Physiology at Harvard / by William Townsend Porter.

PHYSIOLOGY AT HARVARD

BY

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PREFACE TO THE THIRD EDITION

THIS book is written to explain a new method of teaching, sound in theory and feasible in practice; to provide the Harvard Medical School with a precise account of the work done by each student in Physiology; and to create for students and instructors alike a working-plan by which they may find their way unvexed through much detail.

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PHYSIOLOGY AT HARVARD

I

THE NEW METHOD

THE new method of teaching physiology proposed in the *Boston Medical and Surgical Journal*,[1] December 29, 1898, and more fully explained in the *Philadelphia Medical Journal*,[2] September 1, 1900, was adopted by the Harvard Medical School in 1899.

The traditional method of teaching physiology consists of a systematic course of lectures illustrated by occasional demonstrations. For thirty years or more, especially in England, this didactic teaching has been further illustrated by certain experiments performed by the students themselves. Laboratory experiments, therefore, have long been a valued part of the instruction in physiology in many universities. When the new method of teaching was introduced in the Harvard Medical School, and two hundred students worked daily in the physiological laboratories, it was said that this was only doing in a large way that which had been done in a small

[1] Porter, W. T.: The teaching of physiology in medical schools, *Boston Medical and Surgical Journal*, December 29, 1898, pp. 647–652.

[2] Porter, W. T.: The teaching of physiology, *Philadelphia Medical Journal*, September 1, 1900.

way for many years. The enterprise was held to be valuable because it showed that large numbers of first-year medical students could be carried simultaneously through a long series of experiments many of which had been thought beyond their powers; it was a lesson in faith and an example of administration, but nothing more.

It will be obvious that this criticism is based upon a misapprehension. The new method is not an extension of the old. It is a fundamentally different process. The old method is chiefly didactic. The new is a systematic course of experiment and observation by the student himself. In the old the student rests upon the dictum of the professor and the text-book. In the new he relies upon the fundamental experiments done with his own hands. In the old his experiments follow the lecture and attempt to verify its statements. In the new the lecture follows his experiments and discusses them in relation to the work of other observers. In the old the stress is upon the didactic teaching. In the new the stress is upon observation. Under the old method, students in the Harvard Medical School used to ask, "Who is the authority for that statement?" Under the new, they ask, "What is the experimental evidence?" The old method insensibly teaches men to depend upon authority, but the new directs them to nature.

In the old method the experiments performed by the students are almost exclusively such as are quickly and easily done, for example, the simpler experiments in the physiology of muscle and of the circulation of the blood. They are

intended to illustrate physiological experimentation rather than to disclose step by step the groundwork of the science of physiology.

In the new method, on the contrary, the fundamental experiments and observations which form the solid ground in every field of physiology are divided into sufficiently small groups and arranged in the most instructive sequence. With the fundamental experiment of each group are placed the accessory data. The meaning of this term will be clear from the following example. Consider the function of the roots of spinal nerves. The fundamental experiment here is Johannes Müller's well-known section and stimulation of the nerve-roots. The accessory data are such of the observations and opinions of his successors as are necessary to give a clear picture of the present state of knowledge of this subject. The student makes for himself the fundamental observation, and immediately afterward considers the accessory data provided in text-book and lecture. He proceeds systematically from the fundamental experiment and accessory data of one group to those of the next, in an ordered and logical series.

The fundamental experiment and the accessory data are taken as directly as possible from the original sources, and the reference is given in each case.

It should be observed that this new method serves for the instruction of all students, from beginners to those engaged in research. The beginner performs the fundamental experiment in each group and studies the accessory data.

The advanced student performs the fundamental experiments and as many of the accessory experiments as may give him the special training he desires. The research student has before him the classical observations and the original sources of the problem he has chosen.

It should be noticed also that the new need not violently push aside the old method of instruction, but may replace it chapter by chapter as the means and the energy of the instructors shall permit.

It has been urged against the new method that there are fundamental experiments which require more time than the student can possibly give, or which are too complicated to be successfully performed by him. The number of these has certainly been much exaggerated, and is daily lessened by inventions that secure simplicity without loss of accuracy. Pending such labor-saving inventions, the experiments which consume much time may well be done by committees of students, and the results reported to the entire class, who will compare them with the account given by the original discoverers.

Ways and Means

The new method requires:

1. Printed accounts of the fundamental experiments and observations in physiology, taken from the original sources, and arranged in the most instructive sequence. The reference to the original source should be given in each case.

2. Accessory data grouped about the fundamen-

tal experiments. The accessory data should also be taken as directly as possible from the original sources, and the reference given in each case.

3. Apparatus of precision designed with the utmost simplicity upon lines that permit its manufacture in large quantities at small cost.

It is obvious that these conditions cannot be met without prolonged labor. Collections of fundamental and accessory experiments in several fields have been printed in an abbreviated form for the temporary use of Harvard Medical students and other interested persons.[1] These collections are being completed and improved as rapidly as possible, and the data for the remaining fields are being brought together. In its final form this material will constitute "A Laboratory Text-book of Physiology."[2]

Especial consideration should be given to the apparatus for the laboratory teaching of large numbers of students. The making of physiological apparatus distinguished by simplicity of design, sound workmanship, and low cost is at

[1] Porter, W. T.: An Introduction to Physiology. Part I. The Physiology of Muscle and Nerve, pp. 1–235. Second edition, January, 1901. Part II. The Circulation, pp. 237–314. Parts I and II are bound together in green cloth. Part III. The Spinal Cord and Brain, *in preparation*. Part IV. Physiological Optics, pp. 1–99. Bound in gray paper. Pending the publication of the remaining parts of the Introduction to Physiology and of the Laboratory Text-book of Physiology, the experiments not mentioned in Parts I, II, and IV, of the Introduction, and now performed by Harvard students, are printed in *Experiments for Harvard Medical Students*, 1903, third edition, and in supplemental sheets. These deal more or less fully with the spinal cord, brain, cutaneous sensations, taste, vision, metabolism, respiration, blood, and fermentation.

[2] This title is copyrighted.

present of high importance to the development of physiology. The ordinary student of physiology is essentially a book man, while the professional physiologist is essentially a laboratory man. Student and professor should go the same path,— the only road that ever has led or ever will lead to a sound knowledge of a natural science. Few steps can be taken along this road without apparatus of precision. Physiological apparatus has heretofore been made upon the "model" plan, each piece for itself, without regard to the number of mechanical "operations" required, and with little or no thought as to the subsequent maintenance of the apparatus in good condition. The Harvard Medical School requires more than one hundred duplicates of each apparatus, for example more than one hundred kymographs, more than one hundred inductoriums, etc. The course now given requires the issue of at least twenty-five thousand articles, and this number increases steadily with the increase in the experimental work. It is clear that the cost of such an equipment made on the old lines would be beyond the means of any large school. Hence, the sound training of large classes in physiology depends absolutely upon the invention of apparatus that shall serve for exact experimentation, i. e. the repetition of classical experiments, and that shall also be designed with reference (1) to its "manufacture," (2) to its storage and issue, and (3) to its maintenance in good condition. By "manufacture" is meant technically the making of a number of pieces of the same apparatus consecutively, by preference upon special lathes

and with special tools. Thus in the machine shop of the Harvard Physiological Laboratory the parts of five hundred moist chambers were made at one time. For economy, the number of steps or "operations" should be the fewest possible, as each operation must be repeated many times, — five hundred times in the example just given. The labor of setting a turret lathe which will make eight consecutive operations upon the same piece of metal is as great for one piece as for a thousand. Astonishing economies may also be secured by the use of special automatic tools.

Further, it is essential that the apparatus be compact, and that important parts be protected so that they may not be injured when the apparatus is handled rapidly by persons of small experience. Storage and issue must be carefully studied to prevent hopeless confusion and the rapid deterioration of the plant.

Finally, the apparatus should be designed with special reference to durability and cleanliness; otherwise there will be a heavy charge for maintenance.

The supply of apparatus of this type bears the same relation to the advance of physiology that the commissariat bears to the advance of an army.[1]

[1] The Harvard Physiological Apparatus has been especially devised for the laboratory teaching of large numbers of students. It has been described in a special catalogue, in *Science*, 1901, xiv, pp. 567–570, and in the Proceedings of the Annual Meetings of the American Physiological Society, published in the *American Journal of Physiology*, 1903, viii, and 1904, x.

Courses offered in 1903–1904

1. First-Year Course.
2. Fourth-Year Elective Course.
3. Research.
4. Summer Course.

II

THE FIRST-YEAR COURSE

THE first-year course is required of all students. It is designed to give the general introduction to physiology that every Doctor of Medicine should possess. It is valuable also to biologists not intending to become physicians. The medical students who take this course have spent the first four months of the collegiate year in the study of anatomy, histology, and embryology. The mornings of the second four months, February, March, April, and May, are given to physiology, and the afternoons to physiological and pathological chemistry.

The instruction in physiology given each student is shown in the accompanying tables, which are followed by a description of the several exercises.

TABLE I

Showing the Instruction given Each Student in the First-Year Course

Number of Exercises.	Character of Exercise.	Hours of Instruction.
81	Laboratory experiments. Professors Porter and Cannon, and Dr. Maxwell. *Daily, except Saturday.*	168
55	Conferences. Professor Cannon.	27½
77	Written tests. *Daily, except Saturday.*	26
15	Written tests. *Mondays.*	15
86	Lectures, with demonstrations. Professors Porter and Cannon.	43
23	Special demonstrations. Professors Porter and Cannon and Dr. Maxwell.	15
15	Recitations. Professor Bowditch. *Saturdays.*	15
43	Discussion of theses. The entire class and the Staff.	33
	Thesis. Written by each student from the original sources.	
	Reading of investigations. The reading of investigations in the original sources and the discussion of these when the theses upon the same subjects are discussed.	
	Bibliography. The making of a bibliography of one of the subjects listed under "Theses not to be read," p. 36.	

Laboratory Experiments

Pairing. — Many of the experiments cannot be done by one person alone. Others are performed more rapidly and with better results by two workers than by one. Moreover, discussion and mutual criticism are valuable. The class is therefore divided into pairs. Students are urged to select their comrades for themselves. Those who fail to choose are paired by lot. The pair usually decides to divide the experimental work so that upon one day the preparation of the frog, or other material, shall fall to one student, while the arrangement of the apparatus shall fall to the other; the next day, these duties are exchanged.

Distribution of Time. — The sixteen weeks of experimentation are divided as follows:

I. *The General Properties of Living Tissues.*

Feb.	1–4.	Methods of stimulation.
"	5–9.	Electrical stimulation of tissues.
"	10–11.	Chemical and mechanical stimulation.
"	12–16.	Irritability and conductivity.

II. *The Income of Energy.*

Feb.	17–26.	Fermentation and digestion.
"	29.	Absorption.
March	1.	Lymph.
"	2–7.	Blood.
"	8.	Secretion.
"	9.	Respiratory exchange.
"	10–11.	Metabolism.
"	14.	Nutrition. Diet.

III. *The Outgo of Energy.*

March	15.	Animal heat.
"	16–21.	Electromotive phenomena.
"	22–29.	Change of form in contractile tissues.
Mar. 30–Apr.	7.	Spinal cord and brain.
April	8.	Sympathetic.
"	11–12.	Cutaneous sensations.
"	13.	Taste, Smell, Hearing.
"	14–15.	Physiological optics.
"	25–26.	Physiological optics.
"	27–28.	Vision.
"	29.	Special muscular mechanisms. Respiration.
May	2–26.	Circulation.
"	27.	Reproduction.
May 28–June	1.	Practical examination.

The students who enter the physiological course have already studied the special anatomy of organs the structure of which would otherwise be described by the physiologist. This rational preparation materially shortens the time required for certain chapters in physiology.

The space assigned the vegetative functions is small because the laboratory work in the chemistry of the carbohydrates, fats, proteids, bone, cartilage, and muscle is pursued at present in the Department of Chemistry.

List of Experiments

Following is a complete list of the experiments. Students are not permitted to pass to a new exper-

iment until the one in hand has been performed to the satisfaction of the instructors. Only work well done is accepted.

Methods of Stimulation. — The preparation of the gastrocnemius muscle, p. 4.[1] The nerve-muscle preparation, p. 6. Galvani's experiment, p. 12. Make and break induction currents as stimuli, p. 40. Tetanizing currents, p. 42. Exclusion of make or break current, p. 43.

Electrical Stimulation of Tissues. — Opening and closing contraction, p. 61. Changes in intensity of stimulus, Experiment 2, p. 63. Polar stimulation of muscle, Experiment 5, p. 68. Tonic contraction, p. 70. Physiological anodes and cathodes in rectus muscle, p. 72. Law of contraction, p. 75. Changes in irritability, Experiment 1, p. 79. Changes in conductivity, Experiment 2, p. 85. Stimulation of human nerves, p. 89. Stimulation of motor points, p. 92. Polar stimulation of human nerves, p. 93. Reaction of degeneration, p. 97. Influence of duration of stimulus, Experiment 2, p. 101. Rhythmic contraction, Experiment 1, p. 103. Polar fatigue, p. 108. Polar inhibition by the galvanic current, Experiment 1, p. 114.

Chemical and Mechanical Stimulation. — Effect of distilled water, p. 124. Strong saline solutions, p. 125. Drying, p. 125. Normal saline, p. 126. Importance of calcium, p. 126. Constant chemical stimulation may cause periodic contraction, p. 126. Mechanical stimulation, p. 127.

Irritability and Conductivity. — The independent

[1] The page numbers refer to "An Introduction to Physiology."

irritability of muscle; curare experiment, p. 132. Minimal and maximal stimuli; threshold value, p. 137. Summation of inadequate single stimuli, p. 138. The same nerve fibre may conduct impulses both centripetally and centrifugally, Experiment 1, p. 145. Speed of nerve impulse, p. 146.

Additional Experiments on Methods of Stimulation.[1] — Surface tension, p. 15. Surface tension altered by electrical energy, p. 16. The cell, p. 21. Electrolysis of potassium iodide, p. 27. Graduation of the electrometer, p. 28. Magnetic induction, p. 30. Magnetic field; lines of force, p. 33. To produce electric induction, the lines of magnetic force must be cut by the circuit, p. 33. Electromagnetic induction, p. 33. Make and break induction, p. 34. The inductorium, pp. 35–37. Empirical graduation of inductorium, p. 38. The extra currents at the opening and closing of the primary current, Experiments 1 and 2, pp. 41–42. Induction in nerves, p. 43. Unipolar induction, Experiments 1, 2, 3, 4, 5, and 6, pp. 44–49. Changes in intensity of stimulus with indirect stimulation, Experiments 1 and 2, pp. 63–64. Polar stimulation of muscle, Experiments 1, 2, 3, and 4, pp. 65–67. Polar stimulation in heart; monopolar method, p. 74. Changes in irritability, Experiments 2 and 3, pp. 79–81. Changes in conductivity, Experiment 1, p. 82. Galvanotropism, p. 98. Influence of duration of

[1] To be begun only in case the first list is finished in less than the prescribed time. These additions comprise experiments in "An Introduction to Physiology," Part I, not included in the first list.

stimulus, Experiments 1, 3, 4, and 5, pp. 100–102. Rhythmic contraction; skeletal muscle, p. 104. Continuous galvanic stimulation of nerve may cause the periodic discharge of nerve impulses, pp. 105–106. Polarization current; positive variation, p. 107. Opening and closing tetanus, Experiments 1, 2, 3, and 4, pp. 108–110. Polar excitation in injured muscle, p. 112. Polar inhibition in veratrinized muscle, p. 116. Stimulation affected by the form of the muscle, p. 117. Effect of the angle at which the current lines cut the muscle fibres, p. 118. The induced current, Experiments 1, 3, and 4, pp. 119–121. Polar stimulation by the induced current, Experiment 2, p. 120.

