these three directions within elementary bounds.

As old-time physiologists, perhaps some of us have never realized the exact status of our science in the mind of the people at large. The antivivisectionist people have seen to it well that the „average“ man and most women and children shall consider physiology a matter of (necessary) blood and forbidding „internal workings“ far beneath their proper interest. We have scarce had a fair chance as yet to do our relatively new science justice in the world's keen range of reputations, nor have we had time (so full of life is our subject-matter and so teeming with interest), to popularize physiology and so give it its becoming place in the hierarchy of human sciences. To do this, however, is more than our priv-

1) See the author's "Text-Book of Human Physiology, Theoretic and Practical", octavo, pp. 552 with 301 engravings and 9 colored plates, Philadelphia and New York, Lea & Febiger, 1908.

ilege, it is our duty, in order that many minds, many more than at present, may each contribute its possible mite to the advancement of biologic learning. Moreover it is part of the intelligence-birth-right of every human being to understand how he is constructed as a mechanism and how this mechanism works. Only thus can he give his body, at once trainer, temple, and servant of his soul, fit and necessary care. This present work is a step, however short and shuffling, toward this great end.

The standing of this pioneer endeavour as a pedagogic proposition, as a scientific method, we may attempt to justify at the present writing under six heads. The first of these heads we may suggest as the substantiality and the variety of the physiologic principles that can thus be studied. Remembering, if the reader please, that this is a first „edition" and therefore tentative and suggestive only, we may venture to quote a syllabus of the work already arranged, as follows:

**A Laboratory Course in Physiology Based on Daphnia. etc.**

I. Introduction: Vegetal and Animal Histology.

II. Comparison of Living Vegetal and Animal Cells: Bacteria, desmids, diatoms, Edeogonium, Spirogyra, Euglena, ciliated infusoria.

III. Protoplasm and its Streaming: Ameba. Surface-tension. Universal versatility.

IV. Locomotion by Cilia: Paramecium, Stentor.

V. Simple Forms of Muscle: Hydra, Stentor, Vorticella.

- A. The reaction-time of Stentor's or of Vorticella's myonemes.
- B. The relaxation-time of Stentor's or of Vorticella's myonemes.
- C. The spontaneous contraction-rhythm of Vorticella.
- D. Fatigue in Vorticella's myonemes.
- E. Exhaustion in Vorticella's myonemes.
- F. Individual differences in the movements of Stentor and of Vorticella.

VI. The Molar Movements of Simple Metazoa: Hydra, the rotifers Philodina, Brachionus.

VII. Dessication and Re-humidification: Tardigrada, Philodina.

VIII. The Anatomy, Gross and Microscopic, of Daphnia.

IX. Nutrition: Daphnia.

- A. The water-currents toward the mouth.
- B. Deglutition.

C. The digestive glands and their rhythmic movements.
D. Peristalsis.
E. Speed of the antiperistaltic wave.
F. Frequency of the antiperistaltic waves.
G. Defecation.
H. Catharsis.
I. Correlation in the Alimentary canal.

X. Blood: Daphnia. (Compare Hydra and Man.)
A. Number and size of the amebocyte-corpuscles.
B. Shapes and intrinsic movements of the corpuscles.
C. Change of color on exposure to air.

XI. Circulation: Daphnia.
A. The heart. Systole and diastole.
B. The average heart-rate.
C. The effects of varying temperature on the rate.
D. The heart's extreme persistence.
E. The blood-sinusses. Osmosis.
F. The effects of electricity on the heart.
G. The effects of blood-salines on the heart; osmosis.
H. The effects of certain other drugs on the heart.
I. Correlation with extrinsic conditions.
J. The embryonic heart-rate: why slower than the maternal heart-rate? Myogenesis vs. Neurogenesis.
K. The cardio-inhibitory center.

XII. Respiration: Daphnia.
A. Direct respiration.
B. Structure of the gill-feet.
C. Rhythmic movements of the gill-feet.
D. Apnea?
E. Effects of carbon dioxide in excess.
F. Effects of a larck of oxygen.
G. Effects of carbon monoxide.
H. Hemocyanin in solution.

XIII. Muscle and Muscle-Action: Daphnia.
A. Smooth muscle of the alimentary canal.
B. The eye-muscles. Convulsive action.
C. Voluntary muscle of antennae, etc. Fatigue.
D. Cardiac muscle. Tonus. Action of the ions in the various blood-salines. Absence of obvious fatigue.

XIV. The Nervous System: Daphnia.
A. Brain and optic lobe.
B. Moto-sensory circuit: Retzius' work.
C. Augmentory action: heart.
D. Inhibitory action: heart.

XV. Taxes: Daphnia, Cyclops, etc.
- A. Chemotaxis: Paramecium, Anurea.
- B. Phototaxis: Daphnia, Ameba.
- C. Thermotaxis: Paramecium, Oxytricha.
- D. Electrotaxis: Cyclops.

XVI. The Senses: Daphnia.
- A. Vision: range and acuity.
- B. Touch. „Reflex" removal of irritants.
- C. Taste.
- D. Smell?

XVII. Embryology: Daphnia.
- A. Summer eggs and their development.
- B. Winter eggs.
- C. Parthenogenesis.
- D. The brood-sac and its secretion.
- E. Coalescence of embryonic eyes.
- F. Comparison of functional rates in embryos and in mother.

XVIII. Animal Behaviour: Paramecium, Hydra, etc.

XIX. The Mental Life of the Animalcules.

One finds here basal and important principles of universal physiology, and the ingenuity of other experienced physiologists would surely indicate and define many principles more. The essentials of much physiology certainly are here.

