AGRICULTURAL LABORATORY EXERCISES AND HOME PROJECTS

WATERS - ELLIFF

AGRICULTURAL LABORATORY EXERCISES AND HOME PROJECTS ADAPTED TO SECONDARY SCHOOLS

BY

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INTRODUCTION

How we learn. Textbook teaching of agriculture, while very useful, is inadequate because it fails to develop the student's power to see things understandingly. It is through observing and doing that most of the knowledge of farming is acquired. The farm is a great laboratory. The operations in manuring the land, preparing the soil, selecting, testing, and planting the seed, protecting the plants against injury by weeds, insects, and disease, gathering and saving the harvest, feeding the products to live stock so as to bring the largest return in eggs, meat, milk, wool, and work are its exercises. The farmer learns principally by experience, the best though the costliest of teachers. The authors believe that it is possible, by expert teaching and close supervision of the student's work in the laboratory and field, to save a large part of this expense. The exercises are so planned as to teach the student how to make an experiment or an observation accurately and how to record and interpret the results correctly. This gives to the study of agriculture the disciplinary value of an exact science, besides teaching the fundamental lessons of how to farm successfully.

Selection of exercises. In choosing the exercises and projects to be included in the Manual, the authors have sought above everything else to select those which relate definitely to farming and which teach in their results the essentials of farm practice. They have endeavored to make the exercises and projects cover as completely as is possible the important, interesting, and practical farm problems of the country. The instructions to the student are definite. Each exercise and home project has been tried out, and when the directions are carefully followed, results that are decisive will follow.

Use of exercises and projects. The number of exercises to be completed in a year will depend upon the needs of the local community and the time given to the course. The vocational school giving one half of each day to the course in agriculture should be able to complete all the laboratory exercises and in addition provide the required six months' supervised project work. In schools giving less time the teacher should select those exercises of greatest importance to the local community.

Method. It is a great waste of time and effort to require each student to do all of the work of each exercise. In many cases the work of manipulation of apparatus and material can best be done by the teacher or by a group of students. In the table of contents this is indicated by a letter in parenthesis: (t) meaning that the work of manipulation may be done by the teacher, (g) by a group of students, (i) by the individual student.

Coöperation with the best farmers. The closest coöperation between the teacher of agriculture and the best farmers of the neighborhood is necessary to insure the teaching of sound agriculture and also as a means of facilitating the adoption of the teachings of the classroom and laboratory into the farm practices of the community. Sound teaching and close coöperation will be much helped if the teacher will choose an advisory committee consisting of the most progressive farmers of the neighborhood and will use this committee in working out a plan of correlating the school work with the local farm work. These and other leading farmers should be invited to talk to the class on the methods of farming which they have found most feasible and practicable.

Every member of the class in agriculture should be set to work on some problem on the home farm. Use should be made of the best dairy and beef cattle, the best horses, hogs, sheep, and poultry, in the community in the stock-judging work.

The school ground and its use. Many of the students of agriculture in high schools are without farm experience and are taking the work as a part of their preparation for teaching in the rural schools. Many of the students are girls. Even though the girls were reared on the farm they have not, as a rule, given attention to the details of farm operations. To both of these classes some actual field work will

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be of great value. Every school which has a plot of land available, or which can secure the use of as much as a few vacant city lots and can command the needed funds, should arrange to grow a number of the crops that are of principal local importance. It is true that the operations of preparing the land, planting the seed, and cultivating and harvesting the crops will be commonplace to those students in the class who have had farm experience, but the work may be so planned as to demonstrate principles of great importance. In such case the lessons will be of much interest and value to farm boys as well as to those who have had no farm experience.

Project work in agriculture. Although great stress is laid on concrete class and laboratory instruction in field, shop, and classroom, this is not sufficient. In order that a boy may really fix his knowledge of poultry husbandry, it is necessary for him to engage in the poultry business. In order that he may bring together all of his knowledge of agronomy, it is necessary for him to grow a crop in accordance with what he has learned about crop production. It is the verification and application of the knowledge gained in classroom and laboratory that is the real measure of the value of instruction in any subject. In agriculture the supervised project gives full opportunity to apply the knowledge gained and at the same time to acquire actual farm experience. Project work in secondary-school agriculture is that part of the work of the course performed at home or on the school farm, and is a fixed requirement for each pupil in all schools receiving Federal aid under the Smith-Hughes Act.

Common essentials of project work.[1] The common essentials of all project work are:

1. The project must be selected by the student with the advice and consent of the teacher and parent. The parent must sign a written statement to the effect that he will (1) provide all the equipment necessary for the project, (2) allow the student sufficient time to do the work, (3) allow the student the net proceeds of the project.
2. The project must cover a more or less extended period of time, enough to do the work well.
3. It must be part of the instruction in agriculture as taught in the school of which the pupil is a member.
4. It must be a problem *worth while* and more or less new to the pupil.
5. Some competent person, preferably the teacher of agriculture, must supervise the work.
6. Detailed records of time, method, cost, and income must be kept.
7. The amount of school credit for any project should be determined on the basis of hours necessary to do the work well. If school time is used, two hours on the farm should count as one hour in the school.
8. A full report of the work in writing must be submitted to the teacher and kept as a permanent record in the school.

Kinds of projects. Projects may be classified as crop projects, animal-husbandry projects, farm-management projects, etc. They may also be classified as productive projects, demonstration projects, improvement projects, etc., as determined by the aim or purpose. A further classification into individual and group projects is possible. Growing a five-acre plot of corn on the home farm is an individual project. Growing a large vegetable garden on the school farm is a group project.

Acknowledgment is made by the authors to Dr. Otis W. Caldwell of Teachers College, Columbia University, for valuable assistance in determining the plan and scope of the work, and to Charles L. Quear, of the Kansas State Agricultural College, for invaluable help in the detailed preparation of the exercises and projects and in the methods of illustrating them. Credit is given Professor J. O. Morgan, of the Texas Agricultural and Mechanical College, for preparing the exercises on cotton; and to Dean E. C. Johnson, of the Kansas State Agricultural College, for the exercises on plant diseases; to Professor George A. Dean, of the Kansas State Agricultural College, for the exercises on insects and bees; and to Professor Fred H. Merrill for the exercises on orcharding.

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[1] Adapted from *Bulletin 364*, United States Department of Agriculture.

CONTENTS

NOTE. The column headed "Date Completed" is to be filled in by the student as the exercise is completed; the column headed "Approved" is to be filled in by the teacher.

PART I. PLANT LIFE AND GROWTH

PART II. THE SOIL AND ITS MANAGEMENT

PART III. FIELD AND ORCHARD CROPS

MANUAL OF LABORATORY EXERCISES

PART I. PLANT LIFE

EXERCISE 1

THE BEGINNING OF GROWTH

Statement. Every live seed contains a plantlet which, under proper conditions, will grow. The early growth of a plant is usually more rapid than that of any subsequent period. A few days in the early period witnesses a remarkable change in the development of all parts of a seedling.

FIG. 1. The beginning of growth in the corn plant

Object. To discover the way in which growth begins and the conditions which are most favorable for the development of the young plant.

Materials. Seeds of corn, wheat, peas, and lima beans that will germinate; dinner plates; blotters; flowerpots or tin cans; and clay subsoil.

Directions. (1) Place seeds that are alive and those that are dead between blotters in a dinner plate; moisten the blotters with water and set in a cold place. In like manner prepare three other plates of seeds but omit water from one of them. Place one to which water has been added and one to which no water has been added in a warm, light place. Set the other plate of seeds in a warm, dark place. Keep all moist as needed except the one to which no water was previously added. Compare results each day for a week.

Make outline drawings of the seeds of peas, beans, and wheat that germinated, showing changes from day to day. Label the parts, root, stem, and leaf, and number them in order of their appearance.

(2) Fill two flowerpots or cans with finely screened clay subsoil and add water to one of the pots. Stir the soil which has been moistened until it becomes a thick, smooth batter. Plant seeds in each of the two pots and water both alike. Explain the difference in the early growth of the seeds. What does one have which the other lacks?

(3) Boil some water in a small glass vessel and set it aside to cool. As soon as it comes to room temperature drop in a few kernels of corn or beans. Cover the surface of the water with a thin film of kerosene or motor oil to exclude the air. In another vessel of unboiled water place a similar number of seeds and shake the water in this vessel at least twice a day for ten days. What are the results? Explain them.

Questions. What happens when seeds lack air? What happens when they lack moisture? Heat? Light? What are the conditions necessary for germination? Which part of the seedling appeared first? Which last? Is the vitality of seeds affected by their age? What is the effect of freezing upon the vitality of unmature seeds? upon mature seeds that are not dry? upon dry mature seeds?

References. WATERS, H. J. Essentials of Agriculture, pp. 36–37. Ginn and Company. STODDART, C. W. The Chemistry of Agriculture, pp. 17–21. Lea & Febiger. HUNT and BURKETT. Soils and Crops, pp. 185–186. Orange Judd Company.

EXERCISE 1 (*Continued*)

MAKE OUTLINE DRAWINGS ILLUSTRATING THE STAGES OF GERMINATION OF WHEAT

Planted Kernels	Stem and Root Started	Stem above Ground	Fully Germinated Plant with Leaves and Root System
(Soil line)			

MAKE OUTLINE DRAWINGS ILLUSTRATING THE GERMINATION OF LIMA BEANS

Soaked Seed	Rootlet Breaking Seed Coat	Rootlet Breaking Soil Line	Cotyledons (Seed Leaves) Pulled upwards	Plant with Leaves[1]
(Soil line)				

[1] On the drawing of the plant with first leaves, label primary and secondary roots, leaf stalk, leaf blade, and veins of leaf.

EXERCISE 2

HOW PLANTS GROW

Statement. Plants are made of cells which vary in age, size, shape, and content. The mature cells may divide into two or more new cells. These in turn absorb food from the sap of the plant, develop, mature, and may divide into new cells. This is growth.

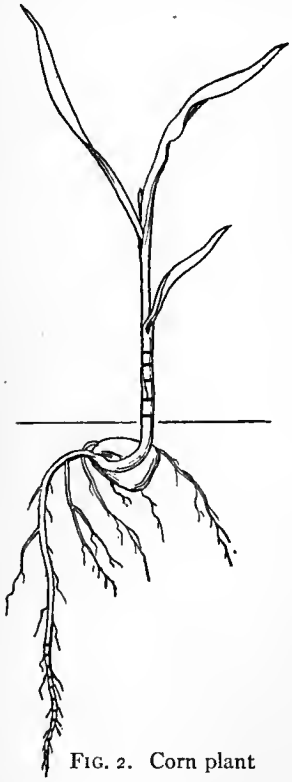


Fig. 2. Corn plant

Growth can take place only in the young tissues of the plant. If the cell walls become hardened, as in the heartwood of a tree, the cells no longer divide and that part of the plant ceases to grow. Growth in length of roots takes place at the tip, and the elongating region at most extends over only a small fraction of an inch. Growth in length of stems, however, is much less confined. It begins at the tip but the elongating region may extend eighteen inches or more back of the tip. Increase in diameter in some plants is accomplished by a layer of growing cells which lies between the bark and wood, as in the case of trees. In other plants new tissues originate at the tip and the increase in diameter as a rule takes place only by the enlargement of the cells of these tissues. The growth of these cells soon ceases and the diameter of the stem is limited, as shown by the corn stalk.

Object. To observe where the growth in roots and stems of various kinds of plants occurs.

Directions. 1. Place kernels of corn between the folds of blotting paper. Keep the blotting paper moist and covered with a cloth until the grain has germinated and the roots are one-half to one inch in length. Beginning at the tip of each root of the sprouted kernels mark fine ink lines across them one-eighth inch apart, being careful not to injure the roots. Replace the kernels in the germinator and allow the plants to grow for a day or two. Explain the results.

2. In like manner mark lines beginning at the stem tips on other plants after they are sufficiently developed. The bean is a good plant to use.

3. Obtain a young bean plant after it has put forth leaves and mark lines one-eighth inch apart along the edge of the leaf and on the leaf stem or petiole. In a few days observe the results. Compare a leaf with a plant stem in the way it increases in length. Perform the same exercise with a corn leaf.

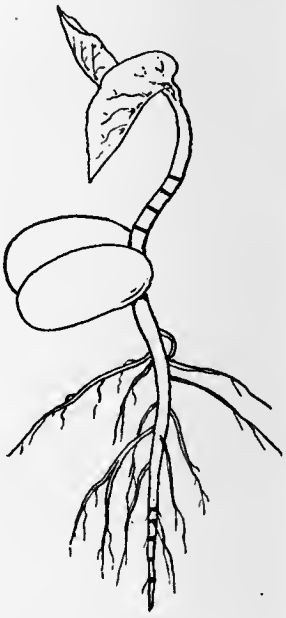


Fig. 3. Bean plant

Questions. What part or parts of a young plant are first to appear from the seed? Explain in what ways knowledge of the manner of growth of the roots is important and why it is difficult to maintain the stem growth independent of a good root growth. Has this fact any bearing upon the relation of soil texture to root development?

References. Waters, H. J. Essentials of Agriculture, p. 193. Ginn and Company. Hunt and Burkett. Soils and Crops, pp. 187–188. Orange Judd Company. Bergen and Caldwell. Introduction to Botany, pp. 20, 67. Ginn and Company.

EXERCISE 3

HOW PLANTS FEED

Statement. That part of a plant's food which is obtained from the soil must be dissolved in water before it can be taken up by the plant. The process by which soil plant food in solution passes into a plant is called osmosis. The greater flow of liquid under osmosis is always from the weaker or less dense solution to the stronger or more concentrated solution. In this process the solution diffuses through the membrane and passes into the interior of the root hairs of the plant. It may then in a similar way pass into other cells of the plant. Ordinarily the plant obtains its soil food in a very weak solution, being able to live where there is as little as one part of such material dissolved in ten thousand parts of water. If the plant solution or sap is weaker than that of the soil solution, as in the case of dying or ripening plants, the flow may be from the plant into the soil.

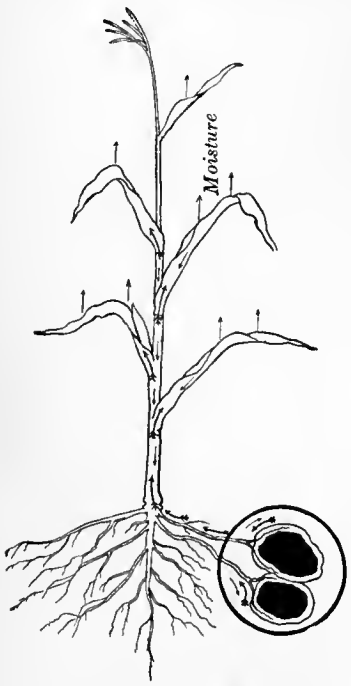


FIG. 4. Diagram showing movement of water from soil through the plant

Object. To demonstrate how the soil food enters a plant.

Materials. Glass funnel or thistle tube; thick sirup; a large-mouthed bottle with cork to fit; and a piece of parchment paper or animal membrane, as a hog bladder. This may be obtained at the butcher shop at any time and softened in water before using. The membrane stripped from a piece of bologna, or the membrane of an egg obtained by dissolving the shell in strong vinegar, may be used.

Directions. 1. Fill a bottle three-fourths full of pure water. Close the small end of a thistle tube or funnel and fill it almost full of sirup. Tie a piece of membrane securely over the mouth of the thistle tube and place it in the bottle, as shown in the illustration. Remove the cork from the small end of the tube and immerse the tube until the level of the two liquids is the same. Note what has happened at the end of an hour. Record the results every hour for six hours. Join another piece of glass by means of rubber tubing to the thistle tube and see how high the water will rise. This process of diffusion of liquids through a membrane as stated above is called osmosis.

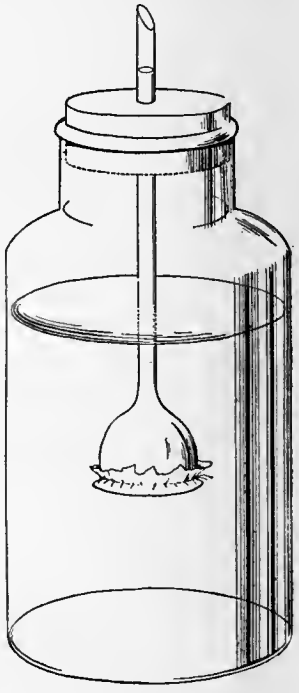


FIG. 5. Movement of liquid through membrane by osmotic action

2. From the center of a potato cut two small cubes of equal size and weigh each. Place each piece in a dish of water, and to one dish of water add a teaspoonful of salt. To each dish add a few drops of iodine solution. Twelve to twenty-four hours later pour off the water, dry each piece of potato on a blotting paper, and weigh. Record and explain results on the opposite page. Apply the principles observed to plant feeding.

Questions. How does the amount of liquid in the tube at the close of the exercise compare with the amount placed in the tube? How did this water get into the tube? Has any of the sirup passed from the tube into the bottle? Taste the water to determine. Explain how the solution inside the roots of a plant is kept more concentrated than the solution outside the roots. Explain why ripe grapes, cherries, apples, or peaches frequently burst following a rain. Why is the green fruit not so affected?

EXERCISE 3 (*Continued*)

RISE OF SOLUTION BY OSMOSIS

Time	One Hour	Two Hours	Three Hours	Four Hours	Five Hours	Six Hours
Rise of solution in inches						

WEIGHT OF POTATO INFLUENCED BY OSMOSIS

Piece Number	First Weight	Final Weight	Gain or Loss
1			
2			

References. Waters, H. J. Essentials of Agriculture, pp. 26–27. Ginn and Company. Coulter, J. M. Elementary Studies in Botany, pp. 263–264. D. Appleton and Company. Hunt and Burkett. Soils and Crops, p. 179. Orange Judd Company.

EXERCISE 4

THE SEED AS A SOURCE OF PLANT FOOD

Statement. The seed contains, in addition to the miniature plant, the food upon which the plant lives during the days when the seed is germinating, and until the young plant has unfolded its leaves in the sunlight and air and its roots have become firmly established in the soil. If, after the food which is necessary to nourish the plant through these periods is consumed there remains a reserve to help the young plant get along while it is delicate, the chances of the plant's living and producing a satisfactory harvest are greatly increased.

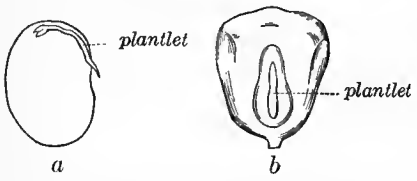


FIG. 6. Ratio of embryo to stored food
a, cross section of bean; *b*, cross section of corn

Object. To show the relationship of the stored food in the seed to the seedling.

Materials. Eight flowerpots or tin cans; sand; corn kernels; lima beans; potatoes.

Directions. 1. In a pot of sand plant four kernels of corn, and in another plant four kernels of corn prepared by paring away all of each kernel except the soft, oily germ which lies on the concave side of the kernel. In a third flowerpot plant four lima beans. Water the three pots alike and place them where the plants can grow to the best advantage. As soon as the beans come up remove all but two of the plants. When the seed leaves on one of the plants begin to spread apart, and the little plant appears between them, remove the seed leaves by use of a sharp knife. Leave the other plant unmolested. Observe them after a few days.

2. Plant in a flowerpot a number of small seeds, such as timothy or radish seed, for comparison with corn and lima beans as to the size and appearance of the plants produced.

3. Select three potatoes of nearly the same size. Remove all the eyes but one from one of the potatoes. Cut the second into four equal pieces, leaving one eye in each piece. Remove an eye from the third potato and leave attached to it a very small piece of potato. Plant these cuttings in sand and compare the rate of growth and the size and vigor of the plants produced.

Questions. When separated from the rest of the kernel, did the corn germ produce a plant? Did the lima-bean plants live after the seed leaves had been removed? What are the sources of food used by the young plant in promoting growth? When the material stored in the part planted is exhausted, what happens to the plant growing in sand? If the plants had been growing in a fertile soil, what would have happened when the food stored in the seed was exhausted? Which will produce the larger and more vigorous plants, large or small seeds, plump or shriveled seeds? Compare the size of young timothy or radish plants with corn or lima-bean plants. What is the explanation of the differences?

References. WATERS, H. J. Essentials of Agriculture, pp. 24–26. Ginn and Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 480–488. The Macmillan Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 13–15. Ginn and Company. BERGEN and CALDWELL. Introduction to Botany, pp. 6–20. Ginn and Company.

EXERCISE 4 (*Continued*)

PLANT FOOD FROM THE SEED

	GROWTH AT THE END OF				
	Four days	Eight days	Twelve days	Sixteen days	Twenty days
Corn, whole kernels					
Corn, germ					
Bean, seed leaves removed					
Bean, untreated					
Whole potato					
One-fourth potato					
Small section of potato					
Potato eye					

EXERCISE 5

THE SOIL AS A SOURCE OF PLANT FOOD

Statement. Mature seeds contain enough food to nourish the plant through the period of germination and for a comparatively brief period thereafter. Soon, however, the growing plant must begin to rely upon other sources for its food supply. One of these sources is the soil.

Object. To show that the soil supplies a part of the food required by the plants for growth.

Materials. Clean sand; garden loam; powdered rock or pieces of rock that may be powdered in the classroom; flowerpots; rain water or distilled water; seeds of corn, wheat, or beans.

Directions. Take enough powdered rock, or powder enough rock material to fill a flowerpot, and in it plant six beans or corn kernels. If these materials are not at hand, clean, fine sand may be used,

FIG. 7. The soil's contribution to the harvest

The scene on the left represents a waste of sand which is incapable of supporting much plant life. That on the right shows the rank growth of plants on a fertile soil

first heating it in a shovel or iron pan until all of the material that will burn has been removed. Fill another pot with garden loam and in it plant a like number of the same kind of kernels. Place both pots where the plants will have a chance to grow and treat them exactly alike. Water both with either distilled or rain water. Compare the plants as to the rate of growth at the end of a week and each week thereafter until results are readily apparent.

Questions. In which kind of material did the plants thrive best, and why? What part of the sand remained after it was heated? What material was destroyed by the heat? What part of the food of the plant is supplied by the soil? In what condition does the growing plant take this material?

References. WATERS, H. J. Essentials of Agriculture, pp. 72–80. Ginn and Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 3–6. The Macmillan Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 26–46. Ginn and Company. STODDARD, C. W. Chemistry of Agriculture, pp. 26–27. Lea and Febiger.

EXERCISE 5 (*Continued*)

COMPARATIVE SIZES OF PLANTS OF DIFFERENT AGES

	First Week			Second Week			Third Week			Average Size
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	
Pot No. 1 (Rain water)										
Pot No. 2 (Soil water)										
Loam										
Clay										
Humus										
Sand										

EXERCISE 6

THE AIR AS A SOURCE OF PLANT FOOD

Statement. The dry matter, or that portion of the fresh plant remaining after the water is evaporated, is largely composed of carbon. The growing plant secured the carbon from the air.

Object. To show that plants obtain food from the air.

Materials. Green twigs; test tube; charcoal; iron spoon; vinegar; two pots of growing plants; clay soil; a shallow pan.

Directions. (1) .Take small twigs of green wood, about one fourth inch in diameter, and place them in a test tube. Heat until all the smoke and gas have been driven off, not allowing them to blaze. Examine what remains. Compare the pieces you have heated to a piece of charcoal. Apply a flame to one of the pieces. Charcoal is almost pure carbon and is made in a method similar to that used here.

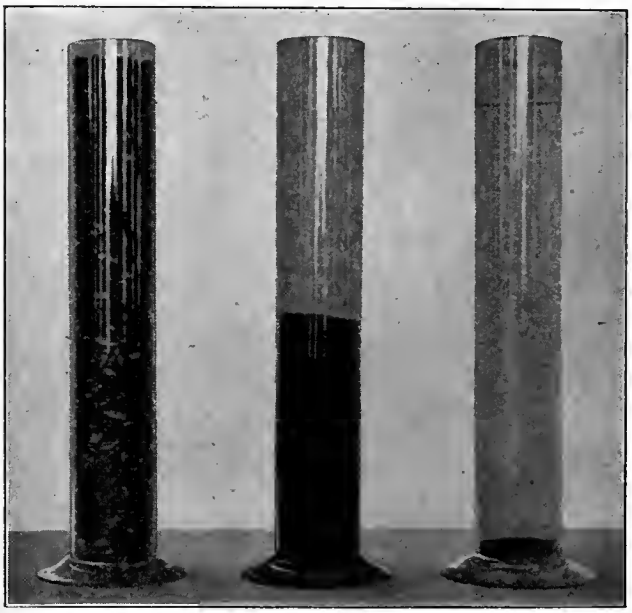


FIG. 8. Showing the proportion of carbon and ash in corn grains

The tube at the left contains the corn which was analyzed; the middle tube contains the carbon which was in the corn; the tube on the right contains the ash which was in the corn.

Boil some of the twigs, which have been heated, in water. Boil some in vinegar. Place the charcoal sticks in an iron spoon and heat until only ash is left. What has become of the carbon? If carbon passed into the air, did it leave as pure carbon? If not, with what did it combine and what is the compound called? Describe fully how carbon enters the plant, how it is fixed and in what common forms it is stored in the plant.

(2) Place some finely powdered clay soil in a shallow pan and add water slowly. Stir constantly, and when a thin batter has been made of the soil, pour about one-half inch of it around the plants in one of the pots. Treat the two pots alike during the next two weeks and observe results.

Questions. Does charcoal burn as wood burns? Does it dissolve in water? in vinegar? What is the source of carbon used by plants? Do the roots absorb the carbon? Why is it necessary to have air in the soil?

References. WATERS, H. J. Essentials of Agriculture, pp. 24–26. Ginn and Company. COULTER, J. M. Elementary Studies in Botany, pp. 268–269. D. Appleton and Company. LYON, FIPPIN, BUCKMAN. Soils their Properties and Management, pp. 480–488. The Macmillan Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 13–15. Ginn and Company.

EXERCISE 7

HOW TO PLANT THE SEED

Statement. The farmer wishes to have his seeds germinate promptly and produce rugged and thrifty plants. He sows some kinds of seeds on the surface and covers them lightly. Other kinds he plants at a depth of several inches. In the depth at which he plants his seeds the farmer is governed principally by the size of the seed, the nature of the soil, and the season of the year.

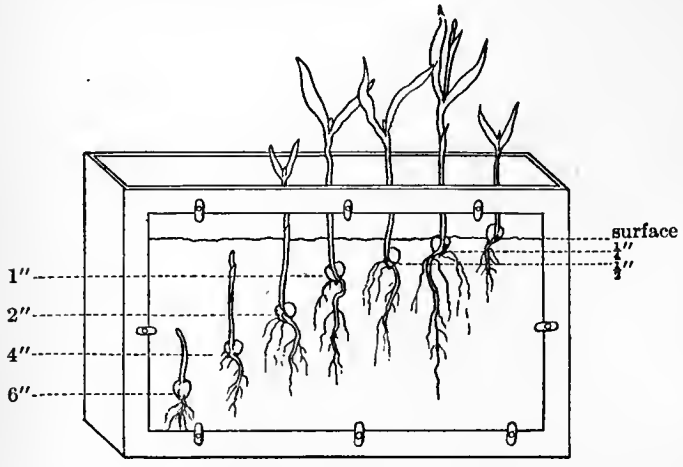


FIG. 9. A convenient device for studying the effect of depth of planting on germination of seeds and early growth of plants

Object. To ascertain what factors determine the depth to which seeds should be planted, and particularly to learn if there is any relation between the size of a seed and the depth to which it should be planted.