Additional Experiments on Chemical and Mechanical Stimulation. — Idiomuscular contraction, p. 127.

Additional Experiments on Irritability and Conductivity. — Nerve-free muscle, p. 130. Muscle with nerves degenerated, p. 131. The nerve-free embryo heart, p. 131. Irritability and conductivity are separate properties of nerve, Experiment 1, p. 134. Alcohol, Experiment 2, p. 136. Threshold value independent of load, p. 138. Relative excitability of flexor and extensor nerve fibres; Ritter-Rollett phenomenon, p. 139. Specific irritability of nerve greater than that of muscle, p. 141. Irritability at different points of same nerve, p. 142. The excitation wave remains in the muscle or nerve fibre in which it starts, p. 143. The same nerve fibre may conduct impulses both centripetally and centrifugally, Experiment 2, p. 145.

Fermentation and Digestion. — Conversion of starch to sugar by germinating barley, pp. 38–39.[1] Conversion of starch to sugar by salivary diastase, pp. 39–40. Extraction of diastase from germinating barley, p. 40. Specific action of ferments, pp. 40–41. Gastric digestion of cooked beef and bread, pp. 41–42. Artificial gastric juice, Experiments 1 and 2, p. 42. Digestion with artificial gastric juice, p. 43. Change of proteid to peptone by pepsin, p. 44. Rennin extract, p. 45. Precipitation of casein, p. 45. Experiments of Arthus and Pagès, pp. 46–48. Buchanan's experiment, p. 48. Extraction of fibrin ferment, pp. 48–49. Extraction of fibrinogen, p. 49. Precipitation of fibrinogen by fibrin ferment, p. 50. Ammoniacal fermentation of urea by urease, Experiments 1, 2, and 3, pp. 50–53. Extraction of urease, pp. 53–54. Splitting of fats by pancreatic juice, pp. 55–56. Preparation of neutral fat, p. 56. Emulsion test for fatty acid, Brucke's experiments 1, 2, 3, and 4, pp. 56–57; Gad's experiments 1, 2, and 3, pp. 57–58; Rachford's experiment, pp. 58–60. Extraction of lipase, p. 60. Hydrolysis of ethyl butyrate by lipase, pp. 60–62. Synthesis of neutral fat by lipase, Experiments 1 and 2, pp. 62–63. Ehrlich's ricin experiments (to be done by a Committee of the Class), pp. 67–69. Ricin antitoxine, Experiments 1 and 2 (by a Committee), p. 70. Bordet's experiments, 1, 2, 3, and 4, pp. 76–79. Schönbein's experiments 1 and 2, p. 79.

[1] The page numbers refer to *Experiments for Students in the Harvard Medical School*, by W. T. Porter. Third edition, 1903. The University Press, Cambridge, Mass.

Further oxidations by animal tissues, Experiments 1 and 2, pp. 79–80. Extraction of nucleo-proteid from liver (by two students), pp. 80–81. Oxidation by nucleo-proteid, p. 81. Oxidation about the nucleus, p. 82. Glycolysis in blood (by a Committee), pp. 82–83. Glycolytic ferment of pancreas, p. 85. Observation of yeast plant, pp. 87–88. Alcoholic fermentation, Experiments 1, 2, and 3, pp. 88–89.

Absorption. — [Experiments will be announced later.]

Blood. — Drawing the blood, pp. 94–95. Determination of specific gravity, pp. 95–96. Experiments 1, 2, 3, 4, and 5 (by a Committee), p. 96. Counting the red corpuscles, pp. 96–99. Counting the white corpuscles, pp. 99–100. Estimation of hæmoglobin, pp. 100–101. Hæmorrhage and regeneration (by a Committee), p. 101. Alkalinity, pp. 102–103. Coagulation time, p. 104. *Additional experiments.*[1] Clotting of plasma, Experiments 1, 2, 3, and 4.

Secretion. — [Experiments will be announced later.]

Respiratory Exchange. — Estimation of oxygen, carbon dioxide, and water, pp. 104–105.

Metabolism.[2] — 1. Estimation of respiratory oxygen, carbon dioxide, and water: (*a*) in quiet respiration, (*b*) during muscular exertion. 2. Nitrogenous equilibrium. 3. Effect of exercise upon nitrogenous metabolism. [Additional experiments will be announced later.]

[1] Furnished on printed unbound sheets.
[2] Furnished on printed unbound sheets.

Nutrition and Diet. — [Experiments will be announced later.]

Animal Heat. — [Experiments will be announced later.]

Electromotive Phenomena. — Polarization current, p. 25, and Experiment 1, p. 106. Demarcation current of muscle, Experiment 1, p. 150 (omit last three lines). Uninjured muscle, p. 153. Stimulation by demarcation current, Experiment 1, p. 153. Measurement of electromotive force of demarcation current; compensation method, p. 158. Demarcation current of nerve, p. 159. Action current of muscle, Experiments 1 (rheoscopic frog) and 2, p. 166. Action current of heart, Experiments 1 and 2, p. 173. Secretion current from mucous membrane, p. 183.

Change of Form in Contractile Tissues. — Volume of contracting muscle, p. 194. The duration of the several periods, p. 196. The excitation wave, p. 199. The contraction wave, p. 201. Influence of load on height of contraction, p. 204. Influence of temperature on form of contraction, p. 205. Superposition of two contractions, p. 209. Superposition in tetanus, p. 210. Graduation of isometric spring, p. 218. Isometric contraction, p. 219. Artificial tetanus of human muscle, p. 221. Natural tetanus of human muscle, Experiments 1 and 2, p. 221. Spontaneous contractions of smooth muscle, p. 221. Influence of load on work done, p. 223. Absolute force of muscle, p. 224. Time relations of developing energy, p. 226. Elasticity and extensibility of a metal spring, p. 229. Of a rubber band, p. 230. Of skeletal muscle, p. 230. Fa-

tigue of skeletal muscle of frog, Experiments 1 and 2, p. 232. Fatigue of human skeletal muscle, Experiment 1, p. 233.

Additional Experiments on Electromotive Phenomena.[1] — Demarcation current of muscle, Experiment 2, p. 151. Oblique section, p. 152. Stimulation by demarcation current, Experiments 2, 3, and 4, pp. 154–155. Interference between the demarcation current and a stimulating current; polar refusal, p. 155. Measurement of electromotive force of demarcation current, Experiment 1, p. 157. Nerve may be stimulated by its own demarcation current, p. 160. The action current in tetanus; stroboscopic method, p. 168. Rheoscopic muscle tetanus, p. 169. Action current of human muscle, p. 172. Action current of heart; the action current precedes the contraction, p. 174. Current of action of human heart, p. 175. Action current of nerve, Experiments 1 and 2, pp. 178 and 179. Positive variation, p. 179. Positive after current, p. 180. Contraction secured with a weaker stimulus than negative variation, p. 180. Current of action in optic nerve, p. 181. Errors from unipolar stimulation, p. 183. Negative variation of secretion current, p. 184. Electrotonic currents, p. 186. Negative variation of electrotonic currents; positive variation (polarization increment) of polarizing current, p. 188. The electrotonic current as a stimulus, p. 191. Paradoxical contraction, p. 191.

[1] To be begun only in case the first list is finished in less than the prescribed time. These additions comprise experiments in "An Introduction to Physiology," Part I, not included in the first list.

Additional Experiments on Change of Form in Contractile Tissues. —Relation of strength of stimulus to form of contraction wave, p. 203. Influence of veratrine on the form of the contraction, p. 208. Muscle sound, Experiments 1, 2, 3, 4, and 5, pp. 211–214. Relation of shortening in a single contraction to shortening in tetanus, Experiments 1, 2, and 3, pp. 215–217. Simple contraction of smooth muscle, p. 222. Tetanus of smooth muscle, p. 223. Total work done; the work adder, p. 224. Total work done estimated by muscle curve, p. 226. Extensibility increased in tetanus, p. 231. Fatigue of skeletal muscle of frog, Experiment 3, p. 233. Fatigue of human skeletal muscle, Experiment 2, p. 234.

Spinal Cord and Brain.[1] — The spinal cord a seat of simple reflexes, Experiments 1 and 2, p. 1. Influence of afferent impulses on reflex action, p. 2. Threshold value lower in end organ than in nerve trunk, Experiments 1 and 2, pp. 2 and 3. Summation of afferent impulses, p. 3. Segmental arrangement of reflex apparatus, Experiments 1 and 2, p. 4. Reflexes in man; from the skin, p. 5. Cornea reflex, p. 5. Throat reflex, p. 6. Pupil light-reflex, p. 6. Consensual reflex, p. 6. Accommodation reflex, p. 6. Knee jerk, p. 6. Ankle jerk, p. 7. Gower's experiment, p. 7. Effect of strychnine on reflex action, p. 8. Removal of cerebral hemispheres, p. 8. Posture, "brainless" frog, p. 9. Balancing experiment, p. 10. Retinal reflex, p. 10. Croak reflex, p. 10. Apparent purpose in reflex action,

[1] Experiments for Students in the Harvard Medical School. Third edition, 1903.

Experiments 1, 2, and 3, p. 12. Reflex time, p. 13. Reaction time, p. 13. Reaction time with choice, p. 14. Inhibition of reflexes through peripheral afferent nerves, p. 15. Inhibition through central afferent paths; the optic lobes, Experiments 1 and 2, p. 16. The roots of spinal nerves, p. 17. Localization of movements at different levels of the spinal cord, p. 18. Distribution of sensory spinal nerves, p. 19. Muscular tonus; Brondgeests's experiment, p. 20.

Sympathetic. — Innervation of sphincter of iris.[1] [Additional experiments in preparation.]

Sensations of Temperature.[2] — Mapping of hot and cold spots, p. 21. Outline, p. 21. Mechanical stimulation, Experiments 1 and 2, p. 21. Chemical stimulation, p. 21. Electrical stimulation, p. 22. Temperature after-sensation, p. 22. Balance between loss and gain of heat, p. 22. Fatigue, p. 22. Relation of stimulated area to sensation, p. 23. Perception of difference, p. 23. Relatively insensitive regions, Experiments 1 and 2, pp. 23 and 24.

Sensations of Pressure. — Pressure spots, p. 24. Threshold value, p. 24. Touch discrimination, Experiments 1 and 2, p. 26. After-sensation of pressure, p. 27. Temperature and pressure, p. 27. Touch illusion; Aristotle's experiment, p. 28.

Sensation of Tickle. — 1. Irradiation. 2. After image. 3. Topography. 4. Summation. 5. Fatigue.

Sensation of Pain. — 1. Threshold value. 2.

[1] Furnished on printed unbound sheets.

[2] Experiments for Students in the Harvard Medical School. Third edition, 1903.

Latent period. 3. Summation. 4. Topography. 5. Individual variation. 6. Temperature stimuli.

Motor Sensations. — 1. Judgment of weight. 2. Sensation of effort. 3. Sensation of motion.

Taste.[1] — 1. Threshold value. 2. Topography. 3. Relation of taste to area stimulated. 4. Electrical stimulation.

Smell, Hearing. — [Experiments will be announced later.]

Introduction to Physiological Optics.[2] — Construction of the path of a ray passing through a prism, p. 11. Refraction by convex lenses: principal focus, Experiments 1 and 2, p. 14. Estimation of principal focal distance, p. 15. Conjugate foci, p. 16. Virtual image, p. 17. Construction of image obtained with convex lens, p. 17. Refraction by concave lenses, p. 20. Refraction by segments of cylinders, Experiments 1 and 2, pp. 20–21. Refraction through combined convex and cylindrical lenses, Experiments 1 and 2, pp. 22–23. Spherical aberration by refraction, Experiments 1, 2, and 3, pp. 25–26. Dispersion circles, Experiments 1 and 2, p. 27. Myopia, p. 28. Hypermetropia, p. 29. Chromatic aberration, p. 30. Aberration avoided by a diaphragm, p. 32. Numbering of prisms, p. 33. Numbering of lenses, p. 33.

Refraction in the Eye. — The eye as a camera obscura, Experiments 1 and 2, p. 35.

[1] Experiments for Students in the Harvard Medical School. Third edition, 1903.

[2] An Introduction to Physiology, Part IV, Physiological Optics, pp. 1–99.

The laboratory work in Physiological Optics is done at night, 7.30 to 10 o'clock.

The Schematic Eye. — *Cardinal points of the cornea* (*System A*). Construction drawing of System A, p. 38. Principal focal distances, p. 39. Determination of principal foci by construction 2, p. 41. Construction of image, p. 41. *Cardinal points of the crystalline lens* (*System B*). Construction drawing of System B, p. 43. Optical centre, p. 44. Nodal points, p. 45. Principal surfaces, p. 46. The point *s*, p. 47. Principal points, p. 48. Principal focal distances, p. 48. *The cardinal points of the eye* (*System C*). Principal surfaces, p. 49. Nodal points, p. 51. Principal foci, p. 52. Calculation of the situation and size of dioptric images, Constructions 1 and 2, pp. 54–56. Reduced eye, p. 56. *Relations of the visual axis*, p. 61. Visual angle, p. 62. Apparent size, p. 62. Size of retinal image, p. 63. Acuteness of vision, p. 63. Smallest perceptible image, p. 64. Measurement of visual acuteness, p. 64.

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Ophthalmoscopy. — Reflection from retina, Experiments 1, 2, 3, and 4, pp. 82–84. Influence of angle between light and visual axis, Experiments 1, 2, and 3, pp. 85–86. Influence of size of pupil,

p. 86. Influence of nearness to pupil, p. 86. Ophthalmoscope, Experiments 1 and 2, p. 87. *Direct method.* Emmetropia, Experiments 1 and 2, pp. 88–90. Ametropia; qualitative determination, p. 91. Measurement of myopia, p. 91. Measurement of hypermetropia, p. 93. Measurement of astigmatism, p. 93. *Indirect method,* Experiments 1 and 2, pp. 94–96.

Vision.[1] — Mapping the blind spot, pp. 33–34. Yellow spot, p. 34. Field of vision, pp. 34–35. Diagnosis of color blindness, pp. 35–37. [Additional experiments in preparation.]

Special Muscular Mechanisms. Respiration. — Inspiration. Expiration. Normal respiration. Forced respiration. Obstructed air passages. Asphyxia. Coughing. Sneezing. Hiccough. Perforation of pleura. [Additional experiments in preparation.]

The Circulation of the Blood.[2] — Conversion of an intermittent into a continuous flow, Experiments 1, 2, and 3, pp. 244–248. The relation between rate of flow and width of bed, p. 248. The relation of peripheral resistance to blood-pressure, p. 250. The curve of arterial pressure in the frog, p. 251. The effect on blood-pressure of increasing the peripheral resistance in the frog, p. 253. Changes in the stroke of the pump; inhibition of the ventricle, p. 253. The effect of inhibition of the heart on blood-pressure in the frog, p. 254. The opening and closing of the valves, p. 255. The period of outflow from

[1] Experiments for Students in the Harvard Medical School. Third edition, 1903.

[2] An Introduction to Physiology, Part II, pp. 239–314.

the ventricle, p. 256. The visible change in form, p. 257. Graphic record of ventricular contraction, p. 258. All contractions maximal, p. 258. Staircase contractions, p. 259. The isolated apex; Bernstein's experiment, p. 259. Rhythmic contractility of heart muscle, p. 260. Constant stimulus may cause periodic contraction, p. 260. The inactive heart muscle still irritable, p. 261. Refractory period; extra-contraction; compensatory pause, p. 261. The transmission of the contraction wave in the ventricle; Engelmann's incisions, p. 262. The transmission of the cardiac excitation from auricle to ventricle; Gaskell's block, Experiments 1, 2, and 3, pp. 263 and 264. Tonus, p. 265. The influence of "load" on ventricular contraction, p. 265. The influence of temperature on frequency of contraction, p. 266. The action of sodium, calcium, potassium in heart muscle, pp. 266–268. The heart sounds, Experiments 1, 2, 3, and 4, pp. 269–271.

