PEABODY'S LABORATORY EXERCISES
IN ANATOMY AND PHYSIOLOGY

LABORATORY EXERCISES

IN

ANATOMY AND PHYSIOLOGY

BY

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PREFACE.

Every pupil in the study of human physiology should be led to see that most of the materials required for observation and experiment in this subject are furnished by the organs and tissues of his own body. The following laboratory directions aim primarily to familiarize the pupil with the working of his own organs of motion, circulation, respiration, and digestion. Much of the necessary supplementary material (soup-bones, meat, foods, etc.) can be easily obtained by the student. The pieces of apparatus needed for the class demonstrations and experiments (test-tubes, bell-jars, thistle-tubes) are usually found in the chemical or physical laboratory of the school.

At the beginning of each topic of study I have given directions which in my experience have been found necessary to guide the pupil in his observations and experiments. The questions which follow these directions have been framed with the object of leading the student to seek the facts *from the material itself.* The student should be trained especially to distinguish in the experiments *observed results* from the *inferences* that may be drawn from those results.

I have found that a considerable amount of laboratory work can be profitably done by the pupil at home and reported in class at the next recitation period. Hence it is possible to carry on experimental work in the large classes of the first year of the high school more satisfactorily in biology than in any other subject. The exercises that can be prepared at home to good advantage are Nos. 4, 6, 7 (last half), 9, 10, 13, 14, 15 (first half), 16, 17, 24, 29, 31, 32, 33, 36, 41, 42, 43, 45, 46, and the larger part of 48 and 49. Whenever the abbreviation (Dem.) is found in any part of an experiment, a demonstration will be given by the instructor.

The most satisfactory method of recording laboratory work I find to be this. The observations and conclusions are stated briefly by the pupil in his note-book as the work is done. Some little time is taken for discussion at the close of the period, when the facts are clearest in mind, special care being taken to see that correct inferences have been drawn. That the work of the day may be more firmly fixed in the pupil's mind, he is required to write on paper of a certain kind and size, and to present at the next lesson a carefully prepared statement of (1) the *steps in the experiment*, (2) the *results* observed, (3) the *conclusions* which were drawn from the experiment. These papers, together with the drawings and other work prepared in class, are arranged in a cover belonging to each pupil, and constitute his laboratory book.

The descriptive terms *dorsal* and *ventral, anterior* and *posterior, median* and *lateral,* employed in comparative anatomy, are used in the following directions, since they seem preferable to the more indefinite terms front and back, upper and lower, middle and side, commonly used in books on human physiology. I have adopted throughout the food study the term *nutrients* (for food-materials, foodstuffs), and *nitrogenous substances* (for proteids, albuminoids, gelatinoids, etc.); these terms are used in the publications of the U. S. Department of Agriculture.

We have found the study of the material at the American Museum of Natural History (especially the skeletons and teeth of mammals) and of the animals in the Zoological Park a valuable means of review and of awakening interest in the subject. With a definite list of questions (see pp. 73 and 107) in the hands of each pupil a division of thirty to fifty can be directed in this work. Time should be taken at the close of such study for a comparison of notes and for general discussion.

Some knowledge of the cell is so essential to any intelligent comprehension of the subject of human physiology that it seems necessary to introduce frequent discussions of *protoplasm* and its properties. Circulating protoplasm is easily demonstrated in the cells of the plant Nitella or Elodea. Epithelium (including gland and ciliated), muscle and nerve cells should be shown if possible. The study of yeast and bacteria is suggested to give the pupil some acquaintance with the physiology of the cell, as well as a series of facts relating to these organisms.

Since physiology precedes physics and chemistry in the ordinary high school courses of study, it is necessary to give the pupil a few ideas of the fundamental principles of these subjects. It seems wise to discuss oxidation and its products more or less thoroughly, and to dwell upon osmosis, atmospheric pressure, and the properties of acids and alkalis. The structure and physiology of the organs of special sense (eye, ear), as well as the thorough consideration of levers, should be omitted, in my judgment, until after a course in physics has been taken.

It is not expected that all of the following experiments will be performed in the limited time usually assigned in the curriculum to this subject. The exercises are, however, sufficiently varied to allow a wide range of choice. The laboratory work on a given topic should, if possible, be given before the study of that topic in the text-book.

The teacher will find the following reference-books to be valuable in experimental physiology: Stirling's "Outlines of Practical Physiology" (P. Blakiston, Son & Co., Philadelphia); Foster and Langley's "Practical Physiology" (The Macmillan Co., New York); Klein's "Micro-Organisms and Disease" (The Macmillan Co., New York). Additional exercises are suggested in "Outlines of Requirements in Anatomy, Physiology, and Hygiene" (Harvard University).

Suggestions for many of the following exercises were found in the publications of J. Y. Bergen, B. P. Colton, H. Newell Martin, H. P. Bowditch, M.D., and in the books mentioned above. Much of the outline for the study of bacteria was suggested by Dr. T. M. Pruden, College of Physicians and Surgeons, N. Y. Many valuable suggestions have been given by Dr. C. B. Davenport of Harvard University. I am especially indebted to Dr. Margaret B. Wilson of the N. Y. Normal College for careful criticism of my manuscript, and to my colleagues in the biological department of the school for their suggestions.

The cut of the microscope on p. 109 was kindly loaned by Bausch & Lomb Optical Company. Most of the other illustrations were prepared from drawings made by one of my first-year pupils, Miss Marietta P. Gates.

J. E. P.

THE MORRIS HIGH SCHOOL,
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LABORATORY EXERCISES

IN

ANATOMY AND PHYSIOLOGY

(The abbreviation (Dem.) means that a demonstration will be given by the instructor.)

1. STUDY OF A MATCH.

Materials: Sulphur-matches, phosphorus, sulphur, lime-water, bottle and stopper, tumbler, pieces of board.

A. Phosphorus.

1. Rub the end of a sulphur-match on your finger in the dark. What is the appearance of the streak?
2. Light a match by rubbing the tip on a rough surface. What is the color of the flame at first? Describe the color and smell of the fumes that first go off into the air. (These fumes are called *oxid of phosphorus.*)
3. (Dem.) Observe the instructor while he cuts off a piece of phosphorus. (*Caution!* Phosphorus must never be handled with the fingers.)
   a. What are some of the physical properties (color, odor, hardness) of phosphorus?

b. Compare the smell of the phosphorus with the smell of the match tip in 1 (above). What, therefore, is one of the substances found in the head of a match?

4. (Dem.) After the water has been removed from the phosphorus by means of blotting-paper, what do you observe? In what other part of this experiment have you observed a similar substance? Why is phosphorus kept under water?

5. (Dem.) What is the result of rubbing a piece of phosphorus between two sticks of wood? What causes this result to take place? (To aid in answering this question rub together briskly your two hands and note the feeling.) (When phosphorus burns it combines with the oxygen gas found in the air and forms oxid of phosphorus.) How was the phosphorus made to combine with oxygen?

B. Sulphur.

1. Examine some common sulphur. What are its physical properties? What evidence of sulphur can you see near the match tip?

2. Light another match, and after the white fumes have disappeared, smell cautiously of the burning match head. (This gas is called *oxid of sulphur*.) What kind of odor has the gas?

3. (Dem.) Light some sulphur with a heated wire. What is the color of the flame? Notice the smell of the burning sulphur. In what other part of this experiment have you noticed a similar odor? (When sulphur burns it combines with the oxygen gas of the air, forming oxid of sulphur.)
4. (Dem.) Rub a bit of sulphur between two pieces of wood, as was done with the phosphorus. What do you observe? Why, then, is phosphorus put on the end of a match?

C. Water.

1. After the wood of a match is burning well, hold it a little distance beneath the mouth of an inverted dry tumbler. What do you see on the sides of the glass?
2. What is one of the substances, therefore, that is formed when wood burns? Why is the tumbler used in this experiment?

D. Carbon.

1. When the wood of the match has been charred, extinguish the flame. (The substance left is called charcoal or *carbon.*) What are some of the physical properties of carbon?
2. Heat the carbon red hot. Does it burn? How do you know?
3. (Dem.) Thrust a piece of wood through a hole in the stopper that fits tightly in the mouth of a bottle. Light the wood,

and insert the burning piece of carbon into the bottle, closing the mouth with the stopper. What do you observe? Suggest an explanation of this fact.

4. (Dem.) Remove the stick, pour into the bottle a little clear lime-water, and shake. What change do you observe in the lime-water? (When carbon burns it combines with the oxygen gas of the air, forming *oxid of carbon*, more commonly known as *carbonic-acid gas* or *carbon dioxid*.) How, then, can the presence of carbon dioxid be demonstrated?

E. Mineral matters.

1. Burn a match as long as you can. What are some of the physical properties of the ashes? (The ashes represent the *mineral matter* of the wood, carried up from the earth in the sap. When the water of the sap evaporated, the solid substances were left behind as a part of the wood.)
2. Heat these mineral matters as hot as you can. Will they burn?
3. How could you determine, therefore, whether or not a substance contained mineral matter?

F. Summary.

1. Name in order the parts of a match that will burn, beginning with the most inflammable.

2. Name the substance produced by the burning of each of the above ingredients, and state how each can be recognized.
3. What are the ingredients of a match that will not burn?

2. STUDY OF OXYGEN. (Dem.)

Materials: **Apparatus-stand, test-tube with perforated stopper, delivery-tube, tray of water, five bottles, a piece of glass to cover each bottle; potassium chlorate, black oxid of manganese, phosphorus, sulphur, splinters of wood, piece of picture-wire, piece of crayon.**

A. Preparation of oxygen.

1. Mix a spoonful of pulverized potassium chlorate with one-fourth this amount of black oxid of manganese. Put the mixture in a test-tube, and attach it to an apparatus-stand in a slanting position. Close the mouth of the tube with a stopper through which passes a delivery-tube. The other end of the delivery-tube should run beneath the surface of the water in the tray. (See Fig. 1.)
    a. Heat the test-tube gently. What do you observe?
    b. Potassium chlorate and oxid of manganese contain a large amount of oxygen. How are these compounds made to give up oxygen?
2. Fill the four bottles with water and cover each with a piece of glass. Invert one in the pan of water over the end of the

delivery-tube and remove the glass cover.

a. Why does the bottle remain filled with water? (See experiment 4.)

b. Continue to heat slowly the mixture in the test-tube. What do you observe? Does oxygen dissolve readily in water? How do you know?

3. When the escaping oxygen has filled the bottle, cover it with the glass plate, remove it from the tray, and turn it right side up. Fill the other bottles in the same way. Why is the glass cover placed over each bottle?

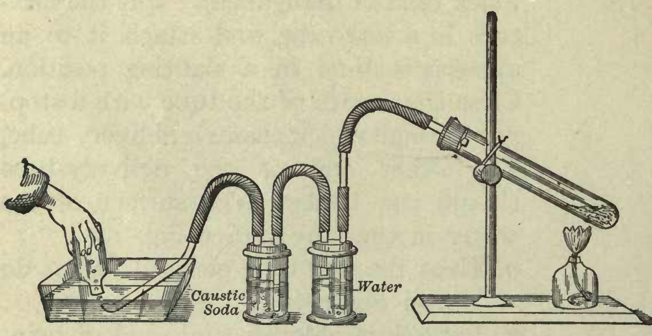

FIG. 1.

4. To obtain pure oxygen the gas should be run through two bottles as shown in Fig. 1. Place in the first water, and in the second a solution of caustic soda. These liquids absorb most impurities. When the oxygen has been washed in this way,

collect it in a fifth bottle as described in 2 and 3 above.

B. Properties of oxygen.

1. What is the color of the oxygen obtained in 4 above? Remove the glass cover from the bottle and smell of it. What do you find? Inhale some of the gas through the mouth. Has it any taste? Enumerate, therefore, some of the physical properties (color, taste, odor) of oxygen. What are the physical properties of the oxygen in the air?
2. Prepare a burning spoon by tying a wire about a small piece of crayon. Place upon the top of the crayon some phosphorus and light it. Remove the glass cover from the top of one of the bottles of oxygen and lower into it the burning phosphorus.
   a. What do you observe? Does phosphorus burn better in air or in oxygen? What is the color of the flame?
   b. What do you see in the jar in which the phosphorus has been burning? Name this compound. (Compare experiments 1, A, 2, 4, 5.)
3. Into a second bottle of oxygen lower some burning sulphur.
   a. What do you observe? Does sulphur burn better in air or in oxygen?

b. When the flame is extinguished cover the bottle with the glass. Cautiously smell of it. What is the gas? (Compare with experiments I, B, 1, 3.) What are the physical properties of this gas?

4. Thrust a burning stick into a third bottle of oxygen.

a. What do you observe?

b. Remove the stick quickly and blow out the flame, leaving a glowing end. Again thrust the stick into the jar of oxygen. What is the result?

c. Repeat the preceding experiment several times. What do you finally observe? Explain this fact.

d. Into the bottle put some clear lime-water and shake. What is the result and what do you infer? (Compare experiment I, D, 4.)

5. Heat the end of a picture-wire and dip it into sulphur. When the little ball of sulphur is burning well, lower the heated picture-wire into the fourth jar of oxygen. Describe the result. Will iron burn in the air?

6. Did the oxygen burn in any of the preceding experiments? Does the oxygen of the air ever catch fire? How do you know? What, then, does the oxygen do in each experiment?

7. (By burning or *oxidation* is meant the chemical union between oxygen and some other substance.) How can you tell when oxidation is going on? Name the compounds that have been formed by oxidation in the preceding experiments.

3. STUDY OF AIR. (Dem.)

Materials: Tray of water, flat piece of cork about two inches in diameter, small porcelain dish (or bit of crockery), phosphorus, glass jar with wide mouth, piece of glass to cover the jar, cylindrical graduate.

A. Preparation of nitrogen.

1. Place the porcelain dish (or piece of crockery) on the piece of cork and float the latter on the water in the tray. Into the dish put a piece of phosphorus twice the size of a pea. Light the phosphorus and then quickly cover it with the inverted glass jar, keeping the rim of the latter about an inch below the surface of the water. (See Fig. 2.)
   a. With what was the jar filled when it was placed over the burning phosphorus?
   b. As the phosphorus burns what do you see within the jar? What is the composition of this substance? How was it formed? (See Exp. 1, A, 5.)
   c. What ingredient, therefore, of the air is being removed? Why does the

phosphorus after a time cease to burn?

d. What change do you see in the level of the water within the glass jar? How do you explain this? (See Exp. 4.)

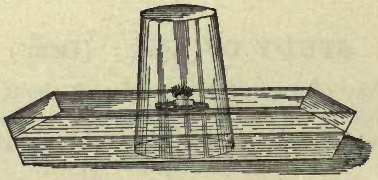

FIG. 2.

e. What change do you see in the compound that was formed within the glass jar? Explain.

2. Slide a piece of glass beneath the mouth of the bottle, turn the latter right side up, taking care not to lose any of the water that has risen in the jar. The ingredient of the air left in the bottle is *nitrogen.* Keep the bottle covered and shake the water about to wash the nitrogen as much as possible.

a. Drop a piece of blue litmus paper (see experiment 7) into the water. What change do you see? (This proves that oxid of phosphorus makes water acid.)

B. Properties of nitrogen.

1. What are the physical properties of the nitrogen in the bottle? What are the

physical properties of nitrogen in the air? Is, therefore, the nitrogen in the bottle pure?

2. Place a piece of phosphorus on the burning spoon and light it. Carefully remove the glass cover sufficiently to lower the burning phosphorus into the jar of nitrogen. Cover again as quickly as possible.
   a. What do you observe?
   b. What, then, is the most striking difference between the effect of oxygen and nitrogen on heated phosphorus?
3. If you are sure that air has been kept out of the jar, see if sulphur, carbon, or iron will burn in nitrogen.
   a. What do you conclude?
   b. Did the nitrogen itself burn in any of the preceding experiments?
   c. Does nitrogen make things burn?
   d. What is the advantage of having air composed of both oxygen and nitrogen?

C. Percentage composition of air.

1. Pour the water at the bottom of the jar into a cylindrical graduate. How much water is there? (This water took the place of the oxygen as fast as the latter was removed from the air by the burning phosphorus.) What, therefore, was the volume of oxygen in the air?
2. Fill the jar with water and then pour it into

the cylindrical graduate. What is the volume of the water, or in other words how much air was in the jar at first?

3. The water measured in 1 above represents the volume of the oxygen and the water in 2 the whole volume of air in the jar. About what fractional part of air is oxygen? What per cent. of oxygen is therefore found in air? What per cent. is nitrogen?