Materials. Depth planting boxes (Fig. 9) filled with clean, fine sand; two dozen seeds each of the following: timothy, millet, kafir, wheat, cowpea, and corn.

Directions. Fill a depth planting box with sand, moisten the sand, lay the box on its side, remove the glass, and plant the seeds next to the glass and replace the glass. Plant four seeds of each kind on the surface, one-fourth, one-half, and one inch deep, also two, four, and six inches deep respectively. Cover the seeds planted on the surface with blotting paper and keep them moist.

Keep the soil moist and maintain a temperature suitable for the germination of seeds. As soon as each plant appears at the surface, remove it and examine the seed under the magnifying glass to observe the amount of food remaining to aid the plant in its further growth. Record results designating amounts as none, small, medium, and large. Make note of the size, color, and vigor of the plants produced from each depth of planting. Record the number of seeds which produced plants at each depth of planting. Note and show by drawings where the whorl of feeding roots appeared on the plants from each depth. Allow the plants to grow for two weeks and note the differences in the vigor of the plants from each depth of planting.

Questions. Did the seeds tested germinate regardless of their size and the depth to which they were planted? Did plants from all the seeds grow sufficiently to reach the surface regardless of the depth to which they were planted? Did seeds of any kind fail to bring plants to the surface from any depth? Explain the reason. Did you notice any difference in the size and vigor of the different plants when they came up? Explain. In sowing timothy, clover, or alfalfa should the seed be covered as deep as the seed of oats, cowpeas, or lima beans? Why? Should seeds be planted as deep when the soil is moist as when dry? Should seeds be planted as deep when the soil is cold as when it is warm, and why? Should corn be planted as deep early in the season as later? Explain.

Reference. WATERS, H. J. Essentials of Agriculture, p. 38. Ginn and Company.

EXERCISE 7 (*Continued*).

RELATION OF SIZE OF SEED TO DEPTH OF PLANTING

Kind of seed								
Depth of planting	0″	0″	0″	0″	0″	0″	0″	0″
Days before plants appear								
Food left in seed								
Vigor								
Depth of planting	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″	$\frac{1}{4}$″
Days before plants appear								
Food left in seed								
Vigor								
Depth of planting	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″	$\frac{1}{2}$″
Days before plants appear								
Food left in seed								
Vigor								
Depth of planting	1″	1″	1″	1″	1″	1″	1″	1″
Days before plants appear								
Food left in seed								
Vigor								
Depth of planting	2″	2″	2″	2″	2″	2″	2″	2″

EXERCISE 8

WHEN TO PLANT SEEDS

Statement. The miniature plant in the seed requires, in addition to the food stored there, proper conditions of temperature, moisture, light, and soil for its growth. Plants differ in their requirements in these respects. Some seeds may be safely sown in winter or early spring, and others only in summer. Some require fertile soil, others will thrive on poor land.

Object. A study of the difference in the power of the seeds of different farm and garden crops to germinate at comparatively low temperatures or when planted in the cold soil of early spring and a comparison of the power of the different plants to withstand freezing and to grow during cool weather.

Materials. Fifty seeds each of timothy, white clover, alfalfa, mustard, cabbage, turnips, rape, wheat, oats, barley, corn, cotton, cowpeas, garden peas, and lima beans.

Directions. If land is available outside of the schoolroom, plant ten seeds of each kind in beds in the fall, about the time the farmers of the neighborhood have finished sowing their winter wheat or as early in the spring as the farmers sow their oats. Fill in the blank form on the opposite page. If outside land is not available, the seeds may be planted in pots or boxes in the schoolroom at any time in late autumn or early spring. By exposing to the weather the pots or boxes in which the seeds are planted, the desired climatic conditions may be obtained.

Record the number of plants produced in each bed, the date when the first plant appeared in each, and how cold weather affects the growth of each. Find the origin of each of the plants whose seeds are being tested and see whether there is any relation between the climate in which they originated and the power of the seeds to germinate at a low temperature and of the young plants to withstand a freezing temperature.

Questions. Which plants withstood the frost and freezing temperature? Which were killed? What do differences in reaction to cold suggest as to the season in which the different crops should be planted? In what order would you plant the following spring-sown crops: oats, rape, corn, garden peas, cowpeas, sorghum, barley, cotton, lima beans, kafir, and milo?

References. WATERS, H. J. Essentials of Agriculture, p. 38. Ginn and Company. PIPER, C. V. Forage Plants and their Culture, pp. 86–87. The Macmillan Company. OSTERHOUT, W. J. V. Experiments with Plants, p. 352. The Macmillan Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, p. 576. Ginn and Company.

EXERCISE 8 (*Continued*)

THE EFFECT OF TEMPERATURE UPON GERMINATION

Kind of seed				
Country where plant originated . . .				
Average temperature of that country .				
Number of plants which appeared . .				
Highest temperature				
Lowest temperature				
Average temperature				

EXERCISE 9

HOW SOME PLANTS ARE PROPAGATED WITHOUT THE USE OF SEED

Statement. Some plants, such as the banana, have been propagated by other means than seeds so long that they have lost the power of producing seeds. Others, though still producing seeds, are more readily propagated in other ways than by planting the seeds.

FIG. 10. Cutting from geranium
Such cuttings soon take root if planted in moist sand

Object. To learn how plants are reproduced without the use of seeds.

Materials. Mature geranium, coleus, begonia, and carnation plants; neighboring blackberry or raspberry bush or grapevine; young shoots of willows; boxes of clean, fine sand with pieces of glass large enough to cover the boxes.

Directions. 1. *Cuttings.* Cut pieces of geraniums, coleus, begonia, and carnations so that each piece consists of a bud (terminal or lateral), one or two leaves, and two or three inches of stem. With a sharp knife or scissors cut away most of the leaf blade. Set the cuttings in sand just deep enough so that the tip of the bud is exposed. Cover the box with glass so that a small amount of ventilation is secured. After twelve or fourteen days carefully lift some of the cuttings, and if roots are started, plant each cutting in soil in a small pot, taking care to protect it against drying, or against cold-air currents. Cut twigs of willow; place them in a jar of water for a few days until roots start at the joints, then plant them in soil.

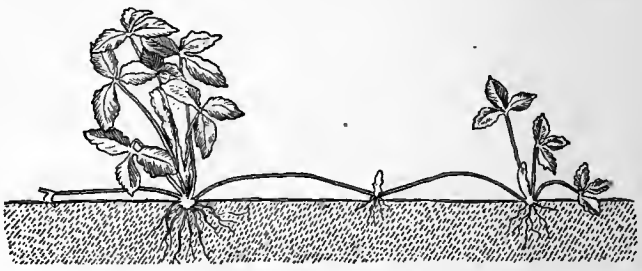


FIG. 11. Strawberry plants started by runners
The runners develop new plants at the nodes, or joints

2. *Layering.* Bend a branch of raspberry, blackberry, or grapevine to the ground, cover it with four or five inches of soil, leaving about a foot of the growing tip exposed. In six weeks or two months cut the old branch free from the parent plant, dig up and transplant the new branch, which in this time should have developed roots from the buried portion.

3. *Runners.* Study strawberry plants to see how new plants are started naturally in strawberry patches.

Questions. What practical uses are made in your neighborhood of these methods of plant propagation? How are Irish potatoes propagated? sweet potatoes? grapes? roses? willows? What aged wood is selected for propagation of the grape? the rose? Why?

Reference. WATERS, H. J. Essentials of Agriculture, pp. 35–45. Ginn and Company.

EXERCISE 10

PROPAGATION BY GRAFTING AND BUDDING

Statement. Common orchard plants produce seed abundantly and may be readily propagated by that means. But the seeds of such plants do not generally "come true." Seeds of a red apple may produce a tree that will bear yellow fruit; the seeds of an early-bearing peach might produce a tree on which late peaches are borne. To make sure that fruit of the variety desired will be produced by the trees that are planted, orchard trees are propagated by grafting and budding.

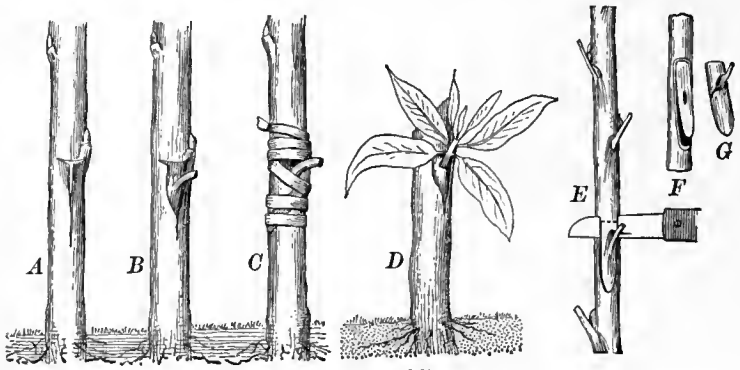


FIG. 12. Budding

A, bark cut to receive bud, as shown at *B*; *C*, bud fastened in place; *D*, growing bud; *E*, *F*, *G*, showing method of preparing the bud for insertion

Object. To learn how to successfully propagate orchard plants by grafting and budding.

Materials. Growing seedlings, in August, September, or the early spring; scions and roots of apple and peach trees or trees near by which may be used for experiment; a sharp knife; raffia fiber; grafting wax.

Directions. 1. *Budding.* About two inches above the soil make a slit 1½ inches long in the bark of a seedling. Across the top of this slit make another cut through the bark about an inch long, thus forming a T. Pull the bark loose along the cut enough to make room for inserting the bud which is obtained from the tree of the desired variety. Cut off this bud and a small portion of bark, starting about ¼ inch below the bud and extending ½ inch above the bud. The bark attached should be a little wider than the bud itself, and should not include much, if any, wood. Insert the bud in the "T-slit," draw the side bark close about it, and secure with raffia or twine, both below and above the bud. When the bud has developed well, cut off the raffia, and when it has developed to a length of one foot, cut the original top from the tree, just above the bud.

2. *Root grafting.* A young stem of the desired variety, containing 3 or 4 buds and from 6 inches to 9 inches long, is grafted to the root by the whip-grafting method. The result is the same as a budded tree.

3. *Whip grafting.* The tree and scion to be joined should be of the same diameter. Each is cut at an angle, and a tongue is made in each piece by slightly pushing a knife into the wood. The scion is then placed on the stock, cut surface against cut surface, and the tongues lapped. The cambium layers on the stock and scion must meet; tying will help to hold them until a union has been made.

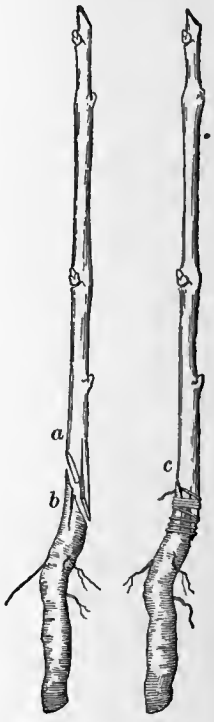


FIG. 13. Piece-root grafting

a, scion; *b*, rootstock; *c*, scion and rootstock joined and wrapped for protection

4. *Cleft grafting.* In cleft grafting, a stem of large diameter — 1½ inches or larger — is cut square off and a split made diametrically across. This is held open while a small scion with the end cut wedge-shaped is inserted on each side, with the cambium layer of stock and scion touching. The wedging tool is removed and the graft waxed. If both scions grow, the weaker may be cut out the following year.

Make grafts on seedlings found in neighboring orchards and plant the trees at the proper time. Record the work done, and each successive year have the class in agriculture observe the preceding grafts as a part of the year's work. Also, when the trees bear fruit, have the class note the fruit on

grafted stock as compared with that on the native stock. Prepare an outline statement with diagrams illustrating the procedure in different kinds of grafting.

Questions. What are the advantages that may be secured by the practice of grafting? In former times fruit trees were usually grafted on the main stem a foot or more above the ground. See if you can locate illustrations of that type of grafts. Why is root grafting now most commonly used in nurseries?

References. WATERS, H. J. Essentials of Agriculture, pp. 38, 42–44. Ginn and Company. WILKINSON, A. E. The Apple, pp. 407–413. Ginn and Company. COULTER, J. M. Elementary Studies in Botany, pp. 330–332. D. Appleton and Company.

PART II. THE SOIL AND ITS MANAGEMENT

EXERCISE 11

THE FORMATION AND TRANSPORTATION OF SOILS

Statement. If the soils of the world were swept into the sea and the rocks beneath were left bare, the entire surface of the earth would again become covered with soil. It would require millions of years to form a new soil, as it has taken millions of years to form the soil we now have. Some kinds of rocks would be changed into soil more quickly than others. A portion of the soil would be washed or blown away from where it was formed and would be deposited elsewhere, leaving at last a great variation in the soil covering the earth. Then, as now, some soils would be coarse and others fine; some would be fertile and others unproductive.

FIG. 14. A soil which was transported by the glaciers

It is a mixture of clay, sand, gravel, and bowlders. (Courtesy of the United States Bureau of Soils)

Object. To learn how the soils of the neighborhood were formed and how they are classified.

Materials. Blank for recording observations.

Directions. Make a trip to the country to study the soils of the neighborhood and to ascertain their origin.

1. Observe the depth of the soil and subsoil in a number of localities. Classify the types of soils found as sedentary or transported. Describe the forces which have had most to do with the formation of each class. Whence did the transported soils come and how were they brought there?

2. Examine stones and pebbles taken from the bed of a stream and note the smoothness of the stones as compared with the sharp corners and rough surfaces of stones not subjected to the action of running water.

3. Find a large bowlder and look for places where small pieces have been slivered from its surface by the action of freezing water.

4. Compare hillside and valley in regard to the color of the soil, and the fertility of the hillside and valley as determined by the plant growth. Observe how rapidly erosion is taking place and in what way it is influenced by vegetation. Find a gully forming in a cultivated field. Note the streams in the neighborhood after a rain. The turbidity of the streams is an indication of the destructive erosion taking place. What becomes of the soil washed from the fields of the neighborhood?

FIG. 15. A good view of a soil, subsoil, and underlying rock

EXERCISE 11 (*Continued*)

Questions. What are the ways by which soil is formed? What materials besides pulverized rocks enter into the composition of soils? What rocks are most readily converted into soil? What rocks make the best soils? Which one makes the poorest soil? From which fields are natural agencies carrying away the most fertility?

References. WATERS, H. J. Essentials of Agriculture, pp. 50–56. Ginn and Company. TARR, R. S. New Physical Geography, pp. 31–50. The Macmillan Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 11–67. J. B. Lippincott Company. HUNT and BURKETT. Soils and Crops, pp. 12–33. Orange Judd Company.

EXERCISE 12

COLLECTING SOIL SAMPLES

Statement. Scarcely any other material appears to be of so little interest or importance as the soil which we thoughtlessly tread under our feet, yet it is the source of more wealth than all other materials in the world combined. More than twice as much wealth is obtained from the soils of the United States in a year as has been taken from the gold and silver mines of the United States in all the years since Columbus discovered America. The origin, the depth, and the texture of a soil determine largely the kind of crops it will produce and how long it will remain productive.

FIG. 16. Method of taking soil samples

Object. To procure samples of different types and grades of soils and subsoils for study and comparison, and to study, in the field, the texture and color of soils in relation to their agricultural value.

Materials. Soil auger, ruler, a dozen or more one-quart mason jars, a piece of oilcloth about 12 by 15 inches, and labels.

Directions. Sample the most productive and least productive soils of the neighborhood, including those from bottom land, upland, and the hillsides.

To obtain a sample remove the vegetation and other rubbish from the spot where the sample is to be drawn. Bore to a depth of 7 inches with the auger. Pack the surface around the auger with the foot and withdraw the auger. Place the sample on the oilcloth, examine it as suggested below, and when the examination is finished, pour the sample into a Mason jar. Seal the jar and label it, "No. 1 — Surface Soil." Insert the auger in the same hole and remove the soil to the beginning of the subsoil. Place this soil in another jar; seal it and label, "No. 2 — Sub-surface Soil." Take a third sample, going into the subsoil about 12 inches, and label it, "No. 3 — Subsoil." The fourth sample should be taken to a depth of about 28 inches or 36 inches and be labeled, "No. 4 — Subsoil." The sealed samples are to be taken to the laboratory for examination of soil texture, structure, and composition. While taking the samples, observe changes in color and the depth at which they occur. Observe the apparent changes in the moisture present at different depths. Note the "feel" of the soil at different depths, that is, whether it feels coarse or gritty, or powdery and smooth, when rubbed between the thumb and fingers. Note changes in the stickiness, hardness, porosity, and density of the soil at each depth. Discuss the results of your observations and their practical application to soil values.

Questions. Which of the soils sampled are fine? Which medium? Which coarse? Which has the finer texture, the soil or the subsoil? Why? What inferences do you draw from the variations in the color of soils? What are the common colors of soils? What color of soil and subsoil do you regard as indicative of a productive soil?

References. WATERS, H. J. Essentials of Agriculture, pp. 58–64. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 116–123. J. B. Lippincott Company. HALL, A. D. The Soil, pp. 47–50. E. P. Dutton and Company.

NOTE. As much as two or three bushels each of washed sand, rich garden loam, and stiff clay should be secured and stored in bins for use in later experiments in crop growth and soil management.

EXERCISE 12 (*Continued*)

CLASSIFICATION OF SOILS

Sample Number	Kind of Soil		Color	Texture		
	Sedentary	Transported		Coarse	Medium	Fine

EXERCISE 13

THE PHYSICAL ANALYSIS OF SOILS

Statement. By physical analysis the constituents of a soil, such as vegetable matter, gravel, sand, and clay, are determined and the properties of these materials observed.

Object. To determine the physical constituents of the soil.

Materials. Finely screened samples of soil collected in a previous exercise; Mason fruit jars; lime; scales accurate to one-tenth gram.

Directions. 1. Weigh out one hundred grams of air-dry soil and heat it at the temperature of boiling water for an hour. Reweigh and note the loss of water. Heat again for an hour and reweigh. If a loss in weight is shown, repeat until the weight is constant. Compute the loss of moisture in per cent of the original weight. Repeat for each soil to be tested, and tabulate the results. Correlate the loss due to heating the soils at this temperature with the fineness and structure of the soils as already determined.

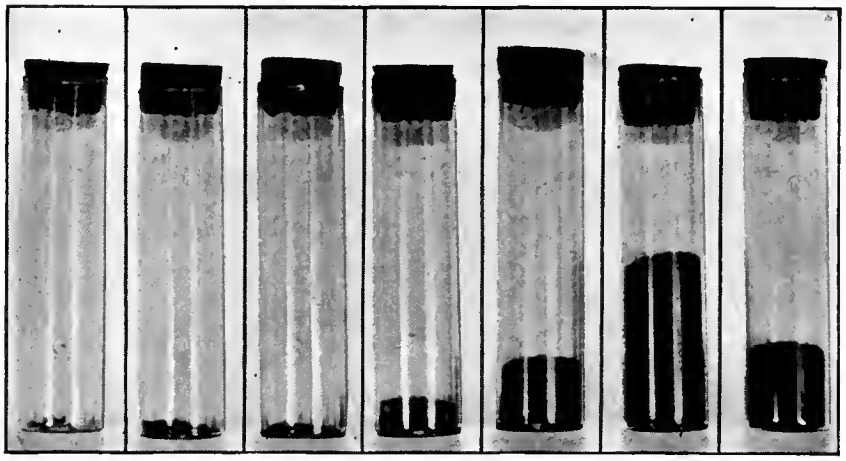


FIG. 17. The physical constituents of a loam soil

a, gravel; *b*, coarse sand; *c*, medium sand; *d*, fine sand; *e*, very fine sand; *f*, silt; *g*, clay. (Courtesy of the United States Department of Agriculture, Bureau of Soils.)

2. Heat the same sample of soil to a red heat until only a reddish ash remains. As soon as the sample is cool reweigh and compute the loss. Classify the soils with respect to their loss from heating at this high temperature. To what is the loss of weight due? Which has lost the greater amount of weight, the soil or the subsoil?

3. Weigh three empty quart jars. Place a tablespoonful of the soil which has been heated in one of the fruit jars and fill it half full of water. Seal the jar and shake thoroughly. Let it stand for thirty minutes and shake it again for ten minutes. Let the soil settle for one minute, then pour off all the water into the second jar. Let the water in the second jar stand for thirty minutes and pour the water from it into the third jar. Evaporate the water in each jar. Note the size of the particles in each of the jars. Compare them under the microscope. Determine the weight of dry material in each jar. Considering the loss of organic matter as determined in 2, compute the percentage of organic matter, sand, silt, and clay in each soil examined. On the basis of this comparison classify them as clay soils, sandy soils, and loams. On the basis of the amount of organic matter contained in the soils, classify them with respect to their productive power. Compare your results with the field notes made when the samples were taken.

Questions. How did the color of each soil sample compare with the amount of organic matter contained in it? How did the water contained in the soil compare with the organic matter present? How did the subsoil compare with the surface soil in amount of organic matter? How did the subsoil compare with the soil in the amount of clay it contained?

References. WATERS, H. J. Essentials of Agriculture, pp. 58–66. Ginn and Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 83–108. The Macmillan Company. BURKETT, C. W. Soils, pp. 25–29, 35–36. Orange Judd Company.

EXERCISE 13 (*Continued*)

PHYSICAL ANALYSIS OF SOILS

Soil Sample Number	Weight before Heating	Weight after Heating	Loss of Water	Weight after Burning	Loss of Organic Matter	Weight of Sand in Jar No. 1	Weight of Silt in Jar No. 2	Weight of Clay in Jar No. 3	Classification of the Soil Sample

EXERCISE 14

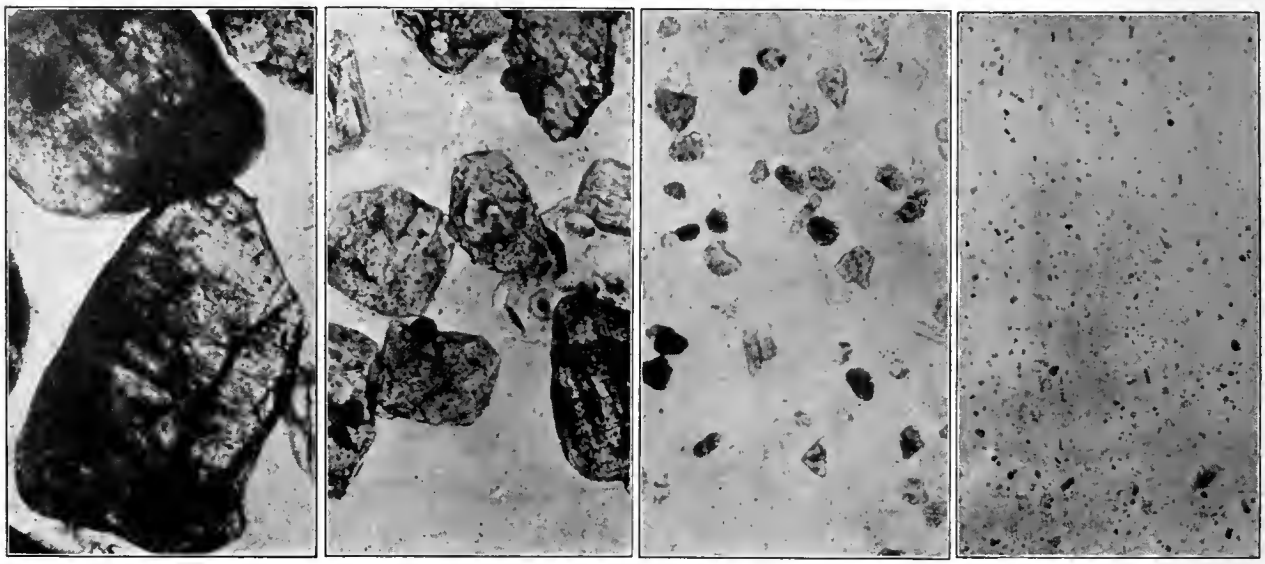
THE TEXTURE AND STRUCTURE OF SOILS

Statement. The size of the soil grains and their arrangement, together with the amount of organic matter present, determine the power of the soil to absorb and to hold water. These factors, to a large extent, determine also the mellowness or tilth of the soil.

Object. To determine the size, shape, color, and arrangement of the soil grains and to form an idea of the amount of organic matter present in a soil.

Materials. Samples of air-dry soil; sources of heat; a microscope.

Directions. 1. Take lumps of dry soil from each sample collected and crumble them in the hand, noting the ease with which the soil mass breaks. This gives an impression of the manner in which



a *b* *c* *d*

FIG. 18. Soil particles as they appear under the microscope

Magnified 150 times; *a*, coarse sand; *b*, medium sand; *c*, very fine sand; *d*, silt. The particles of clay are so small that they are not visible under the magnification used.

the soil will act when plowed. A soil naturally cloddy and hard to crush usually contains a large amount of clay and a small amount of organic matter.

2. Place a few soil grains representing the average of the soil on a microscopic slide, moisten with a drop of water, and examine them under the microscope. Classify the soil grains according to their color. Notice the presence of a black material clinging to the soil grains. This is organic matter.

3. Pour a little water upon a lump of soil from each sample and observe the rapidity with which the water is absorbed. This gives an indication of the readiness with which the water may be taken up by soils. Soils having a gray tint when dry become almost black when wet. When there is only a slight change in color upon wetting, the absence of, or a deficiency in, organic matter usually may be inferred.

4. By noting the effect of alternate freezing and thawing upon the different types of soil, their texture and structure may be determined. Use heavy clay soil, garden loam, and sandy loam. From each sample make two well-puddled mud balls, about the consistency of putty. Place one ball of each soil where it will dry at room temperature and place the others where they will freeze and thaw daily. When the samples are dry, pulverize each with the hands, noting the difference in the hardness as influenced by the action of freezing and thawing.

EXERCISE 14 (*Continued*)

5. Study the structure of the soil grains, that is, whether they consist of single particles or a number of soil particles. If single, they will appear transparent under the microscope. The black or dark particles unless covered with organic matter are compound. Compute the percentage of single and of compound particles.

Questions. Where are the most friable or crumbly soils located,—on the table land, slope, or bottom, and why? How does structure affect the value of soils? What are the principal factors determining the structure of soils?

References. WATERS, H. J. Essentials of Agriculture, pp. 58–64. Ginn and Company. BURKETT, C. W. Soils, pp. 34–40. Orange Judd Company. KING, F. H. Physics of Agriculture, pp. 51–53. Mrs. F. H. King. HILGARD, E. W. Soils, pp. 83–107. The Macmillan Company. KING, F. H. Physics of Agriculture, p. 51. MERRILL, G. P. Rocks, Rock Weathering, and Soils, p. 287. HILGARD. Soils, pp. 83–107.