The Pressure-Pulse. — Frequency, p. 271. Hardness, p. 272. Form, p. 272. Volume, p. 273. The pressure-pulse in the artificial scheme, p. 273. The human pressure-pulse curve, Experiments 1 and 2, pp. 274–275. Low tension pressure-pulse, Experiments 1 and 2, p. 277. Pressure-pulse in aortic regurgitation, p. 278. Stenosis of the aortic valve, p. 279. Incompetence of the mitral valve, p. 280. The volume pulse, p. 280.

The Innervation of the Heart and Blood-Vessels. — Preparation of the sympathetic, p. 283. Action of the sympathetic on the heart, p. 284. The preparation of the vagus nerve, p. 286. Stimulation of cardiac inhibitory fibres in vagus

trunk, p. 287. Effect of vagus stimulation on the auriculo-ventricular contraction interval, p. 289. Irritability of the inhibited heart, p. 289. Intracardiac inhibitory mechanism, p. 290. Inhibition by Stannius ligature, p. 290. Action of nicotine, p. 291. Atropine, p. 292. Muscarine, p. 292. Antagonistic action of muscarine and atropine, p. 292. Inhibitory centre of the heart nerves, p. 292. Augmentor centre, p. 294. Reflex inhibition of the heart; Goltz's experiment, p. 295. Reflex augmentation, p. 296. The bulbar vasomotor centre, Experiments 1 and 2, pp. 296 and 297. The vasomotor functions of the spinal cord, Experiments 1, 2, and 3, p. 298. Effect of destruction of the spinal cord on the distribution of the blood, p. 299. The vasomotor fibres leave the cord in the anterior roots of spinal nerves, Experiments 1 and 2, p. 300. Vasoconstrictor fibres in the sciatic nerve, p. 302. Vasodilator nerves, Experiments 1 and 2, p. 303. Reflex vasomotor actions, p. 304.

Reproduction. — [Experiments will be announced later.]

Laboratory Note-Book

Each student is required to keep in a laboratory note-book an account of his own experiments and observations. The details of the experiment given in the laboratory publications should of course be omitted. Where the experiment includes a graphic record, such as a muscle curve or a curve constructed upon coördinate paper, the record should be fastened in the laboratory note-book with gummed paper. Diagrams should be

employed whenever necessary, but time should not be spent in needlessly detailed drawing of apparatus. The note-books will be collected every Friday and examined by the instructors.

Conference

The conferences are half-hour exercises devoted to questions and explanations.

Written Tests

In the written tests, which are exercises of twenty minutes' duration, held daily during sixteen weeks, two physiological questions are answered in writing. On Mondays there is an additional written test, an hour in length, in which five questions are answered. The answers are written upon ruled paper of uniform size, 24.5 × 19.5 cm., printed as follows:

Form A.

Harvard Medical School,
Department of Physiology.

Name.....Date.....190....

Desk.....Room.....

In all cases the student is required to cite the experimental evidence for his statement.

Each day's papers are filed in a case, in which a pigeon-hole is provided for each student. In the same pigeon-hole are placed in their turn the student's thesis, laboratory note-book, and final examination papers, constituting a complete record of his work.

The written tests form a most valuable method of instruction. They teach the student to state with precision and brevity the experimental evidence for many of the fundamental conclusions in physiology. At the close of the first month of instruction men whose work the written tests show to be poor are personally consulted regarding their difficulties, often to their great benefit.

The following questions illustrate the written tests:

State experiments to prove where stimulation takes place on closure of the galvanic current. Explain the difference between the stimulating electrodes and the physiological anode and cathode in stimulation of human nerves. What is the reaction of degeneration ? What chemical changes take place in dying muscle ? Draw the curve expressing the absolute force of muscle from the beginning to the end of the phase of rising energy and state how it is obtained. Mark on the intraventricular pressure-curve the moment of opening and closing of the mitral and aortic valves. Give the experimental basis for an explanation of the auriculo-ventricular interval. Describe the action of the vagus nerve upon the heart. Give evidence to show that afferent impulses are transmitted by the posterior roots of spinal nerves. What evidence is there that the fibres passing through the white ramus communicans arborize about a sympathetic cell? Cite experiments to prove that the crystalline lens changes its shape in accommodation. Give evidence that the semicircular canals are concerned in equilibrium. State the evidence for the existence of hot and

cold "spots" on the skin. State the difference between voice and tone. Give a brief account of the digestion of fat. Give proof of the existence of internal secretion. What proof exists that hæmoglobin and oxygen are in loose chemical combination in the blood? How may a nitrogen equilibrium be established?

Lectures and other Didactic Exercises

The accessory data not already provided in the laboratory work are given in the conferences and written tests. The distribution of the remaining didactic exercises, namely, the systematic lectures and the theses, is stated in the Calendar, page 60. The Calendar shows that each didactic exercise is given after its subject has been studied in the laboratory. The lectures and theses are not elementary. The student has already learned the elements from his own experiments and their accessory data. It is the function of the lecture and the thesis to discuss the student's observations and to collate them with the work of other observers. Both lecture and thesis are based on original sources. A list of the subjects discussed in the lectures for 1904 will be found on page 30, and a list of the theses which supplement the lectures will be found on page 35. Lectures that deal with subjects upon which members of the Department have published investigations are given by the investigator himself. The student thereby learns at first hand how certain problems have been set, and the methods by which they have been attacked.

Lectures given in 1904

Date.	Hour.	Subject.
Feb. 1	9–9.30	Introductory lecture.
" 5	"	Physical nature of protoplasm.
" 8	"	Functions of the cell nucleus.
" 9	"	Tropisms.
" 10	"	Ionic theory of stimulation.
" 11	"	Phagocytosis.
" 12	"	Influence of light on protoplasm.
" 19	"	Salivary digestion in the stomach.
" 23	"	Theories of proteid digestion.
" 24	"	Bacterial digestion.
" 25	"	Time relations of digestion.
" 26	"	Inter-relation of digestive fluids.
" 29	"	Theories of fermentation.
March 1	"	Absorption of carbohydrates and proteids. Changes in the products of digestion during their passage through the intestinal wall.
" 2	"	Production of lymph. Lymphagogues.
" 3	"	Theories of coagulation.
" 4	"	Relation of vessel wall to hydræmia. Physiological albuminuria.
" 8	"	The pressure theory of secretion.
" "	12.30–1	The chemical theory of secretion.
" 9	9–9.30	The mode of action of secretory nerves.
" "	12.30–1	Internal secretion of thyroid, suprarenal body, and pituitary body.
" 10	9–9.30	Exchange of gases between the air and the tissues.
" "	9.30–10	Effect of changes in the composition and tension of the respired gases.
" 11	9–9.30	Heat value of foods. Nutritive balance.
" "	9.30–10	Effect of proteids, carbohydrates, fats, and inorganic substances on metabolism. Income and outgo of iron. Starvation.
" 14	9–9.30	Production of fat. Obesity. Transport and deposition of fat.
" 15	"	Relation of diets to work done. Economic diets. Vegetarianism.

LECTURES GIVEN IN 1904 (*continued*)

Date.	Hour.	Subject.
Mar. 16	9–9.30	Heat production and loss.
" 17	"	Effect of high and low external temperature. Baths.
" 18	"	Hypotheses regarding the causation of the demarcation current.
" 21	"	Currents of action in plant tissues.
" 22	"	Theories of electrotonus.
" 23	"	Tetanus.
" 24	"	Tonicity.
" 25	"	The isometric contraction.
" 28	"	The organism as a machine.
" 29	"	Fatigue.
" 30	"	Segmental concept of nervous system. I.
" 31	"	Segmental concept of nervous system. II.
April 1	"	The spinal animal.
" "	"	The spinal animal. Reflexes.
" 4	"	The stimulation and removal of the cortex.
" 5	12.30–1	Association centres of Flechsig.
" 6	9–9.30	The cerebellum.
" 7	"	Path of the respiratory impulse.
" 8	"	The sympathetic.
" 11	"	Voluntary control of "involuntary muscles."
" "	9.30–10	Cutaneous sensations. Referred pain.
" 12	9–9.30	Muscular sense.
" "	9.30–10	Relation of reflex time to reaction time.
" 13	9–9.30	Relation between taste and smell and the chemical-physical properties of the stimulus.
" 14	11.30–12.30	Transmission of sound to labyrinth.
" 15	11.30–12	Analytic properties of the ear.
" 27	9–9.30	Retinal processes. Visual sensations.
" 28	"	Binocular vision. Spatial perception.
" 29	9.30–10	Muscle leverage. Flight. Equilibrium.
" "	9–9.30	Specific energy of the senses.
" "	12.15–1	Locomotion.
May 2	9–9.30	Effect on respiration of compression of the lung. Asthma.

Lectures given in 1904 (*continued*)

Date.	Hour.	Subject.
May 2	9.30–10	Innervation of respiration.
" 3	9–9.30	Voice production.
" "	12.30–1	Formation of consonants. Stuttering. Deaf mutism.
" 4	9–9.30	Functions of upper respiratory tract.
" "	9.30–10	Deglutition. Vomiting.
" 5	9–9.30	Movements of stomach and intestines.
" "	9.30–10	Defecation. Micturition.
" 6	9–9.30	Circulation of lymph. Innervation of lymph vessels.
" 9	"	Physiology of embryonic heart.
" 11	"	Origin of heart-beat.
" 12	"	Closure of the coronary arteries.
" 13	"	Infarction in the heart.
" 16	"	Nutrition of the heart through vessels of Thebesius and coronary veins.
" 17	"	Influence of heart-beat on flow of blood through walls of heart.
" 18	"	Intra-cardiac pressure.
" 19	"	Filling of the heart.
" "	9.30–10	The heart valves.
" 20	9–9.30	Coördination of the ventricles.
" "	9.30–10	The pulse.
" 23	9–9.30	Intra-cardiac nerve mechanisms.
" "	9.30–10	Inhibition.
" 24	9–9.30	Relation of afferent nerves to vasomotor centre. Surgical "shock."
" "	9.30–10	Nerves of lymph vessels.
" 25	9–9.30	Regulation of production and loss of heat.
" "	9.30–10	Growth.
" 26	9–9.30	Menstruation. Impregnation.
" 27	"	Gestation. Infancy.
" "	9.30–10	Inheritance.

Special Demonstrations

In addition to the demonstrations forming part of the lectures the following special demonstrations will be made during 1904.

Special Demonstrations

Date.	Hour.	Subject.
Feb. 6	11–12	Irritability of plant tissue.
" 6	"	Extra currents at the opening and closing of the primary current.
" 13	"	Reaction of degeneration in man.
" 20	"	Galvanotaxis.
" 27	"	Gastric digestion in man.
Mar. 5	12–1	The flow of lymph from the thoracic duct. Action of lymphagogues.
" 12	11–12	The action of the chorda tympani and the sympathetic nerves on secretion by the submaxillary gland.
" 16	9.30–10	Alterations in surface tension.
" 19	11–12	Action current of the human heart.
" 26	"	Total work done by muscle. The work adder.
" 26	"	Electromotive properties of an artificial nerve.
April 2	"	Stimulation of the cerebral cortex.
" 4	9.30–10	The pigeon deprived of cerebral hemispheres.
" 9	11–12	The action of the sympathetic on the smooth muscle of the hairs.
" 28	12–1	Methods of testing color blindness in employees.
" 30	9–9.45	The pigeon with severed external semicircular canals.
" 30	"	The action of the vagus and the superior laryngeal nerves upon the respiratory movements.
May 4	12–1	Movements of the stomach and intestines.
" 7	11–12	The action of the valves in the ox heart.
" 7	"	The inhibition of the mammalian heart.
" 14	9–9.30	Nutrition of the heart through the vessels of Thebesius.
" 21	12–1	Action of the depressor nerve upon the vasomotor centre.
" 21	"	The vasomotor fibres in the cervical sympathetic.

The demonstrations are made to not more than ten students at one time. Care is taken that every student shall see the experiments clearly.

Recitations

A recitation is given weekly during fifteen weeks. The recitation is not an examination; its only purpose is instruction. The questions are asked in an order that will systematically develop the subject treated.

Theses and the Reading of Investigations

Each student is required to write a physiological thesis, the material for which must be taken directly from the report of the original investigators. The subjects chosen are as a rule such as will supplement the instruction given in other ways. In 1904 forty-three theses will be discussed by the class.

Each student is also required to prepare from the original sources the bibliography of one other subject, and to verify his references, so far as the literature is accessible to him.

Students chosen to read their theses are further required to acquaint themselves with the literature of three other subjects in the list to be discussed by the class. These students will open the discussion upon the subjects which they have thus especially studied.

Before the beginning of the course a letter of instructions regarding theses is addressed to each student (Form C, page 71).

THESES DISCUSSED IN 1904

Date.	Hour.	Title.
Mar. 1	12.15–1	Absorption of fat.
" 2	"	Absorption from the peritoneal and pleural cavities.
" 3	"	Utilization of enemata.
" 4	"	Œdema.
" 5	9–9.45	Hæmorrhage and regeneration of blood.
" 7	9.30–10.15	Hæmolysis.
" 8	"	Gland cells in rest and activity.
" 9	"	Internal secretion of the pancreas.
" 10	12.15–1	Excretion of urea.
" 11	"	Elimination of poisons.
" 12	9–9.45	Effect of food on the nature of the digestive secretions.
" 15	12.15–1	Production of glycogen.
" 16	"	Origin of urea.
" 17	"	Alcohol as food ; its stimulant effect on metabolism.
" 18	"	Fever.
" 19	9–9.45	Phosphorescence.
" 22	12.15–1	Ciliary activity.
" 23	"	Nature of muscular contractility.
" 30	"	Changes in nerve cells in rest and activity.
" 31	"	Effect on nerve cells of toxines and of changes in temperature and blood supply.
April 1	"	Nature of the nerve impulse.
" 2	9–9.45	Cross-suturing of nerves.
" 5	"	Sensory areas in the cortex of the brain.
" 6	12.15–1	Aphasia.
" 7	"	Trophic nerves.
" 8	"	Reflexes from sympathetic ganglia.
" 9	9–9.45	Effect of mental states on visceral functions.
" 27	12.15–1	Theories of accommodation of the eye.
" 28	9.30–10.15	Color blindness.

Theses discussed in 1904 (*continued*)

Date.	Hour.	Title.
April 30	11.15–12	Functions of the semicircular canals.
May 3	9.30–10.15	Vowel sounds.
" 5	12.15–1	Massage.
" 17	12.15–1	Effect of gravity on the circulation.
" 18	"	Solutions that maintain the heart-beat.
" 19	"	Adaptation of organs to new conditions.
" 20	"	Natural defences of the organism.
" 21	9–9.45	Physiological effects of high altitudes.
" 24	12.15–1	Peculiarities of the cerebral circulation; cerebral pressure.
" 25	"	Hibernation.
" 26	9.30–10.15	Theories of sleep.
" 26	12.15–1	Artificial parthenogenesis.
" 27	12–12.30	Regeneration.
" 27	12.30–1	Senescence and death.

Theses not discussed in 1904

Physical nature of protoplasm.
Functions of the cell nucleus.
Tropisms.
Ionic theory of stimulation.
Phagocytosis.
Immunity.
Influence of light on protoplasm.
Salivary digestion in the stomach.
Theories of proteid digestion.
Relations of bile to digestion of fats.
Bacterial digestion.
Time relations of digestion.
Inter-relation of digestive fluids
Theories of fermentation.