4. STUDY OF ATMOSPHERIC PRESSURE.

Materials: Tumbler of water, piece of paper, apparatus for preparing oxygen, apparatus for preparing nitrogen. (See Figs. 1 and 2.)

A. Fill a tumbler nearly full of water and cover it with a piece of paper, pressing it down firmly upon the glass. Carefully invert the tumbler and then remove the hand from beneath the paper.

a. What do you observe?

b. Slowly turn the glass until the paper stands vertically. Describe result.

c. Turn the glass upright. Describe the appearance of the paper.

d. (The air exerts in all directions at the level of the sea a pressure equal to about fifteen pounds to the square inch.) Keeping in mind this fact explain the preceding experiments.

B. In the preparation of oxygen explain why the

D. [illegible] immersed [illegible] with water [illegible] of the time of [illegible]. When [illegible] between the surface of the water? If the pressure on [illegible] is [illegible] possible, what is the pressure of the atmosphere on the whole surface?

E. When the oxygen was removed from the air in the [illegible] experiment, why did the water rise? [illegible] a jar of air and place it [illegible] the water. What is the level of the water within the jar now? Explain.

A STUDY OF HYDROGEN. (Test.)

Material: Flat wide-mouth bottle [illegible] rubber stopper [illegible] thistle-tube, delivery-tube [illegible] of water [illegible] dilute [illegible] solution.

A. Preparation of hydrogen.

1. Put some small pieces of zinc into the bottle and insert the stopper. Through one hole in the stopper pass the thistle-tube until the lower end nearly touches the bottom of the bottle. Pass one end of the delivery-tube through the other hole [illegible] the water [illegible]. Pour into the thistle-tube [illegible] and until the lower end of the thistle-tube is covered.

2. What do you see when the [illegible]

inverted bottles remained filled with water. Measure the length and breadth of the tray of water. How many square inches are there on the surface of the water? If the pressure on each square inch is fifteen pounds, what is the pressure of the atmosphere on the whole surface?

C. When the oxygen was removed from the jar in the nitrogen experiment, why did the water rise? Invert a jar of air and press it down into the water. What is the level of the water within the jar now? Explain.

5. STUDY OF HYDROGEN. (Dem.)

Materials: **Two small bottles, each fitted with a rubber stopper in which are two holes, thistle-tube, delivery-tube, tray of water, test-tube, wide-mouth bottle, pieces of zinc, diluted hydrochloric acid, potassium permanganate solution.**

A. Preparation of hydrogen.

1. Put some small pieces of zinc into the bottle and insert the stopper. Through one hole in the stopper pass the thistle-tube until the lower end nearly touches the bottom of the bottle. Pass one end of the delivery-tube through the second hole and let the other end of the tube dip beneath the water in the tray. Pour into the thistle-tube dilute hydrochloric acid until the lower end of the thistle-tube is covered.

   a. What do you see within the bottle?

(This is an evidence that chemical action is taking place.)

b. Feel of the bottle. What is a second proof of chemical action?

c. What do you see at the free end of the delivery-tube? This gas is *hydrogen.*

2. Fill a test-tube with water and invert it over the mouth of the delivery-tube.

a. What other gas is collected in a similar way?

b. Wrap the tube in a towel, still holding it upside down, and hold the mouth near a burning match. What do you hear?

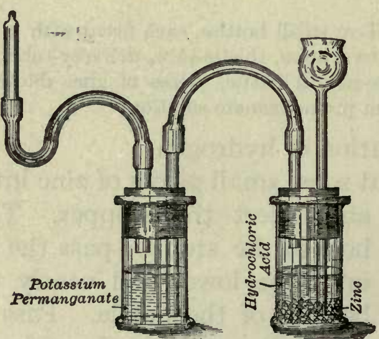

FIG. 3.

c. If an explosion occurs, fill the tube with hydrogen a second time. When the gas burns quietly, collect a bottle as you collected the oxygen, but keep it upside down

after removing it from the tray of water. (If the hydrogen does not come off in sufficient quantity, add some more hydrochloric acid to the zinc in the bottle.)

3. To obtain pure hydrogen, first pass it through a solution of potassium permanganate in a glass bottle and then collect it in a tray of water. This solution removes the impurities from the hydrogen. (See Fig. 3.)

B. Properties of hydrogen.

1. What are some of the physical properties of hydrogen? Hydrogen is the lightest known substance. Why, therefore, are the bottles kept upside down?
2. Carefully lift one of the bottles of hydrogen and thrust up into the mouth a burning splinter of wood.
   a. Does the carbon continue to burn?
   b. What do you notice? What is the color of the flame?
   c. How, then, does hydrogen differ from oxygen? from nitrogen?
3. Remembering that a mixture of oxygen and hydrogen may cause a dangerous explosion, collect a test-tube of hydrogen to make sure that all the oxygen has been driven out of the bottle and delivery-tube. Remove the end of the delivery-tube from the water and attach a piece of glass tubing that has been

drawn out until the opening is small. Stand away from the tube and apply a lighted match. (See Fig. 3.)

a. What do you observe? How does the color of the flame differ from that of B, 2, *b* above? (This difference is due to the heated glass tube.)

b. Hold a dry glass tumbler over the mouth of the delivery-tube. What do you see on the sides of the glass? What, therefore, is formed when hydrogen burns?

c. What was formed when wood first began to burn? What was probably one of the ingredients of wood? (See experiment 1, C, 2.)

6. STUDY OF EVAPORATION.

A. Pour a wine-glass of water into a saucer and place it near a heated stove or radiator. Examine at the end of several (6–12) hours. What do you observe?

B. Pour the same amount of water into a second saucer, put it in a cool place, and compare with (A) above at the end of several hours.

C. Into a third saucer put another wine-glass of water, cover with a glass dish, and place beside (A). What do you find on examining the dishes at the end of several hours? Explain.

D. Fill the wine-glass with water and place it beside

[illegible]

the first and third columns. Compare the amount of evaporation in the three cases. What do you infer?

2. From the preceding experiments:
   1) Define evaporation.
   2) State three conditions that are favorable to evaporation.
   3) Name three ways in which evaporation can be retarded.

7. ACID, ALKALINE, AND NEUTRAL SUBSTANCES.

Materials: [illegible] blue litmus paper [illegible]

a. Tests for acid, alkaline, and neutral substances.
   1. Place a drop of diluted hydrochloric acid on blue litmus paper. Result?
   2. Place a drop of the diluted acid on the tongue. What is the taste?
   3. Put a drop of dilute caustic soda solution (which is alkaline) on red litmus paper. Result?
   4. What is the taste of the caustic soda solution? How does it feel when rubbed between the thumb and forefinger?
   5. Put a drop of water on red and then on blue litmus paper. Water is a neutral substance. How does a neutral substance affect litmus paper?

the first and third saucers. Compare the amount of evaporation in the three dishes. What do you learn?

E. From the preceding experiments:
   1. Define evaporation.
   2. State three conditions that are favorable for evaporation.
   3. Name three ways in which evaporation can be lessened.

7. ACID, ALKALINE, AND NEUTRAL SUBSTANCES.

Materials: Diluted hydrochloric acid, dilute caustic-soda solution, water; red and blue litmus paper; evaporating-dish, alcohol or gas lamp, glass stirring-rod.

A. Tests for acid, alkaline, and neutral substances.
   1. Place a drop of diluted hydrochloric acid on blue litmus paper. Result?
   2. Place a drop of the diluted acid on the tongue. What is the taste?
   3. Put a drop of dilute caustic soda solution (which is alkaline) on red litmus paper. Result?
   4. What is the taste of the caustic soda solution? How does it feel when rubbed between the thumb and forefinger?
   5. Put a drop of water on red and then on blue litmus paper. Water is a neutral substance. How does a neutral substance affect litmus paper?

B. Neutralization.

1. Pour a small amount of the hydrochloric acid into an evaporating-dish; add caustic soda, drop by drop, stirring continually with glass rod, until pieces of red and blue litmus paper remain unchanged when dropped into the liquid. (This process is called *neutralization*.)
2. Evaporate the liquid in the dish to dryness over an alcohol or gas flame.
   a. What is the appearance of the solid that is left?
   b. What is its taste? What substance, therefore, is made by combining hydrochloric acid and caustic soda?

C. Summary. From the above experiments—

1. Give some characteristics of an acid.
2. Give some characteristics of an alkali.
3. How can you tell a neutral substance?
4. Define neutralization.

D. Applications.

1. Drop small pieces of red and blue litmus paper into a solution of each of the following substances: soap of several kinds, lemon juice, ammonia, cream of tartar, saliva, baking soda, apple juice, sugar, milk, white of egg, and other common substances.
2. Record your results by arranging all the substances you have tested in a table like the following:

[illegible]

[illegible]	[illegible]	[illegible]

9. TO DETERMINE THE AMOUNT OF WATER IN FOODS. [illegible]

[illegible]

A. [illegible]

a. [illegible]

b. Record your results in tabular form [illegible]

	Wt. of food.	Loss in weight [illegible]	[illegible]
First day [illegible]			
Second day [illegible]			
Third day [illegible]			

B. [illegible]

1. [illegible]

Acid.	Alkaline.	Neutral.

8. TO DETERMINE THE AMOUNT OF WATER IN FOODS. (Dem.)

Materials: Piece of lean beefsteak; two potatoes; weighing balances.

A. Percentage of water in beefsteak.

1. Weigh the piece of meat and put it aside in a warm dry place; weigh the next day. Continue the weighings each day until the figure remains constant. (The loss is mostly water.)
2. Record your results in tabular form as follows:

	Wt. of steak.	Loss of original wt.	Per cent. of loss.
First day			
Second day			
Third day..........			
etc.			

B. Percentage of water in potatoes.

1. Remove a thin layer of peel from one of the potatoes; weigh each of them and lay

aside in a warm dry place. Weigh each day, and record results for each potato in tabular form as above.

2. What is one use of the peel of potato?

9. TO TEST FOODS FOR STARCH.

Materials: Corn-starch, grape-sugar, white of egg, mutton tallow, various food materials, water; iodine solution;* small butter-plate, test-tubes, glass jar, alcohol-lamp.

A. Method of applying iodine test.

Put a small amount of corn-starch in a test-tube, add water and shake the mixture.

1. Does the starch dissolve? How do you know? (Let the mixture stand.)
2. Boil the mixture.
   a. What change do you notice?
   b. Has the starch dissolved? (Place some sugar and water in another test-tube, boil, and compare with the boiled starch.)
3. Pour a little of the starch paste into a test-tube, add a drop of iodine,* shake, and record result.
4. Add a few drops of the starch mixture to a large glassful of water; stir in a few drops of iodine. What is the result?

* A quart (1000 cc.) of iodine solution is made by dissolving in 5 teaspoonfuls (40 cc.) of water, one-half teaspoonful (4 grams) of potassium iodide, and one-fourth this amount of iodine (1 gram). This solution, when thoroughly mixed, should be diluted to make one quart (1000 cc.). In a clean bottle this mixture will keep indefinitely.

5. Pour a small amount of iodine into a test-tube of water. What do you observe?
6. Put a small amount of grape-sugar into a test-tube; into a second test-tube some white of egg mixed with water; and into a third tube put some mutton tallow (fat). Add a little iodine to each.
   a. Do you notice any change in the color of any of the substances?
   b. Do any of the colors resemble at all the change of color resulting from the addition of iodine to starch?
7. From the preceding experiments state how you can determine whether a substance contains much starch, little starch, or no starch.

B. Application of iodine test to various foods.

1. Test as many foods as you can by adding hot water to a small amount of each on a white butter-dish or saucer, and then applying iodine (e.g., oatmeal, flour, raw meat, egg, milk, parsnip, potato, onions, apples (both green and ripe), beans, rice, pepper).
2. Tabulate your results in columns under the following heads:

Much starch.	Little starch.	No starch.

10. TO TEST FOODS FOR GRAPE-SUGAR.

Materials: Grape-sugar, corn-starch, white of egg, mutton tallow raisins, onions, grapes, granulated sugar, and other foods; Fehling's solution;* test-tubes, alcohol-lamp.

A. Method of applying Fehling's test.

1. Dissolve a small amount of grape-sugar (glucose) in water in a test-tube.
   a. What is the difference in the effect of water on grape-sugar and on starch?
   b. Add some Fehling's solution * and boil. What changes do you notice?
2. Into the first of three test-tubes put some white of egg mixed with water; into a second tube some corn-starch; and into a third tube some mutton tallow (fat). Add Fehling's solution to each and boil.
   a. Does any change take place in the color of the Fehling's solution?
   b. Do any of the colors resemble at all

* To make a quart (1000 cc.) of Fehling's solution dissolve 3 teaspoonfuls (34.64 grams) of pure pulverized copper sulfate (blue vitriol) in a little less than a half-pint of water (200 cc.). Make a second solution by dissolving in a pint (500 cc.) of water twelve heaping teaspoonfuls (150 grams) of Rochelle salt and 3 (5-inch) sticks of caustic soda (50 grams). Mix the two solutions thoroughly, and dilute with enough water to make a quart (1000 cc.). Fehling's solution does not keep for any great length of time, and hence must be made up fresh a short time before it is needed. It is more convenient to prepare it in small quantities from the tablets that may be obtained of druggists. Before making any tests boil a small quantity of the Fehling's solution in a clean test-tube. If it retains its transparent blue color it is ready for use; otherwise a fresh supply must be prepared.

the color of the Fehling's solution when it was boiled with grape-sugar?

3. How can you determine, therefore, whether or not grape-sugar is present in a given food?

B. Application of Fehling's test to various foods.

1. Test as many different kinds of foods as you can, first treating them with water, boiling in a test-tube and then boiling with Fehling's solution (e.g., onions, grapes, both ripe and unripe, pears, granulated sugar, honey, molasses, meat, egg).

2. Tabulate your results in columns under the following heads:

Grape-sugar present.	Grape-sugar absent.

II. TO TEST FOODS FOR NITROGENOUS SUBSTANCES.

(Nitrogenous substances are also known as proteids and albumins.)

Materials: White of egg, corn-starch, grape-sugar, mutton tallow; piece of meat, milk, peas; concentrated nitric acid and ammonia; test-tubes, beaker-glass, thermometer, alcohol-lamp.

A. Effect of heat.

1. Pour a small amount of the white of an egg into a test-tube. (White of egg is com-

posed of nitrogenous substances.) Place a chemical thermometer in the test-tube and hold the tube in a beaker-glass of cool water. Gradually heat the water, stirring continually with the test-tube.

a. What change takes place in the egg albumen?

b. At what temperature does this change occur?

2. Boil some milk in a pan. What do you notice? Heat several times and see if same result follows.

3. Cook a small piece of meat. How does the heat affect its outer surface? What is your conclusion in regard to the composition of meat?

B. Smell when burning.

1. Place a small piece of lean meat on the top of a coal fire and allow it to burn. Have you ever noticed this smell before? If so, what caused it?

2. In the same way test milk, peas, or beans. Result?

C. Effect of nitric acid and ammonia.

1. Pour a little concentrated nitric acid on a piece of hard-boiled egg in a test-tube.

a. What do you observe?

b. Wash off the egg with water, add a little concentrated ammonia, and note result.

2 Put into a test-tube some starch paste made as in 9 above; into a second tube some

grape-sugar; and into a third test-tube some mutton tallow (fat). Add a little concentrated nitric acid to each of the three.

a. Do you observe any change in the color of either of these nutrients?

b. Pour off the acid and add a little concentrated ammonia. Is any effect noticeable?

3. Test with a drop of nitric acid the skin on the tip of one of your fingers.

   a. What is the result?

   b. Of what material is the human body partly composed?

4. Apply the nitric acid and ammonia test to as many foods as you can (e.g., gelatin, peas, white meats, onions, fruits).

5. Tabulate your results in columns under the following heads:

Nitrogenous substances present.	Nitrogenous substances absent.

D. From the above experiments state briefly three ways of testing foods for nitrogenous substances.

12. TO TEST FOODS FOR FATS AND OILS.

Materials: Ground flaxseed, corn-meal, milk, egg, butter, mutton tallow; ether or benzine; beaker-glass, funnel, filter-paper.

Caution! Never handle benzine or ether near a flame or a hot stove, since the vapor of these substances is very inflammable.

A. Method of extracting oils.

To two or three teaspoonfuls of the ground flaxseed add an equal volume of ether or benzine; stir the mixture and let it stand for ten or fifteen minutes. Filter and place the liquid aside in a good draught of air until the odor of ether or benzine has disappeared.

1. What kind of substance have you obtained?
2. What is its smell?
3. Why is benzine used to remove grease-spots from clothing?
4. In the same way extract the fats from milk; from egg; from corn-meal.