MICROSCOPIC EXAMINATION OF SOIL PARTICLES

NUMBER OF SOIL GRAINS	COLOR	SHAPE	SIZE	STRUCTURE	TYPE
Average					

EXERCISE 15

THE TILTH OF SOILS

Statement. The presence of organic matter in the soil has the property of causing the soil grains to cling together in aggregates, making the soil mellow and crumbly. Therefore, a soil rich in organic matter is usually a soil of fine tilth. The presence of organic matter in sandy soil increases its water-holding power without destroying its open or porous structure. The presence of lime makes the soil mellow by causing soil aggregates to form.

FIG. 19. A soil of excellent tilth

Object. To show the effect of the presence of organic matter and lime upon the structure and tilth of soils.

Materials. Clay soil; dry, finely pulverized barnyard manure; three shallow pans; three flowerpots or tin cans; seeds of corn or beans; two eight-inch test tubes or slender bottles, as olive or pickle bottles; tablespoon; teaspoon; one-half pint of air-slaked lime.

Directions. 1. Stir a pan of clay and water until a smooth batter is formed. Pour each of the three shallow pans almost full of this batter. To one add one-fourth pint of pulverized barnyard manure and stir it into the batter. To the second pan add a tablespoonful of lime and stir it into the batter. Leave the third pan of batter untreated. Set them all aside, and when they are dry, compare the ease with which they crumble. Compare the crumb structure under the microscope.

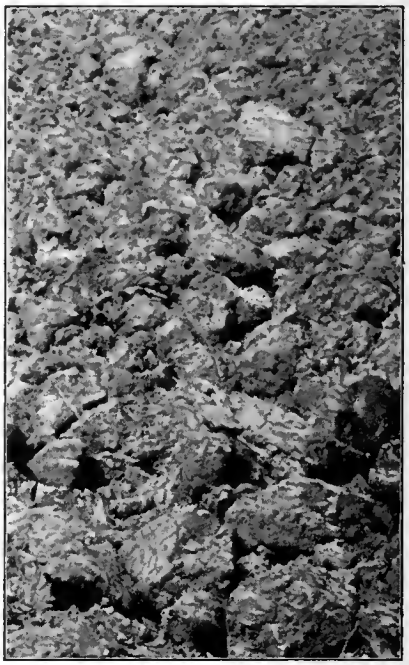


FIG. 20. A soil which lacks tilth

2. Fill three flowerpots each three-fourths full of clay. Fill one of them the remainder of the way with pulverized manure. Pour out the clay and manure, thoroughly mix and replace them in the pot. To the clay in another pot add two tablespoonfuls of lime and stir well into the soil. Leave the other pot untreated. Plant seeds of corn or beans in each pot, and water as necessary. Compare the rapidity of growth. Explain the difference.

3. Place one-half teaspoonful of finely pulverized clay soil in each of the two test tubes, and to one add one-fourth teaspoonful of powdered, air-slaked lime. Fill both with water and stir vigorously. Set them aside and note which clears first. Explain the reason for the difference in the rate at which the soil settles in the two tubes. Which soil has the better tilth, and why?

Questions. Which pot of soil is the best aërated? Why? How does organic matter affect soil structure? How did lime influence the structure of the soil particles?

References. WATERS, H. J. Essentials of Agriculture, p. 110. Ginn and Company. BURKETT, C. W. Soils, pp. 103–108. Orange Judd Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 150–160, 190–193, 218. The Macmillan Company.

EXERCISE 16

HOW WATER GETS INTO THE SOIL

Statement. Drought is the universal disaster. The crops of nearly every part of the globe are injured by drought at some season of every year. In some regions, two days after a heavy rainfall the crops suffer from lack of moisture because the soil is too shallow to absorb and hold much

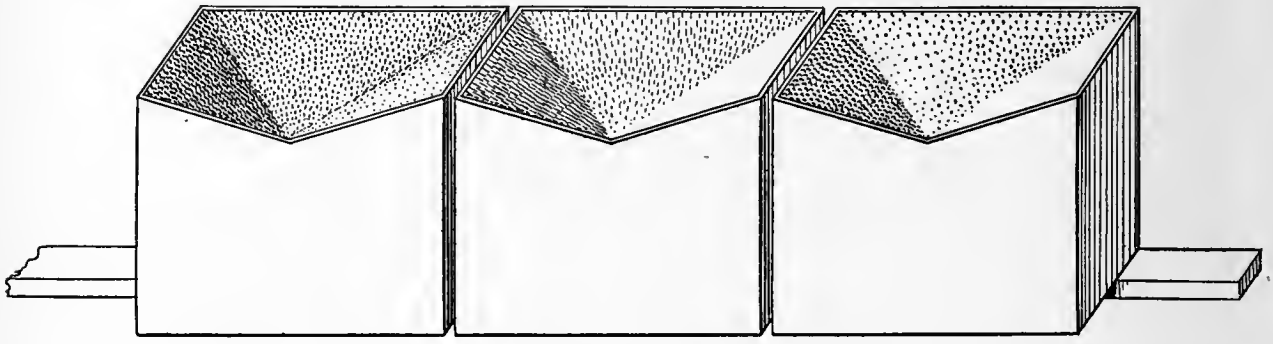


FIG. 21. Apparatus to illustrate how water gets into the soil

moisture and nearly all the water which fell ran off the surface. The water run-off on many soils is greater than the water penetration. It is the water which enters the soil and is held within reach of the plant roots that is of value to growing crops.

Object. To study the conditions which favor the penetration of water into the soil and the percolation of water through the soil.

Materials. Three percolation tubes or lamp chimneys; three glass tumblers; graduated measuring glass; clay, loam, and sandy soils; finely pulverized manure; balances; three boxes, each of the same size; cheesecloth; string; a sprinkling can.

Directions. 1. Cut one end of each box slightly V-shaped, as shown in Fig. 21, and fill each level full with clay soil firmly compacted. Level the surface the same shape as the end of each box and then make a soil mulch in one of the boxes by stirring the soil to a depth of three inches. Leave the second box of soil firm and smooth. Mulch the third with finely pulverized barnyard manure mixed into the surface inch of soil. Place the boxes on an inch strip (Fig. 21) to represent a natural slope, and place vessels under the end of each box to catch the water that runs off. With a sprinkling can apply to each of the boxes of soil a known and equal amount of water. Sprinkle slowly. Measure the amount that runs off and compute the percentage of absorption and penetration in each case. Explain results.

2. Perform a similar experiment, using compacted clay loam and sandy soil respectively. Compare results and explain.

3. Place a piece of cheesecloth in the bottom of each percolation tube or tie pieces over the bottom of lamp chimneys if they are used. Fill one tube with clean, dry sand to within an inch of the top. Likewise, fill the second tube with dry, finely screened loam, and the third with finely screened clay. Jar each tube lightly to settle the soil and suspend them in a percolation rack or in some manner so that tumblers may be inserted under them. Pour water into each tube, keeping the water level near the top of the tube. Note the time it takes the water to begin to drip from the bottom. After the water has been dripping from a tube for a time and the dripping has become constant, catch the water that percolates from each soil in fifteen minutes. Measure the water and compare the percentage that percolates from each soil. This is known as free or gravitational water.

EXERCISE 16 (*Continued*)

Questions. Which soil absorbs water most readily? What is the effect of a surface mulch upon the amount of water which penetrated the soil? Which soil permits the most rapid percolation? How may tillage be utilized to increase the absorption of water by soils? What is meant by gravitational, or free, water? What is meant by the water table of a soil, and what factors determine its height?

References. WATERS, H. J. Essentials of Agriculture, pp. 64–66. Ginn and Company. ROBERTS, I. P. The Fertility of the Land, pp. 72–80. The Macmillan Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 264–265, 279, 713. The Macmillan Company. BURKETT, C. W. Soils, pp. 167–168. Orange Judd Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 217–222. J. B. Lippincott Company.

RECORD OF RESULTS

KIND OF SOIL	SOIL TREATMENT	TOTAL WATER APPLIED	AMOUNT OF SURFACE RUN-OFF	AMOUNT PERCOLATING THROUGH	AMOUNT RETAINED

EXERCISE 17

THE FILM, OR CAPILLARY, WATER OF SOILS

Statement. After the free, or gravitational, water has passed out of the surface soil and the soil is dry enough to be cultivated, there yet remains considerable moisture as a thin film around the soil particles and in the small soil pores. It is this film, or capillary, water which growing plants absorb and which brings to the plant its mineral food dissolved from the soil. In general, the more such moisture a soil can hold, the better the crops growing upon it can withstand drought.

Object. To show the relation of the size of the soil particles and the presence of organic matter to the capacity of the soil to hold film water.

Materials. Glass tumblers; a deep vessel, as a four-gallon crock; three soil tubes, or lamp chimneys; soils of various types; some small pebbles; cheesecloth; balances.

Directions. 1. Fill one tumbler half full of pebbles and place in another tumbler an equal volume of soil. Pour enough water into each tumbler to cover or saturate the pebbles and soil respectively. Pour off into separate tumblers that water which will pour from each tumbler. Measure and compute the percentage of water retained.

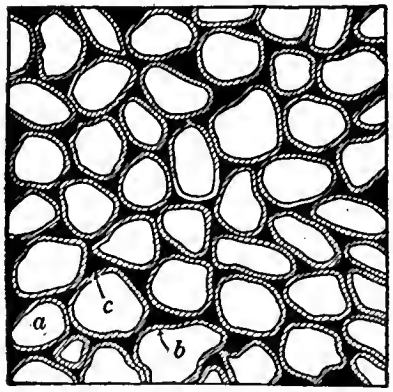


FIG. 22. The structure of the soil
a, soil grain; *b*, water film; *c*, pore space

2. Place a piece of cheesecloth in the bottom of each of the perforated soil tubes or tie it over the bottom of lamp chimneys. Number and weigh the soil tubes or lamp chimneys thus prepared. Fill one tube with washed sand, another with loam, and another with clay. Jar each slightly to settle the soil, which should compact to within about an inch of the top of the tube. Reweigh each tube and determine by subtraction the weight of its contents. Place the tubes in the large vessel provided and pour water around them until it stands a little higher than the soil in the tubes. Note the time required for the water to reach the surface of each soil. Explain the cause for the differences. When all the tubes show water at the surface, remove them and wipe the tubes dry. Immediately weigh each tube and compute the amount of water absorbed by each soil. Cover each tube and set aside where the water will drain away. Weigh each tube at the end of an hour, then at the end of six hours, and daily thereafter until each of the tubes remains at a constant weight. Tabulate and explain all results.

Questions. When the soil in the tubes showed moisture at the surface did it contain only film water or gravitational water as well? After all the water has drained away that will, what kind of water does the soil contain? Do your results show any difference in the time required for the water to reach the surface in the tubes in different soils? In which was the longest time required? In which was the shortest time required? What type of soil will retain the greater amount of film water, clay, loam, fine sand, coarse sand, or gravel, and why? In which type of soil may the water table be the deepest and still be of service to the crops? Which type of soil requires that the water table be near the surface? Why will a fine soil retain more film water than a coarse one? On which of the following soils will plants best withstand wet weather: (1) soil underlaid with rock, near the surface; (2) stiff clay; (3) silt or loam; (4) fine sand; (5) loam sand; (6) coarse gravel? Give reasons for your answer. On which of these soils will plants best withstand drought and why?

References. WATERS, H. J. Essentials of Agriculture, pp. 64–66. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 194–215. J. B. Lippincott Company. BURKETT, C. W. Soils, pp. 37–38. Orange Judd Company. STODDARD, C. W. The Chemistry of Agriculture, pp. 179–183. Lea & Febiger. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 206–213. The Macmillan Company.

EXERCISE 17 (*Continued*)

WATER HOLDING POWER OF SOILS

	Tube No. 1	Tube No. 2	Tube No. 3
Weight of tube and soil			
Weight of the soil			
Weight when saturated with water			
Weight of water absorbed			
Weight at end of one hour			
Weight at end of six hours			
Weight at end of one day			
Weight at end of two days			
Weight at end of three days			
Weight at end of four days			
Weight at end of five days			
Amount of free water lost			
Amount of capillary water lost			
Amount of water retained			

EXERCISE 18

THE MOVEMENT OF FILM, OR CAPILLARY, WATER IN THE SOIL

Statement. Film, or capillary, water is capable of moving through the soil. Its movement is always toward the driest part of the soil. If the subsoil is driest, the movement is downward; if the surface soil is driest, the movement is upward. Large quantities of moisture are stored in the subsoil at depths which the plant roots cannot conveniently reach, but by means of capillary action the moisture is brought within reach of the plants. Soils vary in the ease and rapidity with which films of water may pass through them and in the depth from which moisture may be raised. This is called the capillary power of a soil.

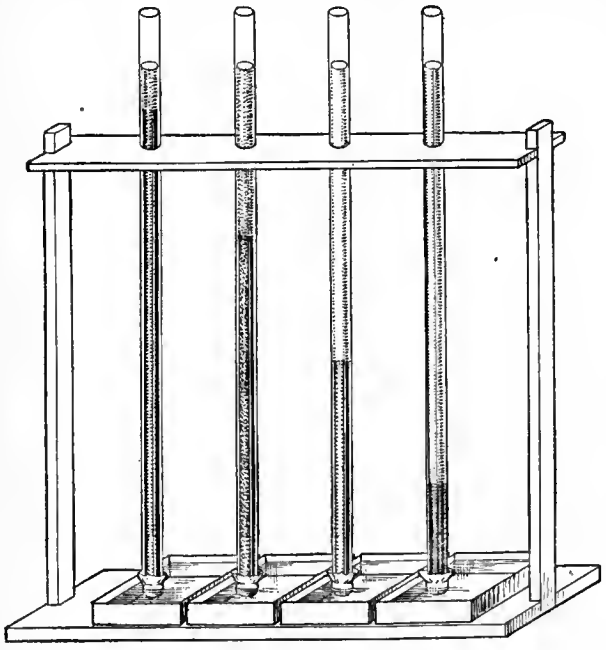


FIG. 23. Rack and tubes for testing the movement of capillary water in the soil

Object. To study the capillary power of different types of soils.

Materials. Sand; light sandy loam; silt loam; clay; four strong glass tubes (1½ to 2 inches in diameter and 2 or 3 feet long) or four lamp chimneys; percolation rack; four shallow pans; cheesecloth; string.

Directions. Tie cheesecloth over the bottoms of the four glass tubes or lamp chimneys and place them in the percolation rack. Fill each tube with a different type of soil and jar it to settle the soil. Let the bottom of each tube rest in a shallow pan and pour water into the pans. Keep the water level, the same in all the pans, and observe the rapidity with which the water rises through the soil. Measure the height to which the water rises every fifteen minutes for an hour. If glass tubing is used, measure the height to which the water rises in five hours in each soil; in one day. Record the amount of water taken up by each soil in one hour; in one day; in one week.

Apply the results obtained and explain their bearing upon the value of the different types of soil of the neighborhood. Also explain what factors affect the capillary power of soils and how this power may be influenced by the way in which the soil is managed.

Questions. In which soil did the water rise with the greatest rapidity? In which did it move most slowly? If the long tubes are used, in which soil did the moisture reach the greatest height? How may the capillary power of a soil be increased? How may the soil in which water rises rapidly for a short distance and then stops be treated so as to cause water to rise to a greater height? Write statements describing capillary (and film) water and free (or gravitational) water and the value of each to growing plants. When the surface of the soil is loose and open, as when cultivated, does the moisture rise to the surface? Why? What means are used to prevent capillary moisture from reaching the surface, and what is the practical effect? How does such practice affect the power of crops to resist drought? What is the effect of rolling upon the capillary rise of water in the surface soil? Why does the farmer usually roll the land after sowing small seed like millet in dry ground?

References. WATERS, H. J. Essentials of Agriculture, pp. 64–66. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 206–208. J. B. Lippincott Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 221–243. The Macmillan Company.

EXERCISE 18 (*Continued*)

CAPILLARY MOVEMENT OF WATER IN SOILS

	Soil Tube No. 1	Soil Tube No. 2	Soil Tube No. 3	Soil Tube No. 4
Height of water in fifteen minutes . .				
Height in thirty minutes				
Height in forty-five minutes				
Height in one hour				
Height in one day				
Height in one week				

	Soil Tube No. 1	Soil Tube No. 2	Soil Tube No. 3	Soil Tube No. 4
Amount of water taken up in one hour .				
Amount in one day				
Amount in one week				

EXERCISE 19

THE SOIL MOISTURE WHICH PLANTS CAN USE

Statement. The amount of soil water which enables the plant to grow most rapidly is called the *optimum moisture content.* The least amount of moisture in the soil which will enable the plant to live in that soil is called the *critical moisture content.* Plants die from lack of moisture before it is all removed from the soil.

FIG. 24. Optimum and critical moisture content

The picture at the left shows a plant growing in a soil with an optimum moisture content; the one at the right shows a plant growing in a soil in which the moisture content has reached the critical stage. The soil in which the plant is wilted contains as much as 4 per cent of moisture.

Object. To determine whether or not all soils give their water to growing plants equally freely and fully, and whether the critical moisture content is the same for different types of soils.

Materials. Three tin cans or flowerpots; lettuce, tomato, or cabbage plants; corn kernels or lima beans; balances; garden soil; evaporating dishes.

Directions. Fill one flowerpot with each of the following: clay, loam, and sandy soils. Transplant some tomato, lettuce, or cabbage plants into each of the three pots of soil. Plant corn kernels or lima beans in the pots and grow them for three weeks before beginning the test. Keep the plants under conditions favorable to growth until they attain a good size. Water freely.

Remove a ten-gram sample of soil from each pot at a depth of an inch below the surface. Weigh each, and after heating for two hours at the temperature of boiling water, reweigh. Compute the percentage of water present in each soil.

Cease watering and observe the plants daily for evidence that they are suffering for lack of moisture. As soon as the plants in any soil have wilted, remove a ten-gram sample of soil from this pot and determine moisture content. Compute the percentage of moisture present in the soil. By subtraction determine the percentage of moisture given up by the soil before the plant shows signs of suffering. When the plants in the other soils are wilted as badly as they were in the first soil, remove a sample and test and compute as before.

Compare the soils as to the percentage of water present in them when they no longer support plant life.

Questions. Which type of soil gave its moisture most freely and fully to the plant? What is the structure of a soil which gives up its water generously? In which type of soil will plants best withstand drought? What is the relation between the tilth of a soil and its capacity to carry plants safely

through a drought? Classify the soils of your father's farm or of some farm in the neighborhood with respect to their ability to absorb and retain moisture.

References. WATERS, H. J. Essentials of Agriculture, pp. 64–66. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 212–213. J. B. Lippincott Company. LYON, FIPPIN, BUCKMAN. Soils, their Property and Management, pp. 252–260. The Macmillan Company.

AMOUNT OF MOISTURE IN THE SOIL WHICH THE PLANTS CAN USE

SAMPLE NUMBER	KIND OF SOIL	MOISTURE CONTENT AT BEGINNING	MOISTURE CONTENT WHEN PLANT WILTED	PERCENTAGE OF MOISTURE GIVEN UP BY THE SOIL

EXERCISE 20

THE EFFECTS OF A SOIL MULCH

Statement. A mulch on the surface of the soil increases the water available to growing crops in three important ways: (1) it helps the moisture which falls on the surface to get into the soil; (2) it helps to prevent the waste of this moisture through the growth of weeds; (3) it reduces evaporation of moisture from the surface of the soil.

Object. To compare the different forms of mulches as to their value in conserving soil moisture.

Materials. Twelve flowerpots or tin cans; loam; clay; sand; balances.

Directions. 1. Label each flowerpot, weigh it, and record the weight. Fill four of them with fine clay, four with loam, and four with sandy soil. Use air-dry soil in each case. Reweigh and record the weight of the soil. In one pot of each soil plant weed seeds, watering as necessary, and allow them to get well started before continuing the exercise. Saturate each soil with water; weigh and determine the percentage of water retained by each. When the surface of the soil is dry enough to work, stir the top inch of soil sufficient to make a soil mulch in one pot of each kind of soil. Remove an inch of the surface soil from one pot of each kind of soil and replace with an equal weight of dry dust. Leave the other pots untreated. Weigh each pot and record the weight. Reweigh at intervals of twenty-four hours for fourteen days and compute the amount of moisture lost daily by each.

2. That capillary action may be interrupted by plowing under weeds and rubbish late in the season may be shown as follows: Fill two lamp chimneys half full of a common type of soil and compact each. Place a layer of finely chopped straw or chaff about one inch thick in one of the chimneys and fill it with soil. Fill the other one with the soil, compact both, and set them in shallow pans of water. Observe the rise of the water through the soil. Explain the results.

3. Test the efficiency of different kinds of mulches by filling boxes with moist soil and covering the surface of each with a different kind of mulch. Use road-dust, chopped straw, sand, and cloddy earth. Cover the surface to the same depth with each kind of mulch and weigh the boxes from day to day to determine the loss of water. Compare the results and explain the reasons for the difference shown.

4. If capillary action is permitted to bring moisture to the surface rapidly, the consequent evaporation decreases the soil temperature. The effect of evaporation upon the temperature may be shown as follows: Cover the back of the hand with cottonseed oil and note the apparent effect upon the temperature of the hand. Remove the oil and wet the back of the hand with water. Note the feeling. Wipe dry and apply alcohol. What is the effect upon the apparent temperature?

5. Compare the moisture in the soil under a board lying on the ground with that of the uncovered soil near by, and explain. Remove the cultivated layer of soil in a cornfield or garden and compare its moisture content with that of the underlying soil and explain. Compare the dryness of a soil which has supported a rank growth of weeds with that of one near by which has been cultivated and kept clean, and explain the difference.

Questions. By what means is water removed at the surface of the soil? Explain the meaning of a soil mulch. Explain how the mulch checks the loss of water. Why should soil be cultivated after a rain? Which is the cause of greater loss of moisture, surface evaporation or weed growth? Name substances, other than soil, that may be used to produce a mulch. Is the layer of finely pulverized soil which serves as a mulch dry or is it as moist as the soil underneath, and why? What happens to the mulch when it rains enough to wet the surface soil, and why? When a crust forms on the surface what should be done?

References. WATERS, H. J. Essentials of Agriculture, pp. 66–67. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 232–236. J. B. Lippincott Company. KING, F. H. Physics of Agriculture, pp. 185–189. Mrs. F. H. King. KING, F. H. The Soil, pp. 194–202. The Macmillan Company.

EXERCISE 20 (*Continued*)

SAVING SOIL MOISTURE BY MEANS OF A MULCH

	Pot No. 1	Pot No. 2	Pot No. 3	Pot No. 4	Pot No. 5	Pot No. 6	Pot No. 7	Pot No. 8	Pot No. 9
Weight of pot									
Weight of soil									
Weight of water retained									
Per cent of water retained									
Per cent of water lost at time of mulching									
Per cent lost one day after mulching									
Per cent lost five days after mulching									
Per cent lost ten days after mulching									
Per cent lost fifteen days after mulching									

EXERCISE 21

THE EFFECT OF WORKING A SOIL TOO WET

Statement. The experienced farmer waits until his soil is dry enough after a rain before he cultivates it. He has learned that if he cultivates his soil while it is wet, it will be very hard and cloddy when it is dry. This is because the grains of a soil when cultivated too wet slide over one another like putty until they become a solid mass instead of sticking together in small aggregates or crumbs. Such a soil is said to be puddled, which means that its granular structure has been destroyed. When a mud ball can be made of the soil or when it will not crumble in the hand, the soil is too wet to be worked. The farmer should know how to keep his soil in fine tilth.

Object. To compare the effect upon different types of soils of working them too wet and to learn how the tendency of soils to puddle may be corrected.

Materials. Six flowerpots or tin cans; clay; loam; sand; dry, pulverized barnyard manure; seeds of wheat.

Directions. Fill two flowerpots each with clay, loam, and sand respectively. Fill another with a mixture of equal parts of clay and finely pulverized barnyard manure. Saturate soils in each with water and stir thoroughly one pot of each kind of soil. Leave the others unstirred. Allow the soils to dry, and plant ten kernels of wheat or five of corn in each. Water as often as is necessary and observe the growth of the plants in each soil. Record the results and explain the reasons for the differences. Examine each soil under the microscope for tilth, granular structure, soil aggregates, etc., according to method described in exercise 14. Make a mud ball of each soil under experiment and allow them to dry. Test them for hardness, and examine their structure. Also make mud balls of some of the type surface soils and subsoils of the neighborhood, including some from cultivated and sod lands, and compare them as above indicated. What lessons in soil handling do these results teach?

FIG. 25. Showing the effect on the structure of soil of working it too wet as compared with working it when it was in the proper degree of dryness

Questions. Which type of soil puddles the most easily and completely? Which soil shows the best tilth? Which the poorest? Give reasons for your findings. Which soil may be plowed with the least amount of harm while wet? What is the effect of the presence of organic matter on the readiness with which a soil will puddle? What is the effect on soil structure of grazing winter wheat with cattle when the soil is wet? Does it injure the soil structure to drive a team and wagon over it while the soil is wet? Ask the farmers of the community whether sod land may be plowed and worked when wet with less injury than can stubble land, and why. Ascertain if land is injured as much by being puddled in the fall as in the spring, and why. Ascertain if the injury is as great from cultivating soil too wet if the weather continues wet as if it becomes dry, and give reasons.

References. WATERS, H. J. Essentials of Agriculture, p. 62. Ginn and Company. KING, F. H. Physics of Agriculture, pp. 231–234. Mrs. F. H. King. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 136–138. J. B. Lippincott Company. ROBERTS, I. P. The Fertility of the Land, p. 90. The Macmillan Company.

EXERCISE 22

SOIL DRAINAGE

Statement. A soil with its pore spaces filled with water is known as a dead soil. Surplus water may be disposed of in part by surface drainage if there is sufficient slope, but in such cases surface erosion or washing usually results. Underdraining, by means of tiles, lowers the water table, checks surface washing, and otherwise improves the soil.

Object. To show that drainage does not deplete usable soil moisture, but that it conserves such moisture by establishing a lower water table and facilitating percolation.

Materials. Two 12-inch flowerpots; wooden box, tightly constructed and 12 inches deep; any common type of soil; 1-inch bit and brace; three round wooden rods 1 inch in diameter, such as broom handles; a sprinkling can.

Directions. 1. Close the hole in the bottom of one of the 12-inch flowerpots with a cork; fill both pots with loam. Plant kernels of corn in each pot, and water both alike. Observe differences in growth and explain the reason for any variation that appears.