Absorption of carbohydrates.
Absorption of proteids.
Changes in the products of digestion during their passage through the intestinal wall.
Influence of nerves on intestinal absorption.
Absorption through the skin.
Production of lymph.
Lymphagogues.
Fibrin ferment.
Theories of coagulation.
Agglutination.
Relation of vessel wall to hydræmia.
Physiological albuminuria.
Origin and fate of red blood corpuscles.
Transfusion of blood.
Estimation of hæmoglobin in blood.
Specific gravity of blood.
Coloring matters of the body.
Pressure theory of secretion.
Chemical theory of secretion.
Action of diuretics.
Mode of action of secretory nerves.
Innervation of salivary glands.
Secretion of bile.
Secretion of foreign substances in milk.
Excretion of water by the skin.
Excretion of nitrogen by the skin.
Internal secretion of thyroid gland.
Internal secretion of the kidney.
Internal secretion of suprarenal and pituitary bodies.
Relations between the functions of the spleen and the pancreas.
Exchange of gases between the air and the tissues.
Excretion of carbon dioxide by the skin.
Effect of changes in the composition and tension of the respired gases.

Poisoning by carbon monoxide.
Heat value of foods.
Syntheses in the animal body.
Nutritive balance.
Effect of proteids, carbohydrates, fats, and inorganic substances on metabolism.
Nitrogen equilibrium.
Origin of the oxalic acid of the urine.
Origin of uric acid.
Income and outgo of iron.
Nature of the sugar in the blood.
Starvation.
Production of fat.
Obesity.
Transport and decomposition of fat.
Relation of diets to work done.
Relation of urea excretion to muscle work.
Relation between the activity of muscle and its metabolism.
Economic diets.
Vegetarianism.
Heat production and loss.
Heat production in glands.
Heat production in nerves.
Effect of high and low external temperature.
Baths.
Effect of varnishing the skin.
Hypotheses regarding the causation of the demarcation current.
Currents of action in plant tissues.
Theories of electrotonus.
Tetanus.
Tonicity.
Nature of voluntary muscle contraction.
Isometric contraction.
Muscle fatigue.
The organism as a machine.

General fatigue.
Segmental concept of nervous system.
The spinal animal.
Reflexes.
Knee jerk.
Efferent nerve fibres in posterior root.
Stimulation and removal of the cortex.
Association centres of Flechsig.
The cerebellum.
Path of respiratory impulse.
The sympathetic.
Voluntary control of "involuntary muscles."
Cutaneous sensations.
Referred pain.
Muscular sense.
Rate of nerve impulse.
Relation of reflex time to reaction time.
Relation between taste and smell and the chemical-physical properties of the stimulus.
Transmission of sound to labyrinth.
Analytic properties of the ear.
Retinal processes.
Visual sensations.
Binocular vision.
Spatial perception.
Muscle leverage.
Flight.
Equilibrium.
Specific energy of the senses.
Locomotion.
Effect on respiration of compression of the lung.
Innervation of respiration.
Cause of the first respiration.
Functions of the epiglottis.
Voice production.
Formation of consonants.
Stuttering.

Deafmutism.
Functions of upper respiratory tract.
Deglutition.
Vomiting.
Movements of stomach and intestines.
Defecation.
Micturition.
Circulation of lymph.
Innervation of lymph vessels.
Physiology of embryonic heart.
Origin of heart-beat.
Closure of the coronary arteries.
Infarction in the heart.
Nutrition of the heart through vessels of Thebesius and coronary arteries.
Influence of heart-beat on flow of blood through walls of heart.
Intra-cardiac pressure.
Filling of the heart.
The auriculo-ventricular valves.
The semilunar valves.
First heart sound.
Coördination of the ventricles.
Fibrillar contraction.
The arterial pulse.
The venous pulse.
Action of the sympathetic nerve on the heart.
Action of the vagus nerve on the heart.
Intra-cardiac nerve mechanisms.
Cause of death by electric currents.
Inhibition.
Cause of death after vagus section.
Nerves of lymph vessels.
Depressor nerve.
Vasodilator nerves.
Vasomotor nerves of the lungs.
Vasomotor nerves of the brain.

Vasomotor nerves of intestine.
Vasomotor nerves of muscle.
Venomotor nerves.
Relation of afferent nerves to vasomotor centre.
Surgical "shock."
Regulation of production and loss of heat.
Growth.
Menstruation.
Impregnation.
Gestation.
Infancy.
Inheritance.

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[1] These bibliographies were prepared by my colleague, Professor Cannon.

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Calendar, 1904

Date.	Laboratory Experiments, Rooms B and H. *Special Demonstrations*, Room A.	Written tests (Rooms B and H); Conferences, Recitations, *Systematic Lectures*, and Theses (Room A).
Feb. 1	9.30–1. Methods of stimulation.	9–9.30. Introductory lecture. Prof. Porter.
" 2	9.50–1. Methods of stimulation.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 3	9 50–1. Methods of stimulation.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 4	9.50–1. Methods of stimulation.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 5	10.20–1. Electrical stimulation of tissues.	9–9.30. Lecture. *Physical nature of protoplasm.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 6	11–12. Demonstrations. *Irritability of plants.* Prof. Cannon. *Extra currents at the opening and closing of the primary current.* Prof. Cannon.	10–11. Recitation. Prof. Bowditch.
" 8	10.20–12. Electrical stimulation of tissues.	9–9.30. Lecture. *Functions of the cell nucleus.* Prof. Porter. 9 30–10. Conference. Prof Cannon. 10–10.20. Written test. 12–1. Written test.
" 9	10.20–1. Electrical stimulation of tissues.	9–9.30. Lecture. *Tropisms.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 10	10.20–1. Chemical and mechanical stimulation.	9–9.30. Lecture. *Ionic theory of stimulation.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20 Written test.
" 11	10.20–1. Chemical and mechanical stimulation.	9–9.30. Lecture. *Phagocytosis.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 12	10.20–1. Irritability and conductivity.	9–9.30. Lecture. *Influence of light on protoplasm.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 13	11–12 Demonstration. *Reaction of degeneration in man.* Dr. E. W. Taylor (by invitation).	10–11. Recitation. Prof. Bowditch.
" 15	9.50–12. Irritability and conductivity.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test. 12–1. Written test.

Feb. 16	9.50–1. Irritability and conductivity.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 17	9.50–1. Fermentation and digestion.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 18	9.50–1. Fermentation and digestion.	9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.
" 19	10.20–1. Fermentation and digestion.	9–9 30. Lecture. *Salivary digestion in the stomach.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 10–11. Recitation. Prof. Bowditch.
" 20	11–12. Demonstration. *Galvanotaxis.* Prof. Cannon and Dr. Maxwell.	
" 23	10.20–1. Fermentation and digestion.	9–9.30. Lecture. *Theories of proteid digestion.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 24	10.20–1. Fermentation and digestion.	9–9.30. Lecture. *Bacterial digestion.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 25	10.20–1. Fermentation and digestion.	9–9.30. Lecture. *Time relations of digestion.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 26	10.20–1. Fermentation and digestion.	9–9.30. Lecture. *Interrelation of digestive fluids.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 10–11. Recitation. Prof. Bowditch.
" 27	11–12. Demonstration. *Gastric digestion in man.* Prof. Cannon.	
" 29	10.20–12. Absorption.	9–9.30. Lecture. *Theories of fermentation.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.
Mar. 1	10.20–12.15. Lymph.	9–9.30. Lecture. *Absorption of carbohydrates and proteids. Changes in the products of digestion during their passage through the intestinal wall.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Absorption of fat.
" 2	10.20–12.15. Blood.	9–9.30. Lecture. *Production of lymph. Lymphagogues.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Absorption from the peritoneal and pleural cavities.
" 3	10.20–12.15. Blood.	9–9.30. Lecture. *Theories of coagulation.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Utilization of enemata.
" 4	10.20–12.15. Blood.	9–9.30. Lecture. *Relation of vessel wall to hydraemia. Physiological albuminuria.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Oedema.

CALENDAR 1904 — (*continued*).

Date.	Laboratory Experiments, Rooms B and H. *Special Demonstrations*, Room A.	Written test (Rooms B and H); Conferences, Recitations, *Systematic Lectures*, and Theses (Room A).
Mar. 5	12–1. Demonstration. *The flow of lymph from the thoracic duct. Action of lymphagogues.* Profs. Porter and Cannon.	9–9.45. Thesis. Hæmorrhage and regeneration of blood. 10–11. Recitation. Prof. Bowditch.
" 7	10.25–12. Blood.	9–9.30. Conference. Prof. Cannon. 9.30–10.15. Thesis. Hæmolysis. 10.15–10.35. Written test. 12–1. Written test.
" 8	10.35–12.30. Secretion.	9–9.30. Lecture. *The pressure theory of secretion.* Prof. Porter. 9.30–10.15. Thesis. Gland cells in rest and activity. 10.15–10.35. Written test. 12.30–1. Lecture. *The chemical theory of secretion.* Prof. Porter.
" 9	10.35–12.30. Respiratory exchange.	9–9.30. Lecture. *The mode of action of secretory nerves.* Prof. Porter. 9.30–10.15. Thesis. Internal secretion of the pancreas. 10.15–10.35. Written test. 12.30–1. Lecture. *Internal secretion of thyroid, suprarenal body, and pituitary body.* Prof. Porter.
" 10	10.20–12.15. Metabolism.	9–9.30. Lecture. *Exchange of gases between the air and the tissues.* Prof. Porter. 9.30–10. Lecture. *Effect of changes in the tension and composition of the respired gases.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. Excretion of urea.
" 11	10.20–12.15. Metabolism.	9–9.30. Lecture. *Heat value of foods. Nutritive balance.* Prof. Porter. 9.30–10. Lecture. *Effect of proteids, carbohydrates, fats, and inorganic substances on metabolism. Income and outgo of iron. Starvation.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. Elimination of poisons.

Mar. 12	11–12. Demonstration. *The action of the chorda tympani and the sympathetic nerves on secretion by the submaxillary gland.* Prof. Cannon.	9–9.45. Thesis. **Effect of food on the nature of the digestive secretions.** 10–11. Recitation. Prof. Bowditch.
" 14	10.20–12. Nutrition. Diet.	9–9.30. Lecture. *Production of fat. Obesity. Transport and deposition of fat.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.
" 15	10.20–12.15. Animal heat.	9–9.30. Lecture. *Relation of diet to work done. Economic diets. Vegetarianism.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Production of glycogen.**
" 16	9.30–10. Demonstration. *Alterations in surface tension.* Prof. Cannon. 10.20–12 15. Electromotive phenomena.	9–9.30. Lecture. *Heat production and loss.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. **Origin of urea.**
" 17	10.20–12.15. Electromotive phenomena.	9–9.30. Lecture. *Effect of high and low external temperature. Baths.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Alcohol as food; its stimulant effect on metabolism.**
" 18	10.20–12.15. Electromotive phenomena.	9–9.30. Lecture. *Hypotheses regarding the causation of the demarcation current.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Fever.**
" 19	11–12. Demonstration. *Action current of the human heart.* Prof. Cannon.	9–9.45. Thesis. **Phosphorescence.** 10–11. Recitation. Prof. Bowditch.
" 21	10.20–12. Electromotive phenomena.	9–9.30. Lecture. *Currents of action in plant tissue.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.
" 22	10.20–12.15. Change of form in contractile tissue.	9–9.30. Lecture. *Theories of electrotonus.* Prof. Porter. 9.30–10. Conference. 10–10.20. Written test. 12.15–1. Thesis. **Ciliary activity.**
" 23	10.20–12.15. Change of form.	9–9.30. Lecture. *Tetanus.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Nature of muscular contractility.**
" 24	10.20–1. Change of form.	9–9.30. Lecture. *Tonicity.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.

CALENDAR 1904 — (*continued*).

Date.	Laboratory Experiments, Rooms B and H. *Special Demonstrations*, Room A.	Written tests (Rooms B and H); Conferences, Recitations, *Systematic Lectures*, and Theses (Room A).
Mar. 25	10.20–1. Change of form.	9–9.30. Lecture. *The isometric contraction.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 10–11. Recitation. Prof. Bowditch.
" 26	11–12. Demonstrations. *Total work done by muscle. The work adder.* Prof. Porter. *Electromotive properties of an artificial nerve.* Prof. Cannon.	
" 28	10.20–12. Change of form.	9–9.30. Lecture. *The organism as a machine.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.
" 29	10.20–1. Change of form.	9–9.30. Lecture. *Fatigue.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 30	10.20–12.15. Spinal cord and brain.	9–9.30. Lecture. *Segmental concept of nervous system* I. Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Changes in nerve cells in rest and activity.
" 31	10.20–12.15. Spinal cord and brain.	9–9.30. Lecture. *Segmental concept of nervous system* II. Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Effect on nerve cells of toxines and of changes in temperature and blood supply.
Apr. 1	10.20–12.15. Spinal cord and brain.	9–9.30. Lecture. *The spinal animal.* Prof. Cannon. 9.30–10. Lecture. *The spinal animal. Reflexes.* Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Nature of nerve impulse.
" 2	11–12. Demonstration. *Stimulation of the cerebral cortex.* Prof. Cannon.	9–9.45. Thesis. Cross-suturing of nerves. 10–11. Recitation. Prof. Bowditch.

Apr. 4	9 30–10. Demonstration. *The pigeon deprived of cerebral hemispheres.* Prof. Cannon. 10.20–12. Spinal cord and brain.	9–9.30. Lecture. *The stimulation and removal of the cortex.* Prof. Cannon. 10–10.20. Written test. 12–1. Written test.
" 5	10.20–12.30. Spinal cord and brain.	9–9.45. Thesis. Sensory areas in the cortex of the brain. 10–10.20. Written test. 12.30–1. Lecture. *Association centres of Flechsig.* Prof. Cannon.
" 6	10.20–12.15. Spinal cord and brain.	9–9.30. Lecture. *The cerebellum.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Aphasia.
" 7	10.20–12.15. Spinal cord and brain.	9–9.30. Lecture. *Path of the respiratory impulse.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Trophic nerves.
" 8	10.20–12.15. Sympathetic.	9–9.30. Lecture. *The sympathetic.* Prof. Cannon. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Reflexes from sympathetic ganglia.
" 9	11–12. Demonstration. *The action of the sympathetic on the smooth muscle of the hairs.* Prof. Cannon.	9–9.45. Thesis. Effect of mental states on visceral functions. 10–11. Recitation. Prof. Bowditch.
" 11	10.20–12. Cutaneous sensations.	9–9.30. Lecture. *Voluntary control of "involuntary" muscles.* Dr. Maxwell. 9.30–10. Lecture. *Cutaneous sensations. Referred pain.* Prof. Porter. 10–10.20. Written test. 12–1. Written test.
" 12	10.20–1. Cutaneous sensations.	9–9.30. Lecture. *Muscular sense.* Prof. Porter. 9.30–10. Lecture. *Relation of reflex time to reaction time.* Prof. Cannon. 10–10.20. Written test.
" 13	10.20–1. Taste. Smell. Hearing.	9–9.30. Lecture. *Relation between taste and smell, and the chemical and physical properties of the stimulus.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.
" 14	8–10 P. M. Physiological optics.	11–11.30. Written test. 11.30–12.30. Lecture. *Transmission of sound to labyrinth.* Dr. C. J. Blake (by invitation). 7.30–8 P. M. Conference. Prof. Cannon.
" 15	8–10 P. M. Physiological optics.	11.30–12. Lecture. *Analytic properties of the ear.* Prof. Porter. 12–12.30. Conference. Prof. Cannon. 12.30–12.50. Written test.
" 16		10–11. Recitation. Prof. Bowditch.
" 25	8–10 P. M. Physiological optics.	11.30–12. Conference. Prof. Cannon. 12–1. Written test.

CALENDAR 1904 — (*continued*).