B. Hold a piece of butter or mutton tallow in a spoon over the stove.

1. What is the effect of heat on fats?
2. How, then, can you distinguish between a piece of fat and a piece of proteid?

C. Rub a little of the flaxseed on paper. Hold the paper to the light.

1. What effect does fat have on the paper?
2. Does starch, sugar, proteid, or water have a similar effect?
3. What, therefore, is a simple way of proving the presence of fat?

13. TO TEST FOODS FOR MINERAL SUBSTANCES.

Materials: Piece of meat, oatmeal, egg, milk; spoon or piece of metal (platinum foil is best).

A. Method of testing for mineral matter.

Place a bit of dried meat on a spoon or on platinum foil, and let it burn on a hot coal fire or over a gas-flame until no further change can be brought about by heat.

1. What is the appearance of the substance which is left behind? (The ash is the mineral substance.)
2. Does heat affect this residue?

B. In the same way test oatmeal, egg, and milk. What do you learn in regard to the presence of mineral substances in these foods?

14. ANALYSIS OF FLOUR.

Materials: Flour, water; concentrated nitric acid and ammonia, iodine, Fehling's solution; cotton cloth, test-tubes, glass dish, piece of metal (platinum foil is best).

Moisten some flour with water until it forms a tough, tenacious dough; tie it in a piece of cotton cloth, and knead it in a vessel containing water. Set aside the dish with the water.

A. Gluten.

1. What are some of the characteristics of the substance (principally gluten) within the cloth? Draw it out into threads.

2. Test it with nitric acid and ammonia. What kind of nutrient is gluten?

B. Carbohydrates.

1. Test with iodine a small amount of the sediment in the water which you used at the beginning of the experiment. What part of the flour was washed through the cloth?
2. Test with nitric acid and ammonia another portion. Are nitrogenous substances present?
3. Test a small portion of the sticky mass in the cloth with iodine. What is the result, and what is your conclusion?
4. Place a little flour in a test-tube, add water and boil; add Fehling's solution and boil again. Is grape-sugar present in flour?

C. Mineral matter.

Place a small amount of dry flour on a piece of tin or platinum foil and cause it to burn over a very hot flame.

1. What changes take place?
2. What is left after the burning?

D. Summary.

1. What nutrients are present in flour?
2. State how each of these nutrients can be separated from the rest.

15. STUDY OF MILK.

Materials: **Pint of fresh, rich milk; nitric acid and ammonia, Fehling's solution, iodine, caustic soda, osmic acid, vinegar; test-tubes, lactometer, cloth, alcohol-lamp.**

A. Fats.

Put the milk into a clean glass dish, and allow it to stand over night.

1. What layers can be distinguished?
2. Remove by means of a spoon the top layer into a bottle or cup (No. 1).
3. Place a drop of it on unglazed paper. Let the paper dry for some time. What kind of nutrient is shown to be present in milk?

B. Nitrogenous substances.

1. Boil the rest of the milk; what change is noticed? What kind of nutrient is affected in this way by heat?
2. Remove the scum from the milk and place it in a second cup (No. 2). Test a little of it with nitric acid and ammonia. Result?
3. Add vinegar to the rest of the milk and strain through a cloth. What kind of substance is left in the cloth? Test it with nitric acid and ammonia. Result? Place this substance in cup No. 2.

C. Carbohydrates.

1. Test a small amount of fresh milk with Feh-

ling's solution. Result? (Milk-sugar or lactose sometimes gives the test with Fehling's solution like grape-sugar.)

2. Test milk with iodine. Is starch present?

D. Specific gravity of milk.

1. Pour some good rich milk into a tall glass jar. Test it with a lactometer and record specific gravity.
2. Set the milk aside to allow the cream to rise. Remove the cream and test the skim-milk with the lactometer.
   a. What change in specific gravity do you note?
   b. Explain this change.
3. Determine the specific gravity of a second portion of milk. Dilute the milk with water and again find specific gravity. (Fresh unskimmed milk usually has a specific gravity of 1028 to 1034.) How can adulteration of milk be detected?

E. Microscopic examination of milk. (In class.)

1. Place a drop of milk on a clean glass slide, and cover with a cover-glass. Examine under the compound microscope.
   a. What is the appearance of the oil-globules?
   b. Are they all of the same size? (The fat in milk is said to be in a state of emulsion, each tiny sphere being surrounded by a thin covering of albumin.)
2. Place a drop of dilute caustic soda at the

[illegible]

III. STUDY OF FOOD CHARTS.

[illegible] Value and Cost [illegible]

[illegible]

[illegible] from [illegible]

Foods: Nutritive Value and Cost [illegible]

[illegible]

edge of the cover-glass. What is the effect of the soda on the oil-globules?

3. Prepare a second drop of milk for examination as directed above (1). Place a drop of osmic acid solution at the edge of the cover-glass. What is the effect of the osmic acid on the oil-globules?

F. Reaction of milk when tested with litmus.

1. Test some fresh milk with red and blue litmus paper. Is it acid, alkaline, or neutral?

2. Set the milk aside in a warm place and allow it to sour. Again test it with the red and blue litmus paper. What is the result? (The souring of milk is caused by the action of certain micro-organisms called bacteria. See study of bacteria, 49.)

16. STUDY OF FOOD CHARTS.

(In "Foods: Nutritive Value and Cost,"* or in "Principles of Nutrition and Nutritive Value of Food."*)

A. Composition of food materials.

(Make estimates from Chart 1, p. 11, and compare with per cents. given in Table A, p. 27, in "Foods: Nutritive Value and Cost.")

1. Which kind of food (animal or vegetable)

* These pamphlets will be furnished free by the U. S. Department of Agriculture, Washington, D. C.

has on the average the larger per cent. of proteid?

2. Which kind has the larger per cent. of fat?
3. Which kind has the larger per cent. of carbohydrates?
4. Note the principal nutrients present in animal foods, and state what use the body can make of this class of foods.
5. In the same way state the principal uses of vegetable foods.
6. Name five animal foods that contain a large per cent. of material for muscle-building.
7. Name five vegetable foods that contain a large per cent. of material for muscle-building.
8. Name five foods that could supply a large amount of heat for the body.
9. Suggest reasons why any of the foods named in answer to questions 6, 7, and 8 above would not be the most healthful foods for the body.

B. Pecuniary economy of food.

(Make estimates from Chart 2, p. 22, and compare with per cents. given in Table B, p. 27, in "Foods: Nutritive Value and Cost.")

1. Can larger amounts of animal food or of vegetable food be purchased for 10c.?
2. Suggest some reasons for the fact you have just stated.
3. Which kind of food material named on the chart is cheapest? (That is, of which

kind could you secure the largest amount for 10c.?)

4. Which kind of food material is most expensive?
5. Which of the three kinds of steak named on the chart is the most economical?
6. About what fractional part of a pound of each kind of nutrient is needed each day by an American at moderate work? (Last line on p. 22 and p. 28.)
7. Which food on the chart comes nearest to supplying the nutrients in the right proportions?
8. Why is it better, therefore, to eat a variety of foods rather than a single kind?
9. On p. 10 learn the definition of (*a*) the most healthful food, (*b*) the cheapest food, (*c*) the best food.

17. THE STUDY OF THE MOUTH.

Take a position with your back toward a strong light and study your mouth-cavity by means of a hand-mirror.

A. Walls of the mouth-cavity.

1. Press the forefinger against the upper, lower, and side walls of the mouth; in which of these regions are the walls rigid (bone)? in which regions are they yielding (muscle)?
2. What differences do you note between the

outer and inner coverings of the cheek? What are the characteristics of *mucous membrane* (inner covering)?

3. Pull aside with the forefinger one corner of the mouth. Notice the small elevation on the inside of the cheek. Opposite what tooth does it lie? (The duct from one of the salivary glands opens on this elevation.)
4. Press the tongue down with the forefinger. Make a drawing of the opening into the throat
5. If possible, locate and describe the tonsils.

B. The teeth.

1. Close the jaws and open the lips; do the front teeth of the upper jaw cover the ends of the lower teeth or *vice versa?*
2. Are the front teeth of the upper jaw larger or smaller than those of the lower jaw?
3. Count your teeth and record result in a table like the following:

	Right half of upper jaw.	Left half of upper jaw.	Right half of lower jaw	Left half of lower jaw.
Incisors......				
Canines......				
Bicuspids....				
Molars.......				

4. Place a piece of string between the teeth and describe motion of jaws in biting it off. Describe the movements of the jaws in chewing.

C. The tongue.
1. What is the shape of the tongue?
2. [illegible] is the tongue attached?
3. [illegible] parts of the [illegible] of the mouth cavity [illegible] by the tip of the tongue?
4. [illegible] between the [illegible] of the tongue?

D. The use of the lips and tongue in speaking.
1. Pronounce the vowels of the alphabet.
a. Are the lips closed or open?
b. Does the tip of the tongue touch the teeth?
c. Does the tip of the tongue touch the palate?
d. What is the shape of the mouth-cavity when you are pronouncing each of these vowels?
2. What consonants necessitate the closing of the lips? (These consonants are called labials.)
3. What consonants require the tongue to touch the teeth? (These are called the lingual consonants.)

III. TO PREPARE DIGESTIVE JUICES. (Dec.)

Note. [illegible]

A. Preparation of [illegible]
1. [illegible]

C. The tongue.

1. What is the shape of the tongue?
2. Where is the tongue attached?
3. What parts of the walls of the mouth-cavity can be touched by the tip of the tongue?
4. What differences do you note between the upper and lower surfaces of the tongue?

D. The use of the lips and tongue in speaking.

1. Pronounce the vowels of the alphabet.
   a. Are the lips closed or open?
   b. Does the tip of the tongue touch the teeth?
   c. Does the tip of the tongue touch the palate?
   d. What is the shape of the mouth-cavity when you are pronouncing each of these vowels?
2. What consonants necessitate the closing of the lips? (These consonants are called labials.)
3. What consonants require the tongue to touch the teeth? (These are called the lingual consonants.)

18. TO PREPARE DIGESTIVE JUICES. (Dem.)

Materials: Cardiac end of pig's stomach; pancreas of pig; gall of ox; strong glycerin, 2% solution of hydrochloric acid, 1 5% solution of sodium carbonate; solid pepsin, pancreatin, and ox-gall.

A. Preparation of pepsin solution.

Procure the stomach of a pig, wash it out with a gentle stream of water. Tear off the mucous membrane from the cardiac (œsophageal) end of the stomach. Dry the membrane between folds of blotting-paper, and mince it finely. Place in a bottle and add 5 times its bulk of strong glycerin. Set aside for several days, stirring occasionally. Filter through muslin. (The glycerin dissolves the pepsin.) The glycerin extract may be kept almost indefinitely.

When required for use in digesting nitrogenous substances, add 10 times its volume of .2% hydrochloric acid, and filter.

Instead of preparing the glycerin extract an artificial gastric juice may be made by dissolving solid pepsin in water and adding the hydrochloric acid.

B. Preparation of pancreatin solution.

Leave the pancreas of a pig moistened with water for a day; then mince it well and add 10 times its volume of strong glycerin. Set the mixture aside for several days, stirring occasionally. Filter through muslin. (The glycerin dissolves out the pancreatin.)

The glycerin extract acts on starch and nitrogenous substances. When required to digest fats add 10 volumes of 1.5% solution of sodium carbonate, shake and filter.

An artificial pancreatic juice can be made by dissolving solid pancreatin in water and adding the sodium carbonate solution.

C. Preparation of bile.

Procure the fresh gall-bladder of an ox: wash

it, make a small opening with a knife, and collect the bile in a bottle. (The bile of herbivorous animals is green in color; human bile when fresh is a golden-brown liquid.)

A solution of solid ox-gall in water may be used instead of the contents of the gall-bladder, if the latter cannot be easily obtained.

19. THE DIGESTION OF STARCH.

Materials: **Corn-starch, saliva, pancreatin solution; test-tubes; alcohol-lamp.**

A. By saliva.

Put a small amount of corn-starch in a test-tube, add water and boil; dilute the paste until a smooth, thin mixture is formed.

1. Pour into a test-tube a small amount of this starch mixture, and test with Fehling's solution. What is the result and what is your conclusion?
2. Allow some saliva to flow from the mouth into a clean test-tube; * test it with Fehling's solution. What is your inference?
3. Pour some saliva into the starch paste made at the beginning of the experiment, shake the mixture and warm gently for a moment or two. Test with Fehling's solution. Result? H+ very
4. What is the effect of saliva on boiled starch?

*** Saliva sufficient for the class may be obtained by the teacher before the exercise.**

5. Name several foods already studied which could be partially digested by saliva.
6. Hold a small amount of the boiled dilute starch paste in the mouth. What is the taste at first? Do you notice any change; if so, what change?

B. By pancreatic juice.

1. Dissolve a little pancreatin in water. Test a small portion of it with Fehling's solution. What is your conclusion?
2. Add some pancreatin solution to some of the starch paste; warm and test with Fehling's solution. Result?

C. What digestive juices of the human body act upon starch? What change do they cause?

20. DIGESTION OF MINERAL SUBSTANCES.

Materials: Table-salt, phosphate of lime, diluted hydrochloric acid; evaporating-dish, alcohol-lamp.

A. Soluble salts.

Put some table-salt into a test-tube, add water, and shake well.

1. Does the salt dissolve? How do you know?
2. In what part of the alimentary canal may salt become liquefied, and how?
3. What is meant by a soluble salt or soluble mineral substance?

B. Insoluble salts.

Put some phosphate of lime (one of the con-

[illegible]

[illegible]

3. Does the [illegible] ? How do you know?

4. Will [illegible] dissolved [illegible]

5. [illegible] of the liquid obtained in 4.

a. What is the appearance of the substance which is left?

b. Will it dissolve in water?

c. Into what kind of a salt has [illegible] changed the insoluble salt?

6. [illegible] is one of the ingredients of [illegible]. In what parts of the alimentary canal are [illegible] soluble, and how are they digested?

IX. DIGESTION OF NITROGENOUS SUBSTANCES. (Lean.)

Reagents. [illegible]

A. [illegible]

1. [illegible]

a. [illegible]

stituents of milk) into a test-tube, add water, and shake well.

1. Does the substance dissolve? How do you know?
2. Add a little diluted hydrochloric acid and shake. What change do you observe?
3. Evaporate to dryness in an evaporating-dish some of the liquid obtained in 2.
   a. What is the appearance of the substance which is left?
   b. Will it dissolve in water?
   c. Into what kind of a salt has hydrochloric acid changed the insoluble salt?
4. (Hydrochloric acid is one of the ingredients of gastric juice.) In what part of the alimentary canal are insoluble salts digested, and how are they digested?

21. DIGESTION OF NITROGENOUS SUBSTANCES. (Dem.)

Materials: **Hard-boiled egg, pepsin, pancreatin, hydrochloric acid, baking-soda; test-tubes, labels.**

A. Action of gastric juice.

1. Experiments.
   a. Thoroughly mince a piece of hard-boiled egg and place a portion of it in a test-tube; half fill the tube with water. Label Test No. 1, minced egg + water.

b. Place in another test-tube the same quantity of minced egg and water as in tube No. 1; add a little dilute hydrochloric acid. Label Test No. 2, minced egg + water + hydrochloric acid.

c. Into a third tube put some minced egg and water, and add a small amount of pepsin. Label Test No. 3, minced egg + water + pepsin.

d. Place some of the minced egg into a fourth tube and add all three ingredients of gastric juice, namely, water, a little hydrochloric acid, and pepsin. Label Test No. 4, minced egg + water + hydrochloric acid + pepsin.

e. Put a lump of the hard-boiled egg in a fifth test-tube; add water, hydrochloric acid, and pepsin, as in Test No. 4. Label Test No. 5, lump of egg + water + hydrochloric acid + pepsin.

f. Put all five tubes in a warm place (98° F.) and shake them at frequent intervals. Examine them at the end of a few hours and at the end of a day or two.

2. Results and conclusions.

a. Compare tests 1, 2, 3, and 4.

(1) In which tube has the egg been liquefied or digested?

[illegible]

(a) [illegible]

[illegible]

(b) [illegible]

b. [illegible]

(a) [illegible]

(b) What do you know in regard to the effect of thorough mastication of food?

(c) What conditions which [illegible] digestion [illegible] food?

B. Action of pancreatic juice.

1. Experiments.

a. Into a test-tube put some of the [illegible] half of the tube with water and add [illegible] the mixture [illegible] Label Test No. 6 [illegible] alkali.

b. In a seventh tube put the same [illegible] and [illegible] Label Test No. 7 [illegible]

c. [illegible]

(2) Are all three ingredients of gastric juice necessary for proteid digestion or not?