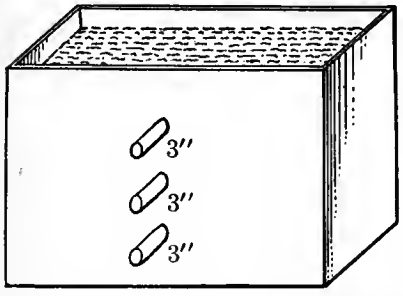


FIG. 26. A simple device for illustrating the principles of soil drainage

2. Bore holes in one end of the box 3 inches, 6 inches, and 9 inches, respectively, from the top and equal distances from the sides. On the opposite end bore three holes at the same distance from the top and sides. Place the three rods through the box, leaving one end of each to protrude beyond the hole, as shown in Fig. 26. Fill the box with soil, tamping it firmly to represent the natural field soil. When full and leveled, turn the box on end and carefully pull out the rods. If the soil is tamped thoroughly and the rods are removed carefully, the openings will remain. Pour coarse sand or gravel into the holes until they are each filled, and turn the box back to its proper position. Sprinkle the surface of the soil very slowly, so that all the water will be absorbed as rapidly as applied, until water begins to run in a stream from one of the holes in the box. From which holes does water flow first, the top ones or the bottom ones? Plug the holes from which water is flowing and continue to sprinkle until water runs from the second hole. Explain what happens, and why. Repeat until the water runs from the top hole. Stop this hole also and water the soil until it is saturated. Then open the holes in their order, beginning at the upper one, and note the lowering of the water table in the box. Apply what you have observed to the soil in the field.

Plan a system of underdrainage,

1. To improve some field in the neighborhood.
2. To reclaim a piece of wet land in the neighborhood.
3. To stop surface washing on a farm in the community.

In each case show location of drains, the size of tile required for each, the slope of each, and make an itemized statement of the cost of the improvements and of the value of the benefits which would result.

Questions. Explain in what respects a soil filled with water differs from one which is only moist. Why will not the common cultivated plants grow in one as well as the other? May the lack of suitable drainage of a soil be detected by the kinds of plants found growing on it? Name a half dozen plants the presence of which indicate poor drainage. A half dozen which indicate good drainage. How may soil erosion be prevented on gentle slopes? How may water that comes to the surface at the foot of the slopes be prevented from passing over the low level ground?

References. WATERS, H. J. Essentials of Agriculture, pp. 122–134. Ginn and Company. KING, F. H. Physics of Agriculture, pp. 292–329. Mrs. F. H. King. BURKETT, C. W. Soils, pp. 161–164. Orange Judd Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 222–229. J. B. Lippincott Company.

EXERCISE 23

SOIL WASTE THROUGH EROSION

Statement. The greatest waste of soil fertility is the waste of the soil itself. It is the best portion of the soil which is carried away by running water and by wind.

Object. To ascertain the conditions under which soil erosion occurs and the most practicable means of checking it.

Materials. Gallon of loam; two 4-to-8-gallon vessels; one half-gallon vessel; one 2-gallon vessel; two glass tumblers.

Directions. 1. As shown in Fig. 27, place a large vessel on a table and fill it with water to which one-half gallon of loam has been added. At *B* place the half-gallon vessel, at *C* the 2-gallon vessel, and at *D* the other large vessel. Connect each by one-fourth-inch rubber tubing as shown, letting the end of the tubing extend one inch below the top edge of the vessel in each case, except at *A*. Here the tube should extend almost to the bottom of the vessel.

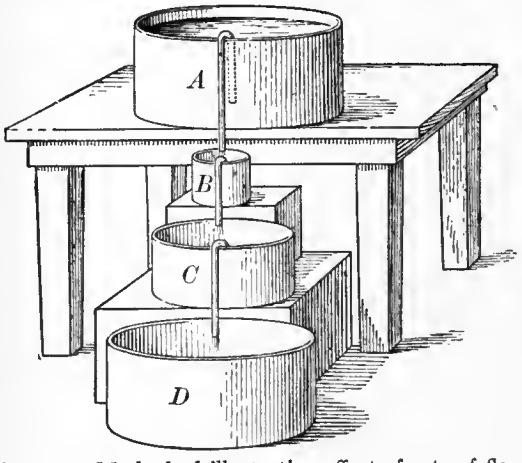


FIG. 27. Method of illustrating effect of rate of flow of water upon soil erosion

Start the water running between *A* and *B*. As soon as *B* is full, start it between *B* and *C*, and likewise when *C* is filled, start it running between *C* and *D*. While all are running, stir the water in *A* continually. When most of the water has been transferred into the other vessels, note the comparative muddiness of the water in each. Examine at intervals of an hour and note which vessel of water becomes clear first. Note which contains the most sediment after it becomes clear. *A* represents the soil, *B* the swiftly-running surface stream, *C* the slower river, and *D* the lake or ocean. Which is the more valuable, the sediment carried to *D* or that deposited at *B*?

2. Embed a tumbler in shallow, swiftly-running, muddy water so that the top of the tumbler is one-half inch above the bed of the stream. In the same manner place a tumbler in slowly-moving water. Leave them a day and then remove and determine the amount of sediment in each and whether it is sand, silt, or clay.

3. Visit local areas of badly-washed soils and plan ways to stop the erosion. Tell how erosion might be prevented by terracing, by planting crops such as pasture crops, by properly-arranged dams, and by drainage.

FIG. 28. A good example of the waste of the soil through surface erosion

Questions. Which tumbler embedded in the stream contained the most sediment? In which was the sediment the coarser? Explain the reason. Apply this principle to checking surface erosion on the fields. What is the source of the soil on bottom lands?

References. WATERS, H. J. Essentials of Agriculture, pp. 84–85. Ginn and Company. KING, F. H. The Soil, pp. 50–61. The Macmillan Company. HILGARD, E. W. Soils, pp. 218–219. The Macmillan Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 358–375. J. B. Lippincott Company.

EXERCISE 24

THE POWER OF SOILS TO TAKE UP PLANT FOOD FROM SOLUTION

Statement. A farmer frequently applies barnyard manure to the surface of the soil in winter, and at other times when it is not convenient to turn the manure under immediately. The soluble portion of the manure is carried down into the soil by the rain as it percolates through the soil.

Object. To learn whether the plant food is carried through the soil and lost in the drainage water or whether it is taken up by the soil and held there until the plants can use it. To determine whether all soils have equal power of absorbing plant food and whether they all give it up equally fully and generously. To determine whether the presence of organic matter in a soil affects its power to absorb soluble plant food.

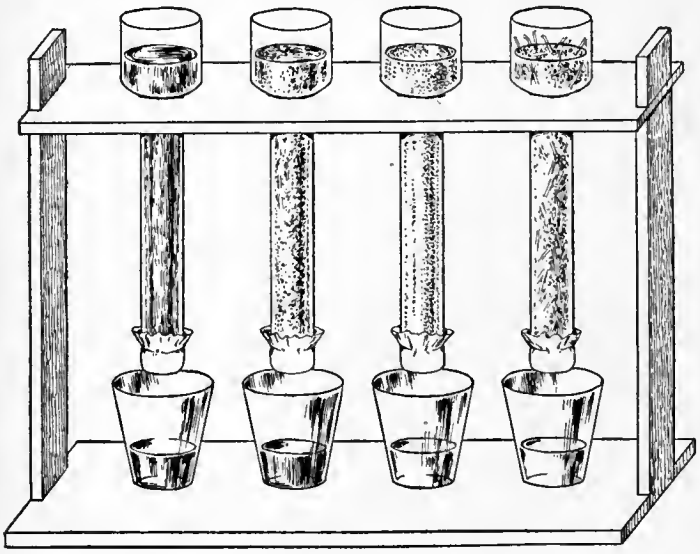


FIG. 29. Percolation rack

Materials. Four lamp chimneys; four glass tumblers; sand; loam; clay; dry, finely pulverized barnyard manure; cheesecloth; string.

Directions. Cover the bottoms of the lamp chimneys with cheesecloth and fill one a fourth full of clay, another a fourth full of loam, and another a fourth full of sand. Fill the fourth lamp chimney one-fourth full of a mixture of equal parts of sand and finely pulverized manure. Place the lamp chimneys in the percolation rack (Fig. 27) and place tumblers under each. Prepare a solution to pour over the soil in each as follows: Fill a gallon vessel one-fourth full of dry, finely pulverized barnyard manure. Fill the vessel three-fourths full of water and stir until the soluble part of the manure has colored the water. Let the organic matter settle, pour off the water, and use it to water the soil in the lamp chimneys. Observe the color of the water which percolates through the various types of soils. Record the amount of manure water which will be clarified by each soil before the drainage water begins to show color and explain the practical significance of this difference.

Questions. What was the color of the first water that percolated through each type of soil? Which soil showed percolation water when the least amount of water had passed through it? Which soil retained the most coloring matter? What was the effect of adding organic matter to sand on the amount of coloring matter retained? Discuss the value in this respect of applying all organic matter possible to the soil. Which soil — clay, loam, or sand — is most retentive of plant food when a manure or fertilizer is applied, and why? As between a soil which admits water readily and one which admits water slowly, what difference would there be in the application of barnyard manure in winter? As between a sloping surface and one which is only slightly rolling? As between a time when the ground is covered with ice or is frozen and when it is not? Prepare a statement giving your views as to the proper time and method of applying manure. Compare the merits of hauling it out frequently, and composting and applying just before planting.

References. WATERS, H. J. Essentials of Agriculture, pp. 72–73, 75. Ginn and Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 163–168. J. B. Lippincott Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 349–373. The Macmillan Company.

EXERCISE 25

THE ACIDITY OF SOILS

Statement. In humid regions there is likely to be a loss of basic, or alkaline, materials in soils that have been long under cultivation, and an accumulation of acids due to the decay of humus and the excretion of acids by the roots of growing plants. As a consequence, such soils may become sour, or acid. Many plants are directly affected in their ability to grow by the acid or the alkaline content of the soil. Among the important plants which are more or less sensitive to acid, and consequently thrive best on alkaline or neutral soils, are alfalfa, red clover, Kentucky bluegrass, tobacco, barley, wheat, and oats. Some of the plants which prefer a slightly acid soil are rye, redtop, millet, and carrots.

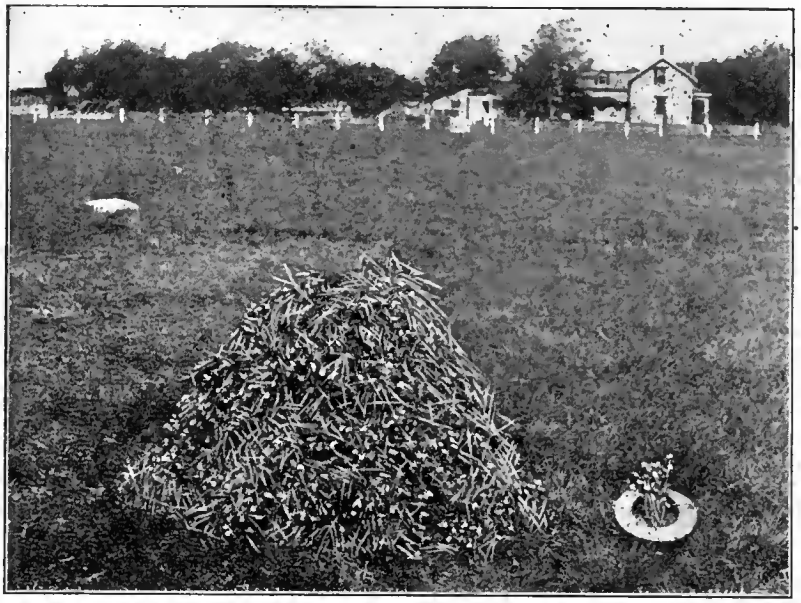


FIG. 30. Clover on an alkaline and an acid soil.

The growth of clover on an alkaline soil is represented by the pile of hay on the left. That produced on an equal area of acid soil is contained in the straw hat on the right. (Rhode Island Experiment Station.)

Object. To test the acidity of soils of the neighborhood and to study the methods of correcting this condition.

Materials. Samples of surface soil chosen from different soil types of the neighborhood and of subsoil; two tumblers; an evaporating dish; red and blue litmus papers; blotting paper; distilled water or clear rain water; ammonia; hydrochloric acid.

Directions. Collect samples of surface soil and subsoil. Secure the surface samples at a depth of seven inches, and the subsoil samples at a depth of about fourteen inches.

1. Cut a piece of filter paper to fit the bottom of the glass tumbler. Place in the bottom of the tumbler a piece of red and a piece of blue litmus paper, and over them place the disk of filter paper. Place soil to be tested in the tumbler and cover with distilled water. Observe any changes that may take place in the color of the litmus papers and record results at the end of thirty minutes.

2. Fill two tumblers three-quarters full of distilled or rain water. To the first add a few drops of ammonia. Then into each tumbler stir for three minutes a tablespoonful of the soil to be tested, being careful to use two spoons and to keep each in its respective glass. At the end of two hours examine the contents of each glass. If the soils need lime, the water standing above the soil in the glass in which the ammonia has been added will have a dark, reddish-brown, or black appearance, while the water in the other glass will be very nearly clear. On the other hand, if the soil is well stocked with carbonates of lime or magnesia, the soil water in both glasses will be entirely clear.

3. Make a mud ball, mold it cup-shaped, and pour several drops of hydrochloric acid on it. If bubbles escape, it is a sign that there is an abundance of carbonates. If there is no effervescence, the soil lacks carbonates and is probably acid.

Questions. What are some of the conditions which cause a soil to become sour? What are the best ways to correct acidity in a soil? What effect does acidity have upon plant growth? The presence of what plants indicates an acid soil? What an alkaline soil? What does ground limestone cost a ton in

your community? What does lime do in addition to correcting acidity? How much ground limestone is usually applied to the acre? How much air-slaked lime? Name the principal crops of the neighborhood which are most sensitive to acid in the soil. Do your tests indicate that the soils of the neighborhood are acid? Is lime used locally as a soil corrective? In which form is it generally used, as ground limestone or as slaked lime? Explain the difference in the preparation, composition, cost and proper use.

References. WATERS, H. J. Essentials of Agriculture, p. 63. Ginn and Company. BURKETT, C. W. Soils, p. 104. Orange Judd Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, pp. 375–391. The Macmillan Company. *Bulletin 77*, United States Department of Agriculture.

EXERCISE 26

PLANT FOOD REMOVED BY CROPS

Statement. The rate at which a farmer exhausts his soil will depend in large part upon what he takes off the soil and what he returns. The wise farmer keeps books with the fertility in his soil just as he does with the money he has in the bank.

Materials. Pencil; paper; tables in Appendix.

Directions. Assume that the element nitrogen is worth 20 cents a pound, phosphorus 8 cents a pound, and potassium 8 cents a pound.

1. If an acre of corn yields 30 bushels, assuming that it is removed from the farm, compute the amount and value of the plant food removed. How does the value of the plant food removed by the grain and the value of the grain itself compare at the present market price? Compute and record in a

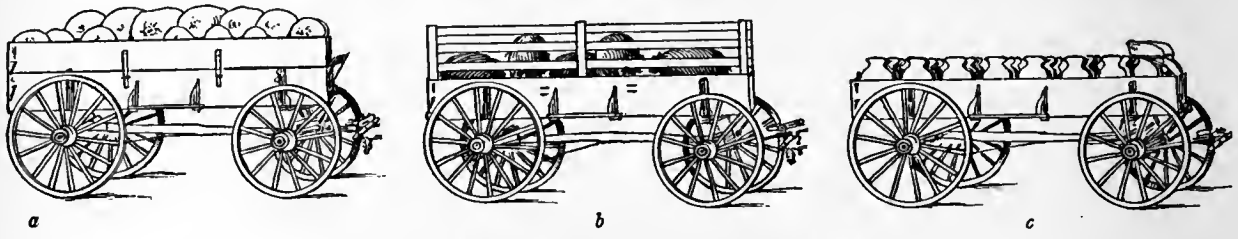


FIG. 31. In which form should the farm products be sold?

a, in a load of 50 bushels of wheat sold from the farm how much plant food is removed and what is it worth as compared with the wheat? *b*, in a load of 6 fat hogs weighing 250 pounds each how much plant food is removed and what is its value compared with that of the hogs at present market prices? *c*, in a load of cream of 1500 pounds, how much plant food is there and what is it worth compared with the cream, assuming the cream to contain 38 per cent butter fat?

table on the following page the amount and value of plant food removed from an acre by each of the following crops: wheat, 16 bushels; oats, 26 bushels; red clover, 1 ton; timothy, 1 ton; alfalfa, 3 tons; apples, 70 bushels. Compute the market value of each of these crops and compare it with the value of the plant food removed from the soil.

2. A ton of alfalfa hay removes $11.45 worth of nitrogen, phosphorus, and potassium. A ton of hogs remove $7.71 worth, and a ton of cream removes $1.85 worth of these materials. Is the plant food contained in these products counted when the buyer fixes the price which the farmer is to receive for them, or does the farmer sell his products and " throw in " the plant food? What does the farmer receive for a ton of each of the products named at present market prices?

3. American farmers produce about 3,000,000,000 bushels of corn, 700,000,000 bushels of wheat, 1,000,000,000 bushels of oats a year. Compute the value of the plant foods taken from the soil each year by each of these crops. Considering only these three crops, compare the value of the mining operations of the farmers in value of mineral removed with that of the gold mined, the silver mined, and the coal mined in the United States in a year.

Questions. What is the most exhaustive crop grown in your community considered alone from the standpoint of the plant food taken from the soil? The least exhaustive crop? What types of farming are most exhaustive of soil fertility? What types are least exhaustive? Make a plan of farming which you think would be profitable and maintain the land.

References. WATERS, H. J. Essentials of Agriculture, pp. 83–84. Ginn and Company. BURKETT, C. W. Soils, pp. 266–274. Orange Judd Company. ROBERTS, I. P. The Fertility of the Soil, pp. 20–29. The Macmillan Company. LYON, FIPPIN, BUCKMAN. Soils, their Properties and Management, p. 418. The Macmillan Company.

EXERCISE 26 (*Continued*)

AMOUNT AND VALUE OF THE PLANT FOOD REMOVED PER ACRE BY DIFFERENT CROPS

Crop	Yield per Acre	Nitrogen removed (pounds)	Phosphorus removed (pounds)	Potassium removed (pounds)	Value of Plant Food	Value of Crop	Difference in Value

EXERCISE 27

DETERMINING DEFICIENCIES OF A WORN SOIL

Statement. Any cultivated soil not fertilized naturally by such means as frequent overflows will eventually need to be fertilized artificially, as by the use of green manure, barnyard manure, or commercial fertilizers. In some soils one element of plant food will become depleted first and another element first in another soil. In some soils depletion already has been carried so far that two or more elements must be applied for successful crop growth. To apply to a soil only the elements which growing crops need is scientific practice. To apply the wrong elements or elements in addition to those needed is waste.

Object. To determine the plant needs of worn soils of the neighborhood.

Materials. Infertile soil; dry, finely pulverized barnyard manure; steamed bone meal; sodium nitrate; wood ashes; nine flowerpots or tin cans; labels; seeds of wheat.

Directions. *Laboratory test.* Number the flowerpots and fill each with an infertile soil from the neighborhood. Treat them as follows:

Pot No. 1 is to be left untreated as a check with which the others are compared. Pot No. 2 is to receive 10 grams of nitrate of soda; No. 3, 10 grams of dry, pulverized barnyard manure; No. 4, 10 grams of steamed bone meal; No. 5, 10 grams of unleached wood ashes; No. 6, 10 grams of nitrate of soda and 10 grams of steamed bone meal; No. 7, 10 grams of nitrate of soda and 10 grams of wood ashes; No. 9, 10 grams of nitrate of soda, 10 grams of steamed bone meal, and 10 grams of wood ashes.

Plant six wheat grains in each pot and place the pots where plant growth can take place to the best advantage. Be sure that all pots have equal advantages. Water each pot with clean rain water. At the end of six weeks compare the plants as to color, vigor, size, etc. Continue the test until the plants in some of the pots cease to grow. Carefully remove the plants from each pot, wash the soil from the roots, and compare the size of an average plant from each pot. Compare the root, stem, and leaf development of each. Under which system of fertilization was the greatest growth produced? Weigh the green plants produced in each pot. Place them in a labeled envelope, allow them to become air dry, and weigh. Record and discuss results. Apply the lesson to the farm practice of the community.

Questions. Under which system of fertilization did the plants have the best color and attain the greatest size? To what do you attribute this result? What did barnyard manure supply that was lacking in the other fertilizers used? What manures and fertilizers are most generally used in your neighborhood? What amounts are usually applied to the acre and to what crops? Is all the barnyard manure made in your locality preserved and applied? To what crops is it usually applied and at what rate per acre? How is it applied, with a hand fork or a manure spreader? Which method should be used?

References. WATERS, H. J. Essentials of Agriculture, pp. 79–84. Ginn and Company. WARREN, G. F. Farm Management, pp. 183–203. The Macmillan Company. PARKER, E. C. Field Management and Crop Rotation, pp. 269–280, 290–305. Webb Publishing Company. MOSIER and GUSTAFSON. Soil Physics and Management, pp. 389–407. J. B. Lippincott Company.

EXERCISE 27 (*Continued*)

RECORD OF RESULTS OF POT EXPERIMENTS

Pot Number	Treatment	Date of Planting	Appearance of Plants at first	Appearance after Two Months	Appearance after Four Months	Weight of Plants	Gain over Plants in Pot No. 1	Remarks

EXERCISE 28

JUDGING SOILS

Statement. A soil is judged on the basis of its capacity to produce crops for a long time and according to the kind of crops to which it is adapted. A farm is judged by its location (with respect to market, church, and school), its improvements, the kind of people living in the community, and the character of the roads, as well as by the quality of the soil.

Object. To judge the soil of the neighborhood as a producing unit.

Materials. Soil; score card; pencil.

Directions. Make a study of certain types of soils of the neighborhood as producing units, evaluating each on the basis of the points given on the score card. The student should be required to apply all the soil knowledge he has thus far obtained in performing this task.

In judging a soil note carefully the kind of rocks from which it is derived and learn the bearing of the origin of a soil upon its value. The depth of the soil and the depth and nature of the subsoil are of much importance and should be ascertained by observing the banks of gullies, roadway cuts and the like. One of the surest indexes of the present productiveness of a soil is the character of the forest, weed and crop growth, but this is not necessarily a safe guide to a knowledge of the wearing qualities of land. The degree to which a soil is eroded or will be eroded when cultivated should be considered. Proper drainage and the probabilities of injury from overflow should be considered. Note also the degree to which the land has been worn by continuous cropping and tillage, and in making an estimate of its value make due allowance for the time and money required to build the land up again. Take as a standard a soil that is well drained, free from overflow, deep, friable. A soil which will not wash, and which will produce a fair crop in wet and in dry seasons and a maximum crop in a favorable season. Such a soil should be adapted to a variety of the leading crops of the community.

Compare the student's estimate with the production of each type of soil in so far as it can be ascertained or approximated. Repeat this work until the student has acquired soil judgment.

Questions. What was the original growth of forests and other plants on the best soils of the neighborhood? What on the poorest soils? What is the difference in the present weed and shrub growth in these three grades of soil? Which soils have the largest proportion of legumes? Which the largest proportion of plants common to sour soils, as sorrels and docks? What is the difference in the color of different soils of the community, and what relation do you find between certain soil colors and productiveness? What relation do you find between color and adaptation to special crops, such as fruit trees, and why? What textures of soil and subsoil do you regard as indicative of good orchard land? What is the depth and the color of the subsoil of each type of soil found in the neighborhood? To what extent has each been eroded or surface washed? How does the slope or topography affect the value of land? How does topography affect the degree of surface erosion? Does the exposure or direction of the slope affect the quality and value of the soil? On which slope — the north, the east, the west, or the south — do you find the deepest layer of soil and the largest plant growth? Give reasons for what you find in answer to these questions. Which slope would you prefer as a site for an orchard? Why?

If you were purchasing a farm, describe fully how you would determine its value and on what facts you would base your judgment. Make a map of the soils of a district based upon their adaptability to the staple crops of the community.

References. WATERS, H. J. Essentials of Agriculture, pp. 62–63. Ginn and Company. WARREN, G. F. Farm Management, pp. 517–535. The Macmillan Company. HUNT, T. F. How to Choose a Farm, pp. 36–55. The Macmillan Company.

EXERCISE 28 (*Continued*)

THE SOIL AS A PRODUCING UNIT (SCORE CARD)

	Possible Score	Field No. 1	Field No. 2	Field No. 3	Field No. 4	Field No. 5
Fertility						
Color	5					
Texture	5					
Structure	5					
Depth of soil	10					
Character and depth of subsoil	10					
Character and nature of forest, weed and crop growth	5					
Total	40					
Topography						
Influence upon yield	10					
Influence upon ease of cultivation	5					
Influence upon erosion	10					
Influence upon drainage	10					
Total	35					
Physical condition						
Ease of cultivation	15					
Retention of fertility and moisture	5					
Adaptability to staple crops of the community	5					
Total	25					
Total	100					

EXERCISE 29

THE MANAGEMENT OF THE SOIL

Statement. If fields of the same size produced at the same rate regardless of their topography, fertility, structure, and methods of manipulation, the study of these factors by the student would be unnecessary.

Object. To study the differences in the productiveness of different farms and fields in the neighborhood, and the reasons for these differences.

Materials. Three or four fields in the vicinity of the school which during the past season were planted to the same kind of crop, such as three or four corn fields, orchards, wheat fields, cotton fields, or alfalfa fields.

Directions. 1. Determine the size of the fields selected, either by actual measurement or by consultation with the owners, and by similar consultation find what was the total yield (bushels, pounds, or tons) from the year's crop on each field. Enter these facts in the blank on opposite page. A second blank is provided for use in case estimates are made of two kinds of crops.

(2) In a similar manner whenever possible learn the history of the management of the soil of two or more farms in the neighborhood in which the management has been strikingly different. Observe the cumulative effect upon the productiveness of the land of a judicious system of rotating the crops and the regular use of manure or fertilizer in comparison with that of growing tilled crops continuously without fertilization.

(3) Study in detail the methods of soil management of two or three of the best farmers of the neighborhood. Ascertain if theirs was the best land in the community when they began to cultivate it. Note whether it has been improved under their management at the same time that they have produced the largest local crop yields. Study their system of crop rotation. To what crops do they apply manure or fertilizer and how much to each acre? Write an account of how their system of soil management differs from that of their neighbors.

Questions. What is the variation in acre yield in your community as shown by your investigation? Can you account for the difference in the yield by any difference in the nature of the soil? by the crop which preceded the one studied? by the amount and character of the manure or fertilizer applied? by the method of preparing the ground for the crop? by different kinds of corn, cotton, wheat, alfalfa, that were grown? by the farming methods used in growing the crop? by the time and methods used in harvesting the crop? How much more would it have been worth to the farmer who got the smallest acre yield if his field had produced the same acre yield as that of the most productive field? Suggest ways that are practicable whereby the smaller yield might be substantially increased. Are the larger yields as great as it is feasible to secure? How might they be increased with profit?

References. WATERS, H. J. Essentials of Agriculture, pp. 82–90. Ginn and Company. WARREN, G. F. Farm Management, pp. 183–203. The Macmillan Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 556–562. Ginn and Company. PARKER, E. C. Field Management and Crop Rotation, pp. 50–62. Webb Publishing Company.