Date.	Laboratory Experiments, Rooms B and H. *Special Demonstrations*, Room A.	Written tests (Rooms B and H); Conferences, Recitations, *Systematic Lectures*, and Theses (Room A).
Apr. 26	7.30–10 P. M. Physiological optics.	12–12.30. Conference. Prof. Cannon. 12.30–12.50. Written test.
" 27	10.20–12.15. Vision.	9–9.30. Lecture. *Retinal processes. Visual sensations.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. Theories of accommodation of the eye.
" 28	10.25–12. Vision. 12–1. Demonstration. *Methods of testing color blindness in employees.* Dr. C. H. Williams (by invitation).	9–9.30. Lecture. *Binocular vision. Spatial perception.* Prof. Porter. 9.30–10.15. Thesis. Color blindness. 10.15–10.25. Written test.
" 29	10.20–12.15. Special muscular mechanisms. Respiration.	9–9.30. Lecture. *Specific energy of the senses.* Prof. Porter. 9.30–10. Lecture. *Muscle leverage. Flight. Equilibrium.* Prof. Porter. 10–10.20. Written test. 12.15–1. Lecture. *Locomotion.* Dr. E. H. Bradford (by invitation).
" 30	11–12. Demonstrations. *The pigeon with severed external semicircular canals.* Prof. Cannon. *The action of the vagus and the superior laryngeal nerves upon the respiratory movements.* Prof. Porter.	9–9.45. Thesis. Functions of the semicircular canals. 10–11. Recitation. Prof. Bowditch.
May 2	10.20–12. Circulation.	9–9.30. Lecture. *Effect on respiration of compression of the lung. Asthma.* Prof. Porter. 9.30–10. Lecture. *Innervation of respiration.* Prof. Porter. 10–10.20. Written test. 12–1. Written test.
" 3	10.35–12.30. Circulation.	9–9.30. Lecture. *Voice production.* Prof. Porter. 9.30–10.15. Thesis. Vowel sounds. 10.15–10.35. Written test. 12.30–1. Lecture. *Formation of consonants. Stuttering. Deafmutism.* Prof. Porter.

May	4	10.20–12. Circulation. 12–1. Demonstration. *Movements of the stomach and intestines.* Prof. Cannon.
"	5	10.20–12.15. Circulation.
"	6	10.20–1. Circulation.
"	7	11–12. Demonstrations. *The action of the valves in the ox heart.* Prof. Cannon. *The inhibition of the mammalian heart.* Prof. Porter.
"	9	10.20–12. Circulation.
"	10	9.50–1. Circulation.
"	11	10.20–1. Circulation.
"	12	10.20–1. Circulation.
"	13	10.20–1. Circulation.
"	14	11–12. Demonstration. *Nutrition of the heart through the vessels of Thebesius.* Prof. Porter.
"	16	10.20–12. Circulation.
"	17	10.20–12.15. Circulation.
"	18	10.20–12.15. Circulation.
"	19	10.20–12.15. Circulation.

9–9.30. Lecture. *Functions of upper respiratory tract.* Dr. J. L. Goodale (by invitation). 9.30–10. Lecture. *Deglutition. Vomiting.* Prof. Porter. 10–10.20. Written test.

9–9.30. Lecture. *Movements of stomach and intestine.* Prof. Cannon. 9.30–10. Lecture. *Defecation. Micturition.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. **Massage.**

9–9.30. Lecture. *Circulation of lymph. Innervation of lymph vessels.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.

10–11. Recitation. Prof. Bowditch.

9–9.30. Lecture. *Physiology of embryonic heart.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.

9–9.30. Conference. Prof. Cannon. 9.30–9.50. Written test.

9–9.30. Lecture. *Origin of heart beat.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.

9–9.30. Lecture. *Closure of the coronary arteries.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.

9–9 30. Lecture. *Infarction in the heart.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test.

10–11. Recitation. Prof. Bowditch.

9–9.30. Lecture. *Nutrition of the heart through vessels of Thebesius and coronary veins.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12–1. Written test.

9–9.30. Lecture. *Influence of heart-beat on flow of blood through walls of heart.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Effect of gravity on the circulation.**

9–9.30. Lecture. *Intra-cardiac pressure.* Prof. Porter. 9.30–10. Conference. Prof. Cannon. 10–10.20. Written test. 12.15–1. Thesis. **Solutions that maintain the heart beat.**

9–9.30. Lecture. *Filling of the heart.* Prof. Porter. 9.30–10. Lecture. *The heart valves.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. **Adaptation of organs to new conditions.**

CALENDAR 1904 — (*continued*).

Date.	Laboratory Experiments, Rooms B and H. *Special Demonstrations*, Room A.	Written tests (Rooms B and H); Conferences, Recitations, *Systematic Lectures*, and Theses (Room A).
May 20	10.20–12.15. Circulation.	9–9.30. Lecture. *Coördination of the ventricles.* Prof. Porter. 9.30–10. Lecture. *The pulse.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. Natural defences of the organism.
" 21	12–1. Demonstrations. *Action of the depressor nerve upon the vasomotor centre.* Prof. Porter. *The vasomotor fibres in the cervical sympathetic.* Prof. Cannon.	9–9.45. Thesis. Physiological effects of high altitudes. 10–11. Recitation. Prof. Bowditch.
" 23	10.20–12. Circulation.	9–9.30. Lecture. *Intra-cardiac nerve mechanisms.* Prof Porter. 9.30–10. Lecture. *Inhibition.* Prof. Porter. 10–10.20. Written test. 12–1. Written test.
" 24	10.20–12.15. Circulation.	9–9.30. Lecture. *Relation of afferent nerves to vasomotor centre. Surgical shock.* Prof. Porter. 9.30–10. Lecture. *Nerves of lymph vessels.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. Peculiarities of cerebral circulation; cerebral pressure.
" 25	10.20–12.15. Circulation.	9–9.30. Lecture. *Regulation of production and loss of heat.* Prof. Porter. 9.30–10. Lecture. *Growth.* Prof. Porter. 10–10.20. Written test. 12.15–1. Thesis. Hibernation.
" 26	10.35–12.15. Circulation.	9–9.30. Lecture. *Menstruation. Impregnation.* Prof. Porter. 9.30–10.15. Thesis. Theories of sleep. 10.15–10.35. Written test. 12.15–1. Thesis. Artificial parthenogenesis.
" 27	10.20–12. Reproduction.	9–9.30. Lecture. *Gestation. Infancy.* Prof. Porter. 9.30–10. Lecture. *Inheritance.* Prof. Porter. 10–10.20. Written test. 12–12.30. Thesis. Regeneration. 12.30–1. Thesis. Senescence and death.
" 28	Practical examination.	
" 31	Practical examination.	

General Instructions to Students

Four weeks before the beginning of the course the following letter is sent to each student :[1]

Form B.

Department of Physiology,
Harvard Medical School,
January 1, 1904.

Dear Sir : —

Since many of the laboratory experiments in physiology require two men for their successful performance, the class will be divided into pairs. Students may work with whom they please, provided those desiring to work together give written notice to Professor W. T. Porter not later than January 20. Where no preference is expressed the pairing will be made from an alphabetical list. The distribution of the pairs at the laboratory desks will be posted on the bulletin board January 27. Students are advised to provide themselves with the following articles:

1. A dissecting case, including scissors, one large and one small forceps, and a seeker.
2. A small towel.
3. A piece of cotton cloth about 40 × 40 cm.
4. A microscope. One of the two microscopes required by each pair of students must be provided with a hinged standard allowing the stage to be tilted to a perpendicular position. Microscopes may be rented from the Department of Histology.
5. The pamphlet entitled "Physiology at Harvard."
6. The Physiological Laboratory Note-book.

[1] Letters, lists of apparatus, and similar matter for the use of students are printed upon the Rotary Neostyle.

7. An Introduction to Physiology, Parts I and II, bound together in cloth.
8. Experiments for Harvard Medical Students, Third Edition, bound in gray paper, with supplemental sheets.
9. An Introduction to Physiology, Part IV, bound in gray paper.
10. The Physiological Thesis Book.

These articles are sold at 707 Boylston Street, Boston, Mass.

First-year medical and dental students, advanced students, and students taking the course a second time, will meet Professor Porter in Room A, February 1, at 9 A. M.

At 9.30 A. M. the students will find their desks in Rooms B and H. Each desk bears the names of the owners upon a printed slip. Each student will receive a key to the locker in his desk. For each key a deposit of one dollar will be required, to be refunded when the key is returned.

Within the cupboard and drawers of the locker will be found the first issue of apparatus, together with a printed receipt (see Appendix, Form G, page 102). Articles marked * will be found in the small wooden boxes. The list should be verified and the receipt signed by each student. This receipt will be retained by the Department.

The apparatus is issued in good condition, and students will be held responsible for its return in good condition. The cost of cleaning, repairing, or replacing articles which become damaged, will be charged to the students to whom they were issued. A list of the articles liable to be broken beyond repair is posted in the laboratories, with the cost opposite each (see Appendix, Form O, page 117). Students desiring additional apparatus

must present a signed requisition for the desired article (see Appendix, Form F, p. 102).

Frogs and tortoises will be issued on the presentation of signed requisitions. Students using more than the average number of animals will be charged ten cents for each additional medium-sized frog, and twenty-five cents for each large frog and each tortoise.

Every charge will be divided equally between the two members of the pair represented by the name on the requisition.

You are advised to keep this letter for reference.

Very truly yours,

W. T. Porter.

Form C.

INSTRUCTIONS FOR THESIS

Harvard Medical School,
Department of Physiology,
Boston, February 2, 1904.

Dear Sir: —

In the first-year course in physiology, each student is required to write a physiological thesis, the material for which must be taken directly from the original investigations. As many of the investigations are in German or French, you are requested to state upon the enclosed card (Form D) whether you can read one or both of these languages. On pages 35–41 of the pamphlet entitled "Physiology at Harvard" you will find a list of subjects for theses which will be discussed by the class in 1904, and a second list of subjects for theses to be written but not discussed during the present year. Your record during your first term

in the Medical School assigns you to the {first / second} list. Your subject will be given you at least four weeks before your thesis is due. If in the first list, you will find references to the original literature of your subject on pages 41–58 of the pamphlet "Physiology at Harvard." If in the second list, you will receive an envelope bearing the subject of the thesis and the references to original sources. The names of the Boston and Cambridge libraries which contain the physiological journals and other sources may be had from the "List of periodicals, etc., currently received, in the principal libraries of Boston and vicinity," published by the Trustees of the Boston Public Library. Your receipt for the reference card will be taken (Form E). The card must be returned when the thesis is handed in. Your assistance in the correction of errors and omissions in the references will be much appreciated.

The thesis should not exceed two thousand words. It should be written with ink in a Physiological Thesis Book. Every statement not the writer's own must be accompanied by a reference to the original source, giving author's name, name of journal or title of book, year of publication, number of volume, and the page upon which the statement appears. The thesis should begin with a brief outline of the problem and the way in which investigators have attacked it, and should end with a summary of the results attained.

You are also required to write upon Form A a bibliography which you yourself will prepare from the "Centralblatt für Physiologie," the "Jahresbericht für Physiologie," the reviews in the "Journal de physiologie et de pathologie générale," and the original sources. The subject for your bibliography will be placed upon Form E.

Students whose rank entitles them to read theses will further be required to acquaint themselves with the literature of three other subjects in the list to be discussed by the class. References to this literature are given on pages 41–58 of the pamphlet "Physiology at Harvard." The subjects assigned to you will be found upon Form E. Each thesis subject, therefore, will be studied in full by the author of the thesis, and by three disputants. When the thesis is read, the three students who have each prepared that subject will open the discussion.

Very truly yours,

W. T. Porter.

Form D.

Harvard Medical School,
Boston, ...

Dear Sir: —

I {cannot / can} read French and German. My preference of subjects for a thesis is as follows:

1. .....

2. .....

3. .....

Very truly yours,

.....

Form E.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
BOSTON,.....

I have received this day the notice / references for the thesis on.....
This thesis, together with the reference card, is to be delivered to Professor W. T. Porter not later than.....
I have also been notified to prepare a bibliography upon the subject.....
This bibliography, written upon Form A, is to be delivered to Professor W. T. Porter not later than June 1.
I have further been notified to prepare for discussion the original literatures of the three subjects the theses upon which are to be read upon the following days.....
(See "Physiology at Harvard," pages 35–58.)
(Signed).....

This form is issued in duplicate. The student will retain one copy.

EXAMINATIONS

In order to receive the degree of Doctor of Medicine the student must have demonstrated to the Department of Physiology that his training in this subject is satisfactory. The character of the student's work during the four months of his instruction counts materially toward his final grade. At the end of the term two formal examinations are held, one of which is practical, while the second is written. Candidates failing

in the June examination may be re-examined in September. In the practical examination, the student is required to perform four out of six experiments assigned him by lot. He is examined during two half-days, receiving each day three experiments, from which he must choose two. The character of this test will be understood from the following instructions to students and the list of experiments assigned in June, 1903.

Department of Physiology

PRACTICAL EXAMINATION, JUNE 2, 3, 4, 5, 1903.

Not more than three hours will be allowed. Each student will perform two of the three experiments allotted to him. In each case he will write on one of the blank forms furnished herewith the problem selected and an account of his results; if the student does not also make a graphic record of his results he must demonstrate them to the instructor, who will then immediately countersign the student's written statement. Graphic records must be marked plainly with the student's name and placed in a shellacking-frame. At the close of the student's work the graphic records, the slip bearing the questions, and the account of the results should all be handed to one of the Staff.

No student may leave his desk until his examination is finished. Necessary apparatus not already in the locker may be obtained by signing a requisition.

Practical Examination in Physiology

[Each student is required to make four of the six experiments drawn by him, and to write an account of his observations on the blank furnished herewith. Where the results of the experiments are not expressed in a graphic record they must be demonstrated to the instructor.]

1. Record the action of the sympathetic on the heart. Demonstrate the progressive spreading of impulses in the central nervous system. Record curves showing the influence of changes in the aortic pressure on the interval between the beginning of ventricular contraction and the opening of the semilunar valves (in the artificial scheme).

2. Demonstrate that the cardiac systole is a simple and not a tetanic contraction. Show the influence of load on the work done by the skeletal muscle. Show where the more complicated coördinated reflex acts have their centres.

3. Show evidence that the ventricular contraction wave may be transmitted by muscular tissue. Prove that the excitability of a nerve is altered in the neighborhood of the anode and the cathode during the passage of the galvanic current. Secure a record of the effect of duration of stimulus on smooth muscle.

4. Furnish experimental evidence for an explanation of the auriculo-ventricular interval. Prove that the galvanic current stimulates during the whole time of its passage through an irritable tissue. Demonstrate the influence of increased load on ventricular contraction.

5. Prove the existence of tonic contraction of muscle. Demonstrate the current of action in muscle or nerve. Give experimental evidence that the vagus connects with the nerve cells in the heart.

6. Demonstrate polar stimulation by the galvanic current. Show the vasomotor functions of the spinal cord. Demonstrate the inhibition of reflex action in the frog.

7. Show the function of the anterior spinal nerve-roots. Record with the artificial scheme pulse curves of low arterial tension and high arterial tension, and discuss their method of production. Construct diagrams showing the formation of the image (1) in myopia, (2) in hypermetropia, (3) in hypermetropia with a correcting lens.

8. Record the effect of inhibition of the heart on arterial pressure in the frog. Demonstrate on muscle the different effect of sudden and of gradual increase in intensity of stimulus. Prove the discontinuous nature of tetanic contraction.

9. Record the effect of stimulation of the vagus on the beat of the ventricle. Show that all contractions of heart muscle are maximal. Give experimental evidence that a nerve fibre may conduct impulses in both directions.

10. Show by diagram the method of determining the size of a retinal image. Demonstrate the limits of the refractory period and the existence of the compensatory pause. Prove that the demarcation current (current of injury) may act as a stimulus.

11. Record curves showing the influence of temperature on the contraction of skeletal muscle. Demonstrate differences in the physiology of smooth and striated muscle. Show that the control of movements is localized at different levels of the spinal cord.