(3) To what, therefore, may some cases of indigestion be due?

b. Compare tests 4 and 5.

(1) In which tube is digestion more complete?

(2) What do you learn in regard to the effect of thorough mastication of food?

(3) What provisions within the stomach, however, might accomplish the digestion of even poorly masticated food?

B. Action of pancreatic juice.

1. Experiments.

a. Into a test-tube put some of the minced egg; half fill the tube with water and add pancreatin; add to the mixture a little baking-soda or other alkali. Label Test No. 6, minced egg + water + pancreatin + alkali.

b. In a seventh tube mix the same quantity of minced egg, water, and pancreatin as was used in Test No. 6; pour in a few drops of hydrochloric acid. Label Test No. 7, minced egg + water + pancreatin + acid.

c. Put both tubes in a warm place (98° F.)

and shake them at frequent intervals. Examine them at the end of a few hours and at the end of a day or two.

2. Results and conclusions.
   a. In which tube has digestion taken place?
   b. Does pancreatin, therefore, perform its digestive action by the aid of an alkali or of an acid?

22. DIGESTION OF FATS.

Materials: Butter, olive-oil, lard, white of egg; sodium carbonate, caustic soda, hydrochloric acid; bile, pancreatin; test-tubes, alcohol-lamp, apparatus-stand; compound microscope, slide, cover-glass.

A. Effect of heat on fats.
1. Put a small piece of butter in a spoon and hold the spoon over a hot stove. What change takes place?
2. How, then, can you distinguish between a fat and a proteid?
3. Hold a piece of butter in your mouth. Does it become liquid at the temperature of the body?

B. Emulsion of fats.
1. In a test-tube shake up a few drops of olive-oil with some caustic soda solution.
   a. What change takes place in the appearance of the mixture after shaking? (This mixture is called an *emulsion.*)
   b. Put a drop of the mixture on a glass

[illegible] water [illegible] covering [illegible] [illegible] with a [illegible] [illegible]

(c) What is the [illegible] of the [illegible]?

(d) Compare this experiment with [illegible] surface of soil. (See experiment 15 B.)

2. In a test-tube make some [illegible] with a mixture of white of egg (albumen) and water.

a. What is the appearance of the mixture?

b. Examine a drop under the compound [illegible] glass.

3. Shake up a few drops of the [illegible] with water in a test-tube and let the tube stand for a time.

a. Compare the mixture of oil and water with [illegible] formed in 2 [illegible]

b. What difference do you notice in the two?

4. Emulsions.

a. Define an emulsion.

b. State two ways in which an emulsion can be made.

C. Separation of [illegible] of fats.

Place some butter [illegible] in a test-tube [illegible]

a. What is the appearance of the [illegible]?

slide, cover with a cover-glass, and examine with a compound microscope.

(1) What is the appearance of the oil droplets?

(2) Compare this appearance with that seen in milk. (See experiment 15 E.)

2. In a test-tube shake some olive-oil with a mixture of white of egg (albumin) and water.

a. What is the appearance of the mixture?

b. Examine a drop under the compound microscope as directed above.

3. Shake up a few drops of the olive-oil with water in a third test-tube, and let tube stand for a time.

a. Compare the mixture of oil and water with the mixtures formed in 1 and 2 above.

b. What differences do you notice in the tubes?

4. Summary.

a. Define an emulsion.

b. State two ways in which an emulsion can be made.

C. Saponification of fats.

1. Put a little lard or olive-oil in a test-tube, add caustic soda, and boil.

a. What is the appearance of the mixture?

b. Examine a drop under the compound microscope as directed above. Do you see any difference between this mixture and that formed in B 1 above?

c. Taste of the mixture. What kind of substance has been formed?

2. What is meant by *saponification?*

D. Effect of acids and alkalis on fats.

1. Pour a little melted butter into each of two test-tubes. Add to test-tube No. 1 some diluted hydrochloric acid; to test-tube No. 2 some sodium carbonate solution. Shake both tubes well, and allow them to stand for a few moments.

2. Does the butter remain mixed better with an acid or with an alkali? Why, then, are fats not digested in the stomach?

E. The digestive action of bile.

1. Test with litmus paper the bile solution. Is it acid, alkaline, or neutral?

2. Pour a little melted butter into a test-tube; add some of the bile solution. Does the mixture resemble that formed in B 1 or B 3 above?

3. Examine a drop of the mixture under the compound microscope. Does this observation agree with that made in 2 just above?

4. Pour a little thin starch paste into a test-tube; add some bile, and after a time test the mixture with Fehling's solution. Does the bile act upon starch?

5. Place in another test-tube a little minced white of egg; add bile and set aside for a day or two. Does the egg dissolve?
6. State what kinds of food-stuffs are acted upon by bile, and what kinds of food-stuffs are not acted upon.

F. The digestive action of pancreatic juice.

1. Prepare some artificial pancreatic juice as directed in 18 B, adding the sodium carbonate solution to make it alkaline.
2. Shake up a little melted butter with some of this pancreatic juice. What kind of a mixture is formed? Examine under the compound microscope.
3. What kinds of food-stuffs are digested by the action of pancreatic juice (compare previous experiments), and what kind of food-stuffs are not acted upon?

23. PRINCIPLES OF OSMOSIS. (Dem.)

Materials: Thistle-tube, beaker-glass, grape-sugar, starch, white of egg, Fehling's solution, iodine, nitric acid, and ammonia. Procure the intestines of a sheep;* clean and inflate them; tie at intervals, and allow this animal membrane to dry.

A. Hold a thistle-tube upright, closing the smaller end with the thumb. Into the larger end pour a thick solution of grape-sugar (honey will answer) until the liquid has half filled the tube and nearly filled the bulb. Slit open one of

* See foot-note p. 46.

the tubes of sheep's intestine,* moisten it, and tie it tightly over the larger end of the thistle-tube, taking care that none of the grape-sugar solution escapes. Stand the thistle-tube (membrane down) in a glass bottle filled with water up to the level of the grape-sugar solution. Mark on the bottle the level of the two liquids. Connect a long piece of glass tubing to the smaller end of the thistle-tube and support it in a vertical position. (The experiment can be demonstrated better in a large class-room if a little red ink is dropped on the top of the grape-sugar solution.) (See Fig. 4.)

1. At the end of several hours notice the level reached by the liquid within the thistle-tube. Measure the difference between the level of the liquid within the thistle-tube and the level of the liquid in the bottle.
2. Remove with a glass-tube some of the water on the outside of the thistle-tube (in the bottle). Test it with Fehling's solution. What is the result? How do you account for this result?
3. Which of the two liquids (the water in the bottle or the grape-sugar solution in the

* Parchment paper may be used instead of the dried sheep's intestine to cover the end of the thistle-tube. Or a membrane may be obtained which will answer the purpose by dissolving the mineral portion of an egg-shell, leaving the lining membranes intact; the membrane may then be tied to the end of the tube

thistle-tube) was the more dense at the beginning of the experiment?

4. Has more liquid passed into the thistle-tube or out from it? How do you know?
5. When two liquids, therefore, of different density are separated by an animal membrane what change tends to take place? Is the greater flow of liquid from the less dense to the more dense or from the more dense to the less dense?

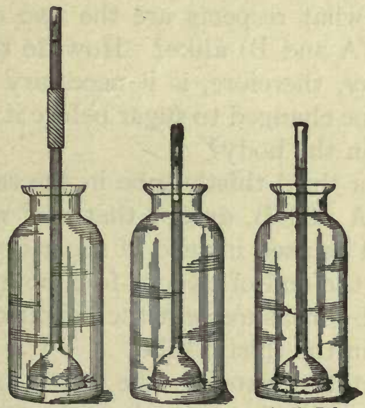

FIG. 4.

6. Mark the level of the liquid in the thistle-tube at the end of each successive twenty-four hours. What inferences do you draw?

B. Into a second thistle-tube carefully pour some starch-paste, cover with animal membrane, and invert in a bottle of water, adding red ink as in A above. The experiment will be more striking if the level of the liquids in the two experiments is the same.

1. What is the level of the liquid within the second thistle-tube at the end of twenty-four hours? Take measurements as in the preceding experiments.
2. Test the water in the bottle with iodine. What is the result and what do you conclude?
3. In what respects are the two experiments (A and B) alike? How do they differ?
4. Why, therefore, is it necessary that starch be changed to sugar before it can be used in the body?

C. Prepare a third thistle-tube in the same manner as in A and B, except that raw white of egg should be used instead of sugar or starch.

1. At the end of twenty-four hours determine by measurement the height of the liquid in the thistle-tube.
2. Test the water in the bottle by boiling it and then testing it with nitric acid and ammonia. What is the result?
3. In what respects are the three experiments alike? How do they differ?
4. (Protoplasm always contains water and albumin.) Explain why the protoplasm of cells can absorb liquid nourishment. Can protoplasm soak out of cells? Give reason.

D. Summary.

1. From the above experiments give a concise definition of *osmosis*.
2. State a law of osmosis that will hold good for all the experiments.
3. Classify all the substances you have tested in a table like the following:

CRYSTALLOIDS. (Substances which will readily pass through an animal membrane.)	COLLOIDS. (Substances which will not readily pass through an animal membrane.)

24. DIGESTION OF NUTRIENTS.

Kind of nutrient.	In what region of alimentary canal is it digested or dissolved?	By what juice is it digested or dissolved?	To what substance is it changed?	In what region or regions of alimentary canal is it absorbed?
Nitrogenous food ..				
Nitrogenous food ..				
Fat				
Fat				
Starch				
Starch				
Sugar				
Soluble salt				
Insoluble salt				
Water				

25. STUDY OF BEEF BLOOD. (Dem.)

Materials: Concentrated nitric acid and ammonia, iodine solution, Fehling's solution; test-tubes, alcohol-lamp, platinum-foil, bottle and rubber stopper; three bottles of blood prepared as follows:

Bottle No. 1.—Take a bottle to the slaughter-house and get the butcher to fill it with fresh blood. Carefully set it aside (in cold storage room if possible), taking care not to jar in the least the contents. At the end of several days the solid clot should be surrounded by a transparent serum of a pale straw color. Label the bottle *Clotted Blood.*

Bottle No. 2.—Get the butcher to collect some blood in a pail and whip it rapidly for some time with a brush-broom or with his hands. Fill bottle No. 2 with the red liquid remaining in the pail, labelling it *Defibrinated Blood.*

Bottle No. 3.—Collect the stringy substance clinging to the broom, wash it with water until it is white, and place it in bottle No. 3, in a 4% solution of formalin* or in 80% alcohol; label it *Blood Fibrin.*

A. Study of clotted blood.
1. Describe the preparation of clotted blood (see Bottle No. 1 under *Materials* above).
2. Pour off all the liquid serum into another bottle of the same size.
   a. What proportion of blood appears to be serum?
   b. What is the color of the serum?
3. The solid mass left behind in Bottle No. 1 is the blood-clot.
   a. Hold the bottle in a horizontal position and compare the shape of the clot with that of the bottle.
   b. What is the size of the clot compared with the size of the bottle? (See 2, *a* above.)

* 4% formalin is prepared by diluting 1 volume of formalin with 10 volumes of water.

c. Gently shake the bottle. Describe the consistency of the clot.

d. What is its color? Is the whole mass of the same color?

4. Determine the composition of the blood-serum by the following experiments:

a. Pour a small portion of the serum into a test-tube and heat gradually over an alcohol lamp; what change takes place? What kind of nutrient do you, therefore, conclude to be present?

b. Dip a piece of unglazed paper into the blood-serum and allow the paper to dry. How is the paper affected? What is the second food-stuff found in serum?

c. Test a little of the serum with iodine. What is the result? Why ought this result to have been expected?

d. Pour into another portion of the serum some Fehling's solution and boil. What is the result? Did you expect this result? Can you suggest any possible explanation of this result?

e. Put a few drops of the serum on a piece of platinum foil and heat as hot as you can in a gas flame. Describe the various changes that take place and explain each. What kind of material is left after the blood is completely burned, and what does this prove as to the composition of serum?

f. Warm some blood-serum in a test-tube. What do you find on the inner surface of the upper part of the tube? What ingredient is therefore present in blood in large quantity?

g. From the preceding experiments name all the food materials you have found present in blood-serum and state those that are absent.

B. Study of defibrinated blood.

1. Describe the preparation of defibrinated blood (see Bottle No. 2 under *Materials* above).
2. What ingredient of blood has been removed? (See Bottle No. 3.)
3. Where is this substance found in the clotted blood?
4. What, therefore, is the effect of whipping blood, and why?
5. Remove a piece of blood fibrin from bottle No. 3.

   a. What is its color?

   b. Pull it apart. Describe some of its characteristics. Is it elastic?

   c. Test a piece of blood fibrin with nitric acid and ammonia. What do you conclude as to its composition?

C. Change in blood after mixing with oxygen.

1. Pour a small quantity of defibrinated blood into a glass bottle. Describe its color.
2. Stopper the bottle tightly and shake it violently for a minute or two.
    a. What change has taken place in the appearance of the blood?
    b. With what was the blood mixed during the process of shaking?
    c. In the human body where does this change take place?

26. MICROSCOPIC STUDY OF CORPUSCLES. (Dem.)

Materials: **Prepared slides of frog's blood and of human blood; compound microscope (500 diameters).**

A. Corpuscles of frog's blood.
   1. How many distinct types of solid bodies (*corpuscles*) can you see in the frog's blood?
   2. Is there any variation in the form or size of different corpuscles of the same type?
   3. Draw two corpuscles (differing as much as possible) of each type, much enlarged, labelling *nucleus* and *cell-body*.

B. Corpuscles of human blood.
   1. What is the form of the corpuscles in human blood? (Examine several corpuscles before deciding.)
   2. In what respects do these corpuscles differ from those found in frog's blood?

27. STUDY OF THE BEEF HEART. (Dem.)

Materials: The best material for demonstrating the structure of the heart to large classes is an ox heart. In procuring the heart from the butcher make sure that the pericardium is uninjured and that the blood-vessels are left as long as possible

Cut around the pericardium just below its attachment to the upper part of the heart, and lay the sac aside, so that it may again be put around the heart. Attention should be called to the connective tissue, of which the pericardium is largely composed, and to its smooth, serous lining.

Dissect away the fat from the auricles in order that their shape may be demonstrated. Make careful incisions into each of the four chambers in such a way that when the walls are pulled aside, the following structures may be demonstrated: the openings from the auricles to the ventricles, the mitral and tricuspid valves that guard these openings, the semilunar valves at the mouths of the arteries, and the openings from the veins into the auricles. Call attention also to the relative thickness of the walls in each chamber, and to the differences between arteries and veins.

Many points can be shown more clearly if a second beef heart is cut horizontally into three parts. The first cut should be made through the two auricles, just above the auriculo-ventricular orifices; the second should pass across the two ventricles, half-way between the apex and the openings from the auricles. It is worth while to make a careful dissection of the two hearts, since they can be preserved in 4% formalin,* and so used year after year. If possible, fresh sheep hearts, dissected as directed in the preceding paragraph, should be supplied the students, so they can verify the facts demonstrated by the teacher.

The following outline is suggested for recording the principal facts relating to the structure of the heart.

A. Using the descriptive terms anterior and posterior, dorsal and ventral, right and left (with reference to the animal), locate the following

* 4% formalin is prepared by diluting 1 volume of formalin with 10 volumes of water.

structures in the heart, giving, when possible, the number of each:

1. Auricles.
2. Ventricles.
3. Semilunar valves.
4. Tricuspid valve.
5. Mitral valve.
6. Papillary muscles.
7. Chordæ tendineæ.

B. Name the chamber of the heart with which each of the following blood-vessels is connected:

1. Aorta.
2. Pulmonary artery.
3. Pulmonary veins.
4. Venæ cavæ.

C. State all the differences which you note between—

1. Dorsal and ventral surfaces of the heart.
2. Anterior and posterior ends of the heart.
3. Auricles and ventricles.
4. Largest veins and largest arteries.
5. Mitral and tricuspid valves.
6. Mitral and tricuspid valves and semilunar valves.