EXERCISE 29 (*Continued*)

COMPARATIVE CROP YIELDS IN DIFFERENT FIELDS

Kind of Crop	Field Number	Location	Size of Field in Acres	Total Crop Yield	Yield per Acre	

PART III. FIELD AND ORCHARD CROPS

EXERCISE 30

THE CORN PLANT

Statement. Our interest in farm operations is greatly quickened if we understand fully the life habits of the plants and animals which we are raising. Besides, such knowledge points the way to the most successful farm practice. Corn is the most important crop in American agriculture, and this plant is more dependent upon man's care than any other of the great cereals. Therefore a detailed knowledge of the corn plant is of the highest importance.

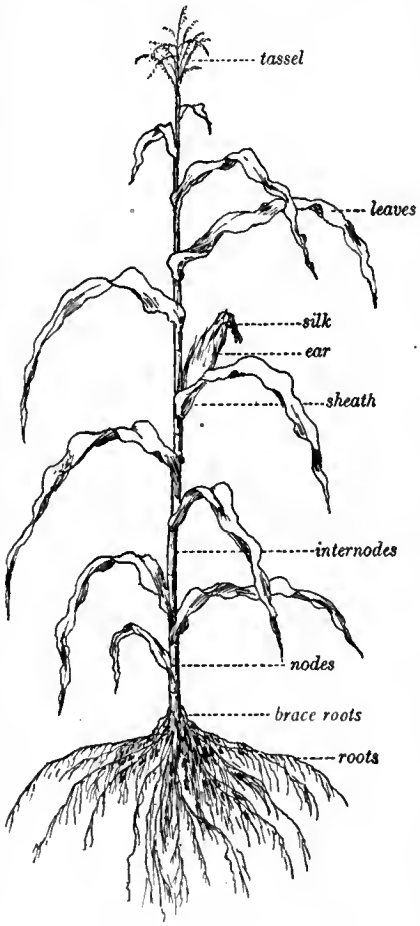


FIG. 32. Parts of the corn plant

Object. To learn how the corn plant grows, its structure, and the relationship of its parts.

Materials. Microscope; grains of corn which have been soaked in water for twenty-four hours; seedlings of corn which were started at periods of one, two, and four weeks before the date of the exercise; mature corn plants.

Directions. Study the oldest seedlings and make a sketch showing accurately roots, stem, and leaves. Trace these structures back through younger seedlings and finally to the grain, and discover the stages in the development of the different parts. Examine a transverse section of a mature stalk of corn. Describe its structure. Examine a cross section under the microscope and make drawings to show the plant fibers. What are they called, and what purpose do they fulfill? Note the hard outer fiber around the stalk. What is its use? Note the shape of the stalk between the joints. Observe the manner in which the leaves are arranged on the stalk. Notice the shape of the leaves and how they are equipped to withstand a strong wind. Take hold of a leaf near the end and pull it around as if to break it from the stalk. Study the sheath. Notice where it bends and how difficult it is to break from the stalk. What purpose does it serve? Observe how water is prevented from passing into the sheath. Explain the advantage to the plant of this arrangement. Note the whorls of roots just above the surface of the ground. Explain their value. Explain how a corn plant assumes an upright position after having been blown over by a wind.

Questions. Is the shape of the internodes of any advantage to the plant? What is the most valuable part of the plant to man? Is the remainder of the plant of any value? In what respects? Name as many products as possible that are made from the corn plant. About how many days does it require for corn to mature from the date of seeding? What is the average yield of corn in your community? What is the highest yield? What is the average yield for the United States?

References. WATERS, H. J. Essentials of Agriculture, pp. 26–27, 138. Ginn and Company. MONTGOMERY, E. G. The Corn Crops, pp. 26–38. The Macmillan Company. MYRICK, HERBERT. The Book of Corn, p. 6. Orange Judd Company. DUGGAR, J. F. Southern Field Crops, pp. 80–88. The Macmillan Company.

EXERCISE 31

THE CORN FLOWER

Statement. The flowers of the corn plant are arranged in clusters in two different parts of the plant. The male flowers form in the tassel, while the female flowers form on the cob and are surrounded by the husks. The flowers in the tassel contain the pollen grains which, when ripe, are liberated from pollen sacs. When a pollen grain falls upon a corn silk it begins to grow, and the long, slender thread which it puts forth reaches the base of the silk and carries with it the cell which fertilizes the female cell within the undeveloped kernel. This fertilized cell grows and becomes the embryo corn plant and the kernel then develops to maturity and is ready to reproduce its kind.

FIG. 33. Corn tassel and ear showing silk

Object. To observe how the corn flower is pollinated, where the pollen forms, and how it is distributed.

Materials. Ears of mature corn; a microscope; corn tassels and ear shoots which were preserved in formalin just as the flowers were opening, or fresh flowers if available.

Directions. Examine ear shoots and mature ears, noticing where the silks are attached. Examine the tassel of the corn plant and observe how the pollen sacs are attached to the tassel. Examine a pollen sac under the microscope and make a drawing to show its shape. Show in the drawing where the ripe pollen escapes from the sac. Examine the surface of a pollen grain under the microscope. Describe it. Observe whether the pollen grains and silks of a stalk of corn ripen at the same time or whether the silks of one plant are, as a rule, pollinated by the pollen from neighboring plants. In other words, observe whether the corn is self- or cross-pollinated. Observe the nature of the surface of the silks and how dust or pollen grains stick once they come in contact with the silks. Explain the significance of this.

Notice the amount of pollen a corn plant produces. Observe the ground, the plants, and your clothing when walking through a field of corn that is in full bloom. Does there seem to be a scarcity of pollen?

FIG. 34. Results of poor pollination

When scanty pollination occurs, few ovules are fertilized and few kernels develop.

Questions. What does a pollen grain do after reaching the silks? Is there an excess of pollen produced? What happens if pollen from one kind of corn fertilizes the female cell of another kind of corn? Is corn inbred or crossbred? When two varieties of corn are planted side by side will the crop from each be pure and true to the seed planted? Explain fully what will happen and how it is brought about. How far may corn pollen be carried by the wind? In growing pure seed corn what precautions should one take? Are the same precautions necessary in growing pure seed of other farm crops and why?

References. WATERS, H. J. Essentials of Agriculture, p. 138. Ginn and Company. DUGGAR, J. F. Southern Field Crops, pp. 88–89. The Macmillan Company. HUNT, T. F. The Cereals in America, p. 185. Orange Judd Company.

EXERCISE 32

A DETAILED STUDY OF THE CORN KERNEL

Statement. In selecting seed corn it is very important to choose a type which is adapted to the conditions of soil and climate under which the crop is to be grown.

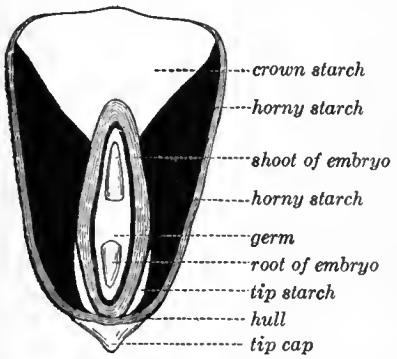


FIG. 35. Physical parts of corn kernel

Object. To determine how near corn kernels conform to the standard and to develop skill in judging seed corn.

Materials. A small piece of board or a shingle $\frac{3}{16}$ inch thick; ears of show or seed corn; a sharp knife; a few small nails.

Directions. 1. Cut notches in the board or shingle into which corn kernels of the proper size and shape for the locality will fit and use this form in measuring the length, breadth, and thickness of kernels from the standard varieties of corn; from different types of the same variety and from different parts of the same ear.

2. Choose a dozen type ears and compare and classify the kernels with respect to uniformity in size, shape, and color; in depth, width, and thickness, using the specifications of the score card as a basis. Compare the germs as to size, shape, plumpness, and color as discussed in the text. Select the type of kernel best suited to rich land with abundant moisture; the type best adapted to upland or a dry season. With the aid of the teacher and the most successful corn growers of the community choose the type of grains best suited to the soil and climatic conditions of the locality.

Measure the grains chosen and determine their approximate dimensions. Compare these dimensions with those of grains which are believed to be unsuited to local conditions. Make natural-sized drawings of the desirable kernels and discuss fully their qualifications. Give the reasons for your conclusions.

3. In consultation with the experienced stockmen of the neighborhood classify the selected corn kernels according to their value as feed for fattening stock, giving in writing the reasons for your classification. Compare in detail the character of the best class of kernels for feeding stock with those which you have chosen as the best for planting.

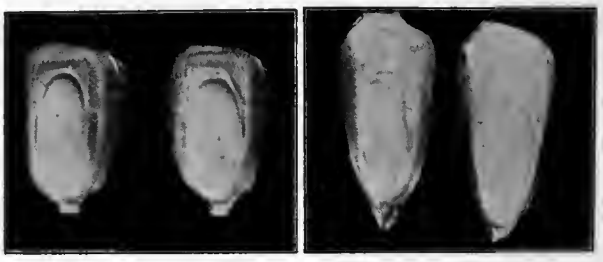


FIG. 36. High and low producing seed grains

At the left, strong, vigorous grains with well-formed germs; seed of the ear from which these grains were taken yielded 81 bushels to an acre in an ear-row test in Kansas; at the right, weaker grains of the same variety as at the left; germs not so well developed; yield of seed from this ear 51 bushels.

Questions. Which part of the ear shows the most uniformity in size and shape of kernel? How may the size and shape of the kernels planted influence the yield? Why is a thin kernel undesirable to plant? What relationship does the size of the germ have to the early growth of the plant? Why should we grade seed corn before planting it? How is corn usually graded? Should kernels with dark colored or moldy germs be chosen for seed? Give reasons for your answer. Should kernels with small or shriveled germs be chosen? Give reasons. What does a deep, narrow, thin, chaffy kernel indicate as to the nature of the soil and climate required by the type of corn it represents? What does a shallow, broad, flinty kernel indicate? In what respects will the season affect the type of kernel produced? A dry season; an ideal season; a wet season; a short season or one in which the corn fails to mature fully. How do the seasons affect the feeding value of the grain?

References. WATERS, H. J. Essentials of Agriculture, pp. 140–145. Ginn and Company. MYRICK, HERBERT. The Book of Corn, pp. 84–85. Orange Judd Company. DUGGAR, J. F. Southern Field Crops, pp. 92–95. The Macmillan Company. MORGAN, J. O. Field Crops for the Cotton Belt, pp. 159–160. The Macmillan Company.

EXERCISE 33

THE BUTT AND TIP KERNELS OF SEED CORN

Statement. In the development of the corn ear the silks attached to the butt kernels mature first, therefore the butt kernels are the first to form their embryos. The silks attached to the tip kernels mature last, and the kernels are the last to form their embryos. The pollen which first ripens is usually produced by barren stalks or by plants which because of their earliness are small. The pollen last produced is from late-maturing stalks, many of which are weak and unproductive. Since the butt and tip kernels are fertilized by pollen from these undesirable plants, such kernels should not be used for seed. Also, the tip kernels do not contain enough stored food for the little plant, nor are they properly shaped to contain a strong germ.

FIG. 37. Desirable and undesirable types of kernels

Object. To compare the relative value of butt, body, and tip kernels for seed.

Materials. Ears of corn; a corn planter; plot of ground, or a box of sand if no plot of ground is available; a corn grader.

Directions. 1. Examine kernels from the butt and tip. Note the shape, soundness and size of the grains.

2. Prop up a corn planter and by turning the wheels test the accuracy of the drop, first using body kernels of corn and then using kernels from the entire ear; then from the butt; then from the tip.

3. Plant in one row of the seed plot or of the box of sand butt kernels of corn. In another row plant body kernels and in the third row plant tip kernels. Give the three rows the same treatment and observe any differences that may occur. Record the number of barren stalks produced in each row; number of ears of corn; amount of corn by weight; number of "suckers," and uniformity of stand. If the exercise is performed indoors, only the early growth can be observed.

4. Sort one-half peck of shelled corn through a corn grader. Figure the percentage of kernels that are removed. Is the grading of corn in this manner a slow or difficult process? Take the corn that has passed through the grader and sort it by hand, removing any broken, ill-shaped, or undesirable kernels.

FIG. 38. Good and poor butts and tips

Questions. What percentage of the kernels are found to be undesirable when run through the grader? Considering what would have been lost by planting the bad kernels, would it be worth while to hand grade the kernels? How do uniform kernels help to produce a uniform stand? Explain how a kernel of seed corn which has been fertilized from a weak or barren stalk is likely to be affected in its power to produce.

References. WATERS, H. J. Essentials of Agriculture, p. 143. Ginn and Company. HUNT, T. F. Cereals in America, pp. 148, 200. Orange Judd Company. MYRICK, HERBERT. The Book of Corn, pp. 78–79. Orange Judd Company.

EXERCISE 34

A DETAILED STUDY OF THE CORN EAR

Object. To estimate the points of superiority in ears of corn and to determine the character of the qualities essential to good seed corn.

FIG. 39. Grand sweepstakes. Single ear at the Iowa State Corn Show

Materials. Three ears of corn for each student in the class, with a few extra ears for further comparison. Textbook statements of what constitutes a good ear.

Directions. In each vertical column in the following outline enter the statements which express your judgment of the character of each of the qualities listed for an ear of corn. Repeat this for two other ears; then compare your statements and compare the ears to see if you have described them accurately.

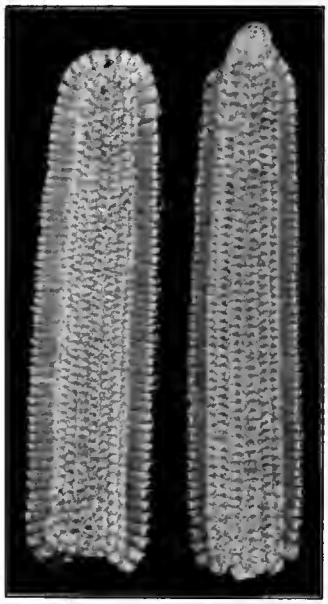


FIG. 41. Deep and shallow kernels
At left, deep; at right, shallow

Classify the shape of ears as cylindrical, tapering, or irregular. Length of ears should include extreme length, considering projecting cob as a part of the ear. The circumference should be taken at one third the distance from the butt to the tip. Color of kernels should show the number of kernels not of the same color as the ear. Indentation should be classed as broad, deep, or chaffy. The number of rows depends upon the type and variety of corn. The spacing of the kernels should be such as to allow a maximum amount of corn; that is, the kernels should fit tightly one against another. Designate the spacing at the crown and at the cob as close or loose. Classify the pairing of the rows as distinct or indefinite; classify tips as blunt or tapering; classify butts as expanded, contracted, or cylindrical; classify shanks as large, medium, and small.

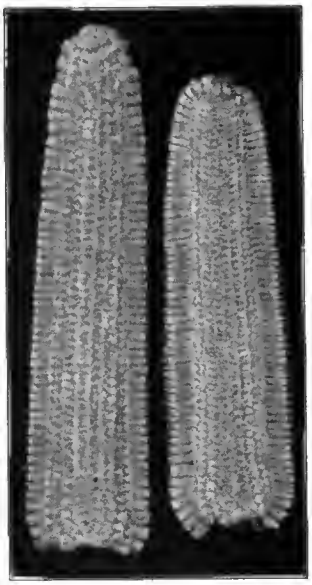


FIG. 40. Wide and narrow spacing on the cob

Questions. What is the proper length for an ear of dent corn in your community? What has happened when ears of corn display more than one color? Describe the appearance of a chaffy kernel of corn. In what dimension is a chaffy kernel usually deficient? If kernels are narrow, what about the spacing at the crown? If narrow, what about spacing at the cob? If narrow, how is size of the germ affected?

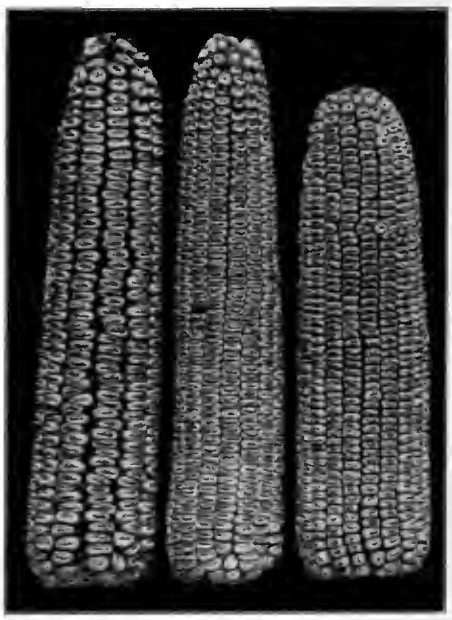


FIG. 42. Undesirable types of ears
At the left, grains spaced too wide; in the middle, ear too slender; at the right, ear too short and thick

References. WATERS, H. J. Essentials of Agriculture, pp. 142–147. Ginn and Company. DUGGAR, J. F. Southern Field Crops, pp. 101–111. The Macmillan Company. MYRICK, HERBERT. The Book of Corn, pp. 75–87. Orange Judd Company.

EXERCISE 34 (*Continued*)

A DETAILED STUDY OF AN EAR OF CORN

	Ear No. 1	Ear No. 2	Ear No. 3	Ear No. 4	Ear No. 5
Ear					
1. Shape					
2. Length					
3. Circumference					
Kernel					
1. Color					
2. Amount of indentation					
3. Shape					
Broadside					
Narrowside					
Rows					
1. Number					
2. Spacing					
At crown of grains					
At cob					
3. Pairing of rows					
Tip					
Butt					
Shank					

EXERCISE 35

SCORING A TEN-EAR SAMPLE OF CORN

Statement. When an individual is able to compare and judge ears of corn rapidly and accurately, he has developed "corn judgment," a trait which can only be acquired by experience and study. To a beginner a score card designating the principal points to be considered is very helpful. It is not a rule; it is only a device to aid in forming correct judgment.

Object. To determine the relative merits of ears of corn from a physical examination.

Materials. Ten selected ears of corn for each pupil; tape measure 12 inches long; a sharp pocket knife; a magnifying glass.

Directions. 1. Score each ear of the ten selected, and record the score of each on the score card which follows. After your score has been gone over by the instructor, make notes at the bottom of the score card showing where errors were made, and why. After all exhibits are scored, examine carefully those receiving the highest score.

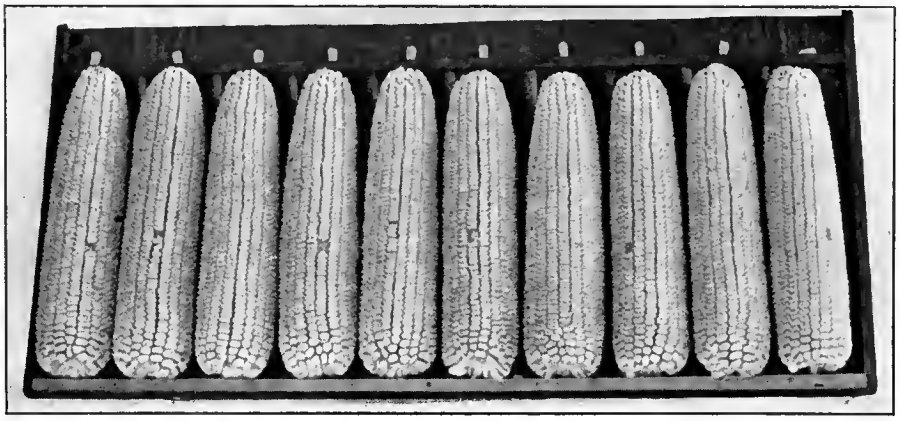


FIG. 43. A grand sweepstakes exhibit at the Indiana State Corn Show

2. Each pupil should select the best single ear from his ten-ear exhibit and enter it in a single-ear contest. After the best ear in the entire lot is selected, mount it and label it the prize winner from the standpoint of appearance. In a home project exercise outlined later the prize winner will be chosen from the standpoint of performance in an ear-row test. Selection by means of physical examination is very helpful and is the only feasible plan of general seed selection, but the final test is the record of performance in the field.

3. Save for future use all the ears judged, being sure to keep them properly tagged so that their history may be traced at any time.

Questions. What points on the score card are given the most consideration? Why? What is the required length for a standard ear of corn in your community? Why does the size of the ideal ear vary in different regions? If a kernel of corn produces a stalk containing one or two average-sized ears, how many kernels are produced from the one planted? How many ears of average size for your community are required to plant an acre? How many acres of corn will a bushel of seed plant? At $1, $2, $3, $5 a bushel respectively, what is the seed cost for an acre? If properly selected seed will produce five bushels an acre more than ordinary seed how much more could the farmer afford to pay for it rather than use ordinary seed? How many hours could he afford to spend growing or selecting such seed rather than plant the unselected sort?

References. Waters, H. J. Essentials of Agriculture, pp. 138–148, 211. Ginn and Company. HUNT, T. F. The Cereals in America, pp. 170–171. Orange Judd Company. MYRICK, HERBERT. The Book of Corn, pp. 75–87. Orange Judd Company. DUGGAR, J. F. Southern Field Crops, pp. 101–111. The Macmillan Company. MONTGOMERY, E. G. The Corn Crops, pp. 253–259. The Macmillan Company.

EXERCISE 35 (*Continued*)

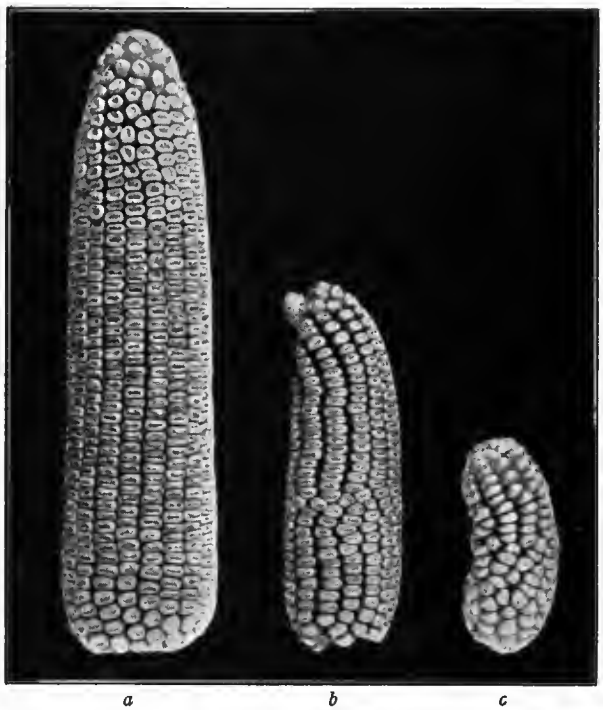
SCORE CARD FOR INDIVIDUAL EARS OF CORN

Scale of Points	Possible Score	Points Deficient																			
		Student's Score										Corrected Score									
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1. **Variety type.** The ear should conform to the general type of the variety to which it belongs, in respect to size and shape of ear, color of kernels and cob, and width, thickness, depth, shape, spacing, and indentation of kernels. When variety type is not known, give perfect score on this point . . .	5																				
2. **Maturity and soundness.** The ear should be well-matured, dry, firm when twisted, and of good weight for its size and condition. Sappiness, moldiness at the crowns of the kernels and at the cob, looseness of corn on cob, chaffiness, adherence of tip caps to cob and of considerable chaff to the tips, are all indications of immaturity. Decayed, mouse-eaten, and insect-injured kernels are unsound and also indicate a poor seed condition . . .	15																				
3. **Purity.** (1) *Of kernels.* Kernels should be free from mixture with corn of other colors. Mixture in yellow corn is shown on the caps of the kernels and in white corn usually on the sides. Deduct one-half point for each kernel distinctly showing undesired color. If in competition, ten or more mixed kernels should bar the ear. (2) *Of cob.* Cobs in yellow corn usually should be red (the shade of red desired varying with variety); and in white corn, white. For pink cobs, cut according to shade. A cob of distinctly undesired color, unless a variety characteristic, should be given a score of zero, and if in competition, the ear should be barred	5																				
4. **Shape of ear.** In general a well-shaped ear should (1) be nearly cylindrical; (2) have straight rows running directly from butt to tip; (3) be full and strong in the middle portion; (4) not be flattened. Such an ear will shell a high percentage of uniformly shaped kernels . .	10																				
5. **Size and shape of kernels.** Size of kernels includes the depth, width, and thickness. For average corn-belt conditions a medium depth of kernel usually produces the largest yield of mature corn. The width, thickness, and shape of kernels vary with varieties. As a general rule, however, they should be keystone-shaped, permitting the edges of the kernels to touch from crown to tip. As to thickness, the kernels should number about six to the inch in the row	10																				
6. **Uniformity of kernels.** The kernels should be uniform in depth, width, thickness, and shape throughout the ear. Irregular kernels are objectionable	5																				
7. **Size and condition of germs.** The germs should be long, wide, thick, smooth, and bright and should not be shriveled, blistered, shrunken, moldy, or discolored. The embryo proper should show a fresh, oily, and live appearance and be yellowish-white in color	10																				
8. **Butt.** The butt should carry out the circumference of the ear uniformly and not be pinched, enlarged, expanded, or flattened. It should be well rounded out with straight rows of regular kernels having nearly the same depth, width, thickness, and shape as the body kernels. The grains on the butt should be uniformly arranged around a medium-sized, cup-shaped cavity	5																				
9. **Tip.** The tip should be covered to the end of the cob with kernels arranged in straight rows and having nearly the same size and shape as the body kernels. Shallow, narrow, irregular, glistening, and shot-shaped kernels are objectionable	5																				
10. **Space between rows and kernels.** Large, open spaces between the rows either at the crowns or the tips of grains or between the kernels in the same row are objectionable. There should be only enough space to permit satisfactory drying of the ear. Too close spacing is also objectionable.	5																				
11. **Proportion of grain to cob.** The proportion of grain to cob differs with varieties and with the latitude under which grown. A reasonably good seed ear should shell from 85 to 87 per cent. The occurrence of one or more of the following factors may indicate a low proportion of grain to cob: (1) large cob; (2) moist and heavy cob; (3) shallow kernels; (4) wide space between rows either at the crowns or the tips of the kernels in the same row; (5) butts and tips much exposed; (6) butt and tip kernels extremely shallow.	5																				

EXERCISE 36

FACTORS DETERMINING THE YIELD OF CORN

Statement. The average corn yield of the United States is about 24 bushels an acre, while the best farmers secure from 70 to 100 bushels. As many as 228¾ bushels have been produced by a Corn Club boy in South Carolina. Is the reason for the low average yield the small size of the ears produced, or the small number of ears, or both?



a *b* *c*

FIG. 44. Comparative weights of ears of corn

a, 12 ounces; *b*, 6 ounces; *c*, 2½ ounces. Which of these ears of corn represents the size of ear produced in the neighborhood? Is the small size of ear the principal cause of low yields?

Object. To determine the cause for the wide variation in the acre production of corn.

Materials. Scales; tape measure; ears of corn of average size. An ear weighing six ounces and one weighing approximately 2½ ounces.

Directions. 1. Have each student secure an ear of corn of approximately the average size for the locality. Ascertain the weight, length, and circumference of these average ears and compare the results with the standard for your section of the state as determined by the score card of your Agricultural College or Corn Growers' Association.

2. When corn is planted in hills 3½ feet apart each way, there are 3556 hills on an acre.

3. Compute the yield of corn per acre with three stalks to the hill, a perfect stand, and each stalk bearing an ear, assuming that each ear weighed the same as the average of the ears brought in by the students. How does this yield compare with the actual yield of the neighborhood?