12. Show that a constant stimulus may cause periodic contraction. Show the influence of fatigue on muscular contraction. Draw a construction showing the formation of the image in the indirect method of observing the retina.

13. Show the segmental arrangement of the reflex apparatus. Draw a diagram showing the course of the rays in astigmatism. Show the influence of an increase in peripheral resistance on the blood pressure in the frog.

14. Prove the independent irritability of muscle. Show experimental proof of the law of contraction with weak, medium, and strong ascending currents. Demonstrate with the artificial thorax the relations between pulmonary and intra-thoracic pressure during inspiration and expiration. State these relations in writing, with diagrams.

15. Compare an isometric contraction with an isotonic contraction. Obtain from the artificial scheme of the circulation a characteristic pulse curve of aortic regurgitation and explain its production. Demonstrate and discuss the apparent purpose in reflex action.

16. Demonstrate that the physiological anode and cathode may differ from the physical poles. Prove that oxidation may be caused by animal tissue. Demonstrate the influence of the sympathetic nerve on the iris of the frog.

17. Demonstrate polar inhibition. Demonstrate the importance of the nucleus in intracellular oxidations. Prove that tonic and simple contractions of the same tissue may occur at the same time.

Written Examination

In the written examination four[1] subjects are announced. Of these, the student chooses three, upon each of which he must write a brief account of the more important knowledge in that subject.

[1] In September, 1900, six, and in June, 1901, five, subjects were presented, of which were chosen four in each case.

The subjects from September, 1900, to June, 1903, were as follows:

1. Describe the coagulation of either blood or milk, stating both the physical and chemical phenomena.
2. Describe and draw an artificial scheme upon which the physical phenomena of the circulation of the blood can be demonstrated.
3. Give experimental evidence to show how the tetanic contraction of muscle is produced.
4. Describe fully the interchange between the air in the alveoli and the gases in the blood.
5. Give the complete course of any one of the ascending or descending tracts in the central nervous system.
6. Give experiments establishing the importance of any one of the internal secretions.
7. Draw curves showing the changes of pressure in the auricle, ventricle, and aorta from the beginning of one auricular contraction to the beginning of the next. Add brief explanatory notes.
8. Give an account of the physiology of smooth muscle.
9. Discuss the chemistry of respiration.
10. Draw the motor area of the cortex and give evidence in support of the theory of cortical localization.
11. Write a sketch of the physiology of absorption.
12. Give an account of the physiology of ferments.
13. Describe the principal conducting paths in the spinal cord.
14. Give a general description of the vasomotor nervous system.
15. State experiments in support of a theory of accommodation in the eye.

16. Give an account of the innervation of the heart.
17. Describe the digestion of proteids.
18. Discuss the sensory functions of the skin.
19. Sketch the metabolism of carbohydrates.
20. Give a brief account of the electrical properties of muscle.
21. Sketch the metabolism of proteids.
22. Discuss the functions of the glomeruli of the kidney.
23. State the principal facts regarding the physiology of the sympathetic nerves.
24. Give an account of the physiology of ferments.
25. Draw a diagram of the "reduced" eye and state how this simplification is justified.
26. State the principal observations establishing "internal" secretion.
27. Sketch the physiology of the pulse.

The last examination paper, September, 1903, is reprinted in full.

Physiology

[Answer any three questions, but not more than three. The answer to any one question must not exceed three hundred words. Mention, where possible, experimental evidence in support of your opinion. Matter not bearing directly on the question asked will count against the writer.]

1. Compare the functions of the cerebral hemispheres with those of the spinal cord.
2. Discuss the pressure theory of secretion.
3. Discuss the mechanics of respiration.
4. Sketch the general methods by which food values may be determined.

III

THE FOURTH YEAR ELECTIVE COURSE

STUDENTS in the fourth year of the Medical School may elect additional work in any field of physiology. It is to be presumed that such students desire additional work in physiology to fit them for some special field of medicine, for example the diseases of the nervous system; or they may wish to pursue physiology, pathology, or some other biological science as a profession. They will be received into the research laboratories of the department, and will carry on their studies side by side with the members of the Staff. The work will consist of fundamental experiments, the study of accessory data, and the reading of selected original investigations. The student will be guided by personal conferences with the professor in charge, and, if desirable, by informal lectures.

This course counts toward the degree of Doctor of Medicine, and an examination, largely practical, will be required.

IV

PHYSIOLOGICAL RESEARCH

THE laboratories are open at all times to students qualified to undertake research. The following investigations have been published during the past eight years:

1896

PORTER, W. T.: The vasomotor nerves of the heart. Boston medical and surgical journal, 1896, cxxxiv, pp. 39, 40.

PORTER, W. T.: Weiteres über den Verschluss der Coronararterien ohne mechanische Verletzung. Centralblatt für Physiologie, 1896, ix, pp. 641–647.

PORTER, W. T.: The use of anthropometrical measurements in schools. Educational review, 1896, pp. 126–133.

PORTER, W. T.: Further researches on the closure of the coronary arteries. Journal of experimental medicine, 1896, i, pp. 46–70.

PORTER, W. T.: A new method for the study of the intracardiac pressure curve. Journal of experimental medicine, 1896, i, pp. 296–303.

1897

MAGRATH, J. B., and H. KENNEDY: On the relation of the volume of the coronary circulation to the frequency and force of the ventricular contraction in the isolated heart of the cat. Journal of experimental medicine, 1897, ii, pp. 13–34.

PORTER, W. T.: 1. On the cause of the heart-beat. 2. The recovery of the heart from fibrillary contractions. 3. Note on the relation between the beat of the ventricle and the flow of blood through the coronary arteries. Journal of the Boston society of the medical sciences, 1897, i, pp. 15–21.

PORTER, W. T.: On the cause of the heart-beat. Journal of experimental medicine, 1897, ii, pp. 391–404.

1898

PORTER, W. T.: The recovery of the heart from fibrillary contractions. American journal of physiology, 1898, i, pp. 71–82.

PRATT, F. H.: The nutrition of the heart through the vessels of Thebesius and the coronary veins. American journal of physiology, 1898, i, pp. 86–103.

PORTER, W. T.: The influence of the heart-beat on the flow of blood through the walls of the heart. American journal of physiology, 1898, i, pp. 145–163.

HYDE, I. H.: The effect of distention of the ventricle on the flow of blood through the walls of the heart. Americal journal of physiology, 1898, i, pp. 215–224.

Cleghorn, A.: The reinforcement of voluntary muscular contractions. American journal of physiology, 1898, ii, pp. 336–345.

Cannon, W. B.: The movements of the stomach studied by means of the Röntgen rays. American journal of physiology, 1898, i, pp. 359–382.

Cannon, W. B., and A. Moser: The movements of the food in the œsophagus. American journal of physiology, 1898, i, pp. 435–444.

Bancroft, F. W.: The venomotor nerves of the hind limb. American journal of physiology, 1898, i, pp. 477–485.

Muskens, L. J. J.: An analysis of the action of the vagus nerve on the heart. American journal of physiology, 1898, i, pp. 486–510.

Porter, W. T.: A new method for the study of the isolated mammalian heart. American journal of physiology, 1898, i, pp. 511–518.

1899

Porter, W. T.: The coördination of the ventricles. American journal of physiology, 1899, ii, pp. 127–136.

Stewart, C. C.: On the course of impulses to and from the cat's bladder. American journal of physiology, 1899, ii, pp. 182–202.

Baumgarten, W.: Infarction in the heart. American journal of physiology, 1899, ii, pp. 243–265.

Cleghorn, A.: The action of animal extracts, bacterial cultures, and culture filtrates on the mammalian heart muscle. American journal of physiology, 1899, ii, pp. 273–290.

Cleghorn, A.: The physiological action of extracts of the sympathetic ganglia. American journal of physiology, 1899, ii, pp. 471–482.

WOODWORTH, R. S.: Studies in the contraction of smooth muscle. American journal of physiology, 1899, iii, pp. 26–44.

MATHEWS, A. P.: The origin of fibrinogen. American journal of physiology, 1899, iii, pp. 53–85.

1900

DEARBORN, G. V. N.: Notes on the individual psycho-physiology of the crayfish. American journal of physiology, 1900, iii, pp. 404–433.

PORTER, W. T., and H. G. BEYER: The relation of the depressor nerve to the vasomotor centre. American journal of physiology, 1900, iv, pp. 283–299.

PORTER, W. T., and W. MUHLBERG: Experiments concerning the prolonged inhibition said to follow injury of the spinal cord. American journal of physiology, 1900, iv, pp. 334–342.

FRANZ, S. I.: On the methods of estimating the force of voluntary contractions and on fatigue. American journal of physiology, 1900, iv, pp. 348–372.

CLEGHORN, A.: The physiological effects and the nature of extracts of sympathetic ganglia. Journal of the Boston Society of the Medical Sciences, 1900, iv, pp. 239–242.

1901

MATHEWS, A. P.: The spontaneous secretion of saliva and the action of atropine. American journal of physiology, 1901, iv, pp. 482–499.

McCurdy, J. H.: The effect of maximum muscular effort on blood-pressure. American journal of physiology, 1901, v, pp. 95–103.

Cleghorn, A., and C. C. Stewart: The inhibition time of a voluntary muscular contraction. American journal of physiology, 1901, v, pp. 281–286.

Cannon, W. B.: Cerebral pressure following trauma. American journal of physiology, 1901, vi, pp. 91–121.

1902

Cannon, W. B.: The movements of the intestines studied by means of the Röntgen rays. American journal of physiology, 1902, vi, pp. 251–277.

Opitz, R. B.: A comparative study in the viscosity of the blood. American journal of physiology, 1902, vii, pp. 243–260.

Lillie, R. S.: On the oxidative properties of the cell-nucleus. American journal of physiology, 1902, vii, pp. 412–421.

Opitz, R. B.: The flow of the blood in the external jugular vein. American journal of physiology, 1902, vii, pp. 435–459.

Franz, S. I.: On the functions of the cerebrum: I. The frontal lobes in relation to the production and retention of simple sensory-motor habits. American journal of physiology, 1902, viii, pp. 1–22.

Woodworth, R. S.: Maximal contraction, "staircase" contraction, refractory period, and compensatory pause, of the heart. American journal of physiology, 1902, viii, pp. 213–249.

1903

CANNON, W. B.: Further observations on the movements of the stomach and intestines. American journal of physiology, 1903, viii, pp. xxi–xxii.

PORTER, W. T.: The tonus of heart muscle. American journal of physiology, 1903, viii, p. xxvi.

PORTER, W. T.: New inductorium, kymograph, heart lever, heavy muscle lever, and square rheochord. American journal of physiology, 1903, viii, pp. xxxv–xli.

CANNON, W. B., and H. F. DAY: Salivary digestion in the stomach. American journal of physiology, 1903, viii, p. xxviii; and ix, pp. 396–416.

PORTER, W. T., and W. C. QUINBY: The condition of the vasomotor neurons in "shock." Boston medical and surgical journal 1903, cxlix, pp. 455–456.

CANNON, W. B.: Observations on the mechanics of digestion. Journal of the American medical association, 1903, xl, pp. 749–753.

V

THE SUMMER COURSE

THE summer course in physiology will be given daily during the five weeks from June 27 to July 30, 1904, inclusive. This course will be found to be valuable to instructors of schools and colleges who seek experience in the teaching of physiology by laboratory methods. Students who wish to prepare themselves for the courses in the Medical School, or who may desire to recover ground lost by illness or other misfortune, will also find an opportunity here. The instruction will consist of fundamental experiments performed by the students themselves, and the study of accessory data. An informal lecture or conference will be given daily.

The fee for these thirty days of laboratory instruction, including the necessary material, will be forty dollars.

APPENDIX

APPARATUS

The desk assigned each pair of students is 155 cm. long and 61 cm. wide. A ledge 7 cm. high guards the farther side. At one end are placed a locker 35 cm. wide, and two drawers; a single lock secures the three. Not all the apparatus used in the course can be placed in the locker and drawers at one time. That used in the earlier chapters is issued first (see Appendix, Form G, page 102). From time to time, articles no longer in use are returned to the instructors (see Appendix, Form J, page 107).

The department finds it advisable to maintain a stock of apparatus large enough to enable broken articles to be replaced at once from the reserve. Thus the student is not delayed while repairs are making; moreover, the repairing for the entire course can then be done in the summer, after the instruction is finished. The expense, per instrument, is thereby diminished.

List of Articles used in the First-Year Course [1]

Adjustable plate, or nerve holder.[2]
Artificial scheme, see circulation scheme.
Balances, four, sensitiveness 1 mg., maximum weight, 1500 g.
Balancing board, see board, balancing.
*Band, rubber, diameter 9 cm., for the head.
Beaker, 13 cm. high.
Beakers, 3, 7 × 6 cm.
Block, 8.6 × 8.6 × 1.6 cm., for +10 D lens, in artificial eye box.
——, 8.6 × 8.6 × 1.6 cm., for cylindrical +7 D lens, in artificial eye box.
——, 8.6 × 8.6 × 1.6 cm., for mirror, in artificial eye box.
——, 8.6 × 8.6 × 1.6 cm., for retina, in artificial eye box.
Board, balancing, 38.5 × 20.5 × 4.5 cm.
——, mesentery, with 6 fine pins.
Book, for laboratory notes, 21 × 17.5 cm., 180 pages.
——, for thesis, 21 × 17.2 cm., 32 pages.
Bottle, glass stopper, 9 × 3.7 cm., 45 c.c. curare; 2 drops should paralyze a frog in about 10 minutes.
——, 5 × 3 cm., 20 c.c., with 100 grams of mercury.
——, glass stopper, 13 × 5.3 cm., 135 c.c. normal saline.
——, glass stopper 13 × 5.3 cm., 135 c.c. saturated solution zinc sulphate.

[1] Articles for the subjects in preparation will be added when the experiments are ready.

[2] Articles marked * will be placed in the small wooden boxes.

Bottle, round, 9.5 × 4 cm., 72 c.c. distilled water, cork flush with neck, in artificial eye box.
——, square, 7.5 × 4.3 × 4.3 cm., filled with 68 c.c. of 75 per cent glycerine tinged with eosin; cork flush with neck; in artificial eye box.
——, flat, 11.5 × 4.5 × 2.2 cm., 60 c.c. chrome alum solution.
——, large, for used alcohol.
Bottles, 3, glass stoppers, 10 × 4.2 cm., 70 c.c., for solutions.
Bowl, earthenware, 18 × 5.5 cm., 1200 c.c.
Box, black, to cover retina.
——, 43.5 × 20.4 × 24 cm., to mount electrometer.
Boxes, 2, wooden, 12 × 8.7 × 5 cm.
*Brush, camel's-hair, for handling nerves.
Burette, glass stop-cock, 10 c.c., divided 1 : 20.
Burette holder, metal.
Burner, Bunsen, with 150 cm. rubber tubing.
——, fish-tail, with perfect tip.
*Cannula, metal, for aorta, with 10 cm. rubber tube, and 3.5 cm. glass rod to fit tube.
Carbon dioxide generator, with wash bottle, marble, 20 per cent HCl in beaker, and connecting tubes.
Card, with No. 20 copper wire.
Cell, Daniell, amalgamated zinc, copper, porous cup, saturated solution copper sulphate, 5 per cent sulphuric acid.
Cells, 2 dry.
*Cement, colophonium 1 part, beeswax 4 parts, piece 2 × 2 × 2.5 cm.
Centrifugal machine.
Circulation scheme.
Clamp, curved iron.
——, 4 double iron.
Clamp, femur, or muscle clamp.
Clay, potter's kaolin in dish, 5.5 × 3.7 cm., moistened with 0.6 per cent NaCl solution.