D. Enumerate the differences between the right and left sides of the heart.

28. CIRCULATION OF THE BLOOD IN THE TAIL OF THE TADPOLE. (Dem.)

Cut a hole a half-inch square near the end of a piece of thin board three inches long and one inch wide; glue a thin cover-glass over the hole. Cover the rest of the piece of wood with absorbent cotton soaked in water. Lay a live tadpole on the cotton, placing the tip of the tail on the cover-glass. Lay a cover-glass on top of the tail, and fasten cheese-cloth over the animal to keep it in place. Keep a plentiful supply of moisture about the animal, by allowing the end of the strip of cloth to dip into a dish of water. Examine the tip of the tail with a compound microscope magnifying about 75 diameters

1. At the highest focus note the epithelial cells forming the outside layer of the body covering. What is their shape?
2. What is the shape of the dark pigment-cells seen just beneath the epithelial cells?
3. Focus still lower and study the flow of the blood in the small capillaries.
   a. Is the current steady in all the blood-vessels which you see?
   b. Do the red corpuscles alter in shape as they move along?
   c. Can you distinguish any colorless corpuscles?
   d. Draw a small area of the tail, representing the course of the capillaries. Indicate by arrows the course of the blood in each capillary.

NOTE.—If tadpoles cannot be obtained, the web of a frog's foot may be examined after confining the frog on a larger piece of board than that described above.

29. PULSE IN THE PUPIL'S OWN BODY.

To feel the pulse place the forefinger of the left hand on the radial artery of the right hand at the lower end of the radius bone on the palm side. Count the number of beats during a minute.

A. Variations in the pulse-beat.

1. Make out in your note-book a statement of your pulse-rate taken under the following conditions:
    a. Before rising in the morning.
    b. Just before eating breakfast.
    c. Just after breakfast.
    d. Just after some violent exercise.
2. What is your conclusion from these observations?

B. Find your pulse in the following places on your body, locating each with reference to the bones of the skeleton:

1. On the side of the head in front of the ear. Trace this artery as far as possible.
2. On the back of the head near the top of the neck.
3. On the side of the lower jaw.
4. In the hollow back of the knee-joint.
5. On the ankle.

30. STRUCTURE OF BONES.

Materials (for each two pupils): A complete rib of sheep, carefully separated from its attachment to a vertebra; a piece of a rib of beef, an inch long, sawed lengthwise in halves; a leg-bone of sheep, from which meat has been removed; one-half leg-bone like the preceding, sawed lengthwise; a piece of the shaft of a leg-bone of sheep, sawed cross-wise; dissecting-needle and scalpel. (After completing the study of the structure, lay aside the bones for the next experiment.)

A. Structure of a rib (flat or tabular bone).

1. What is the general form of the bone?
2. Try to bend it. What do you conclude?
3. Cut off a thin slice of the covering of the enlarged end of the rib. Give some characteristics of this *cartilage*.
4. Stick the point of the dissecting-needle into the surface of the bone where it is free from muscle. Peel off some of the thin membrane of connective tissue. This membrane is *per-i-os′-te-um*.
   - *a*. What are some of the characteristics of periosteum? Try to tear it.
   - *b*. Where is periosteum found on the rib? Where is it wanting?
5. Study the section of the rib, pricking the different parts with the dissecting-needle.
   - *a*. In what respects does the outside layer of *hard bone* differ from the *spongy bone* in the interior?
   - *b*. Describe the color of the *marrow*. What does this color suggest as

to the presence of blood? Is the marrow hard or soft? Dig out a bit of it and rub it on a piece of paper. Hold the paper to the light. Of what nutrient is marrow largely composed?

B. Structure of a soup-bone (long bone).

1. What is the general form of the bone? How does it differ from a rib? How do the two *heads* at the end of the bone differ from the *shaft?* Can you suggest the use of the heads?
2. What kind of tissue covers the end of each head? Suggest a reason for this.
3. Where is periosteum found and where is it absent?
4. In the longitudinal section of the long bone distinguish periosteum, cartilage, hard bone, spongy bone, and marrow. State the region or regions of the bone in which each is found.
5. Compare the cross-section of the shaft of a long bone with the cross-section of a rib. In what respects do the two resemble each other? How do they differ?

C. Summary.

1. Name all the kinds of tissue found in bones.
2. Suggest, as far as you can, the use of each.
3. Can you give any reasons to explain why bones are not solid throughout? (Compare with the frame of a bicycle.)

D. Drawings.

1. Represent in a drawing the longitudinal and cross-section of the piece of rib, indicating diagrammatically the different kinds of tissue.
2. In the same way make drawings of the longitudinal and cross-sections of the long bone.

31. COMPOSITION OF BONES.

Materials: Two clean ribs; the two halves of the soup-bone used in **30**; diluted hydrochloric acid (6 parts water to 1 part acid); weighing balances; a piece of wire.

A. Action of acid on bone.

Compare the two ribs as to form and size; place one of them in a bottle of diluted hydrochloric acid. Allow the bone to remain in the acid for a few days and then compare the two ribs again.

1. Has the acid changed the form of the bone?
2. Has it changed the size of the bone?
3. Try to bend the two rib bones. What change do you observe to have taken place in the one which has been in the acid?
4. Pour some of the liquid in which the bone has been soaking into an evaporating-dish and heat over an alcohol-lamp or over a gas-flame until the liquid has disappeared. What kind of substance is

lye in the bone? What substance is [illegible] moved? [illegible] formed from the [illegible] of the bone [illegible] and [illegible]

3. What importance [illegible] the [illegible] to the [illegible] general [illegible]

B. Effect of [illegible]

[illegible] half of the bone [illegible] a piece of wire about it and place it in a hot [illegible] Allow it to [illegible] for a half-hour and then remove it [illegible] by means of the wire.

1. Write in your notebook a brief account of the changes which you observed while the bone was in the lye.
2. Has the bone been changed in form or size?
3. What change has occurred in the bone?
4. What part of the bone has been most affected by the lye?
5. Try to break the bone. What is the use in bone of the substance which has been [illegible]
6. Weigh the bone and determine what per cent of the [illegible]

C. Effect of [illegible]

[illegible]

left in the dish? (This substance is a kind of mineral matter formed from the mineral matter of the bone by the action of the acid.) See experiment 20, B.

5. What properties of bone are due to the presence of mineral matter?

B. Effect of burning bone.

Weigh half of the long bone used in 30. Tie a piece of wire about it and place it in a hot coal fire. Allow it to remain for a half-hour and then remove it carefully by means of the wire.

1. Write in your note-book a brief account of *all* the changes which you observed while the bone was in the fire.
2. Has the bone been changed in form or size?
3. What change can you see in the bone?
4. What part of the bone has been most affected by the fire?
5. Try to break the bone; what is the use in bone of the substance which has been lost?
6. Weigh the bone and determine what per cent. of the original bone remains as ash (mineral matter) and what per cent. has disappeared (animal matter).

C. Effect of boiling bones in water.

Place the other half of the soup-bone in a pint of water and allow it to simmer on the back of the stove for 4 to 6 hours. Strain the liquid through a cloth and allow it to cool.

1. Describe the substance which is obtained.

2. Test a small portion of this "soup-stock" for nutrients. (Experiments 8–13.)

32. CLASSIFICATION OF BONES.

From the articulated skeleton make lists of—

1. Long bones (distinguished by shaft and articular extremities or heads).
2. Short bones (more or less cubical in shape).
3. Tabular or flat bones (flat like rib and with no marrow cavity).
4. Irregular bones (all others).

33. STUDY OF THE MUSCLES.

Definitions.

1. The part of the muscle which contracts is the *belly;* the bands or cords at the ends are the *tendons.*
2. The end of the muscle, that is, the tendon, which moves least is called the *origin;* the tendon which moves most, the *insertion.*
3. Muscles which bend or flex the limb are called *flexors;* muscles which straighten or extend the limb, *extensors.*

A. The biceps muscle (a flexor muscle).

1. Clasp the front of the right upper arm with the left hand; draw up or flex the right forearm as far as possible. What changes do you notice in the belly of the muscle?

2. Place the tips of the fingers of the left hand at the lower end of the belly of the right biceps muscle and the thumb at its upper end. Flex and extend the right forearm several times. What change takes place in the length of the muscle?
3. Enumerate, therefore, three changes you have found to take place in the belly of a muscle when it contracts.
4. Roll the sleeve above the biceps muscle. Let the arm hang free, and with a tape-measure get the circumference of the upper arm around the middle of the belly of the biceps muscle. Flex the forearm as strongly as you can and then determine the circumference. What is the amount of increase in size?
5. With the thumb and forefinger of the left hand grasp the tendon at the lower end of the right biceps muscle; rotate the right forearm. To which of the bones of the forearm, therefore, is the biceps attached? Point out on the skeleton the rough prominence where the tendon is attached to this bone.
6. (Dem.) Demonstrate on the shoulder-blade the point of attachment of each of the two upper tendons of the biceps.
7. Which tendon (upper or lower) of the biceps moves the more when you lift a book? Which end is, therefore, origin, and which insertion? Locate the belly

of the biceps with reference to the humerus.

B. The triceps muscle (an extensor muscle).

1. Clasp the back of the right upper arm with the left hand; forcibly straighten or extend the right forearm as much as you can. Locate the belly of the triceps with reference to the belly of the biceps, and with reference to the humerus.
2. By flexing and extending the forearm determine the position of the lower tendon of the triceps. To which bone of the forearm is it attached?
3. (Dem.) Point out on the shoulder blade and humerus the attachment of the three upper tendons.

C. The flexor muscles of the fingers and of the thumb.

1. Clasp the right forearm near the elbow; clench the hand quickly and forcibly. Locate the belly of these flexor muscles with reference to the bones of the forearm.
2. Press the forefinger and thumb strongly together. What change is noticed in the thick mass of muscle at the base of the thumb? Along what bone does this flexor muscle of the thumb lie?
3. What would be the form of the hand if the flexor muscles of the fingers were located in a position corresponding to the flexor muscle of the thumb? What is gained by placing these muscles in the forearm?

4. Measure the circumference of the forearm when the hand is open, and again when it is tightly closed. Record your results. Compare amount of increase with figures for biceps.
5. Pull up your sleeve. Flex the fingers several times, and note the movements of the tendons in the wrist. Along what bones do these tendons pass?

D. The extensor muscles of the fingers.

1. Straighten back the fingers as far as possible, and by feeling of the back of the forearm locate the belly of the extensor muscles of the fingers.
2. Move the middle finger alone. Describe the movements of the tendons on the back of the hand. What do you conclude?
3. Flex the middle finger of each hand until it touches the palm of the hand; place the two hands together (palms facing) so that the tips of the forefingers, fourth fingers, and little fingers touch, pressing the backs of the middle fingers closely together. Try to separate each of the pairs of fingers, still keeping the middle fingers pressed together. Explain result. (See 2 above.)

E. The muscles which move the ankle.

1. Stand on tiptoe and locate in the calf of the leg the belly of the extensor muscles of the foot which cause this movement. To

which bone is the lower tendon of this muscle (tendon of Achilles) attached?

2. Determine the position of the flexor muscle of the foot by flexing the ankle as far as possible. Which is the larger, the flexor or the extensor? Why?

F. The jaw-muscles.

Alternately close the jaws tightly together and open them. Find the muscles which cause these movements. Watch in the glass and describe the movements of these muscles.

Fill out in your note-book a table like the following:

Name of muscle.	Belly opposite what bone or bones.*	Origin attached to what bone or bones.	Insertion attached to what bone or bones.
Biceps..................			
Triceps..................			
Flexor muscles of fingers....			
Extensor muscles of fingers.			
Flexor muscles of foot......			
Extensor muscles of foot....			

* Before deciding as to position of origin and insertion be sure to put the forefinger on the middle of the belly of each muscle.

34. STUDY OF BEEFSTEAK.

Materials: Slices of meat from the shank of beef about an inch thick. Cut the slices into blocks about a half-inch square. The structure is seen more clearly if the meat is allowed to dry in the air for a few hours. Dissecting-needles, slide and cover-glass, compound microscope $\frac{1}{8}''$ objective

A. Gross structure of muscle.

1. Pull apart more or less the small *bundles* of which the meat is composed. What is their shape? Are they all the same size?
2. What is the color of the meat? What do you infer as to the presence or absence of blood?
3. What are the characteristics of the tissue (*perimysium*) which surrounds and connects the muscle bundles?
4. Can you distinguish any fat in the piece of meat you are studying? Make sure of your answer by rubbing it on a piece of paper. If fat is present, where is it situated and what are its characteristics?
5. Is tendon (gristle) present? If so, give some of its characteristics.
6. Make a drawing of the piece of muscle showing cross and longitudinal sections ($\times 5$). Label bundles, perimysium, and fat and tendons if present.

B. Microscopic structure of muscle.

Separate with dissecting-needles a small portion of the muscle; cover it with water and tear it apart with the needles until you have the smallest portion of the bundle which you can get. Place this bit of muscle on a glass slide, add a drop of water, and tease it out with needles; cover with glass and examine under the high power of the compound microscope.

1. Of what is the piece of muscle found to consist?
2. Why is this kind of muscle called *striped muscle?*
3. Draw a muscle-bundle as seen under the microscope. Label fibres, cross-stripes.

35. STRUCTURE OF A JOINT.

Materials: **Fresh leg-joint of lamb or veal; scalpel.**

A. Movement at the joint.

1. Hold one of the bones in a fixed position; in how many directions can the other bone be moved?
2. What prevents the joint from moving in other directions?

B. Muscles and tendons.

1. Dissect away the muscle with the scalpel; by what are the muscles attached to the bones?
2. Try to stretch or break these cords (tendons); what properties of tendons does this demonstrate?
3. What is the advantage of the absence of muscle-tissue over joints?

C. Ligaments.

1. What kind of tissue holds the bones together after the muscle is removed?
2. How is this tissue attached to bone so as to allow movement at the joint?

D. Joint-cavity.

1. Cut through the *ligaments* with a scalpel so as to open the joint-cavity; what is the appearance of the liquid within (*synovial fluid*)?
2. Suggest the use of the synovial fluid.

E. Cartilage.

1. Cut thin slices of cartilage from the ends of the bones; what are the characteristics of cartilage?
2. Why is cartilage placed at the ends of bones where motion occurs?

F. Bones.

1. Describe the way the bones fit together at the joint.
2. Is twisting motion possible at this joint?

G. Periosteum.

Stick the point of the scalpel into the surface of the bone where all the muscle has been removed. Peel off some of the thin membrane (periosteum).

1. What are the characteristics of periosteum?
2. Where do you find periosteum on long bones?

H. Make a list of all the structures found in the joint, giving the use of each.

36. STUDY OF THE JOINTS IN THE BODY.

A. Ball-and-socket joints.

1. Note on the articulated skeleton what bones form the joint at the shoulder.
2. Point out the bones forming the hip-joint.
3. State the points of resemblance between these two joints.
4. What differences can you see in the sockets of the two joints? How does the head of the femur differ from that of the humerus?
5. Move your right arm and right leg at the same time from a vertical position in an arc sideways toward the right; state in number of degrees the greatest range of motion possible at the shoulder-joint and at the hip-joint.
6. In the same way move the arm and leg in an arc forward as far as possible; backward as far as possible. Compare the range of motion at each joint.
7. Describe a cone with the extended arm and leg; twist the arm and the leg at their proximal ends. What kinds of movements are, therefore, possible at these joints other than those suggested in 5 and 6 above?
8. Press the thumb on the hip-bone during these movements, then on the edge of the shoulder-blade. Is either of the two girdles movable? What advantages are

gained by the difference in the structure of these two girdles?

B. Hinge-joints.

1. Determine from the articulated skeleton the bones which form the hinge-joint at the elbow.
2. What bones form the joint at the knee?
3. What projection at the elbow occupies a position corresponding to the knee-cap or patella?
4. Move the right forearm and the right leg at the same time; state in which direction (i.e., anteriorly or posteriorly) each is bent.
5. Hold the humerus and the femur in a fixed position. Is lateral motion possible at the knee or elbow-joint? Show from the articulated skeleton the reason for this.
6. In how many directions can a hinge-joint be moved? How, therefore, can you distinguish between a ball-and-socket and a hinge-joint?
7. Are the joints between metacarpals and phalanges ball-and-socket or hinge? Why?
8. Make a list of all the hinge-joints in the body, naming the bones which form the joint in each case.

C. Pivot-joints.

1. Place the right forearm on the table with the palm of the hand upward. Without lifting the elbow from the table turn the

hand until the palm of the hand rests on the table.

a. Which of the bones of the forearm has crossed the other?

b. Note on the articulated skeleton what two bones form this pivot-joint at the elbow.

2. Study the two top vertebræ of the spinal column; move the vertebræ on each other. Describe the provisions that enable a person to turn his head from side to side.

D. Gliding joints.

1. Count on the articulated skeleton the bones forming the wrist.
2. How many form the ankle?
3. Which bones are the larger, those of wrist or ankle? What advantage is gained in each case?
4. Move your right wrist and right ankle in as many directions as you can. At which joint is the greater range of movement possible?
5. Move your lower jaw in as many directions as you can.

   a. Between what bones does this movement take place?

   b. To which classes does this joint, therefore, belong?
6. Study the joints between the vertebræ; show how the vertebræ move on each

other, enabling one to bend the back or twist the spinal column.