4. Compute the yield, assuming that the ears weigh 6 ounces each. How does this yield compare with the local yield? Secure a 6-ounce ear. How does it compare with the average ear brought in by the students?

5. Compute the yield on the basis of a 2½-ounce ear to each stalk. Compare this yield with the local yield and with the average yield of the United States. Compare a 2½-ounce ear with the ears brought in by the students.

6. Assuming that the students have brought in ears of average size for the neighborhood and assuming the average yield for the United States to be 24 bushels an acre, what proportion of the stalks have ears on the basis of a perfect stand of three stalks to the hill? What proportion have ears on the basis of two stalks to the hill and a perfect stand?

Questions. Is the low yield of the neighborhood due to the small size of the ears or to the small number of ears produced per acre? Is the small number of ears produced due to the imperfections of stand or to the large number of barren stalks, or both? How in your judgment may the corn yield be most readily increased?

References. WATERS, H. J. Essentials of Agriculture, p. 135. Ginn and Company. DUGGAR, J. F. Southern Field Crops, pp. 114–119. The Macmillan Company. MORGAN, J. O. Field Crops for the Cotton Belt, pp. 243–244. The Macmillan Company. MONTGOMERY, E. G. The Corn Crops, pp. 57–58, 122–123. The Macmillan Company.

EXERCISE 37

A FIELD STUDY OF THE DEFICIENCIES OF CORN PLANTS

Statement. Low yields of corn are not due to a single cause. The deficiencies in the average field of corn are numerous and require wide knowledge of soils and plant life to correct them.

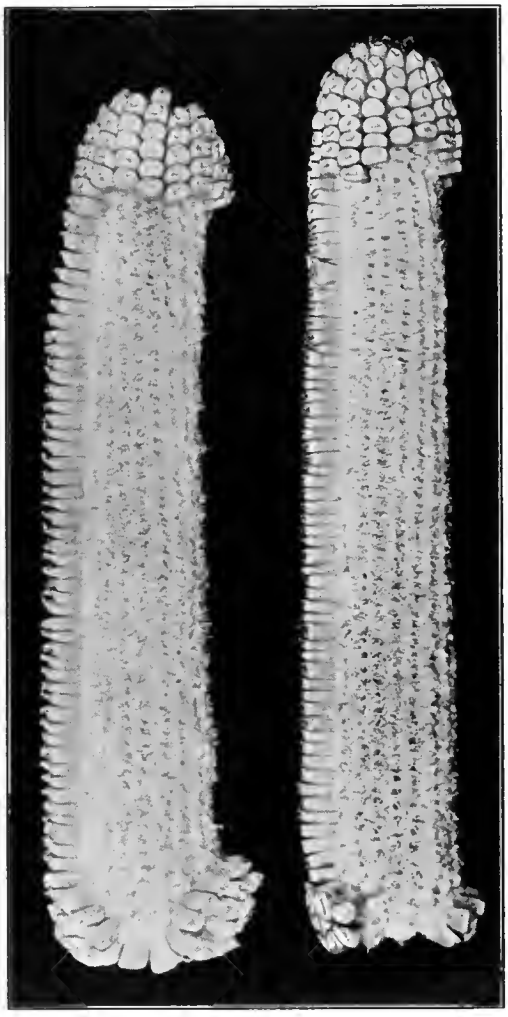


FIG. 45. High and low yielding ears

The difference in the yielding power of different ears of corn of the same variety is well illustrated by the producing record of the ears shown. These two ears were selected from the same field as good seed and the grains planted side by side and given the same care. The seed from the ear at the left yielded 16 bushels to the acre, and seed from the ear at the right yielded 70 bushels per acre. (Courtesy of the Kansas State Agricultural College)

Object. To determine the influence of the stand and the proportion of barren to fruitful stalks upon the yield of corn; also the causes of poor stands and of barrenness of stalks.

Materials. Measuring stick or tape measure; spring balances; a bag or bushel basket.

Directions. Select a row of corn that represents, as nearly as may be ascertained by the eye, the average of the field and measure the distance between the rows. If the rows are $3\frac{1}{2}$ feet apart, a row 125 feet long will be the equivalent of one hundredth of an acre. In any case, measure off a row long enough to be the equivalent of one hundredth of an acre.

Count the hills in the row; the number of hills missing; the number with one stalk, with two stalks, with three stalks, with more than three stalks. Compute the average number of stalks in a hill; the total number of stalks in the row. Count the number of stalks with one good ear, with two good ears; the number bearing nubbins (ears under five inches in length); the number of barren stalks; the total number of ears; the total weight of ears; the percentage of stalks bearing good ears; the estimated yield; and the number of ears to the acre.

Compute the yield per acre on the basis of a perfect stand and each stalk bearing an ear weighing 12 ounces, and compare the result with the actual increase in yield per acre if each stalk found barren or producing only a nubbin had borne a normal ear.

Explain some of the causes for poor stands and barrenness and how these defects may be remedied.

Fill in these data on the form opposite and discuss the results obtained.

Questions. How could the farmer have increased his yield? Would the row you have examined be a good place for the farmer to obtain seed for the next year's planting? On the basis of 90 per cent of a perfect stand what would have been the yield of the row you counted? What would have been the yield if each stalk had borne a 12-ounce ear? Will the ears be as large and the proportion of fruitful stalks as large with a perfect stand as with 80 per cent of a stand? In a very dry season is a thick or a thin stand best and why? In a wet season which is best and why? On rich land? On poor land? Which when the variety planted is large? When it is small?

References. WATERS, H. J. Essentials of Agriculture, pp. 137, 141. Ginn and Company. HUNT, T. F. The Cereals in America, pp. 196–197. Orange Judd Company.

EXERCISE 37 (*Continued*)

FIELD SURVEY OF CORN

	Row No. 1	Row No. 2	Row No. 3	Row No. 4
Number of hills counted				
Number of hills missing				
Number of hills with one stalk				
Number of hills with two stalks				
Number of hills with three stalks				
Number of hills with more than three stalks				
Total number of stalks				
Average number of stalks per hill				
Number of stalks with one good ear				
Number of stalks with two good ears				
Number of stalks bearing nubbins				
Number of barren stalks				
Total number of ears				
Percentage of stalks bearing good ears				
Estimated acre yield				
Estimated number of ears to the acre				
Average weight of each ear				
With each stalk producing one 12-ounce ear what would have been the yield per acre?				

EXERCISE 38

SELECTING SEED CORN FROM THE FIELD

Statement. After the measurements of a desirable ear of corn are known and the shape and characteristics of the various parts understood, there still remains the practical application of the principles. Selecting seed from the field applies these principles and develops in the individual the power of quick decision and sound judgment.

Object. To learn how to select seed corn in the field.

Materials. A bag swung over the shoulder like a game sack or a basket; a tape measure; a notebook; some small tags; a field of well-bred, mature corn.

Directions. Each student should go into the field and select ten ears of seed corn, noting carefully the points governing seed selection. The blank form on the opposite page should be used, and all data

FIG. 46. Students acquiring corn judgment and securing seed for their home project

concerning the ears chosen and the plants which produced them should be entered. Wrap and number each ear selected so that it may be preserved and identified. Keep a complete record for reference.

After selecting the ten ears and collecting the data return to the laboratory and place the ten ears side by side. Judging from the appearance of the ears and from the data collected concerning them, select the best ear of the ten. Enter it in competition with the ears selected by other students in an ear-row test to be conducted the following summer as a home project and as a means of securing good seed. Use, also, in this ear-row test the ear selected in Exercise 35.

At the close of the competitive judging each pupil should be required, as a home project, to select enough of his father's seed corn for the next season's planting or to select enough seed further to develop and fix his judgment.

Questions. What determines the value of an ear of seed corn? What are the advantages of field selection over crib selection? When, in the fall, should seed corn be selected? How should it be

protected after being selected? What are the most common defects of seed corn used in your community? Suggest three convenient ways of storing seed corn so that it will dry quickly and be protected against injury from mice and rats. Is seed corn injured by low temperature when moist? When dry?

References. WATERS, H. J. Essentials of Agriculture, pp. 139–142. Ginn and Company. MONTGOMERY, E. G. The Corn Crops, pp. 85–93. The Macmillan Company. HUNT, T. F. The Cereals in America, p. 196. Orange Judd Company. MYRICK, HERBERT. The Book of Corn, p. 70. Orange Judd Company. MORGAN, J. O. Field Crops for the Cotton Belt, pp. 192–196. The Macmillan Company. DUGGAR, J. F. Southern Field Crops, pp. 130–131. The Macmillan Company.

SCORE CARD FOR SELECTING SEED CORN IN THE FIELD

	Possible Score	Ear No. 1	Ear No. 2	Ear No. 3	Ear No. 4	Ear No. 5	Ear No. 6	Ear No. 7	Ear No. 8	Ear No. 9	Ear No. 10
Stalk . . . . . The stalk should be strong and vigorous but not coarse. It should be medium sized, well developed at the base, and taper gradually to the tassel. It should stand up well, showing a good root system. The ears should be borne at a height of from three to four feet, which is most convenient for husking. Record the average height of the ears from the ground on each stalk from which you make a selection. Record the number of ears on each stalk; the number of stalks in the hill; the distance in each direction to the next stalk; the leaf surface of the plant from which ears are selected. A large leaf area indicates well-developed ears containing hardy, well-filled kernels.	30										
Shank . . . . . The shank should be of medium length and size. If large or too short the ear will stick up when mature, which is objectionable. If the shank is large, it makes the ear difficult to break off in husking. The shank should not be exceptionally small or it will not support the maturing ear, which will break sharply over, thus cutting off its own food supply.	10										
Ear . . . . . The ear should be strong, mature, well developed, cylindrical, and its circumference near three fourths of its length. It should have straight rows of well-filled kernels and tips filled with well-filled kernels. Ears with double-pointed or flattened tips should be discarded.	40										
Kernels . . . . . The kernel should possess medium indentation. If the kernels are smooth, they are generally quite shallow, and if too rough, the strain is not likely to produce well. The kernel should show purity of color.	20										

EXERCISE 39

TESTING SEED CORN

Statement. Only vigorous seeds will produce vigorous plants. Only a germination test made before the seeds are planted will answer the question as to what proportion of the seeds will grow.

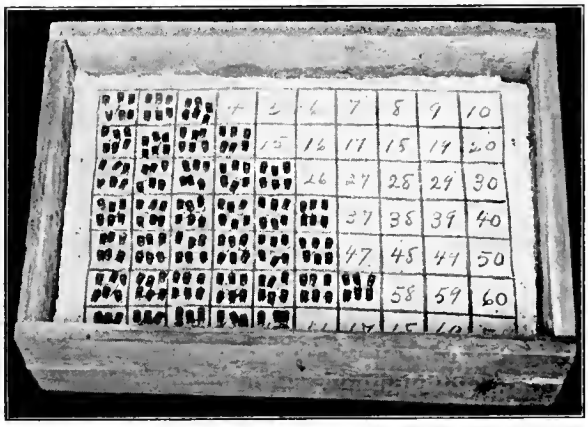


FIG. 47. Germination-box tester

Object. To ascertain what proportion of the corn which the farmers of the neighborhood are expecting to plant will germinate and which ears will produce vigorous plants.

Materials. Shallow box, clean, fine sand; nails; string; a piece of white cloth; seeds to be tested such as 50 ears of corn.

Directions. 1. *Germination-Box Method.* Entirely around the top of the box drive nails partly into the edges, 2 inches apart. Tie string to these nails both ways across the box in such a manner that the box will be divided into 2-inch squares. On the edge across the top and between the nails letter each space. On the edge down one side and between the nails number each space. Label each ear of corn to be tested by placing a tag on it marked A-1, A-2, A-3, etc. Plant in the square six kernels taken from different parts of an ear. When the tester is filled, cover the kernels with sand to a depth of about one half an inch. Water as needed. After the kernels have germinated, record the results.

2. *Rag-Doll Method.* On the strip of cloth about 12 inches wide and 2 yards long mark a heavy black line lengthwise in the center. Mark cross lines about three inches apart on one half of the cloth. Number each rectangle thus made and place kernels of corn, from ears numbered to correspond, in the space. Beginning at the end of the cloth that is not lined, roll it up, being careful not to disturb the kernels. Tie the roll at the ends and at the middle. Soak the roll for an hour in water and place it in a warm place for the seed to germinate. At the end of a week examine the seeds.

FIG. 48. Rag-doll tester

Questions. Is it possible to determine by the appearance of the kernel or germ whether or not the grain will germinate? Is vigorous seed of more importance at the first planting when the ground is wet and cold than for late planting when the soil is warm, and why? What does it cost per acre to plant corn over? What when the ground must be replowed? Which is the better prospect for a good crop, corn which is planted early or that which is planted late? Get the judgment of some of the best farmers of the neighborhood on this point and their reasons for their answers. Ask them also what they estimate to be the loss per acre in planting corn over, including the possible reduction in the yield due to later planting. What is the safest insurance you can suggest against a poor stand? Does your school test the seed corn for the farmers of the community?

References. WATERS, H. J. Essentials of Agriculture, pp. 147–148. Ginn and Company. MONTGOMERY, E. G. The Corn Crops, pp. 192–195. The Macmillan Company. MYRICK, HERBERT. The Book of Corn, pp. 71–72. Orange Judd Company. MORGAN, J. O. Field Crops for the Cotton Belt, p. 238. The Macmillan Company. DUGGAR, J. F. Southern Field Crops, pp. 138–139. The Macmillan Company.

EXERCISE 39 (*Continued*)

RECORD OF GERMINATION TEST

	Ear No. A–1	Ear No. A–2	Ear No. A–3	Ear No. A–4	Ear No. A–5	Ear No. A–6	Ear No. A–7	Ear No. A–8	Ear No. A–9	Ear No. A–10
Number of dead kernels . . .										
Number of weak kernels . . .										
Number of strong kernels . . .										
Average germination										

RECORD OF GERMINATION TEST

	Ear No. A–1	Ear No. A–2	Ear No. A–3	Ear No. A–4	Ear No. A–5	Ear No. A–6	Ear No. A–7	Ear No. A–8	Ear No. A–9	Ear No. A–10
Number of dead kernels . . .										
Number of weak kernels . . .										
Number of strong kernels . . .										
Average germination										

RECORD OF GERMINATION TEST

	Ear No. A–1	Ear No. A–2	Ear No. A–3	Ear No. A–4	Ear No. A–5	Ear No. A–6	Ear No. A–7	Ear No. A–8	Ear No. A–9	Ear No. A–10
Number of dead kernels . . .										
Number of weak kernels . . .										
Number of strong kernels . . .										
Average germination										

EXERCISE 40

CORN CULTIVATION

Statement. Some crops, such as the pasture grasses, are grown successfully without cultivating the soil in which they are growing. Other crops, such as wheat and oats, need only the tillage required properly to prepare the seed bed. A large number of important crops, like corn, cotton, fruits, and garden vegetables, must have the soil about them tilled several times during their growing period if satisfactory results are to be obtained.

Object. To understand the purposes and proper methods of cultivating corn.

Materials. Kernels of corn; three large boxes at least two feet square and one foot deep, with holes in the bottom to provide drainage, and filled with finely screened garden soil.

Directions. Label the boxes 1, 2, and 3, respectively, and in each plant three kernels of corn. Wet the soil in each box, using the same amount of water for each. As soon as the soil is dry enough to work stir the surface in box 1 to a depth of one-half inch and leave the others untreated. Observe whether this makes any difference in the time required for the plants to get above ground. Explain.

FIG. 49. The effect of cultivation on the growth of corn

The field at the left was plowed, harrowed, and cultivated three times; yield 40 bushels an acre. The field at the right was plowed and harrowed, but not cultivated; the weeds so completely choked the corn that the yield was less than half a bushel to the acre. (Courtesy Illinois Experiment Station)

After the corn is up and growing well, remove all but one healthy plant from each box. Give each box the same amount of water. Every ten days after the plants are up cultivate the soil in boxes 1 and 2. Cultivate box 1 three inches deep the first time, two inches deep the second and third times, and one inch deep the last. Cultivate box 2 four inches deep each time. In cultivating do not stir the soil within two inches of the plant. Leave box 3 undisturbed, allowing the weeds to grow. Toward the end of the experiment cease watering the plants and allow them to suffer for moisture as corn plants do in a drought. Compare the growth of the plants as long as it is possible to continue the experiment and note under which treatment the plants best withstood the effects of the drought.

Study the root system of the plants in each box and note where the roots are located and if any roots were destroyed by any system of tillage. Remove the weeds in box 3 at the surface. Weigh them and compare this weight with that of the corn stalks cut off at the surface. Compute the proportion of moisture used in corn growth and weed growth respectively.

Questions. What are the principal benefits of cultivation of corn? In what ways do weeds hinder the growth of the corn plants? When and how may weeds be most easily and completely destroyed?

What depth of mulch is most effective in conserving moisture and keeping down weed growth? How many times and at what stages of growth should corn be cultivated? At what stage of development should the crop be cultivated the last time or "laid by"? What principles should guide the farmer in regard to the depth to cultivate corn, (*a*) when the plants are small; (*b*) when the plants are large and their roots have fully permeated the soil; (*c*) in a wet season when there is a rank growth of weeds to be killed; (*d*) in a dry season when there are no weeds and the surface is covered with a mulch; (*e*) when a thin crust is formed on the surface? Name the principal implements used in tilling corn in the community. How many acres can a man till in a day, when the corn is small? When it is ready to be "laid by"?

References. WATERS, H. J. Essentials of Agriculture, pp. 150–152. Ginn and Company. DUGGAR, J. F. Southern Field Crops, pp. 158–188. The Macmillan Company. MORGAN, J. O. Field Crops for the Cotton Belt, pp. 245–251. The Macmillan Company. MYRICK, HERBERT. The Book of Corn, pp. 123–128. Orange Judd Company. MONTGOMERY, E. G. The Corn Crop, pp. 197–214. The Macmillan Company. MOSIER, J. G., and GUSTAFSON, A. F. Bulletin 181 Illinois Experiment Station, Urbana.

EXERCISE 41

A STUDY OF THE WHEAT PLANT

Statement. The plant consists of roots, stems, leaves, flowers, and fruit. The relationship of the parts and the difference in the time at which they appear are strikingly shown in the case of the wheat plant.

Object. To study the structure and relationship of the principal parts of a wheat plant.

Materials. Wheat seedlings grown in the classroom and a bundle of full-grown plants.

Directions. 1. Study the arrangement and structure of the roots, stems, and leaves of the wheat seedlings and of the mature plants. Make a diagram showing the position and relation of the parts. Compare the wheat seedlings and a full-grown plant to determine what changes have occurred, and what new structures have appeared. Examine the relationship of the grain formed to the husks surrounding it. Explain how the kernel is protected. Determine how the flower is pollinated.

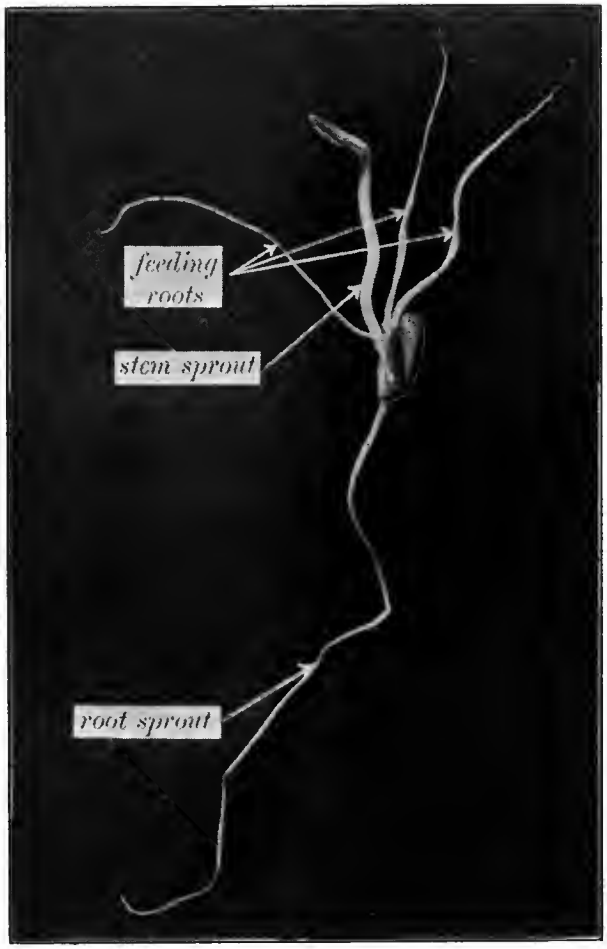


FIG. 50. A young wheat plant showing the beginning of an elaborate system of roots, stalks, leaves, and heads

2. Ascertain, by counting, the average number of plants on a square foot in a near-by wheat field, (1) in the fall, shortly after germination, and (2) in the spring when the plants are starting their growth again. Explain the cause for the difference shown. Count the number of shoots coming from different plants and compute the maximum and minimum number produced by a plant. Note any evidence of winter killing and explain the cause. Is the damage uniform throughout the field? If not, explain why. (3) Visit the wheat field as late in the season as possible before school closes and note the thickness of the stand and the size of the heads on the different shoots of a plant. Compare the size and type of the heads of different plants. Note the difference in the rankness of growth, color of foliage, and thickness of stand between different spots in the field. Explain the reason for any difference that may exist. Give the cause for any lodging that may have occurred. Draw graphs on the opposite page, showing results of your observations.

Questions. How does one wheat seed produce a number of plants? How does the habit of stooling affect the crop of wheat? Why is spring wheat seeded thicker than winter wheat? Why is the former seeded thicker in the late sown than early sown wheat? Are the pollen and ovules of the wheat present in the same flower? How does the wheat plant differ from the corn plant in this respect? Is wheat self fertilized or cross fertilized? Explain the difference between the two.

References. WATERS, H. J. Essentials of Agriculture, pp. 156–158. Ginn and Company. CARLETON, M. A. The Small Grains, pp. 27–32. The Macmillan Company. DONDLINGER, P. T. The Book of Wheat, pp. 11–29. Orange Judd Company.

EXERCISE 41 (*Continued*)

A STUDY OF WHEAT GROWTH

Seed Sown per Square Foot	Number of Plants Produced	Number of Shoots Produced	Number of Heavy Healthy Heads
60			
50			
40			
30			
20			
10			
0			

Number of Lodged Shoots	Number of Diseased and Chaffy Heads	Number of Diseased Plants	Number of Heads Off Type
20			
15			
10			
5			
0			

EXERCISE 42

TYPES OF WHEAT

Statement. There are eight types of wheat: common wheat, club wheat, durum, speltz, emmer, einkorn, polish, and poulard. About 90 per cent of the wheat grown in the United States is of the common type. Common wheat is divided into two principal classes: winter wheat and spring wheat.

FIG. 51. Heads of some of the principal types of wheat

Top row (from left to right): common (karkov), marquis, polish, speltz, emmer (spring); lower row (from left to right): poulard, einkorn, durum, club

Object. To distinguish the types of wheat and to learn the points of merit of each.

Materials. A collection of heads representing all the local types of wheat. These should be collected before fully ripe, but after the grains are formed. They may be fastened in shallow boxes, and when dry may be kept for class use for a long time. Since the school is not in session when wheat is ripening, this collection should be assigned for home work for pupils. Besides the different types, varieties of each type should be obtained.

Directions. Make sketches showing the surface characters of each type of head. In your notes describe the way in which the heads are formed. Remove and study a cluster of kernels (spikelet) from the wheat head, and make a drawing to show how the spikelets are attached to the stem (rachis) and how the kernels are protected. Does the number of kernels vary in different spikelets? Notice how the spikelets are arranged on the rachis. Count the number of kernels in each head; the number of heads produced by a plant.

Find the embryo or germ in a wheat kernel. In proportion to the size of the grain how does it compare with the germ of the corn kernel?

Classify wheat heads which are examined on basis of the spacing of the spikelets on the rachis as (1) close and (2) wide. Classify them on basis of the beards as (1) bearded, (2) slightly bearded, and (3) beardless. Measure the length of each head. Note whether it is slender, medium, or club shaped. Fill out the descriptive blanks given on the opposite page.

Questions. Name the types of wheat. Name two classes of common wheat. How many rows of spikelets on an average wheat head? Which yields the more kernels when planted, a kernel of corn or a kernel of wheat?

References. WATERS, H. J. Essentials of Agriculture, pp. 158–160. Ginn and Company. CARLETON, M. A. The Small Grains, pp. 27–87. The Macmillan Company. HUNT, T. F. The Cereals in America, pp. 47–55. Orange Judd Company. TEN EYCK, A. M. Wheat, p. 21. Campbell Soil Culture Publishing Company. DONDLINGER, P. T. The Book of Wheat, p. 11. Orange Judd Company.

EXERCISE 42 (*Continued*)

TYPES OF WHEAT

Type_____ Variety_____

	Head No. 1	Head No. 2	Head No. 3	Head No. 4	Head No. 5
Vigor (appearance of vitality)					
Number of stalks per plant					
Leafiness of plant					
Number of spikelets per head					
Spacing of the spikelets					
Length of the head					
Number of kernels per head					
Total weight of kernels per plant					
Resistance to disease					
Color of kernels					
Adaptability to locality					

GRADING WHEAT

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6	Sample No. 7	Sample No. 8	Sample No. 9	Sample No. 10
Class										
Grade										
Weight per bushel										
Description										

EXERCISE 43

THE PROPERTIES OF WHEAT WHICH AFFECT ITS VALUE AND USE

Statement. The physical properties of wheat indicate its milling properties, its value as seed, and its freedom from disease. The properties of first interest to the miller are quality and yield of flour, which is indicated by the color, texture, hardness, and gluten content. These properties are also of first interest to the farmer, for in general the value of wheat for milling purposes determines its value for seed.

Object. To study those physical properties of wheat which are factors in determining its food and seed value.

Materials. One-half pint sample of each type of wheat obtainable.

Directions. From the various samples of wheat select kernels showing variations of color, from whitish to deep red. Select kernels with a bright luster and glossy in appearance; also kernels that are dull and bleached. Find kernels that are light colored, translucent, and hard. Such kernels are described as clear amber in color. Compare different varieties of wheat as to color; as to hardness; as to texture.

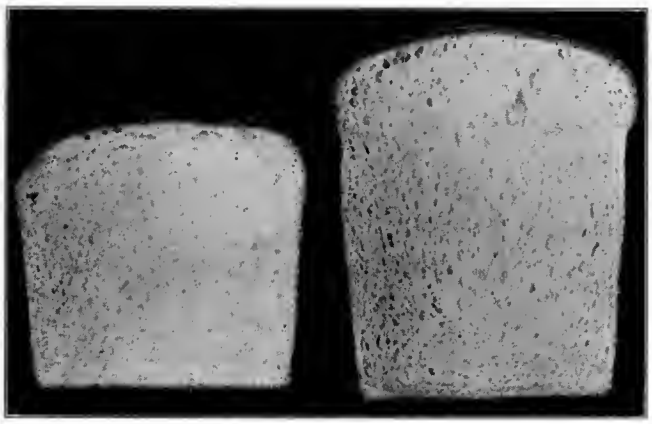


FIG. 52. A comparison of the size of the loaf of bread made from the same quantity of soft and hard wheat

The slice at the left was cut from a loaf made of soft winter wheat; the one at the right from a loaf made from the same quantity of hard wheat

In general the darker wheats have a high gluten content, and are very hard and flinty in texture. These are desirable characteristics in the milling of wheat. The light-yellowish, translucent kernels are also hard and flinty and even more desirable in these respects than the darker wheats. Durum wheat is an example of the clear amber-colored kernels.