A second possible feature of this manner of teaching elementary physiology has been alluded to by implication already: the transparency and the smallness of the animals used make more striking and easy of acceptance the essential unification of parts into the animal whole. In Daphnia this is notable in the interest a first viewing of the animalcule invariably excites whether in man or child. One actually sees for example the blood corpuscles that are kept in circulation by the heart pulsating under the observer's eye; and the intestinal peristalsis can be actually seen to advance up the gut in relation with the pulsations of the digestive gland. Here is unification too obvious to be missed even by the careless child. Without a comprehension of the interdependence of his bodily parts he can learn neither to understand himself nor how to keep well!

A third advantage of such a course certainly lies in the simplicity and the inexpensiveness of the apparatus required. Many elementary schools have compound microscopes and every school or even every student could provide at least a strong pocket-lens, which might be made to suffice. Beyond the microscope the apparatus required is almost nothing not afforded by every laboratory of chemistry, if we except a few always-present implements such as a watch, a millimeter rule, and small and simple glass-ware. To those of us who know the considerable expense of most of the apparatus that we use, this factor will appeal. At any rate, it puts this course within range of any school no matter how simple or indigent or isolated.

In similar manner, the life-material required is always obtainable with great ease and with little or no expense, summer or winter, and throughout the world. As is well known, these animals have an almost Earth-wide distribution and are easily gathered from pools and streams. If this be not convenient, a few cents for postage brings most of these animalcules within easy reach of such few schools as for special reasons might not care to maintain the simple jar-aquaria for breeding them. They come in such countless numbers so readily, that whoever made a business of supplying them could not conscientiously, one would hope, charge for them more than the smallest public class could easily pay. Ease of maintenance of the animalcules is an advantage close to that just mentioned. Instead of ill-smelling animal-rooms expensive to maintain, containing unhappy large animals often both hard and expensive to properly feed, the animalcules are kept in more or less attractive glass aquaria that need contain no more than a few liters of water each for use of large classes. Many of these little animals maintain themselves year after year, Daphnia, for example, not „running out" as long as one uses just ordinary intelligence in imitating a simple environment somewhere near that which is natural to it. The infusoria of course, Stentor, Paramecium, etc., can be readily developed at any time in two weeks from old leaves and hay and similar commonplace material, everywhere and always at hand.

No one with a quirkless brain can nowadays fail to justify vivisection by competent scientists, but many, none the less, men as well as women and children, savants as well as fools, dislike to do this work, especially for purposes of routine class-instruction. This repugnance to blood-shedding and mutilation is obviously a necessary human feeling worthy to be cultivated rather than blunted. (In the vivisection polemics one sees too seldom perhaps due credit given us animal-experimentalists for the performance of disagreeable death and mutilation on animals whom we of all men best appreciate at their marvellous value and perfection). Strangely enough the size of the animal is a factor in the determination of the strength of this feeling of repugnance to mutilation found in all normal human beings, while another of its determinants is complexity. Men of culture who would hesitate to kill a mouse or to drown a puppy have no such feelings ordinarily in regard to ants however wonderfully efficient in their complex living, or in regard to the medusoids however large and conspicuous. Thus the animalcules, unlike dogs and rabbits and frogs, may be adequately studied by young or old, without a prohibitive feeling of repugnance to the destruction of life. This circumstance is both justifiable biologically and ethically and practically convenient for teaching purposes, and gives the animalcules an advantage for scientific purposes not easy to exaggerate.

It has been already sufficiently implied perhaps that this course in practical physiology is for elementary use, although it serves a helpful purpose also as an introduction and advance summary-epitome for courses of physiology the most advanced and technical, as routine experience indeed has shown. In high schools, in academies, and in academic (collegiate) curricula, particularly in those for women, one might expect its value especially to be demonstrated. From such schools laboratory-physiology worthy of the name has been heretofore excluded. It is on this basis and with this intent that the present tentative suggestions have been offered to the science of physiology.

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## G. Cuvier und K. F. Kielmeyer.

Von J. H. F. Kohlbrugge.

Sicher ist Kielmeyer ein wenig bekannter Naturforscher, obgleich sein Einfluss, solange er lebte, sehr groß war. Dafür liegt auch ein guter Grund vor, nämlich dieser, dass er sich fast nie entschließen konnte, seine Gedanken der Druckpresse zu übergeben.

Cuvier, der von 1784—1788 Schüler auf der Karlsschule in Stuttgart war, hatte ihn dort kennen gelernt und blieb dem 3 Jahre älteren Freunde zeitlebens verbunden. Da nun vor einigen Jahren der handschriftliche Nachlass Cuvier's allgemein zugänglich wurde, indem seine Großnichten diesen dem „Institut de France“ schenkten, so war wohl zu erwarten, dass sich daraus auch näheres über Kielmeyer entnehmen lassen würde. Dieser „Fonds Cuvier“ ist sehr groß und vom Bibliothekar Herrn Henri Dehérain in musterhafter Weise katalogisiert worden. Der Katalog erschien in der Revue des Bibliothèques (1907—1908). Obgleich Hamy schon mehreres aus diesem Nachlass veröffentlichte [1]), so wurde trotzdem deutscherseits noch gar nicht darauf geachtet, welche Schätze für die Geschichte der Naturwissenschaften und deutscher Naturforscher

1) Hamy, E. T. Les débuts de Lamarck suivis des recherches sur Adanson, Jussieu, Pallas, Geoffroy Saint-Hilaire, Cuvier, Paris 1909. — Ders. Étienne Geoffroy Saint-Hilaire. Lettres écrites d'Egypte à Cuvier, Jussieu, Lacépède etc. Paris 1901.

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