Cloth, cotton, 30 × 40 cm.
——, linen, 20 × 20 cm.
*Collar button.
*Compressor, or cork clamp, or Gaskell clamp.
Containers, 2, for haemoglobin estimation.
Cork, diameter 2 cm.
Cotton ; fill beaker loosely.
Cover-glass, thin.
Cylinder, cardboard, 20.5 × 5.5 cm., for kymograph paper.
——, cardboard, 5.5 × 30 cm.
——, cardboard box, 26 × 4 cm., for straws.
——, graduated, 50 c.c.
——, tin, cork plug, incense, in artificial eye box.
Diaphragm, 0.2 mm. aperture, in artificial eye box.
——, L aperture, in artificial eye box.
——, vertical and horizontal slit, in artificial eye box.
Dish, evaporating, diameter 8 cm.
——, paper, diameter 16 cm., for rocking key.
Dissecting case, with scissors, one large and one small forceps, and a seeker.
Distilling apparatus.
*Electrodes, brass, 1 flat, and 1 wire.
——, for inductorium.
*——, needle, 2 pair, each pair passed through a cork, diameter 1 cm.
——, 4 unpolarizable boots, with 4 spring clips, 4 zincs, and 4 No. 27 wires, 10 cm. long, in moist chamber.
——, 2 platinum, 2 × 0.5 cm.
——, 1 zinc, 7 × 0.5 cm.
Electromagnetic signal, see signal magnet.
Electrometer, capillary, 20 per cent sulphuric acid, with box, and curved iron clamp.
Ergograph, iron stand with spring, with adjustable rod, hand rest, and curved iron clamp.

Eudiometer.
Eye, artificial, see optical box.
——, artificial ophthalmoscopic, in artificial eye box.
Filter pump.
Flasks, 3, Erlemeyer, 150 c. c., with rubber stoppers.
Frog, sciatic nerve cut 4 days before use.
Frogs, medium size, average number for each student, 45.
——, large, average number for each student, 4.
Frog board, 4 clips.
Frog-heart manometer, see manometer, small mercury.
Funnel, diameter 4 cm.
Funnel, separating.
Funnels, 3, diameter 7 cm.
Galvanometer.
*Gas chamber, cork with 2 tubes and 2 electrodes, normal saline clay.
Gauze, 3 pieces, 20 × 20 cm.
*Handles, 4 wooden, for pressure-hairs.
Heart-holder, wooden stand.
Holmgren's worsteds, for testing color vision.
*Hooks, 2 S-shaped, one end sharp.
*——, 2 double.
Hydrogen peroxide apparatus.
Hydrometer (urinometer).
Hypobromite apparatus, for urea estimation.
Ice.
Incense, 4 pieces, 3 cm. long, in artificial eye box.
Inductorium.
Ink, black and red.
Interrupter wheel.
*Iron filings, 2 grams.
Jar, glass, battery, 20 × 17 cm., to hold frog.
Key, rocking, with paper dish.
——, simple.
Kymograph.

Lantern, 2 draw tubes.
Lens, convex, +2 D, in small envelope, in artificial eye box.
——, convex, +10 D, in wooden block, in artificial eye box.
——, concave, —2 D, in small envelope, in artificial eye box.
——, cylindrical, +2 D, in small envelope, in artificial eye box.
——, cylindrical, +7 D, in wooden block, in artificial eye box.
Lever, light muscle, with small scale pan and vertical pin.
Lever, heavy muscle, with large scale pan.
Ligature, linen thread, 100-yard spool.
——, silk, 2 yards, on spool.
*Magnet, bar.
Manometer, small mercury, with glass float and rubber tube.
Marble, for carbon dioxide generator.
Membrane, finest rubber, diameter 2 cm., for sphygmograph tambour.
*——, rubber dam, diameter 5 cm., for sphygmograph thistle tube.
*Menthol pencil.
Mercury cup, for vibrating reed.
Mesentery board, see board, mesentery.
Metronome, one in each room.
*Micrometer ocular.
Microscope, with jointed stand for horizontal adjustment.
*Millimetre paper, strip 15 × 1.5 cm.
Mirror, concavo-convex, in wooden block, in artificial eye box.
——, plane, glass, 5 × 5 cm., in artificial eye box.
Moist chamber, with 4 unpolarizable boots, 4 clips, 1 femur clamp, and glass shade.

Mortar, diameter 7 cm., and pestle.
Mounting rod, for boot electrodes.
Muscle clamp, see clamp, femur.
——, lever, heavy, see lever, heavy muscle.
——, lever, light, see lever, light muscle.
——, warmer, with thermometer, lead shot, and ice.
Needle, three-sided.
Nerve holder, see adjustable plate.
Optical box, see also
block, holding +10 D lens.
——, holding cylindrical +7 D lens.
——, holding concavo-convex mirror.
——, holding retina.
bottle, round, 9.5 × 4 cm., 72 c.c. of distilled water, cork flush with neck.
——, square, filled with 75 per cent glycerine tinged with eosin; cork flush with neck.
cover, plate glass.
cylinder, tin, with cork plug.
diaphragm, 0.2 mm. aperture.
——, L aperture.
——, vertical and horizontal slit.
——black paper, 8.6 × 8.6 cm., aperture 4 mm.
incense, 4 pieces 3 cm. long.
lens, convex, +2 D, in small envelope, in artificial eye box.
——, convex, +10 D, in wooden block, in artificial eye box.
——, concave, −2 D, in small envelope, in artificial eye box.
——, cylindrical, +2 D, in small envelope, in artificial eye box.
——, cylindrical, +7 D, in wooden block, in artificial eye box.
mirror, plane, silvered glass.
ophthalmoscopic eye, with rod.

Optical screen, 1 cm. diameter.
slide, glass, to cover window.
—— ground glass.
*Paper, black, 1 × 1 cm., stroboscopic method.
——, coördinate, 10 × 10 cm.
——, filter, 1 sheet, 50 × 50 cm.
*——, filter, 5 × 5 cm., soaked in starch paste with potassium iodide.
——, glazed on one side, in cardboard case, 25 sheets, 54.8 × 18.5 cm. gummed 0.8 cm. at one end.
Paper, lacmoid, impregnated with saturated neutral sodium chloride solution.
——, lacmoid, after Dr. Loewy, 3 × 3 cm.
——, litmus.
——, paraffin, 10 × 7 cm.
——, black, red, green, blue, 1 cm. square.
——, white, 50 × 60 cm.
——, for written tests, 24.5 × 19.5 cm., printed.
*——, for writing-points, 5 × 5 cm.
Paramecia.
*Pins, 6, for mesentery.
Pipette, glass tube, 20 cm. long, diameter 0.6 cm., drawn out.
——, fine glass.
——, Engel, marked 0.05 and 5.0 ccm.
——, rubber bulb.
——, Thoma-Zeiss, small.
——, Thoma-Zeiss, large.
Plate, glass, 12.8 × 10.3 cm.
——, glass cover, for artificial eye box.
Plethysmograph tube, with rubber collar 4 cm. long, rubber tubing, and ⊤-tube.
Pole changer, see key, rocking.
Rabbit, uninjured, in rabbit holder, for heart reflex.
Reed, vibrating, 20 cm.

Respiration apparatus, for estimation of O, CO_2, and H_2O:
- 2 aspirator bottles 36 × 14 cm., 4000 c.c.
- wooden tray containing seven bottles, 18 × 7.3 cm., 500 c.c.; 1 and 4, filled with soda-lime; 2, 3, and 5 filled with pumice stone soaked in sulphuric acid; 6, a Müller's mercury valve; 7, a quart glass jar, with metal screw top and rubber ring.
- 2 small velvet corks to stop tubes when not in use.
- 2 rubber tubes 17 × 1.1 cm.
- 4 rubber tubes 5 × 1 cm.
- 2 rubber tubes, 40 × 1.1 cm.

Rheochord.
*Ring, brass, 0.1 gram.
——, 2 straw fasteners.
——, iron, with rod, diameter 8 cm.
——, iron, with rod, diameter 3.5 cm.
*Rod, glass, 3.5 cm., for aortic cannula tube.
——, glass, L-shaped, Exp. salts on heart-muscle.
——, stirring, 20 cm. long, end drawn out.
——, wooden, 8.5 × 0.6 cm.
Scale pan, large.
—— pan, small.
Shellac dissolved in 96 per cent alcohol.
*Shot, lead, 1 gram, split.
Signal magnet.
*Slide, glass, 7.6 × 2.6 cm.
——, glass, 7.6 × 3.9 cm., in artificial eye box.
——, glass, with metal ring, for coagulation time.
——, ground glass, 7.6 × 3.9 cm., in artificial eye box.
——, Zappert-Ewing.
Sodium chloride, crystals in salt mouth, 30 c.c. bottle.

Solutions,[1]

acetic acid (strong).
——, 1 per cent.
——, glacial, $\frac{1}{3}$ per cent.
alcohol, 13 per cent.
——, 96 per cent.
a-naphthol solution, fresh:

a-naphthol	1 mol.
sodium carbonate . . .	3 mols.
para-phenylenediamine .	1 mol.

amyl nitrite.
ammonia, NH_3.
atropine, 0.5 per cent.
barium hydroxide, saturated.
benzol-chloroform, sp. gr. 1.059.
Biedermann's fluid,
sodium chloride, NaCl, 5 grams; disodium hydrogen phosphate, Na_2HPO_4, 2 grams; sodium carbonate, Na_2CO_3, 0.4 gram; water, H_2O, 1000 c.c.
butyric acid, $\frac{n}{100}$.
calcium chloride, $CaCl_2$, 1 per cent.
——, to precipitate equal quantities of 2 per cent potassium oxalate solution.
cane sugar, 0.5 per cent.
copper sulphate, $CuSO_4$, saturated solution.
distilled water, H_2O.
ether.
Fehling's.

[1] The composition of each solution for general distribution is written upon as many tags as there are pairs of students. The writing is coated with shellac dissolved in alcohol. The necessary quantity of the liquids is transferred from large stock bottles to three small bottles, upon which the corresponding tags are placed. Each tag has a metal ring which slips readily over the neck of the bottle. At the close of the exercise the tags are stored away, and the bottles carefully washed.

Solutions (*continued*) —

fermentation liquid:

potassium phosphate	20 grams.
calcium phosphate	2 "
magnesium sulphate	2 "
ammonium tartrate	100 "
cane sugar	1,500 "
water	8,376 "
	10,000 "

ferric chloride, 2 per cent.

Gower's:

sodium sulphate	7.3 grams.
acetic acid	20 c.c.
water	125 c.c.

guiac, freshly dissolved in alcohol.

haemoglobin, carbon monoxide, 0.2 per cent, saturated with carbon monoxide.

hydrochloric acid, HCl, 20 per cent.

——, $\frac{n}{10}$.

——, 0.281 per cent.

——, sp. gr. 1.124

iodine:

iodine	1 gram.
potassium iodide	1 gram.
water	100 c.c.

litmus, neutral.

magnesium sulphate, saturated solution.

muscarine (trace).

nicotine, 0.2 per cent.

olive oil, commercial.

——, neutral.

——, 5.5 per cent rancid.

oxalic acid, normal.

potassium chloride, KCl, 5 per cent.

——, 0.9 per cent.

potassium chromate, 5 per cent.

potassium ferricyanide, 5 per cent.

Solutions (*continued*) —
potassium hydrate, $\frac{n}{20}$.
potassium oxalate, neutral, 2 per cent.
Ringer's fluid:
calcium chloride, $CaCl_2$. 0.0026 gram.
potassium chloride, KCl. 0.035 gram.
sodium chloride, NaCl . 0.7 gram.
water, H_2O, to make . . 100 c.c.
soap.
sodium acetate, saturated solution.
sodium carbonate, Na_2CO_3, 1 per cent.
——, 0.25 per cent.
sodium chloride, NaCl, saturated solution.
——, 8 per cent.
——, 0.6 per cent, "normal saline."
——, 0.75 per cent.
sodium hydrate, $\frac{n}{10}$.
——, 0.1 per cent.
——, sp. gr. 1.34.
sodium hydroxide, sp. gr. 1.12.
strychnine sulphate, 0.5 per cent.
sulphuric acid, H_2SO_4, 5 per cent.
——, 0.2 per cent.
——, 0.2 per cent, sterile.
tartaric acid, $\frac{n}{75}$.
urea, 2 per cent, neutral.
veratrine acetate, 1 per cent.
Sphygmograph tambour, with rubber tubing, T-tube, fine straw, finest rubber membrane, thistle tube, rubber dam, and collar button.
Stand, two iron, with 4 clamps.
——, iron, tripod base.
——, wooden.
Starch paste.
Stoppers, rubber, 3, to fit Erlemeyer flasks.
Straw, fine, for sphygmograph tambour.
——, large, 36 cm. long, with platinum wire soldered to thin copper wire.

Straws, large, 20 cm. long, 3 in cardboard case.
Sulphuric acid drying apparatus.
Tags, written and shellacked.
Test tubes, 6, 2 × 15 cm.
——, 3, 1 × 7.5 cm.
Thermometer, diameter not over 0.8 cm.
*Thread, silk, 50 cm.
Tin foil, see Paper.
Tortoise, average number for each student, 1.
Towel, small.
Tracing holders, 3.
Tube, glass, pointed, for coagulation time.
Tuning fork.
Vertebral saw.
Volume tube, 2 corks with hook electrode.
Wash bottle, for carbon dioxide generator.
Watch glasses, 6, diameter 5 cm.
Water bath, 25 × 25 × 38 cm. on iron support.
Web board; may use mesentery board.
*Weights, 10 one-gram in box.
——, 90 ten-gram in large scale pan.
——, 1-1000 grams, for balance.
Wire gauze, 10 × 10 cm.
Wire, 300 cm., fine copper, no. 33, on spool.
——, copper, 10 cm.
——, iron, 10 cm.
——, zinc, 10 cm.
Wires, copper, 13 No. 25, 60 cm. long, on spool.
——, copper, 2 No. 25, 150 cm. long, coiled.
——, connecting, for lantern, with plug.
Work adder.

Form F.

[Requisition blank.]

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 190.....

The undersigned desires the following supplies:

.....

.....

Room.....

(Signed).....

Number .....

Form G.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
February 1, 1904.

The undersigned students have received the first issue of apparatus, for experiments upon the methods of stimulation, electrical stimulation of tissue, chemical and mechanical stimulation, irritability, and conductivity.[1]

(Signed).....

.....

Desk.....Room.....

[1] Articles marked * will be found in the small wooden boxes.

[First Issue of Apparatus.]

Adjustable plate.
Beakers, 3.
Bottle, with curare.
——, with 0.6 per cent NaCl.
——, with saturated $ZnSO_4$.
——, with Hg.
Boxes, 2 small wooden.
Bowl.
*Brush, camel's hair, for handling nerves.
Burner, Bunsen, and tubing.
——, fish-tail with perfect tip.
Cells, 2 dry.
*Cement, colophonium.
Clamps, femur.
——, 4 double iron.
Clay, in glass dish.
*Compressor (Gaskell clamp).
Cork.
Cylinder, cardboard, with 25 sheets kymograph paper.
——, cardboard box, with 2 straws.
Dish, paper, for rocking key.
*Electrodes, brass, one flat and one wire.
——, for inductorium.
*——, 4 needle, with 2 small corks.
——, unpolarizable (4 boots, 4 spring clips, 4 zincs, in moist chamber).
Frog board with 4 clips.
*Hooks, S-Shaped, 2.
*——, double, 2.
Inductorium.
Jar, battery.
Key, rocking, with paper dish.
——, simple.
Kymograph.

Lever, light muscle, with vertical pin.
Ligatures, thread, on spool.
Millimetre paper.
Moist chamber, glass cover.
Mounting rod for unpolarizable electrodes.
Paper, coördinate.
——, filter.
*——, for writing points.
——, glazed, 25 sheets in cardboard case.
Pipette.
——, fine glass.
——, with rubber bulb.
Plate, glass.
Porcelain dish.
Rheochord.
*Ring, wire straw fastener, 2.
Rod, glass.
Scale pan, small.
Signal magnet.
Stand, wooden.
Stands, 2 iron, and 4 clamps.
Straws, 3 in case.
Tracing holders, 3.
Tuning fork.
*Weights, 10 ten-gram.
Wire, 300 cm. fine copper, on spool.
——, copper, 10 cm.
——, zinc, 10 cm.
Wires, copper, 13, each 60 cm., one, 150 cm.