The color, hardness, and texture of a wheat are indications of the gluten content. The dark-colored and amber-colored wheats have a flinty texture, contain a high percentage of gluten, and have high milling qualities.

The gluten content of hard and soft wheats may be compared as follows:

Place twenty-five grams of flour from each in a cup and add water sufficient to make a dough of the proper consistency for bread-making purposes. Work each to a uniform dough, cover, and allow to stand one hour. Wash out the starch with running water, using a cheesecloth screen to prevent the loss of bits of gluten during washing. When the gluten is apparently free from starch, work out as much water as possible without the gluten's becoming too sticky to handle, and dry at a moderate temperature, as in a warming oven, but do not burn. Weigh it as dry, crude gluten. Record the results in the blank form.

Repeat the exercise with other types of flour and compare the results.

Questions. For what purpose is flour that is high in gluten used? For what purpose is flour that is low in gluten used? Name the principal hard-wheat regions of the United States; the principal soft-wheat regions.

References. WATERS, H. J. Essentials of Agriculture, pp. 158–163. Ginn and Company. HUNT, T. F. The Cereals in America, pp. 59–60. Orange Judd Company. DONDLINGER, P. T. The Book of Wheat, pp. 10, 48–49. Orange Judd Company. LYON and MONTGOMERY. Examining and Grading Grains, pp. 9–14. Ginn and Company.

EXERCISE 43 (*Continued*)

CLASSIFICATION OF WHEAT KERNELS

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5
Hardness					
1. Soft					
2. Medium					
3. Hard					
4. Very hard					
Texture (cross section)					
1. Starchy					
2. Dull (denoting mealy texture)					
3. Transparent (denoting hard texture)					
a. Flinty					
b. Vitreous					
Color					
1. Whitish					
2. Yellowish					
3. Deep red					
4. Clear amber					

GLUTEN IN WHEAT

Type of Wheat	Amount	Weight after Drying	Dry Crude Gluten	Per Cent of Dry Gluten

EXERCISE 44

JUDGING WHEAT

Statement. The value of wheat varies with its quality and the purpose for which it is to be used. Those conditions which determine quality are considered in detail in judging and grading wheat.

Object. To take up systematically the points influencing the commercial grades of wheat and to score samples on these points.

Materials. A number of peck samples of wheat and a grain tester.

Directions. As a preliminary step toward the commercial grading of wheat and assigning a market value to it, the student should learn to recognize quickly and accurately the defects and impurities of the grain. He must also acquire skill in determining the test weight per bushel of wheat. Examine each sample and record the scores on the next page. In judging the factors enumerated in the score card observe the following points:

Weight per bushel (25). Grain is now purchased by weight rather than by volume as formerly, and from 59 to 61 pounds, depending upon the type of wheat, constitutes a bushel, regardless of the volume required. While the miller buys wheat by weight he knows that the heavy, plump grains yield a higher percentage of flour of better quality, and, therefore, are the most valuable.

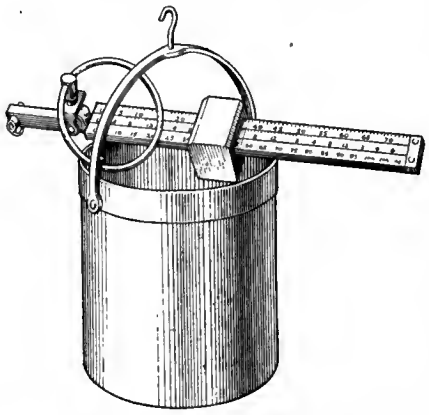


FIG. 53. Apparatus for making test weight of wheat

In addition to the scale and vessel a wooden straightedge for striking the vessel is required. To avoid error in making the test a funnel device is used for filling the vessel in such a manner that the grain flows into it at a uniform rate and from a constant height

Soundness (25). Soundness is very valuable, for the flour-making value of wheat is largely dependent upon the soundness of the kernels. Smutted kernels may be detected by the grayish color, the ease with which they are crushed, the black powdery internal composition, and by the foul odor. Moldy kernels produce an irritating, unpleasant odor, and the kernels affected are readily visible. Sprouted kernels have a peculiar puffed appearance and a tiny sprout projects from the kernel. Bin-burned kernels become grayish and dull and later they are usually badly molded. Stack-burned kernels become dark, especially at the germ. Insect injury may either completely destroy the inside of the kernel or merely the germ.

Purity (10). Wheat should be true to type, free from other grains, weeds, or trash. Each type of wheat mills a little differently from another and requires a different adjustment of the machinery. A mixture of types that is not uniform cannot be milled to the best advantage.

Plumpness and size of kernels (15). Plumpness indicates that the wheat will test well. It is desirable that the grains should be of uniform size to mill to the best advantage.

Hardness and texture (15). Hardness of wheat bears close relationship to gluten content, and this, in turn, influences the value of the flour. Texture determines the milling qualities of wheat, especially the percentage of flour which can be obtained.

Color (10). Color is an indication of the hardness and texture and also indicates whether or not it is bleached or stack- or bin-burned.

Questions. What causes stack burning? What causes bin burning? How may wheat be treated to prevent smut? Is smut present in the wheat of your community? Collect samples of wheat heads afflicted with smut just before they are ripe. Describe them. Does there seem to be more than one kind of smut? Distinguish between them. Name the factors that influence the yield of wheat.

References. WATERS, H. J. Essentials of Agriculture, p. 156. Ginn and Company. Standards for Grading Grain. United States Department of Agriculture. Office of Markets and Rural Organization. DONDLINGER, P. T. The Book of Wheat, pp. 36–37. Orange Judd Company.

EXERCISE 44 (*Continued*)

SCORE CARD FOR WHEAT

	Possible Score	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5
Weight per bushel . . . . . Wheat to grade No. 1 should weigh as follows: hard red spring wheat, 58 pounds; Durum and hard red winter wheat, 60 pounds; soft red winter and white wheats, 60 pounds per bushel. A measured bushel contains 2150.42 cu. in., and wheat varies from less than 50 pounds to more than 65 pounds per measured bushel. Cut the sample two points per pound deficient in weight.	25					
Soundness Smutty kernels . . . . . 5 Moldy kernels . . . . . 5 Sprouted kernels . . . . . 5 Bin- or stack-burned . . . . . 8 Insect injury . . . . . 2 Total . . . . . 25 Cut the sample two points for each per cent of smutted, moldy, and sprouted kernels. Cut the sample two points for each per cent of bin- or stack-burned kernels and one point for each per cent of insect-damaged kernels.						
Purity . . . . . Cut the sample 1 per cent for each per cent of foreign matter, or kernels decidedly off type.	10					
Plumpness and size of kernels . . . . . Cut the sample one point for each 2 per cent of shriveled and undersized grains.	15					
Hardness and texture . . . . . Cut the sample one point for each per cent of soft or starchy grains.	15					
Color . . . . . Cut the sample one point for each 3 per cent of kernels not uniform in color.	10					

EXERCISE 45

THE COMMERCIAL GRADING OF WHEAT

Statement. The most important factors in determining the commercial grades of wheat are class, soundness, purity, moisture, content, dockage, and test weight. In grading wheat, official standards have been prepared by the United States Department of Agriculture, under which wheat of any class may be classified and graded.[1]

Object. To study the factors which affect the quality of wheat.

Materials. Samples of wheat from at least ten different homes or that number of samples from a local mill or elevator.

Directions. Grade the samples obtained, and in the following blank form record the grades. In grading wheat the region in which it is grown largely indicates the class to which it belongs. Most of the wheat grown east of the Mississippi River is classed as "Red Winter"; in eastern Kansas, Missouri, and in the south, it is Red Winter; Kansas and Nebraska produce Hard Red Winter, and Minnesota and the Dakotas, Hard Red Spring wheat; Durum wheat is grown chiefly in western North and South Dakota and Minnesota. Wheat of the Pacific coast states is Pacific Coast White or Pacific Coast Red, according to color.

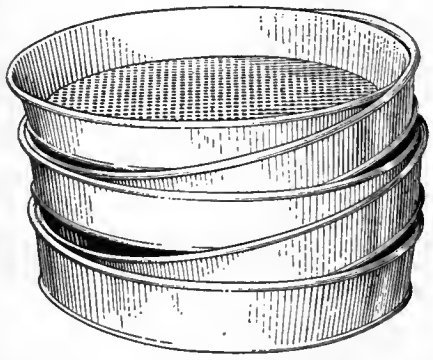


FIG. 54. Sieves for determining dockage of wheat

If there is a flour mill or a grain elevator in the town, invite the grain buyer to give one or two illustrated lessons to the students, on grading wheat, oats, corn, etc., and then secure the privilege of taking the class to the mill or elevator and using the equipment and material in one or more laboratory exercises. Perform these exercises at the mill or elevator and have the students do the grading under the supervision of the teacher and the manager.

In testing the sample of wheat first determine the dockage. All other determinations are based on grain free from dockage. The materials removed from dockage include sand, dirt, weed seeds, stems, straw, chaff, grains other than wheat, shriveled or undeveloped wheat, wheat grains, small pieces of wheat kernels, and any other material which may be readily removed from wheat by means of the sieves shown in Fig. 54.

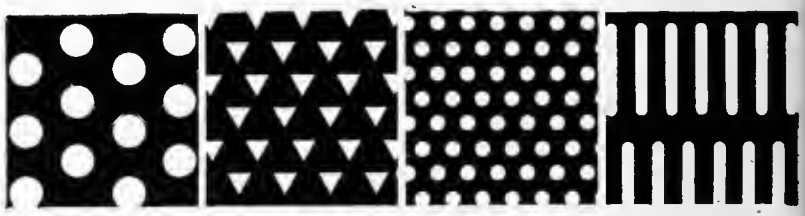


FIG. 55. Showing the perforations of the wheat dockage sieves

The one on the left is the scalper sieve, with circular perforations $\frac{3}{16}$ inch in diameter; next is the buckwheat sieve, with triangular perforations $\frac{1}{8}$ of an inch; the next is the fine-seed sieve, with perforations $\frac{1}{12}$ of an inch in diameter; and the one on the right is the chess sieve, with slot perforations $\frac{1}{16} \times \frac{1}{2}$ inch. (Courtesy of the United States Department of Agriculture)

Commercial wheats are divided first into classes, of which there are five: (1) Hard Red Spring, with three subclasses: Dark Northern, Northern Spring, and Red Spring; (2) Durum, divided into three subclasses: Amber Durum, Durum, and Red Durum; (3) Hard Red Winter, divided into three subclasses: Dark Hard Winter, Hard Winter, and Yellow Hard Winter; (4) Soft Red Winter, divided into two subclasses: Red Winter and Red Walla; (5) Common White, divided into two subclasses: Hard White and Soft White.

The classes and subclasses are again divided into grades, of which there are six, designated as 1-, 2-, 3-, 4-, 5-, and 6-sample respectively. The specifications for the numerical grades are given in the table on the opposite page. Sample grade comprises all wheats which do not fall into one of the numbered grades of the class by reason of unsoundness, excessive moisture, garlicky odor, etc. Such wheats are sold by sample instead of by grade.

[1] For complete regulations in reference to grading commercial grains write the Bureau of Markets, United States Department of Agriculture, Washington, D. C.

EXERCISE 45 (*Continued*)

Questions. In what class does the wheat of your locality belong? What is the legal weight of wheat per bushel? Does the weight per bushel of wheat have anything to do with the price when it is sold to the miller? How does weight per bushel indicate quality? How does the miller determine the exact weight per bushel? When a farmer says that his wheat tests sixty pounds, what does he mean?

References. WATERS, H. J. Essentials of Agriculture, p. 156. Ginn and Company. LYON and MONTGOMERY. Examining and Grading Grains, pp. 17–21. Ginn and Company. DONDLINGER, P. T. The Book of Wheat, pp. 223–224. Orange Judd Company.

FEDERAL WHEAT GRADES

Grade Number	Minimum Weight per Bushel in Pounds			Maximum Limits of —						
				Percentage of moisture		Percentage of damaged kernels		Percentage of foreign material other than dockage		Percentage of wheats of other classes
	Class Hard Red Spring	Classes Durum, Hard Red Winter, Common White, and White Club; and subclass Red Winter	Subclass Red Walla	Classes Hard Red Spring and Durum	Classes Hard Red Winter, Soft Red Winter, Common White, and White Club	Total	Heat damage	Total	Matter other than cereal grains	Total
1[1]	58	60	58	14.0	13.5	2	0.1	1	0.5	5
2	57	58	56	14.5	14.0	4	0.2	2	1.0	10
3	55	56	54	15.0	14.5	7	0.5	3	2.0	10
4	53	54	52	16.0	15.5	10	1.0	5	3.0	10
5	50	51	49	16.0	15.5	15	3.0	7	5.0	10

RECORD OF STUDENT'S GRADE

Sample Number	Class	Test Moisture (Weight per Bushel)	Wheat of Other Classes	Damaged Kernels		Inseparable Foreign Materials		Grade
				Total	Heat damaged	Total	Kinghead, corn, cockle, vetch darnel, wild rose, either singly or combined	

[1] The wheat in grade No. 1 shall be bright; the wheat in grades Nos. 1 to 4, inclusive, shall be cool and sweet; the wheat in grade No. 5 shall be cool, but may be musty or slightly sour.

EXERCISE 46

THE COMMERCIAL GRADING OF OATS

Statement. In grading oats the matter may be considered from the standpoint of the miller, the feeder, or the person who will sow the seed. In the score card on the opposite page emphasis is placed on those points which most affect the feeding value of the grain.

FIG. 56. A typical head of white spring oats (Swedish select)

Object. To examine oats with reference to their commercial value.

Materials. A number of peck samples of oats and a grain tester. (See Fig. 54.)

Directions. Score samples in accordance with the following score card and record all scores. Observe the following points under each heading:

Weight per bushel (35). A good sample weighing 32 pounds or more indicates that the grain is mature, well filled, and does not contain a high percentage of hulls.

Soundness (20). Factors principally affecting soundness are mold, smut, and sprouted kernels.

Color (15). The color of the grain should be bright and uniform.

Purity (10). The sample should be free from other grains, weed seed, chaff, and any other foreign matter.

Per cent of hull (20). Good oats may test as high as 30 per cent of hull.

The commercial grade of oats is determined by the foregoing factors, although various states have rules established by grain-inspection departments for determining the grades. Nearly all grading and inspection of oats is in accordance with the rules adopted by the Grain Dealers' National Association. The rules below are those adopted by this association for the grading of white oats:

No. 1 White Oats shall be white, dry, sweet, sound, bright, clean, free from other grain, and weigh not less than 32 pounds to the measured bushel.

No. 2 White Oats shall be 95 per cent white, dry, sweet; shall contain no more than 1 per cent of dirt and 1 per cent of other grain, and weigh not less than 29 pounds to the measured bushel.

Standard White Oats shall be 92 per cent white, dry, sweet; shall not contain more than 2 per cent of dirt and 2 per cent of other grain, and weigh not less than 28 pounds to the measured bushel.

No. 3 White Oats shall be sweet, 90 per cent white; shall not contain more than 3 per cent of dirt and 5 per cent of other grain, and weigh not less than 24 pounds to the measured bushel.

No. 4 White Oats shall be 90 per cent white; may be damp, damaged, musty, or very dirty.

Questions. If oats were being purchased for feed, which would be the more objectionable factor under purity, the presence of chaff or the presence of other grains than oats? Which would be the more objectionable if the oats were being used for seed?

References. WATERS, H. J. Essentials of Agriculture, pp. 169–170. Ginn and Company. HUNT, T. F. The Cereals in America, p. 313. Orange Judd Company. LYON and MONTGOMERY. Examining and Grading Grains, pp. 51–66. Ginn and Company.

EXERCISE 46 (*Continued*)

SCORE CARD FOR OATS

	Possible Score	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5
Weight per bushel . . . . . The legal weight of oats per bushel is 32 pounds. Cut the sample four points for each pound deficient.	35					
Soundness						
Moldy 10						
Smutted 5						
Sprouted 5						
Total	20					
The sample should be bright, dry, and free from damaged grains. Cut the sample one point for each per cent affected.						
Color . . . . . Cut the sample one point for each 4 per cent off color.	15					
Purity . . . . . Cut one point for each per cent of mixture, and one point for each per cent of foreign matter.	10					
Per cent of hulls . . . . . Cut the sample two points for each per cent above 30, and for each point below add one point to the score.	20					
Total	100					

EXERCISE 47

THE COMMERCIAL GRADING AND SCORING OF BARLEY

Statement. In scoring barley the points considered are those affecting the commercial grade, as approximately one half of the barley produced is sold on the market.

Object. To study the factors influencing the grade and quality of barley and to become familiar with the different grades.

Materials. Peck samples of barley to be scored and a grain tester.

Directions. Score samples and place results on the following page. Note the instructions given below.

Trueness to type (5). Take 100 kernels, constituting a fair sample of the grain. Divide the kernels not true to type into three grades. In the grade badly off type cut one-tenth point for each kernel; in the next grade cut one-tenth point for each 2 kernels, and in the best grade cut one-tenth point for every 3 kernels.

FIG. 57. Type heads of barley

From left to right: two-row; common six-row; common six-row (*Parallelum*); true six-row (*Pyramidatum*). Courtesy of the Wisconsin Experiment Station

Kernel uniformity in size and shape (5). The kernels should be uniform in size and shape. Classify and cut samples as in "Trueness to type."

Color of grain (15). Six-rowed barley should be yellowish white; two-rowed barley nearly dead white in color. Classify closely and cut sample as under "Trueness to type."

Size of kernels (10). All kernels should be large and plump. Classify into three groups: large, medium, and small and shriveled. Cut the sample as under "Trueness to type."

Texture (10). Barley should be mealy to somewhat vitreous in texture. Take 10 representative kernels and cut each crosswise. Cut one-tenth point for each kernel vitreous throughout in its texture.

Purity (30). Factors chiefly affecting purity are other grains, foreign material, damaged, smutted, and moldy kernels. For each foreign grain cut the sample one-fifth point. Use 100 grains in examining for purity. Also cut the sample one-fifth point for each per cent of foul material and one-fifth point for each per cent of damaged, smutted, moldy, or bin-burned kernels. Cut the sample from one to ten points for bad odor.

Weight per bushel (15). The standard weight per measured bushel is 48 pounds in most states. Cut one point for each pound below the legal weight per measured bushel in your state.

Viability (10). Barley should have a germination test of 100 per cent. Cut one-half point for each per cent deficient in germination.

The commercial grading of barley is influenced by the above factors, but the grain-inspection departments of the various states provide rules governing the inspection and grading. For example, the following rules govern the inspection of barley in many states.

No. 1 Barley shall be sound, bright, sweet, clean, and free from other grain.
No. 2 Barley shall be sound, dry, and of good color.
No. 3 Barley shall include shrunken, stained, dry barley unfit for No. 2 grade.
No. 4 Barley shall include tough, musty, dirty barley.

EXERCISE 47 (*Continued*)

Questions. In what climate does barley thrive to the best advantage? Where in the United States is barley most generally grown? What country produces the largest share of the world's crop of barley? What are the principal uses to which barley is put?

References. LYON and MONTGOMERY. Examining and Grading Grains, pp 68–82. Ginn and Company. DAVIS, K. C. Productive Plant Husbandry, pp. 212–215. J. B. Lippincott Company.

SCORE CARD FOR BARLEY

	Possible Score	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5
Trueness to type	5					
Kernel uniformity in size and shape	5					
Color of grain	15					
Size of kernel	10					
Texture	10					
Purity						
Other grains	10					
Foreign material	10					
Damaged and diseased kernels	10					
Total	30					
Weight per bushel	15					
Viability	10					
Total	100					

EXERCISE 48

A STUDY OF THE SORGHUM PLANT

Statement. The yield of kafir, milo, feterita, or other grain sorghum will depend greatly on the variety chosen. Some varieties require as much as one hundred and thirty-five days to mature, while others will mature in less than one hundred days. Some varieties are adapted to poor soil, others to rich soil; some to high altitudes, others to low altitudes.

Object. To study the characteristics of the varieties of grain sorghums.

Materials. A mixed lot of sorghum seed containing black-hull kafir, pink kafir, yellow milo, white milo, feterita, Freed sorghum, kaoliang, Jerusalem corn, brown durra, shallu, and varieties of sweet sorghum; the heads and stalks of the different varieties to be studied; description of the varieties as contained in the publications named in the references.

Directions. 1. From a mixed lot of sorghum seed pick out twenty-five grains of each kind of grain sorghum. Place each kind on a separate piece of paper. Compare each kind of seed with seeds of a known variety and thus identify each lot. Compare each kind of seed with the heads of the different varieties and with the printed descriptions. Identify each lot and submit the results to the instructor for verification.

2. Fill in the form on the opposite page, giving the color, relative size and shape of seed, length and shape of heads, and, if growing in the field, height of stalk, number of leaves per stalk, relative juiciness and sweetness of the stems, and the date of ripening.

3. Write a statement of the principal uses to which two selected types of sorghums studied are put, how they are grown, and the kind of season and soil which is best suited to them.

Questions. What are the leading varieties of sorghums in your community? Which is the more drought-resistant, corn or sorghum? Can you explain why? Describe the climate to which the sorghums are best adapted. How are sorghums planted? How cultivated? How harvested? How utilized?

References. WATERS, H. J. Essentials of Agriculture, pp. 223–230. BORMAN, T. A. Sorghums, The Kansas Farmer Company, Topeka. BAILEY, L. H. Cyclopedia of American Agriculture, Vol. II, p. 384. The Macmillan Company. *Bulletin 218* (1918), Kansas Agricultural Experiment Station.

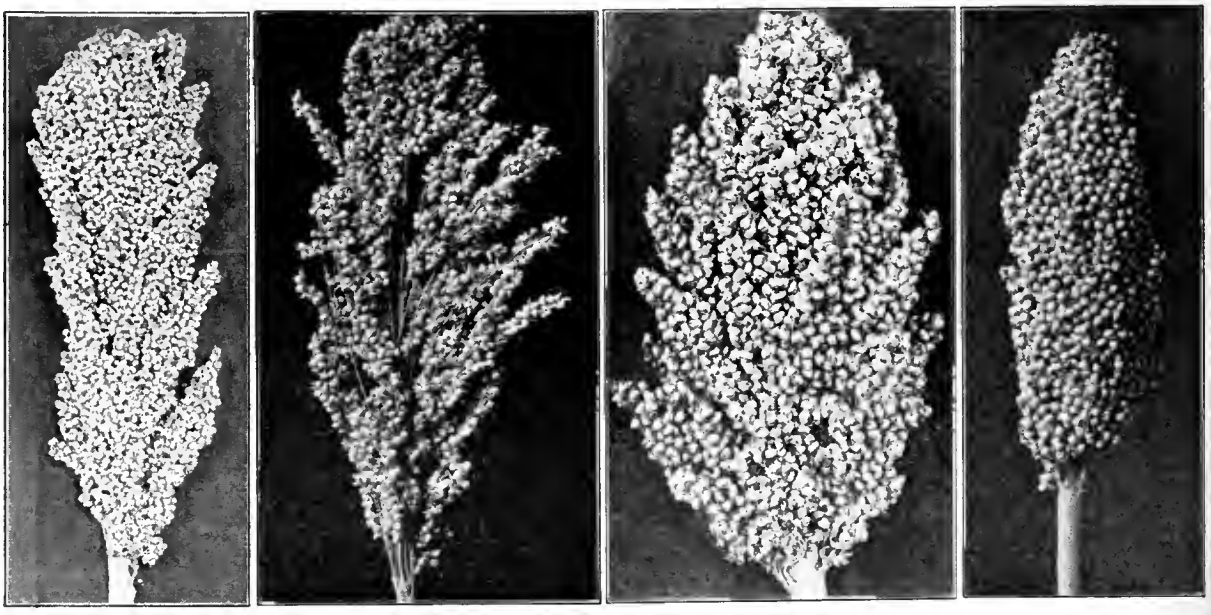


FIG. 58. Types of sorghum heads

From left to right: kafir; sweet sorghum; milo maize; feterita. (Courtesy of the Kansas State Agricultural College)

EXERCISE 48 (*Continued*)

VARIETIES OF SORGHUMS

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6
Color of seed						
Size of seed (small — medium — large)						
Shape of seed						
Length of head						
Shape of head						
Average height of the stalk						
Average number of leaves per stalk						
Juiciness and sweetness of stems						
Average date of ripening						
Variety						

EXERCISE 49

JUDGING GRAIN SORGHUMS

Statement. Sorghums are similar to corn in many respects, each producing an abundance of both grain and forage. Sorghums are especially valuable in their ability to withstand severe droughts, thus being enabled to grow in the semiarid regions of the United States. A knowledge of what constitutes a good head of sorghum for seed is important and is the first step in successful sorghum production.

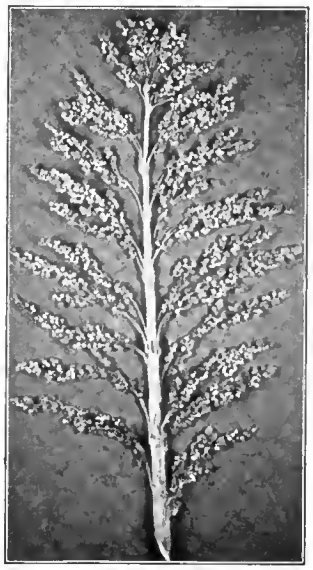


FIG. 59 Sectional view of a high-yielding Kafir head with long main stem and large seed-bearing capacity

FIG. 60. Sectional view of the interior of a low-yielding Kafir head with short main stem and light-yielding seed-bearing stems

Object. To judge standard varieties of grain sorghums.

Materials. Samples to be scored and descriptive sheet on the following page.

Directions. 1. Arrange an exhibit of ten heads. Score one head at a time while learning to use the score card. Beginning with head No. 1, estimate the score that should be given for each point. When judging single heads, the score for uniformity will be based on the degree to which the head conforms to the most common type in the exhibit and the type of the variety it represents. Repeat the estimate for each of the ten heads and find the average score for them. Compactness of the head is an important consideration. To determine this quality cut away the branches on two sides of the head as shown in the illustrations and note carefully the length of the main stem and the seed-bearing stems, and how thickly and uniformly the seeds are set on.

FIG. 61. The interior of a dwarf Milo head of desirable form

2. After scoring single heads each member of the class should arrange a ten-head exhibit. Then the entire display should be judged by each pupil, using the ten-head exhibit as a unit. Total the values and rank the exhibits.