37. COMPARATIVE STUDY OF THE MAMALIAN SKELETON.

(At the American Museum of Natural History, 8th Ave. and 77th St.)

NOTE.—The skeletons of the lion, horse, seal, musk-ox, sea lion, and elephant are among those best adapted for observation.

A. Spinal column.

1. How many vertebræ are found in the neck (cervical) region?
2. How many vertebræ bear ribs (dorsal vertebræ)?
3. How many vertebræ in the lumbar region?
4. Can you determine how many vertebræ have united to form the sacrum?
5. How many vertebræ in the tail (caudal vertebræ)?
6. In what regions of the spinal column are curves noticeable? How do they differ from the curves in the human skeleton?
7. Are spinous processes specially developed in any region? (The head is supported by muscles attached to these processes.)

B. Ribs and sternum.

8. How many pairs of ribs has the animal?
9. How many are attached to the sternum?
10. Is the sternum a single piece of bone? If not, of how many parts does it seem to consist?

C. Anterior appendage.

11. Can you distinguish a shoulder-blade (scapula)?
12. Has the animal a collar-bone (clavicle)?
13. What fractional part of the length of the anterior appendage is formed by the humerus?
14. What is the relative size of radius and ulna?
15. Are radius and ulna anywhere united or is it probable that rotation of the radius about the ulna is possible?
16. Is the projection ("funny-bone") on radius or ulna?
17. How many wrist-bones (carpals) in the anterior appendage?
18. Does the animal walk on the palm of the hand or on the tips of the fingers?
19. How many fingers (or toes) of anterior appendage does it use?
20. How many bones are there in each finger?
21. Is a thumb distinguishable?
22. What use does the animal make of the anterior appendages? (Walk, swim, fly, catch prey, burrow, etc.)

D. Posterior appendage.

23. Is a knee-cap (patella) distinguishable?
24. What is the relative size of tibia and fibula?
25. How many ankle-bones (tarsals) are found in the posterior appendage?
26. How many toes of the posterior appendage does the animal use?
27. Are the bones of the appendages long and

slender or short and clumsy? Does the animal, therefore, seem to be adapted for swift or for slow locomotion? Give reasons for your answer.

E. Teeth.

28. What is the dental formula (number of incisors, canines, grinders in each half-jaw)?
29. Did the animal probably eat animal or vegetable food? Reason for answer?

38. ACTION OF THE DIAPHRAGM AND THE LUNGS. (Dem.)

Procure a bell-jar with an opening at the top for a stopper. Place a marble in the centre of a sheet of rubber, tie the rubber about it, and stretch the sheet of rubber over the larger end of the bell-jar, tying tightly. Secure a rubber stopper (provided with two holes) which will fit the opening in the top of the bell-jar. Pass a thistle-tube through one of the holes in the rubber stopper and tie a toy balloon to its lower end. Through the other hole pass a glass tube, attaching to the upper end a piece of rubber tubing closed with a clamp. Insert the rubber stopper in the opening at the top of the bell-jar with the toy balloon within the jar. Make sure that all connections are tight, by applying paraffin to the top surface of the cork.

The balloon represents a lung; the thistle-tube to which it is tied, the larynx and windpipe; while the bell-jar itself represents the chest-cavity, and the sheet rubber the diaphragm.

A. Exhaust some of the air from the bell-jar by applying the mouth to the rubber tubing, and then replace the clamp.

1. Is the pressure of air greater now within the bell-jar or without?

2. What is the effect on the sheet rubber of removing air from within the jar? Explain.
3. How is the toy balloon affected? Why?

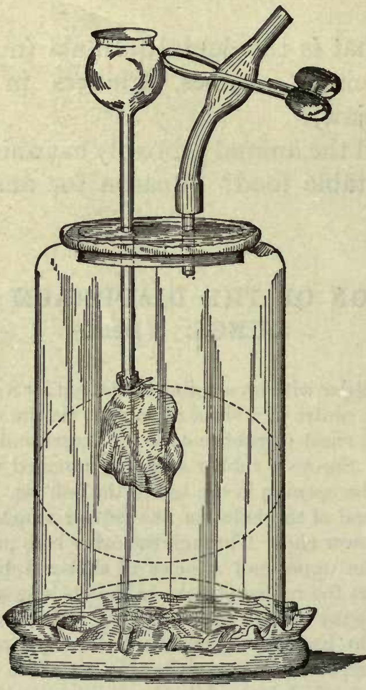

FIG. 5.

B. Seize the marble tied into the sheet of rubber and make the latter move up and down.

1. Does the air within the bell-jar have more or less room when the rubber is pulled down?
2. Is the pressure within the glass jar now

greater or less than when the rubber diaphragm was pushed up into the glass bell jar?

3. What is the effect on the rubber balloon of thus increasing the size of the cavity in which the balloon is hung? Why?

C. Application to the action of human diaphragm and lungs.

1. In what respects does this model illustrate the process of inhaling and exhaling air in our own bodies?
2. In what respects does the model fail to illustrate the process of respiration?

39. CIRCULATION OF AIR IN SCHOOLROOM. (Dem.)

Materials: Concentrated hydrochloric acid, concentrated ammonia; evaporating-dishes.

Pour into an evaporating-dish some concentrated hydrochloric acid; into another dish pour some concentrated ammonia.

A. Bring the two dishes near together.

1. What is the effect?
2. Place the two dishes near the hot-water or steam-pipes. Describe the course of the fumes.
3. Place the dishes near the opening to a ventilator. What course do the fumes take ?
4. Draw a diagram of the room and indicate by arrows the course of the moving air as demonstrated by the fumes.

B. Open a window, and place the two dishes near a steam-pipe near the window.
   1. Does the moving air take the same course as before?
   2. Does the open window help or retard the ventilation of the room?

Note.—Gunpowder or flash-paper may be used instead of the acid and ammonia.

40. INSPIRED AND EXPIRED AIR. (Dem.)

Materials: **Thermometer, bottle fitted as described in C below; lime-water.**

A. Difference in temperature.
   1. Note on a thermometer the temperature of the air in the room.
   2. Breathe for a few seconds on the bulb of the thermometer. Note temperature.
   3. What is the difference in temperature between inspired and expired air?

B. Difference in amount of moisture.
   1. Breathe again upon the polished bulb of the thermometer. Describe result.
   2. What substance is thus shown to be one of the wastes excreted by the lungs?

C. Differences in chemical composition.

Secure a bottle fitted with a rubber stopper with two holes. Through one hole in the stopper pass a glass tube (No. 1) until it reaches nearly to the bottom of the bottle. Pass the end of another tube through the other hole, al-

lowing the tube to project but a short distance into the bottle; attach a piece of rubber tubing to the upper end of this tube (No. 2). Half-fill the bottle with clear lime-water and insert the stopper. (See Fig. 6.)

1. Apply the mouth to tube No. 2, exhausting the air from the bottle. Describe result.
2. Draw into the lungs through the lime-water a considerable quantity of air in this way. Does any change take place in the lime-water?
3. Does inspired air therefore contain a large amount of carbon dioxid?
4. Apply the mouth to tube No. 1 (which passes below the level of the lime-water). Expel the air from the lungs through the lime-water. Describe any changes in the lime-water.
5. What is your inference from 4?

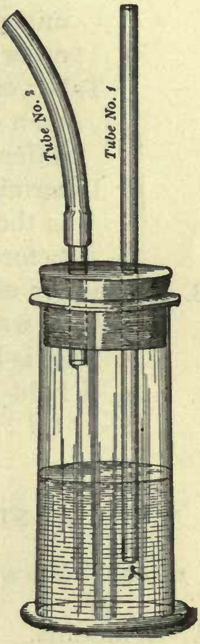

FIG. 6.

D. Name three differences between inspired and expired air.

41. TEMPERATURE OF THE BODY.

A. Place the bulb of a chemical thermometer beneath the tongue, closing the lips over it.

1. To what point does the mercury rise?
2. Is the temperature which you have determined the same as that found by the other pupils?
3. Take your body temperature on a cold day, then on a warm day; do you notice any difference?
4. Determine whether the body temperature is the same after violent exercise as it is before.

B. Production of heat.

1. How was heat produced in experiment 1?
2. How is heat produced in your body?
3. Is light produced in the human body (as in 1)?

42. STUDY OF THE SKIN.

Materials: **Clean needle; printer's or mimeograph ink.**

A. Epidermis.

1. Wash the hands thoroughly in warm water, then dry them; rub together the palms and fingers of both hands briskly for a moment. What do you see on your hands as the result? (This material was a part of your non-living epidermis.)

2. Run the point of a clean needle beneath the thin outer layer of the skin on the palm of the hand.
    a. Does the needle cause blood to flow? Is the outer layer of skin (*epidermis*) supplied with blood-vessels?
    b. Does the insertion of the needle cause any pain? Can you feel the point of the needle touch the skin? Would you infer that nerves entered the epidermis or not?
3. In what regions of the surface of the hand is the epidermis thickest? How do you know? In what region is it thinnest?
4. Press the tip of the forefinger on a piece of cloth covered with some thick ink (printer's ink or mimeograph ink is best), then press the finger-tip on a page in your note book. Study the impression made.
    a. Are the black lines (made by the ridges on the finger) all of the same width? Are they all parallel to one another?
    b. In the same way take the impression of the tips of your other fingers and of your thumb. In what respects do these various impressions differ?
    c. Where else on your hand can you see similar ridges?
    d. What other lines are visible on the palm of the hand?

B. Hair.

1. On what portions of the hand is hair found? Where is it wanting?
2. Compare the hair on the surface of your hand with that on the hand of an older person. What difference do you note?
3. Do blood-vessels run into the hair? How do you know?
4. Which part of the hair is supplied with nerves? How do you know?

C. Nails.

1. What different areas do you notice in your thumb-nail? How do they differ in appearance?
2. Make a drawing of your thumb-nail, showing these different regions.
3. Scrape off a little of the outer surface of the nail; does this cause blood to flow? Are nails supplied with blood-vessels?

D. Deeper layers of the skin.

1. With the thumb and forefinger of the right hand grasp a portion of the skin on the back of the left hand. Can you lift the skin from the muscles and tendons lying below?
2. In the same way determine whether the skin on the palm of the hand and on the fingers is closely or loosely attached to the underlying tissue. What do you find to be true?
3. Determine the effect of pushing a clean

needle point a little distance into the tissue lying beneath the epidermis.

a. Is the under skin (*dermis*) supplied with blood-vessels? How do you know?

b. Is the dermis supplied with nerves? How do you know?

E. Blood system in the skin.

1. Press the finger of the right hand on the back of the left hand; quickly remove the finger. What difference do you note in the color of the spot pressed and in the skin about this spot? Give an explanation of this difference.
2. From the preceding experiment can you explain the cause of sudden paleness in the face?
3. State the difference in the relative quantity of blood flowing through the cheek when it is flushed and when it is pale.

43. STUDY OF EXCRETION.

A. Excretion from sensible perspiration.

1. Find the exact weight of your body immediately after breakfast. Record the figure.
2. Exercise vigorously for several hours without eating or drinking.
3. Find again the weight of the body. Do you note any difference in weight?

B. Excretion from insensible perspiration.
1. Lay the palm of your hand (when your body feels cool) on a cold mirror. What evidence do you find of the activity of the skin?
2. Lay the back of your hand on the mirror.
a. Do you find any difference between the amount of perspiration from the palm and from the back of the hand?
b. Study your hand on a hot day and answer the same question.

44. STUDY OF THE KIDNEY OF THE SHEEP.

Materials: Fresh kidneys of sheep or pig in capsule, prepared for the pupil as follows: Slit the capsule on convex side enough to allow the kidney to be removed; cut the kidney from the convex border toward the hilum sufficiently to open up the cavity within; replace the kidney within the capsule; probe.

A. Exterior of the kidney.
1. Describe the capsule by which the kidney is surrounded.
2. Carefully remove the kidney from the capsule, taking care not to tear the latter. Where is the capsule attached to the kidney?
3. What is the shape of the kidney?
4. What is the color of the kidney? Why?
5. How many tubes can you find connected with this organ? Can you suggest the use of any of these tubes? (The depres-

sion in the kidney to which the tubes pass is called the *hilum*.)

B. Gross structure of the kidney.

1. Pull apart the halves of the kidney sufficiently to look within.
2. What is the shape of the cavity near the hilum (*sinus* of the kidney)?
3. By means of a probe locate the tube (*ureter*) which passes out from this cavity.
4. The layer on the outside of the kidney section is called the *cortical layer*.
    a. Does this layer anywhere reach down to the sinus?
    b. What characteristics distinguish the cortical layer from the rest of the solid portion of the kidney?
5. The bodies which form the medullary portion of the kidney within the cortical layer are called the *pyramids of Malpighi*.
    a. Why is the name pyramid given to them?
    b. Do these pyramids project into the sinus of the kidney?
    c. Press one of the pyramids of Malpighi. Can you see any substance ooze out?

45. SENSATION OF TOUCH.

Materials: Pen and ink, pin, ruler, pair of scissors.

A. Blindfold a person, touch lightly some portion of his body with a pen dipped in ink, and ask him to point out with a pin the point touched, as soon as you have removed the pen.

1. Measure the distance with a rular between the ink-dot and the point touched with the pin. Record result as directed below in 4.
2. Try the experiment several times on the same region of the body. Do the results agree?
3. Try the experiment on different parts of the body.
4. Record results in tabular form as follows:

Part of body experimented upon.	Distance between points.		
	1st trial.	2d trial.	3d trial.

B. Apply lightly the points of a pair of scissors (separated about a quarter of an inch) to the palm of your hand.

1. Can the points be felt as two, or do they feel as one?
2. Separate the points of the scissors a little more than a quarter of an inch, and ap-

[illegible] and at what distance apart can the points be felt as two?

[illegible] compare [illegible] can be felt as two [illegible] finger [illegible] the tip [illegible] the back of the neck [illegible]

12. Record your results in tabular form as follows, placing the smallest distance first, and arranging the distances in order from smallest to greatest.

Part of body experimented upon	Distance between points

13. Apply the points of the scissors at the upper part of the arm near the elbow, at the wrist, and on the palm, noting at what distance apart the points are felt as two.

a. Is the distance greater as you approach the shoulder or as you near the hand?

b. Do you notice any difference whether the points are applied across the arm or lengthwise [illegible] of the arm?

[illegible]

ply again. At what distance apart can the points be felt as two?

3. In the same way determine at what distance apart the points can be felt as two on the tip of the middle finger, on the tip of the tongue, on the back of the neck, on the back of the hand.
4. Record your results in tabular form as follows, placing the smallest distance first, and arranging the distances in order from smallest to greatest.

Part of body experimented upon.	Distance between points.

5. Apply the points of the scissors at the upper part of the arm, near the elbow, at the wrist, and on the palm, noting at what distance apart the points are felt as two.
   a. Is the distance greater as you approach the shoulder or as you near the hand?
   b. Does it make any difference whether the points are applied in transverse or in longitudinal axis of the arm?

C. Cross the middle finger of the hand over the forefinger, and rub the tips of these two fingers against the point of your nose at the same time. What impression do you receive in regard to your nose?

46. SENSATIONS OF TASTE AND SMELL.

Materials: Potato, onion, apple, spices, flavoring extracts, sugar, salt, mustard, quinine solution, vinegar.

A. Flavors of substances.

1. Secure a bit of potato, a bit of onion, and a bit of apple; close your eyes and hold your nose tightly; place each of the three in your mouth successively. Can you distinguish by taste alone one piece from the others?
2. Keeping the eyes closed, repeat the experiment without holding the nose.
   a. Can the foods be distinguished now?
   b. What do these experiments teach you in regard to the real nature of what is commonly thought to be the taste of certain foods?
   c. Why are many foods tasteless to a person with a cold in the head?
   d. What method of taking disagreeable medicines is suggested by these experiments?
3. Close your eyes and hold your nose; experiment with spices, sugar, salt, mustard, quinine solution, vinegar, peppermint, vanilla, etc. Record your results as follows:

[illegible]	[illegible]

[illegible] Wipe the tongue dry and place upon it a small [illegible].

1. Can it be tasted?
2. To what condition must it be brought in order to be tasted?
3. What use is the saliva in the mouth and the tongue?
4. Name a reason which may account for [illegible] [illegible].

[illegible] Localization of taste sensations on the tongue.