Form H.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The undersigned students have received the second issue of apparatus, comprising the additional pieces necessary for experiments on fermentation and digestion, absorption, lymph, blood, and secretion.

(Signed).....

.....

Room.....Desk.....

[Second Issue of Apparatus.]

Bottles, wide mouth, 3.
Burette.
Burette clamp.
Burette stand.
Cotton.
Cylinder, graduated.
Filter papers, round, 20.
Funnel ring, iron.
Funnels, 3.
Gauze.
Hypobromite apparatus (chemical department).
Hydrogen peroxide apparatus.
Linen cloth.
Mortar.
Pestle.
Stirring rod.
Surgical needle.
Test papers.
Thermometer (chemical department).
Tubing, rubber, length 1 inch.

Form I.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The undersigned students have received the third issue of apparatus, comprising the additional pieces necessary for experiments upon electromotive phenomena, change of form in contractile tissues, spinal cord, and brain, sensations of temperature, pressure, tickle, and pain, motor sensations, and taste.

(Signed).....

.....

Room.....Desk.....

[Third Issue of Apparatus.]

Cork clamp.
Cotton.
Electrodes, 2 platinum, 2 × 0.5 cm.
Ergograph, with adjustable rod, and hand rest.
Funnel ring.
Interrupter wheel.
Lever, heavy muscle (rigid muscle lever).
Menthol pencil.
Micrometer ocular.
Muscle warmer, with mounting rod.
Rod, pointed wooden.
Rubber band.
Scale pan, large, with 90 ten-gram weights.
Shot, lead, split.
Vertebral saw.
Volume tube; rubber stopper with capillary tube, glass rod, and electrode; cork stopper, with electrode.
Weights, 10 one-gram, in box.

Weights, 90 ten-gram, in scale pan.
Wire gauze.[1]

Form J.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
March....., 1904.

The following apparatus has been returned by students.....and.....

Room.....Desk.....

[First Return List.]

Adjustable plate.
Bottle, with saturated $ZnSO_4$.
Cork clamp.
Dish with clay (kaolin).
Electrodes, 2 platinum, 2 × 0.5 cm.
——, 4 unpolarizable (4 boots, 4 spring clips, 4 zincs).
Ergograph, with adjustable rod, and hand rest.
Interrupter wheel.
Micrometer ocular.
Moist chamber, glass cover.
Mounting rod for unpolarizable electrodes.
Lever, heavy muscle.
Muscle warmer, with mounting rod.
Nerve holder, see adjustable plate.
Rheochord.
Wire, copper, 10 cm.
——, zinc, 10 cm.

(Signed).....

For Department of Physiology.

[1] The balancing board and the electrometer, mounted on box with curved iron clamp, will be separately issued upon the days they are to be used.

Form K.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The undersigned students have received the fourth issue of apparatus, for experiments on physiological optics and on vision.

(Signed).....

.....

Room.....Desk.....

[Fourth Issue of Apparatus.]

Artificial eye, with rod.
Optical lantern, two draw-tubes.
Optical box, containing
block, holding +10 D lens.
——, holding cylindrical +7 D lens.
——, holding concavo-convex mirror.
——, holding retina.
bottle, round, 9.5 × 4 cm., 72 c.c. of distilled water, cork flush with neck.
bottle, square, filled with 75 per cent glycerine tinged with eosin; cork flush with neck.
cover, plate glass.
cylinder, tin, with cork plug.
diaphragm, 0.2 mm. aperture.
——, L aperture.
——, vertical and horizontal slit.
—— diaphragm, black paper, 8.6 × 8.6 cm., aperture 4 mm.
incense, 4 pieces 3 cm. long.
lens, convex, +2 D, in small envelope.
——, convex, +10 D, in wooden block.
——, concave, −2 D, in small envelope.

Optical lens, cylindrical, +2 D, in small envelope.
——, cylindrical, +7 D, in wooden block.
mirror, plane, silvered glass.
ophthalmoscopic eye, with rod.
screen, 1 cm. diameter.
slide, glass, to cover window.
——, ground glass.

Form L.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The undersigned students have received the fifth issue of apparatus, comprising the additional pieces necessary for experiments on the circulation.

(Signed).....

.....

Room.....Desk.....

[Fifth Issue of Apparatus.]

Beaker, small.
Board, mesentery.
Cannula, brass.
Circulation scheme.
Collar button.
Heart holder.
Manometer, small mercury, with glass float, glass rod, and rubber tube.
Membrane, rubber dam, diameter 5 cm.
Rubber collar 4 cm. long.
Sphygmograph thistle tube with rubber tubing and T-tube.
Stand, wooden.
Tambour, with finest rubber membrane.

Form M.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The following apparatus has been returned by students.....and.....

Room.....Desk.....

[Second Return List.]

Bottle with chrome alum.
Dish, paper, for rocking key.
Electrodes, brass, one flat and one wire.
Key, rocking, with paper dish.
Lantern, two draw-tubes.
Mounting rod for unpolarizable electrodes.
Optical box, containing
block, holding +10 D lens.
——, holding cylindrical +7 D lens.
——, holding concavo-convex mirror.
——, holding retina.
bottle, round, 9.5 × 4 cm., 72 c.c. of distilled water, cork flush with neck.
——, square, filled with 75 per cent glycerine tinged with eosin; cork flush with neck.
cover, plate glass.
cylinder, tin, with cork plug.
diaphragm, 0.2 mm. aperture.
——, L aperture.
——, vertical and horizontal slit.
——, black paper, 8.6 × 8.6 cm., aperture 4 mm.
incense, 4 pieces 3 cm. long.
lens, convex, +2 D, in small envelope.
——, convex, +10 D, in wooden block.
——, concave, −2 D, in small envelope.
——, cylindrical, +2 D, in small envelope.
——, cylindrical, +7 D, in wooden block.

Optical mirror, plane, silvered.
ophthalmoscopic eye, with rod.
screen, 1 cm. diameter.
slide, glass, to cover window.
——, ground glass.
Pole changer, see key, rocking.
Rubber band.
Scale pan, large, with 90 ten-gram weights.
Slide, glass.
Tuning fork.
Weights, 90 ten-gram, in scale pan.

(Signed) .....

For Department of Physiology.

Materials for Experiments on Fermentation

Crushed freshly germinating barley, 38, 40.[1] Potato starch, 38. Fehling's solution, 38, 39, 85. Cupric sulphate, 38. Potassium sodium tartrate, 38. Sodium hydroxide, sp. gr. 1, 34, 38. Iodine solution, 39. Starch paste, 39, 40. Saliva, filtered, 39, 41. Linen cloth, 40, 48, 81. Alcohol, 40, 53. Diastase, 40. Fibrin, 41, 44, 49. Olive oil, neutral, 41, 56, 57. Cooked beef, 41, 43. Bread, 41. Cat, fasting twelve hours, to be fed cooked beef and bread, 41. Ligatures, 41. Mucous membrane from fourth stomach of calf, 42, 44. Hydrochloric acid, dilute, 42, 43, 44, 45, 54. Hydrochloric acid, sp. gr. 1,124, 42. Mucous membrane of pig's or rabbit's stomach, 42. Glycerine, 42, 62. Three test-tubes, 43. Artificial gastric juice, 43. Glycerine extract of pepsin, 44. Commercial pepsin, 44. Fresh milk, 45, 46. Litmus

[1] The numbers refer to pages in "Experiments for Students in the Harvard Medical School," third edition.

paper, 46. Solutions of Arthus and Pagès, 46. Neutral potassium oxalate, 2 per cent, 46. Rennin, 46. Calcium chloride, solution to precipitate equal quantities of the potassium oxalate solution, 47. Blood clot, 48, 49. Blood clot washed free from corpuscles, 49. Serous fluid that does not clot spontaneously, such as ascitic, pleural, or hydrocele fluid, 48. Serum from blood of ox, dog, or horse, 48. Sodium chloride, 8 per cent solution, 49, 50. Blood directly from an artery, 49. Magnesium sulphate, saturated solution, 49. Centrifugal machine, 49. Sodium chloride, saturated solution, 49. Funnels, 49. Filter paper, 49. Fibrin ferment, 50. Three flasks, 50. Fresh urine, 50. Ammoniacal urine, 50, 53. Carbolic acid, saturated solution, 51. Hydrochloric acid, dilute, 51. Hypobromite apparatus, 51. Bottle for used alcohol, 53. Urea, neutral 2 per cent solution, 53. Fresh pancreas or extract of pancreas, 56. Commercial olive oil, 56. Separating funnel, 56. Barium hydroxide, saturated solution, 56. Rancid olive oil, containing 5.5 per cent fatty acid, 57. Sodium carbonate, 0.25 per cent solution, 57. Water containing soap, 57. Watch glasses, 57. Pancreatic juice or extract, 58. Pig's pancreas, 60. Mortar and pestle, 60. Coarse, well-washed white sand, 60. Glycerine, 60. Pig's liver, 60. Two test-tubes, corked, 60. Toluene, 60. Ethyl butyrate, 60. Lipase, aqueous extract, 61. Ice water, 61. $\frac{n}{20}$ KOH solution, 61, 62, 63. Neutral litmus solution, 61. Normal oxalic acid solution, 61. Rosolic acid, 61. $\frac{n}{100}$ butyric acid, 62. Alcohol, 13 per cent, 62. Glycerine extract of pig's pancreas, or aqueous extract of pig's liver, 62. Isobutyric acid, 62. Neutralized blood serum, 62. Albert biscuit, 67. Ricin, 67. Defibrinated blood from immunized mouse, 70. Defibrinated rabbit

blood, 76, 79. Four guinea-pigs, 76. Guinea-pig serum, 76. Fresh guinea-pig serum, 76. Hydrogen peroxide, 79, 81. Guiac resin freshly dissolved in alcohol, 79. Malt, concentrated aqueous extract, 79. Fresh a-naphthol solution, 79, 82. Sodium carbonate, 79. Para-phenylenediamine, 79. Bibulous paper, 79. Potassium ferricyanide solution, 80. Potassium chromate solution, 80. Finely divided frog's liver, 80. Two fresh pigs' livers, 80. Several thicknesses of gauze, 81. $\frac{n}{10}$ HCl solution, 81. Lacmoid, 81. Wide-necked bottle, 81. Fresh nucleo-proteid, 81. Hydrogen peroxide apparatus, 81. $\frac{n}{10}$ NaOH solution, 81. Eudiometer, 81. Frog's thymus or spleen, 82. Dog's blood, 82. Calf's blood containing grape sugar, 83, 84. Filter pump for stream of air, 83. Acetic acid, 1 per cent, 83. Chloroform, 84. Sodium acetate, saturated solution, 84. Ferric chloride, 2 per cent, 84. Dog's pancreas, 85. Sterile water containing 0.2 per cent sulphuric acid, 85. Pure glucose, 85. Fermentation liquid, 88. Fermentation liquid in alcoholic fermentation, 87. Fresh compressed yeast, 88. Sodium hydrate, sp. gr. 1.12, 89. Distilling flask, 89. Water bath, 89. Sodium carbonate, 89. Potassium dichromate, 89. Dilute sulphuric acid, 89.

Materials for Experiments on Blood

Absorbent cotton, 94.[1] Three-sided surgical needle, 94. Benzol-chloroform mixture, sp. gr., 1,059, 95. Hydrometer, 95. Chloroform, 95. Benzol, 95. Glass cylinder, 95. Linen, 95. Thoma-Zeiss pipette for red corpuscles, 96. Zappert-Ewing ruled

[1] The numbers refer to pages in "Experiments for Students in the Harvard Medical School," third edition.

slide, 97. Cover glass, 97, 104. Gower's solution, 97. Alcohol, 99, 102. Ether, 99. Glacial acetic acid solution, one third of one per cent, 99. Carbon monoxide hæmoglobin solution, 0.2 per cent, saturated with carbon monoxide, 100. Two containers for hæmoglobin estimation, 100. Sodium hydrate solution, 0.1 per cent, 100. Engel pipette, marked 0.05 and 5.0 ccm., 100. Blackened tube, 101. Rabbit, guinea-pig, or cat, for bleeding, 101. $\frac{n}{75}$ tartaric acid, 102. Burette, divided 1 : 20, 102. Lacmoid paper, impregnated with saturated neutral sodium chloride solution, 103. Glass slide with metal ring, 104. Vaseline, 104. Pointed glass tube, 104. The following materials are required for the experiments printed on additional sheets: cane sugar solution, 0.5 per cent; watch glass; magnesium sulphate, saturated solution.

Form N.

HARVARD MEDICAL SCHOOL,
DEPARTMENT OF PHYSIOLOGY,
....., 1904.

The locker keys must be returned to the mechanic in the gallery of the Physiological Laboratory between.....and....., ..., ... The deposit for the key will be refunded only at this time. You are reminded that the cost of replacing lost apparatus, the repair of broken parts, and the cleaning of apparatus and lockers left dirty will be charged against your account.

In Rooms B and H, at.....o'clock..... morning, receipts will be issued for the third return of apparatus.

[Third Return List.]

....., 1904

The following apparatus has been returned by students..... and .....

Room.....Desk.....

Beakers, 4, one small.
Board, mesentery.
Bottle, with curare.
——, with chrome alum.
——, with 0.6 per cent NaCl.
——, with Hg.
——, 2, with $CaCl_2$ and KCl solutions.
Boxes, 2 small wooden.
Bowl.
Brush, camel's-hair.
Burner, Bunsen, with tubing.
——, fish-tail with perfect tip.
Cannula, brass.
Cells, 2 dry.
Cement, colophonium.
Circulation scheme.
Clamp, curved iron.
——, 4 double iron.
——, femur, see muscle clamp.
Collar button.
Compressor (Gaskell clamp).
Cylinder, cardboard, with kymograph paper.
——, cardboard box, with 3 straws.
Electrodes, for inductorium.
——, 4 needle, with 2 small corks.
Electromagnetic signal, see signal magnet.
Frog board with 4 clips.
Funnel ring.
Heart holder.
Hooks, S-shaped, 2.

Hooks, double, 2.
Inductorium.
Jar, battery.
Key, simple.
Kymograph.
Lever, light muscle, with vertical pin.
Ligatures, thread, on spool.
Manometer, small mercury, with glass float, glass rod, and rubber dam.
Membrane, rubber dam, 5 cm. square.
Millimetre paper.
Muscle clamp.
Paper filter.
——, for writing points.
——, glazed, with cardboard case.
Pipette, large glass.
——, fine glass.
——, with rubber bulb.
Plate, glass.
Plethysmograph tube with rubber collar 4 cm. long.
Porcelain dish.
Ring, wire fastener, 2.
Rod, glass.
——, glass, L-shaped.
Saw, vertebral.
Scale pan, small.
Signal magnet.
Sphygmograph thistle tube with rubber tubing and T-tube.
Stands, 2 iron, and 4 clamps.
——, wooden.
Straws, 3 in case.
Tambour, with finest rubber membrane.
Tracing holders, 3.
Weights, 10 ten-gram.
Wire, fine copper, on spool.

Wires, copper, 13, each 60 cm., one 150 cm. long.
Wire gauze.

(Signed).....

For Department of Physiology.

.....

Form O.

[List of apparatus liable to be broken.]

Beakers	20 cents
Boot electrodes	10 "
Capillary tube on electrometer	25 "
Cover to moist chamber	20 "
Gas chamber	10 "
Glass plate	2 "
Jar of Daniell cell	25 "
Pipettes	3 "
Stirring-rod	2 "
Tip to gas burner	2 "