1. Place a bit of sugar on the tip of the tongue, [illegible] the back of the tongue.
   a. Determine where the sweet taste is [illegible].
   b. Determine whether sweet substances are tasted more distinctly along the [illegible] of the tongue or at the edge.
2. By using a [illegible] determine in the same way what region of the tongue is most affected by bitter substances.
3. [illegible] the amount of quinine [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Substances distinguished by taste alone.	Substances distinguished by taste and smell.

B. Wipe the tongue dry and place upon it a bit of sugar.
   1. Can the sugar be tasted?
   2. To what condition must foods be brought in order to be tasted?
   3. What use of the saliva in the mouth does this suggest?
   4. Give a reason which may explain why sand is tasteless?

C. Localization of taste sensations on the tongue.
   1. Place a bit of sugar on the tip of the tongue; another bit on the back of the tongue.
      a. In which case is the sweet taste more distinct?
      b. Determine whether sweet substances are tasted more distinctly along the middle of the tongue or at the edge.
   2. By using a bit of salt determine in the same way what region of the tongue is most affected by saline substances.
   3. Prepare a strong solution of quinine by dissolving 10 grains sulphate of quinine in 1 oz. water by the aid of 5 drops sulphuric acid. Determine what portion of the tongue is most sensitive to bitter substances; the portion which is least sensitive.

4. Test the various portions of the tongue with vinegar.
5. Record your results as follows:

Kind of substance.	Part most affected.	Part least affected.
Sweet............		
Sour		
Bitter............		
Salt		

47. STUDY OF BRAIN OF SHEEP.

Materials: Sheep heads can be obtained from any butcher, and the brain may be carefully removed in the following way: With a small saw make two cuts along the top of the skull, each about three-quarters of an inch from the mid-line of the head, care being taken not to cut into the brain. The saw-cuts should extend from front of the eye-sockets back to the openings into the ears. Connect these longitudinal cuts by sawing across the skull in the regions just indicated. In this way a rectangular piece of bone is loosened which can be pried off by the use of a chisel. The cerebral hemispheres of the brain, enveloped in tough dura mater, are thus exposed. The bony top of the skull should be preserved in 4% solution of formalin (one volume formalin to ten volumes of water).

Continue the side cuts backward through the hard bony processes by which the skull was attached to the spinal column, and with a chisel pry off the rest of the top and back wall of the cranium. Beneath it lie the cerebellum, the medulla, and the beginning of the spinal cord.

To remove the brain from the skull the head should be supported with the tip of the skull downward. By means of forceps take hold of the dura mater on the ventral surface of the spinal cord and carefully pull it away from the base of the cranium. With dissecting scissors or with the point of a scalpel cut off the various nerves, leaving as much as possible of each nerve attached to the brain. If the opening in the roof of the skull is not large enough to allow the brain to be taken out easily, the sides can be cut away with bone forceps.

If the work has been carefully done, when all the nerves are cut, the uninjured brain comes out of the skull completely enclosed in its membrane of dura mater. This connective tissue-sac should then be cut along the mid-line of the dorsal surface, removed from the brain, and placed in 4% formalin solution. The brains, as fast as they are removed, should be put in a shallow dish, the bottom of which is covered with a soft layer of cotton, and over them should be poured a 4% solution of formalin. When the brains are once hardened in this way they can be kept in alcohol and used year after year.

To show the internal structure of the brain a horizontal cut should be made about half an inch from the lower surface of the brain through one of the cerebral hemispheres and through half of the cerebellum. By making a vertical cut also, along the ventral surface, at one side of the median line the lower third of one-half of the brain is removed, and the disposition of the gray and white matter within the brain is shown.

Each two pupils should be supplied with a hardened brain prepared as described, a piece of, or, if possible, a whole dura mater, a rectangular piece of bone from the top of the skull with skin and wool attached, a dissecting needle.

A. Protection of brain.

1. What kind of outer covering has the sheep? How does it protect the brain?
2. Examine the piece of bone which was removed from the top of the skull. What layers can you distinguish? Why is this arrangement of bone-tissue of great advantage as a means of protection?
3. What are the characteristics of the *dura mater* (the sac covering the brain)? Try to tear it.
4. By means of a dissecting needle lift from the surface of a portion of the brain a thin covering called the *pia mater.* Describe it. Does it cover all parts of the

brain? Does the pia mater have any blood-vessels?

B. Fore-brain.

1. Describe the form of the two large masses (the *cerebral hemispheres*) that constitute the principal portion of the fore-brain.
2. Where are the cerebral hemispheres attached to each other? (The groove between them is called the *longitudinal fissure.*)
3. What is the appearance of the dorsal surface of the fore-brain? (The elevations are called *convolutions*, the grooves between them, *fissures.*)
4. Near the anterior end of the ventral surface of the brain notice two small masses. (These are the *olfactory lobes*, which connect with the nose region.) Describe their form.
5. Moisten the section made in the lower portion of one of the cerebral hemispheres and examine it. Distinguish *gray* and *white matter*. Where is gray matter found and where is the white matter?
6. Note the cavity in the hemispheres. What is its shape and size?

C. Hind-brain.

1. What is the form of the enlargement (the *cerebellum*) on the dorsal surface of the brain posterior to the cerebral hemispheres?

2. Is it divided into two parts like the fore-brain?
3. What is the appearance of its outer surface? (Compare with the surface of the cerebral hemispheres.)
4. In the section of the cerebellum describe the distribution of gray and white matter.
5. On the ventral surface of the hind-brain, just beneath the cerebellum, note a band of white matter (the *pons* = bridge) connecting the lateral portions of the cerebellum. Does the pons, therefore, run crosswise or lengthwise of the brain?
6. The rest of the hind-brain is called the *medulla* (or *medulla oblongata*). Name and locate, now, each of the three regions of the hind-brain.
7. The portion of the nervous system which forms a posterior continuation of the medulla is the *spinal cord*. What is the general shape of the cord? Describe its cross section. Can you distinguish gray and white matter? If so, locate each.

D. Mid-brain.

1. Carefully bend the brain near the middle in such a way as to enable you to look down between the cerebral hemispheres and the cerebellum. This connecting isthmus is the mid-brain. Describe its position with reference to fore- and hind-brain.

2. How many elevations can you distinguish on the dorsal surface of the mid-brain? (These are the *optic lobes* which connect with the eyes.)

E. Cranial nerves (Dem.).

From what region of the brain do each of the following pairs of nerves originate and what is their distribution?

1. First pair or *olfactory*.
2. Second pair or *optic*. (Note crossing of these nerves on ventral surface of brain.)
3. Third, fourth, and sixth pairs.
4. Fifth and seventh pairs.
4. Eighth pair or *auditory*.
6. Ninth, tenth, eleventh, and twelfth pairs.

48. STUDY OF YEAST.

Materials for home work: Compressed yeast, molasses; two pint bottles, small bottle, tin cup; refrigerator; stove; thermometer.

Materials for class demonstrations: (A, 9, 10, D); Flask, rubber cork (two holes); U-tube, test-tube; chemical thermometer; glass and rubber tubing; water-bath; condenser; compound microscope (500 diameters), slide; cover-glass; lime-water, eosin or methyl violet.

A. Study of the growth of yeast.

Mix about an eighth of a cake of compressed yeast in a tablespoonful of water and stir until a smooth thin mixture is formed. Add this to about a half-pint of water in which a tablespoonful of molasses has been dissolved. Place this mixture in a wide-mouthed bottle which holds about a pint; stopper very loosely.

1. State in your note-book the color of the mixture. Does it appear clear or cloudy?
2. What is the smell and taste of the mixture?
3. Place the liquid where the temperature is 70° to 90° F. Determine the exact temperature by the use of a thermometer, and record it.
4. At the end of several hours examine the liquid. What evidence is there that the yeast is "working"?
5. At the end of 12 hours smell the mixture of molasses and yeast remaining in your large bottle. How does it differ from that observed in 2?
6. Taste of the liquid at the same time. Compare with result obtained in 2.
7. What differences do you note in the color or in the general appearance of the mixture since the experiment was begun? (Compare with observations in 1.)
8. Determine the effect of temperature on the working of yeast in the following manner:
   a. Shake up the mixture when it is working well, and pour some off into a small bottle; immerse the latter up to its neck in ice-water for an hour, or place it in a refrigerator.
      (1) What is the effect on the activity previously noticed in the liquid?
      (2) Warm the liquid again to the

temperature of the room and record result.

(3) (Yeast is a plant.) Has it been killed by the cold? Give reason for your answer.

b. Pour some more of the working yeast mixture into a tin cup, place it on the stove and boil it. Allow the mixture to cool to the temperature of the room, and turn it into a small bottle.

(1) What effect does boiling have on the activity of the yeast?

(2) Keep the mixture for a day or two. Was the yeast killed by the heat?

c. Summary.

(1) What temperature do you find to be most favorable for the growth of yeast?

(2) What is the effect of extreme cold?

(3) What is the effect of a high degree of heat?

9. (Dem.) Nearly fill a bottle with a yeast mixture which is working well. Insert a rubber cork in the mouth of the bottle through which passes one arm of a U-tube. Half-fill a test-tube with lime-water. Allow the free end of the U-tube to dip below the surface of the lime-water. Be sure all the connections are

tight. Set the apparatus aside in a warm place for a few hours.

a. What change has taken place in the lime-water?

b. What kind of gas is produced by the growth of yeast?

10. (Dem.) Pour into another flask some of the yeast mixture which has been working

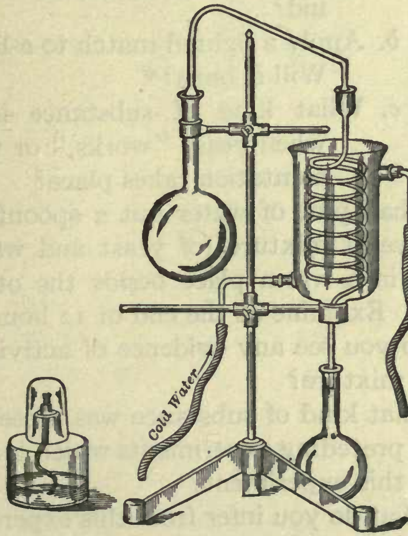

FIG. 7.

for some time. Procure a rubber stopper with two holes. Through one hole pass the bulb of a chemical thermometer so that it reaches half-way down to the bottom of the flask. Through the other hole pass a glass tube, allowing it to project just inside the flask. Connect this glass tube with rubber tubing to a condenser (used in distillation). Place the flask over a water-bath, and keep the temperature at the point where the thermometer registers 78° C. Collect the liquid which comes from the condenser.

a. What is the smell and taste of the liquid?

b. Apply a lighted match to a little of it. Will it burn? *

c. What kind of substance is formed when yeast "works," or when fermentation takes place?

B. Into a half-pint of water put a spoonful of the thin yeast mixture (of yeast and water); set aside in a warm place beside the other mixture. Examine at the end of 12 hours.

1. Do you see any evidence of activity in the mixture?
2. What kind of substance was present in the preceding experiments which is absent in this experiment?
3. What do you infer from this experiment?

C. Summary.

1. What conditions are necessary for the rapid growth of yeast?
2. What changes are caused by the yeast in a mixture in which it is growing?

* The experiment will be more successful if the liquid is distilled a second time.

3. What substances are produced by the growth of yeast?

D. Microscopic study of yeast. (In class.)

By means of a pipette put a drop from the bottom of a yeast mixture on a glass slide; cover with a thin cover-glass, and examine under the high power of the microscope.

1. What is the color of the solid bodies (*yeast-cells*) which you see?
2. Yeast-cells form new cells by *budding*, the bud (*daughter-cell*) usually remaining attached to the cell (*mother-cell*) which produced it.
   a. Draw a group of cells showing a mother-cell and two daughter-cells.
3. Can you distinguish a *nucleus* in any of the yeast-cells? (The colorless *vacuole* is not the nucleus.)
4. Place a drop of stain (eosin or methyl violet) on the slide at the edge of the cover-glass, allowing it to run beneath the glass to stain the cells. Can you make out any further facts regarding the structure of yeast?
5. Add a drop of iodine to a little yeast mixture and examine with the compound microscope. What kind of bodies are mixed in with the yeast-cells? What does their color indicate as to their composition?

49. STUDY OF BACTERIA.

Materials for home work (A, B): Three bottles (two provided with stoppers), ice-box, thermometer; pint of milk; handful of dried hay.

Materials for class-room work (C, D, E): Arnold steam sterilizer, flask, Petri-dishes, cotton-wool, inoculator, compound microscope (500 diameters), slide, cover-glass, eosin, carbol-fuchsin or Loeffler's blue, corrosive sublimate solution (1:1000), made by dissolving one antiseptic tablet in a pint of water.

Nutrient agar-agar is probably the best medium in which to grow all kinds of bacteria. It can be readily prepared in the laboratory or home kitchen from the following materials: 1000 cc water, 10 grams salt, 10 grams peptone, 10 grams Liebig's beef extract, small amount of cooking soda, and 10 grams agar-agar (called, also, Japan isinglass). If agar-agar cannot be obtained, 100 grams of the best French gelatin may be used instead.

Dissolve the beef extract in the 1000 cc. water. The agar, cut into small pieces, is then added, together with the peptone and salt. The mixture should be heated to cause the agar to dissolve, care being taken that it is not allowed to burn. Just enough cooking soda is added to cause red litmus paper dipped in the mixture to turn blue, that is, the liquid should be faintly alkaline. Filtering the hot agar sometimes involves more or less difficulty. The process can be easily carried on, however, within the steam sterilizer. A glass funnel should be put in the mouth of a Florence flask (used commonly in a chemical laboratory), and one or two layers of absorbent cotton placed within the funnel If the agar, flask, and funnel are kept hot within the sterilizer, the liquid will readily pass through the cotton. After filtering, close the mouth of the flask with a plug of absorbent cotton, and boil in the cooker for half an hour. The flask may be set aside as stock agar until needed for use. (If the agar mixture is not clear, it should be filtered through the same cotton a second time.) In case any bacteria or mould colonies appear within the flask, it should be heated within the sterilizer for half an hour on two or three successive days.

A. Growth of bacteria in hay infusion (at home,.

1. Cut the hay into small pieces, place them in a mason jar, and half fill it with water.

Shake the mixture and put it in a warm place, noting the temperature.

a. What becomes of the hay? Why?

b. What is the color and smell of the hay infusion?

2. Examine the mixture after each 24 hours for a week.

a. What has now become of the hay? Why?

b. What change takes place in the color and smell of the liquid? (These changes are caused by *bacteria.*)

c. What do you see on the surface of the infusion? (This is composed of countless numbers of bacteria.)

B. Growth of bacteria in milk (at home).

Secure three clean bottles of about the same size, two of them provided with stoppers.

Into one of the bottles pour some good fresh milk; cover and place in the ice-box, or in some other cold place. Label the bottle "No. 1."

Pour into the second bottle about the same amount of milk, and set it aside in a moderately warm place, leaving it uncorked. Note the temperature by means of a thermometer. Label "No. 2."

Clean the third bottle and the cork in boiling water. Boil some of the milk 5 minutes, and pour it into the bottle while hot. Cork the bottle and place it beside the second bottle. Label "No. 3, Sterilized milk."

Examine the three bottles of milk at the end of 12 hours.

1. Do you notice any difference in the smell or taste of No. 1, No. 2, and No. 3?
2. Boil the milk in bottle No. 3 again; clean the bottle and cork in boiling water as before, and replace the milk in the bottle; cork the bottle. Put bottle No. 1 back in the ice-box; return bottles No. 2 and No. 3 to the place from which you took them.
3. Examine all three bottles at the end of a second 12 hours. Have any further changes taken place?
4. Carry out the directions given in 2 above a second time. Repeat your examinations at the end of each successive 12 hours for two or three days, each time boiling the milk in bottle No. 3. Record in your note-book each time the changes which you observe in each of the bottles.
5. The changes in the milk are caused by the growth of bacteria from the air or on the bottles or stoppers.
   a. What effect does a cold temperature have on the growth of bacteria?
   b. What effect does boiling have on the growth of these cells.
   c. What is the most favorable temperature for the growth of bacteria?
   d. What effect do some bacteria have on the milk?

e. Compare the results obtained in this experiment with those already obtained in the experiment with yeast.

C. Growth of bacteria on nutrient agar.

Pour a thin layer of the nutrient agar into several Petri-dishes which have been heated for a half-hour in the steam sterilizer, quickly replacing the covers on the dishes, also the cotton plug in the flask. Number the dishes 1, 2, etc., and write date of each part of the experiment.

Keep some of the dishes carefully closed throughout the experiments. Label each of these dishes "Not exposed."

Open several of the other dishes, exposing the gelatin to the air of the room for 10 minutes. Replace the covers, and label each dish "Exposed to the air 10 minutes."

Open the other dishes sufficiently to spread on the surface a little of the dust from the floor or from the street. Label each dish "Exposed to dirt."

Open a third set of dishes of the gelatin and pour on the surface a thin layer of the city water obtained from the school faucets. Label each "Exposed to city water."

Set aside the dishes where the temperature is about 70° F. Examine the dishes at the end of a day or two.

1. Do you find any differences between the dishes which have been exposed to the

air, the dirt, and the water, and those which have not been exposed?

2. Draw a figure of the dish you are studying, representing carefully the form and size of the spots (*colonies* of *bacteria* or *mould*).
3. Study the same dish several days later. Make a careful drawing as in 2 above. Have the colonies changed in size or appearance since your last study?
4. Describe the color of the colonies.
5. Do any of the colonies appear to affect the agar around them? (Smell of the agar.)

D. Microscopic study of bacteria.

Carefully lift the cover from one of the plates of agar which has been exposed. Touch one of the colonies of bacteria with the point of a needle, and then rub the needle-point on a clean glass slide; add a drop of water to the spot touched by the needle, and cover with a cover-glass. Examine with the highest powers of the microscope.

1. What is the color of the tiny bodies (bacteria) which you see?
2. Do you find more than one kind of bacteria? If so, what is the shape of each?
3. Do any of the bacteria seem to be in motion?
4. Place a drop of stain (eosin, carbol fuchsin, or Loeffler's blue) at the side of the cover-glass and allow it to run beneath the glass, staining the cells. Can you make

out any further points of structure in the bacteria?

E. Sterilization.

Prepare three dishes of nutrient agar as directed above.

Remove the cover from No. 1, and allow it to remain exposed to the air for several minutes. Label it "Agar No. 1."

Remove the cover from a second dish, expose it as in No. 1; then pour over the surface a thin film of corrosive sublimate (1:1000). This solution is made by dissolving one antiseptic tablet in a pint of water. Replace the cover and label "Agar No. 2 + Poison."

Expose a third dish of agar to the air for the same length of time as in No. 1 and No. 2. Heat this dish for a half-hour every 12 hours in a steam sterilizer or over a water-bath. Label "Heated Agar." Keep all three dishes covered, and set them aside where the temperature is about 70° F.

Compare the three dishes at the end of three days.

1. What differences do you note between the three dishes?
2. What is the effect of the poison (corrosive sublimate) on the growth of bacteria?
3. What effect does heating and cooling have on the growth of bacteria?
4. In what two ways can a substance be sterilized?

F. From all your experiments state—

1. What conditions seem to favor the growth of bacteria?
2. What conditions seem to hinder the growth of bacteria?

G. Practical questions in bacteriology.

1. Why are fruits cooked before canning?
2. Why should fruit-jars be filled completely before screwing on the cover?
3. Why do fruit-jars sometimes burst long after being filled?
4. Why is grass dried before it is put into the barn?
5. Why are milk, meat, etc., put in the refrigerator in summer-time?
6. Why should the prohibition against spitting in public places be rigidly enforced?
7. Why should sweeping be done so far as possible without raising a dust?
8. Why are hard-wood floors more healthful than carpets?
9. Why should the teeth be brushed often?
10. Why should the refuse be removed from the streets every morning early, especially in summer-time?
11. Why should sink-drains be carefully inspected?
12. Why should wounds be carefully cleansed and dressed at once?
13. Why are typhoid fever, diphtheria, and other infectious diseases often better treated in hospitals?

14. In what ways do bacteria prove to be of benefit to mankind?
15. In what ways do they prove to be "man's invisible foes"? (Read "The Story of Bacteria," "Dust and its Dangers," "Drinking-water and Ice Supplies, and their Relations to Health and Disease," by T. M. Prudden, M.D. Published by G. P. Putnam's Sons.)

50. STUDY OF LIVING VERTEBRATES.

A. Habitat.

1. Does the animal live on land or in water?
2. In what part of the world is it common?
3. What is the climate of that region?

B. Locomotion and breathing.

4. What appendages has the animal?
5. Which of these appendages are used in locomotion?
6. How many digits of each appendage are used?
7. What method or methods of locomotion does the animal have?
8. In proportion to its size is its locomotion rapid or slow?
9. What other use does the animal make of its appendages?
10. What movements indicate that the animal is breathing?

C. Food-getting.

11. What kind of food (animal or vegetable) does it eat?

12. How does the animal seize hold of its food?
13. Does it chew its food before swallowing?
14. If possible, describe the teeth.

D. Means of protection.

15. Does it have as an outer covering hair, feathers, scales, or a naked skin?
16. Of what use to the animal is this outer covering?
17. Is this covering shed by the animal? If so, when and how?
18. What different colors do you find on the animal?
19. Do these colors resemble at all the colors in the natural environment of the animal, i.e., is the animal protectively colored?
20. How can the animal protect itself against its enemies?

E. Sense-organs.

21. What is the position of the eyes? How are they protected?
22. Locate the nostrils. Do you see them close?
23. What evidence is there that the animal hears? Can you see any ears? If so, describe them.

51. PARTS OF A COMPOUND MICROSCOPE.

A. *Base.*—This is the solid foundation on which the instrument rests. It is usually shaped like a horseshoe.

B. *Pillar.*—The vertical column which is fastened

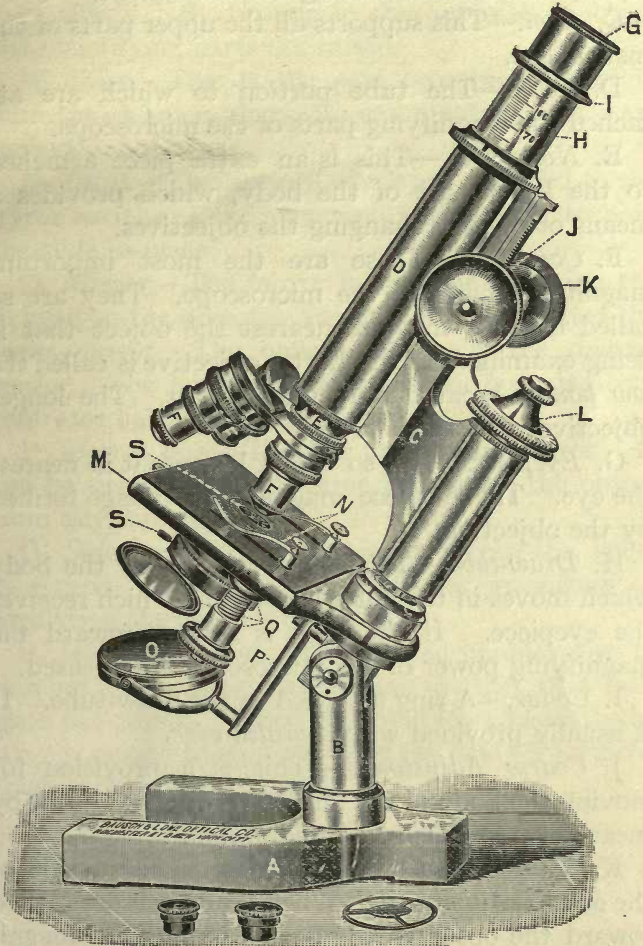

FIG. 8.

to the base and which carries upon its upper end the joint provided for inclining the instrument.

C. *Arm.*—This supports all the upper parts of the instrument.

D. *Body.*—The tube portion to which are attached the magnifying parts of the microscope.

E. *Nose-piece.*—This is an extra piece attached to the lower part of the body, which provides a means of quickly changing the objectives.

F. *Objectives.*—These are the most important magnifying parts of the microscope. They are so called because they are nearest the object that is being examined. The shorter objective is called the *low power*, because it magnifies least. The longer objective is the *high power*.

G. *Eyepiece.*—It is so called because it is nearest the eye. The eyepiece magnifies the image formed by the objective.

H. *Draw-tube.*—This is the portion of the body which moves in the outer sheath and which receives the eyepiece. If the tube is drawn upward the magnifying power of the microscope is increased.

I. *Collar.*—A ring attached to the draw-tube. It is usually provided with a *milled edge*.

J. *Coarse Adjustment.*—This is a provision for moving the body of the microscope up and down by means of a so-called *rack and pinion*.

K. *Milled Heads.*—The wheels on either side of the coarse adjustment. When the wheels are turned toward the observer the body carrying the magnifying parts is raised.

L. *Fine Adjustment.*—This horizontal wheel is attached to a fine screw. When it is turned in the direction of the hands of a clock the body is lowered very slowly. By turning in the opposite direction the magnifying parts are raised.

M. *Stage.*—This is the part on which the slide with the object is placed for examination. It is attached to the arm.

N. *Clips.*—Two springs which are attached to the upper surface of the stage and which serve to hold the slide in place.

O. *Mirror.*—The mirror is used for reflecting the light upon the object. The flat surface is called the *plane mirror.* The hollow surface is the *concave mirror.* The latter not only reflects but also concentrates light upon the object.

P. *Mirror Bar.*—This bar carries the mirror. It can be turned so as to throw light upon the object from any direction.

Q. *Substage.*—An arrangement below the stage to receive various extra devices for increasing or regulating the amount of light.

S. *Iris Diaphragm.*—This device enables one to shut off or increase the amount of light that falls upon the object. When the small lever beneath the stage is moved toward the right the hole through the stage is diminished in size.

52. RULES FOR THE USE OF THE COMPOUND MICROSCOPE.

I. *To lift the microscope*, always grasp it firmly by the pillar beneath the stage.

II. *To use the low power-objective.*

1. Place the stand so the two arms of the base face the window. Keep the microscope out of the direct sunlight.
2. See that the nose-piece is in the position which will bring the low-power objective over the opening in the stage.
3. Move the tube up or down by the coarse adjustment until the lower end of the low-power objective is a little more than a quarter of an inch above the level of the stage.
4. See that the plane side of the mirror is facing the source of light. Looking down through the tube, move the mirror about until the field of the microscope has the best possible illumination. (The field of the microscope is the lighted circular area which appears when looking down through the tube.)
5. Place the slide on the stage (cover-glass on top) in a position so the object to be examined is over the centre of the hole in the stage. Fix the slide in place with the clips.
6. Look through the microscope and slowly

move the tube up by turning the coarse adjustment until the object is seen as clearly as possible. Be careful *never* to push the tube down so the objective touches the slide.

7. In examining a slide, focus the tube by means of the fine adjustment.

III. *To use the high-power objective.*

1. Place the slide upon the stage and focus upon it with the *low-power* objective as directed in II above.
2. Turn the mirror so the concave surface faces the source of light. Looking through the tube, move the mirror about until the field of the microscope has the best illumination.
3. Place the eye at the level of the stage and carefully turn the nose-piece so the high-power objective is brought into position above the hole in the stage. If the lower end of the objective touches the cover-glass, turn the fine adjustment screw in a direction opposite to that of the hands of a clock.
4. When the objective is in position look at the object through the microscope and focus slowly with the *fine adjustment-screw* until the image is clearest. Take great care, as directed in 3 above, to see that the objective does not touch the cover-glass.
5. After using the high-power objective, turn

the nose-piece so as to leave the low-power objective in position over the diaphragm.

IV. The pupil should learn to look through the microscope using the right and left eye alternately. Both eyes should remain open.

V. Table of approximate magnifications of the Bausch & Lomb microscopes:

	Objective	Eyepiece.	Magnification.
1	2-inch	2-inch	About 15 diameters.
2	2-inch	1-inch	" 30 "
3	$\frac{2}{3}$-inch	2-inch	" 50 "
4	$\frac{2}{3}$-inch	1-inch	" 100 "
5	$\frac{1}{6}$-inch	2-inch	" 250 "
6	$\frac{1}{6}$-inch	1-inch	" 450 "
7	$\frac{1}{12}$-inch	2-inch	" 600 "
8	$\frac{1}{12}$-inch	1-inch	" 1100 "

LIST OF APPARATUS AND CHEMICALS REQUIRED TO SUPPLY A CLASS OF TWENTY-FOUR.

An articulated skeleton can be obtained of the Kny-Scheerer Co., 225 Fourth Avenue, New York City, for $25. Large physiological wall-charts are most useful in oral recitations. Those made by L. W. Joutel, 164 E. 117th St., New York City, cost $10 to $15 each, but they have been found invaluable as a means of demonstration. The micro-photographs prepared by W. H. Walmsley, 4248 Pine St., Philadelphia, Pa., are also of great assistance in teaching the minute anatomy of various organs and tissues. In large quantities these prints (unmounted) cost about 10 cents each.

The following supplies will be furnished to schools by Bausch & Lomb Optical Co., 1123 Broadway, New York City, at the special prices quoted. (The numbers and letters refer to Bausch & Lomb's Catalogue.).

1	Compound microscope B1, with $\frac{2}{3}''$ and $\frac{1}{6}''$ objectives.	$23 50
24	Magnifiers, 5–10″ diameter, QR..................	6 30
1	Weighing balance, No. 8104........................	12 50
24	Evaporating dishes (porcelain), No. 10034, 45 cc....	2 50
24	Alcohol-lamps, No. 8470, 100 cc....................	9 00
1	Gross slides, No. 1290..............................	75
1	oz. round cover-glasses, $\frac{3}{4}''$, No. 1274................	75
24	Scalpels, No. 1450..................................	6 30
24	Pairs forceps, straight, No. 1400....................	4 50
24	Pairs dissecting scissors, No. 1550..................	9 00

50 Dissecting needles, No. 1516	$1 13
144 Test-tubes, No. 9460, 150 × 15 mm	2 16
1 Chemical thermometer, No. 9760 B	94
1 Lactometer, No. 9892	38
12 Iron apparatus stands, three rings, No. 10216	5 85
24 Pieces wire gauze, 3″ × 3″, No. 9840, per lb	38
24 Glass stirring rods, No. 9326, per lb	38
10 Ft. glass tubing, 5 mm., No. 9320, per lb	30
6 Thistle tubes, 300 mm., No. 9242	45
6 Beaker glasses, No. 8916, 200 cc	90
1 Glass bottle, No. 8958, 3 oz., with rubber cork, No. 10126, with two perforations	10
1 Bell jar, No. 8932, with opening at top, 200 × 150 mm.	75
1 Piece of sheet rubber, 1 ft. × 1 ft., per lb	1 50
2 Flasks, No. 9192, 250 cc	23
1 pair of bone forceps, No. 1374	1 88
1 Bone saw, No. 1536	3 00
12 Probes, No. 1590	1 80
1 Cylindrical graduate, No. 9660, 250 cc	57
1 Piece platinum foil, 1″ × 1″, No. 9960, per grm	75
1 Box slide labels, No. 1762	8
1 Arnold steam sterilizer, No. 6038A, heavy tin, copper bottom	3 75
24 Petri dishes, 80 mm., No. 9150	3 60
1 Distilling apparatus, Muencke's, of glass with ground joints, 500 cc	6 00

CHEMICALS.

½ lb. hydrochloric acid, c. p. 500 cc., S. G. 1.190	22
½ " nitric acid (conc.), c. p. 500 cc., S. G. 1.425	23
½ " ammonia (conc.), c. p. 500 cc., S. G. 0.90	21
¼ " sulphuric acid, 500 cc., S. G. 1.840	19
1 oz. iodine, pure, resublimed	48
5 " potassium iodide	1 35
¼ lb. ether sulphuris, 250 cc., S. G. 0.722	28
5 gr. caustic potash, white sticks	10
5 " " soda, purified sticks	10
100 cc. lime-water	10

100 pieces red litmus paper, 2″ × ½″, No. 7600	$0 10
100 " blue litmus paper, 2″ × ½″, No. 7600	10
4 gr. quinine	20
500 cc. 95% alcohol, deodorized	58
100 cc. glycerin, refined, white	17
5 gr. pancreatin (Fairchild)	20
5 " ox-gall	10
5 " pepsin, powder	10
10 gr. common salt	05
1 " phosphate of lime, c. p.	10
10 " glucose, crystallized, pure	10
500 cc. Fehling solution	83
10 gr. eosin, yellowish, dry	23
10 " methyl violet, dry	23
½ lb. agar agar, best quality, in shreds	40
12 gr. peptone (U. S.), pure	25
2 lbs. formaldehyde, 40%	85
1 stick phosphorus	10
½ lb. sulphur flowers	10
½ lb. chlorate potash, pure crystals	15
½ lb. oxid of manganese, pulverized	10
24 small pieces zinc, ½″ square	10
1 lb. cotton wool	38
1 oz. potassium permanganate	10