Questions. What are sorghums that have an abundance of sweet juice called? Name some varieties of sorghum that do not contain sweet juice. In your community is sorghum grown for sirup, for grain, for forage, or for the brush? Why are sorghums grown in preference to corn in parts of the semiarid regions of the Great Plains area? What is the average yield of grain of the varieties of sorghums produced in your community?

FIG. 62. Interior of a good head of Feterita

All photographs on this page from "Sorghums: Sure-money Crop," *Kansas Farmer*, Topeka

References. WATERS, H. J. Essentials of Agriculture, pp. 223–228. Ginn and Company. BORMAN, T. A. Sorghums. The Kansas Farmer Company, Topeka. MONTGOMERY, E. G. The Corn Crops, pp. 279–328. The Macmillan Company. LIVINGSTON, G. Field Crop Production, pp. 228–239. The Macmillan Company.

EXERCISE 49 (*Continued*)

DESCRIPTION SHEET FOR THE STUDY OF SORGHUMS[1]

Common name .....

Names sometimes used .....

1. **Stalk:**
   Tall, medium short, dwarf.
   Thick, medium, thin.
   Peduncles: erect, inclined, recurved.
   Internodes: long, medium, short.
   Stooling: abundant, not abundant.
   Pith: soft, fibrous.
   Juice: abundant, not abundant, sweet, slightly sweet.
2. **Leaf:**
   Number per stalk.....
   Wide, medium, narrow.
   Thick, thin, long, short.
   Sheath: overlapping — little, much.
3. **Head:**
   General color: black, dark red, light red, brown, yellow, green, white.
   Length in inches.....
   Width in inches.....
   Length equals.....times width.
   Very open, open, compact, very compact.
   Flattened, equally developed on all sides, cylindrical.
   Spherical, ovoid, obovoid, umbelliform.
   Rachis: erect, drooping.....as long as panicle.
   Branches: short, long, very long, erect, tips drooping, drooping, strongly drooping.
4. **Spikelet:**
   Elliptic, oval, obovate, broadly obovate.
5. **Glumes:**
   Color: black, straw, gray, greenish.
   Spreading, not spreading.
   Short, long, large, open, covering seed.
   Wrinkled.
   Pubescent, slightly pubescent.
6. **Seed:**
   Brown, red, white, ivory white, white with spots, yellow, reddish yellow.
   Conical, spherical, cylindrical, round, flattened, much flattened.
7. **Lemma:** awned; awnless.
8. **Characters for identification.**

[1] From Kansas State Agricultural College.

EXERCISE 50

A STUDY OF LEGUMES

Statement. Wherever legumes thrive, and wherever many members of this great plant family grow wild, the farmers are almost certain to be prosperous. Wherever legumes do not thrive farming is likely to be conducted under great difficulties and is generally unprofitable.

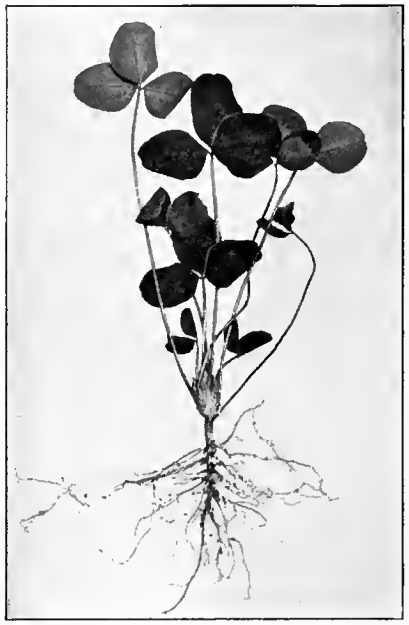


FIG. 63. A typical young red clover plant

Courtesy of the Bureau of Plant Industry, United States Department of Agriculture

Object. To study the legumes adapted to the community and the uses to which they are put.

Materials. Collecting case; spade; access to the farms of the neighborhood.

Directions. 1. Early in the fall or late in the spring take the class to the country and study the growth habits of both wild and cultivated forms of legumes present. Have the students make a collection of representative plants of each for detailed study in the laboratory. Make careful note of the types of soil upon which each is found growing most abundantly and also the types upon which each thrives least well. Make note of the place of the legume in the crop rotation and explain the reason for the rotations followed by the farmers.

2. In the laboratory make a detailed study of the more important types of legumes collected, compare their leaves, stems, seed pods, seeds, roots, and root tubercles.

3. Make a list of all the legumes, domestic and wild, found growing in the neighborhood, together with a statement of the value of such as have economic importance. Name the more important cultivated legumes of the United States and state the principal uses to which each is put.

4. Explain in detail how you would proceed to secure a stand of red clover and alfalfa, and how you would manage each to secure the best results.

FIG. 64. A typical young alfalfa plant

Courtesy of the Bureau of Plant Industry, United States Department of Agriculture

Questions. What do you consider the two greatest values of legumes? Give reason for each answer. What legume is of most importance in the local community and why? What other legumes than those grown locally should be introduced? At what place in the rotation does the legume usually come? What crop usually precedes the legume in the local farm practice? At what stage of development would you cut red clover for hay? At what stage would you harvest alfalfa for the largest yield?

References. WATERS, H. J. Essentials of Agriculture, pp. 78–79, 204–206. Ginn and Company. BURKETT, C. W. Soils, pp. 143–152. Orange Judd Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 210–214. Ginn and Company.

EXERCISE 51

INOCULATION OF SOILS FOR LEGUMES

Statement. Attached to the roots of growing legumes are many nodules, or tubercles, which were caused by bacteria. These bacteria penetrate the roots of the plant and draw part of their sustenance from the legumes and part from the air. They have the power to use free, or pure, nitrogen from the air and change its form so that the legume can use it. The legume in turn absorbs the substance of the nodules and is nourished thereby. In this indirect way legumes are able to use free nitrogen.

FIG. 65. Taking soil from an alfalfa field with which to inoculate soil upon which alfalfa has not been grown successfully

Object. To ascertain whether the presence of bacteria is necessary for the best growth of legumes.

Materials. Roots of as many legumes as can be obtained; soils from an alfalfa or red or sweet clover field where bacteria are present; alfalfa seed; clean fine sand; a one-gallon or two-gallon pail; flowerpots or tin cans; formalin; distilled rain water.

Directions. Fill the two flowerpots or tin cans with clean fine sand. Heat the sand for half an hour at a temperature which will destroy all life. Place 10 cubic centimeters of formalin in 50 cubic centimeters of distilled water and place alfalfa or red clover seeds in the solution for five minutes. Remove and wash with distilled water and plant the seeds in the two pots of soil previously heated.

Water one pot with distilled water and the other with water prepared by filtering distilled or rain water through a pail half full of soil from an alfalfa or clover field containing plants upon which root tubercles have developed. Stir the soil and water thoroughly and after the soil has settled pour off the clear water and use it. Use fresh soil each time that water is to be prepared. Let the plants grow until a difference is apparent in their growth. Remove the plants and examine their root systems.

Questions. What do bacteria supply to the plants? From whence is it obtained? Suppose the clover crop is removed from the field and only the roots left, has much fertility been added to the soil? Do you think that clovers in the rotation will solve the soil-fertility problem if the crops are largely removed and only the roots and stubble are returned?

References. WATERS, H. J. Essentials of Agriculture, pp. 78–79, 205–206. Ginn and Company. BURKETT, C. W. Soils, pp. 143–152. Orange Judd Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 210–214. Ginn and Company.

FIG. 66. Tubercles or nodules on the roots of the cowpea

EXERCISE 52

A STUDY OF THE POTATO

Statement. Some plants store most of their food in the seed, as in the case of wheat or corn; others in the stem, as the sugar cane; others in the leaf, as the cabbage; others in the roots, as the sugar beet or the sweet potato; others in enlarged underground stems called tubers, as in the Irish potato.

FIG. 67. Desirable and undesirable types of tubers

Note the sunken eyes, peaked ends, and irregular forms of the lower line of tubers in contrast with the regular outline and smooth surface of those in the upper row. (Courtesy of the Pennsylvania State College)

Object. To study the growth and habits of the potato and to learn how to select and care for seed potatoes.

Materials. A supply of potato tubers; a box or pot of potatoes growing from cuttings planted four weeks previously; some potatoes which have been allowed to sprout in a damp, partially lighted cellar or the school basement.

Directions. 1. Make a study of buds (eyes) and determine if there is a scale or leaf-like structure at the sides of the buds; note its position; note whether the buds are arranged in any regular order; whether they are equally abundant at both ends of the potato. Make a cross section of the potato and observe the smaller cells which represent the woody stem tissues. Note the arrangement of the starch grains in the tubers. Examine the sprouts and the planted potato cuttings; determine, and make sketches showing, how new potato plants grow from old ones, and where the young plant obtains its sustenance.

2. Keep one lot of half a dozen tubers in a warm cellar so that by planting time they have produced long sprouts and keep another lot of similar tubers in a cool cellar so they will remain dormant. Expose the dormant tubers to the light until short sprouts appear. Plant the lots alongside of each other and note which produces the earliest plants, the most vigorous growth, and the largest yield.

3. Make a collection of the varieties of potatoes commonly grown in the community and grade them according to the commercial grades. Have students judge them according to the following score card.

FIG. 68. Potatoes at the time of planting

The proper condition of the tubers at the time of planting is shown by the specimens on the plate at the right; the vitality of the tubers on the plate at the left has been lowered by the growth of the sprouts. (Courtesy of the Pennsylvania State College)

Questions. Are the tubers used for planting in your locality home-grown? If not, where do they come from and why are they the best to plant? Do the farmers use certified potato seed and why? Where does the potato come in the local crop rotation and why? What fertilizers are best for potatoes in your locality and what amount should be applied per acre?

References. Potato Culture, *Extension circular 45*, Pennsylvania State College, State College, Pennsylvania. Commercial Handling, Grading, and Marketing of Potatoes, *Farmers' Bulletin, 753*, United States Department of Agriculture.

EXERCISE 52 (*Continued*)

SCORE CARD FOR POTATOES

	Perfect Score	Students' Score							
Uniformity of exhibit	20								
Conformity of type	10								
Shape of tubers	15								
Size of tubers	15								
Eyes	5								
Skin	5								
Texture of meat	10								
Soundness	10								
Freedom from blemishes	10								
Total	100								

EXERCISE 53

IMPURITY OF FARM SEEDS

Statement. The value of a seed depends first upon its vitality. If it will not grow well, then all other considerations are of no value. Next comes the quality of the seed. Pure-bred and pedigreed seeds are always to be preferred, but we have not begun to pedigree clovers and grasses generally. However, something of quality may be judged by the size, brightness, and uniformity of the seeds. The amount of impurities affects their value in two ways. Cracked and broken seeds, trash, and chaff add to the bulk and cause the farmer to pay more for the seed he actually obtains. Much more harmful, however, are the weed seeds acquired with impure seed, because they add to the cost of the seed purchased and cause much damage to the cultivated crops, or else entail expense in keeping the weeds in check.

Object. To determine the comparative value of seed samples.

Materials. Commercial seeds of red and alsike clover, alfalfa, timothy, etc.

Directions. Determine by actual calculation from the samples the relative amounts of dirt in the seed, the amount of weed seed, and the amount of seed of the kind supposed to have been bought. Then count out 100 grains of seed from the weediest sample and 100 grains from the purest sample of the same kind of seed and plant both lots to determine whether more or less of the weedy seed than of the pure seed is *growing* seed.

Questions. Can you determine what kinds of weed seeds are present in the above samples? What are the objections against buying and using seed which contains weed seed? Which sample contains dirt? What is the actual cost per bushel of pure seed obtained from the poor seed purchased because of its low price?

References. HILLMAN, T. H. "Testing Farm Seeds in the Home and the Rural Schools," *Farmers' Bulletin 428*, United States Department of Agriculture. DAVIS, K. C. Productive Plant Husbandry, pp. 50–53. J. B. Lippincott Company.

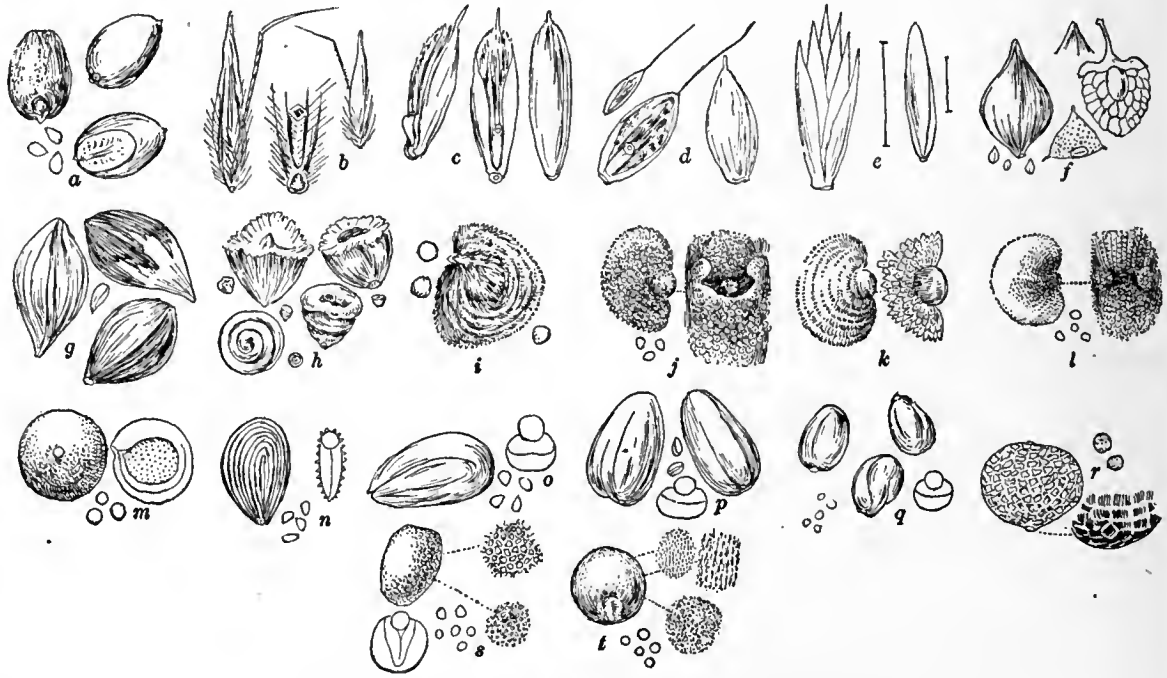


FIG. 69. Some noxious weed seeds found in farm seeds

a, sand burr; *b*, wild oat; *c*, chess; *d*, darnel; *e*, quack grass; *f*, dock; *g*, black bindweed; *h*, Russian thistle; *i*, corn cockle; *j*, white campion; *k*, bladder campion; *l*, night-flowering catchfly; *m*, cow cockle; *n*, pennycress; *o*, field peppergrass; *p*, large-fruited false flax; *q*, small-fruited false flax; *r*, ball mustard; *s*, black mustard; *t*, English charlock. Enlarged and natural size

EXERCISE 53 (*Continued*)

IMPURITY OF SEEDS

	Sample No.1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6	Sample No. 7	Sample No. 8	Sample No. 9	Sample No. 10
Total number of seeds in sample										
Per cent of dirt .										
Per cent of damaged seeds . .										
Per cent of weed seeds										
Per cent of good seed										
Per cent of vitality										

EXERCISE 54

A STUDY OF THE COTTON PLANT

Statement. Cotton is the world's most important fiber crop. The cotton belt of the United States produces more than two thirds of the world's supply of this staple.

FIG. 70. Flower of upland cotton, showing sepals, petals, and stigma
(Courtesy of Bureau of Plant Industry, United States Department of Agriculture)

Object. To learn something of the conditions of growth, form, structure, and characteristics of the cotton plant.

Directions. Carefully remove the soil from the base of a growing plant containing squares, flowers, green bolls, and open bolls. Note the number, depth, and size of the roots. What is the function of the tap root? Of the fibrous roots? What would be the effect of deep, close cultivation at this time? Note the size, height, and color of the central stem. Describe its structure. Study carefully the branches and distinguish between the fruiting and vegetative branches. Of what use are the vegetative branches? At what place on the main stem are the longest branches produced? The shortest? How are the leaves arranged on the stem? Are there differences in the shape, size, and arrangement of the leaves on the fruiting branches and the vegetative branches? Describe the cotton flower according to the following outline: (1) calyx—size, shape; (2) corolla—color, size, shape; (3) petals — number, separated or united; (4) stamens — number, position; (5) pistils — number, position. Make drawings as follows: (1) front view of bud showing bracts and calyx; (2) ventral view of flower with bracts removed showing arrangement of calyx, calyx lobes, and petals; (3) draw a cross section of a half-grown boll showing each part; (4) make a collection of open bolls and classify them according to their size, shape, number and size of seed, amount and length of fiber, and proportion of fiber to seed; (5) make a collection of the plants and open bolls of the principal varieties of cotton growing in the community and compare them for earliness, productiveness of lint and seed, and for length of fiber. Write a description of each, laying emphasis on the advantages and disadvantages of each variety, and kind of soil to which each is best adapted.

FIG. 71. Stamens and stigma of Egyptian cotton
(Courtesy of the Bureau of Plant Industry, United States Department of Agriculture)

FIG. 72. A cluster of bolls from a prolific plant in different stages of development
(Courtesy of Ed. Kosch, San Marcos, Texas)

Questions. Which are the principal cotton-producing states of the Union? What is the highest yield of cotton per acre in the locality and what is the average yield? What is the lowest yield? What

makes the difference in the yield? What insects are most injurious to cotton and what are the most feasible ways of combating them? State in writing how the injuries of the cotton boll weevil may be prevented and indicate which of the ways suggested is more generally used in the neighborhood. Has the presence of this insect changed to any degree the cropping systems of the south? Have these changes been advantageous and in what way and why? State in detail how the yield of cotton in the neighborhood may be increased.

References. WATERS, H. J. Essentials of Agriculture, pp. 177–185. Ginn and Company. BERGEN and CALDWELL. Introduction to Botany, p. 313. Ginn and Company. DUGGAR, J. F. Southern Field Crops. The Macmillan Company.

EXERCISE 55

THE IMPROVEMENT OF COTTON

Statement. Cotton, like all other domestic plants, is susceptible of improvement, and very rapid strides have been made in this direction in recent years. As a result of natural variation, selection, and breeding there are many types, varieties, and strains of cotton, just as there are of corn, apples, and strawberries. Much of this improvement has been made by selecting for propagation the best of each season's crop. To make such selection intelligently, the breeder must know what characteristics are of greatest importance, and must be able readily to detect these characteristics in the field.

FIG. 73. A poor cotton plant

A late unproductive plant; the joints are long and the bolls are far out from the center or base of the stalk; the limbs have few joints and few bolls

Object. To develop further the cotton industry by learning how to select the best cotton seed for planting.

Material. A field of cotton ready to pick; a small balance; pocket comb; small ruler graduated to $\frac{1}{16}$ inch.

Directions. 1. Select five early- and five late-maturing plants. Compare the two groups of plants as regards (*a*) the height at which the first leaves are borne on the main stem; (*b*) the length of the internode on the fruiting limbs; (*c*) the position of the bolls, whether mostly at the top of the plant and on the outer end of the branches, or whether they are borne mostly in the central and lower portions of the plant; (*d*) leafiness.

2. Select twenty-five of the least productive plants and twenty-five of the most productive plants in the field. Pick the cotton from each of the two groups of plants separately and weigh it. How many plants of each type would be required to give a yield of 1500 pounds of seed cotton or one bale of 500 pounds of lint?

3. What is the average number of bolls per plant for each group? Pick the cotton from 100 large bolls and weigh it. Do likewise for 100 small bolls. How many bolls of each class would it take to yield 1500 pounds of seed cotton?

4. Select five fully-open bolls, which in opening have permitted the walls or burrs to curl backward to the extent of allowing the seed cotton to be easily blown out by the wind. Select also five fully-open bolls in which the burrs have not curled backward sufficiently to make picking easy. Is there any relation between the extent to which the burrs curl backward and the thickness of the burr?

5. Select bolls showing each of the following defects: small-size spots on the burr due to disease, imperfectly developed lobes.

6. Pick the cotton from ten bolls from each of five different plants, keeping the five lots separate. Place these lots of cotton in the sun and allow them to dry. Remove the seed from the lint by hand. For each lot carefully weigh the seed and lint separately. Is there any difference in the percentage of lint produced by the different plants?

FIG. 74. A productive cotton plant, the sort from which to select the seed for next year's crop

7. By means of the hands carefully separate the lint on a seed of cotton into two equal parts without removing the lint from the seed. Carefully comb the two portions of lint out straight in opposite directions and determine its length. Compare different plants as regards the length of lint; the color of the lint, and the strength of the fiber. From which should seed be selected?

EXERCISE 55 (*Continued*)

Questions. What are the leading varieties of cotton of the country? Of the local community? What varieties are best adapted to rich soils? Which to poor soils? How many planters in the neighborhood use pedigreed seed? How many grow a distinct variety? How many make field selections of seed? Describe the method of selecting seed for the largest yield, naming the characteristics of stalk, stem, leaf, boll, lint, and seed most desirable.

References. WATERS, H. J. Essentials of Agriculture, pp. 185–186. Ginn and Company. DUGGAR, J. F. Southern Field Crops. The Macmillan Company. *Bureau of Plant Industry Bulletin 222; Farmers' Bulletin 591.* Cotton score card published by the state agricultural college; state cotton growers' association, if there is one; *Bureau of Plant Industry Circular 66; Farmers' Bulletin 501.* Office of Experiment Stations Bulletin, 33, pp. 211, 212.

SCORE CARD FOR THE COTTON PLANT [1]

	Score		
	Possible	Student's	Corrected
PLANT (Vigorous, Stocky) — 25 Points			
Size: medium to large as influenced by soil, location, season, and variety	5		
Form: symmetrical, spreading, conical, height; and spread according to soil, etc.	5		
Stalk: minimum amount of wood in proportion to fruit	5		
Branches: springing from base, strong, vigorous, in pairs short-jointed, inclined upward	5		
Head: well-branched and filled, fruited uniformly	5		
FRUITING — 24 Points			
Bolls: large, abundant, uniformly developed, plump, sound, firm, well-rounded, apex obtuse, singly or in clusters	4		
Number of bolls: according to variety, soil, and season	4		
Bolls per plant: thin uplands, 10–20; fertile uplands, 20–25; "bottoms," 50–100; special selection, 100–500	4		
Bolls per pound of seed cotton: large, 40–60; medium, 60–75; small, 80–110	4		
Character of bolls: number of locks 3 to 5; kind of sepals; retention of cotton	4		
Opening of bolls: uniform including top crop, classify as good, medium, poor	4		
YIELD (Standard 1 Bale per Acre) — 30 Points			
Seed cotton (estimated by average plant, distance of planting, per cent of stand, plants per acre): thin uplands, 10,000; fertile uplands, 6,500; "bottoms," 4,500; distance of plants 3½ by 1½ feet, 4½ by 1½ feet, 4½ by 2 feet, respectively	12		
Per cent lint: not less than 30, standard 33 to 35	12		
Seeds: 30–50 per boll, large, plump, easily delinted, color according to variety; germination not less than 95 per cent	6		
QUALITY AND CHARACTER OF LINT — 21 Points			
Strength: tensile strain good, even throughout length	5		
Length: common standards for upland, short ⅞ to 1 inch, premium 1⅛ to 1¼ inches; long staple, 1⅛ inches and better	5		
Fineness: fibers soft, silky, and pliable, responsive to touch	5		
Uniformity: all fibers of equal length, strength, fineness	5		
Purity: color dead white; fiber free from stain, dirt, and trash	1		

[1] For plants departing only slightly from the variety standard as to size, a cut of 1 to 1½ points should be made. If the departure is very marked, a cut of 3 points may be made. For excessively long joints and poorly placed and developed branches, cut a maximum of 2 to 5. For slight defects in these respects, cut from 2½ to 3 points. For a plant which develops a single central stem bearing numerous horizontal fruiting branches, allow five points as the perfect score. When the head is full, on account of the superabundance of long upright branches, cut a maximum of three points. As these faults are less pronounced, reduce the cuts until for slight defects on these accounts a minimum cut of one half point should be given. Adapted from directions published by the Georgia State College of Agriculture.

EXERCISE 56

GRADING COTTON

Statement. Cotton is graded on the market on the basis of the length, body, color, and strength of the fiber, and also on its purity or freedom from foreign substances. Fixed grades have been established by the United States Department of Agriculture and by the cotton exchanges of the country on which all commercial cotton is bought and sold.

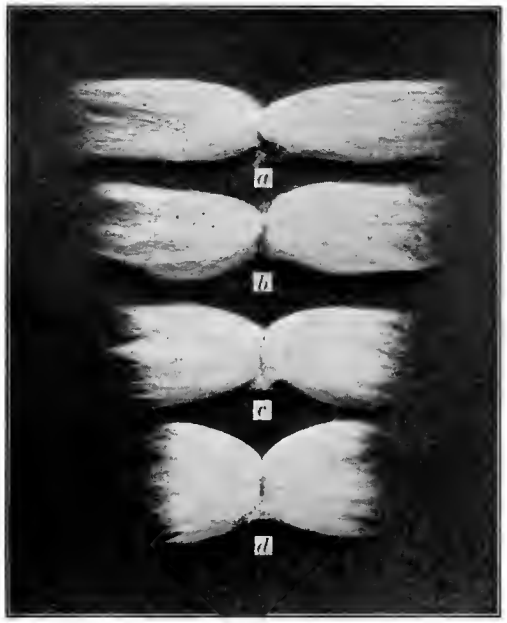


FIG. 75. American-grown cotton fibers

The four principal commercial types are shown as follows: *a*, sea island; *b*, Egyptian; *c*, long staple upland; *d*, short staple upland; the fibers are combed to show the relative lengths of the staples. (Courtesy of the Bureau of Plant Industry, United States Department of Agriculture)

Materials. Samples of fiber of different grades, copy of the Cotton Standards of the United States Department of Agriculture.

Directions. 1. In examining the fiber, attention should be given not only to the length and purity of the sample, but also to the maturity and strength of the fiber and its color. Examine also the body of the fiber and observe whether it is firm and solid or fluffy.

2. If there is a cotton gin or warehouse in the vicinity ask the cotton buyer to give the students one or more demonstrations in cotton grading and then take the class to the gin or warehouse and give the members one or more laboratory exercises in grading under joint supervision of the teacher and buyer.

The grading exercises should be made to embrace all the types and grades commonly produced in the country and especially all those usually grown in the neighborhood. Compare the market prices of the different grades and estimate the proportion of the normal crop of the community that will fall into each class. This work should be continued until the students are capable of recognizing with a fair degree of accuracy each of the principal grades of cotton and of placing on them their approximate market value.

Questions. How many grades of cotton are recognized in the United States standard? Name them in the order of their commercial value. What grades are recognized by the cotton exchanges above this list? What grades are recognized by them below this list? Ascertain the market value of the principal grades produced in the community. Of what grade is most of the cotton produced in the community? How may the planters most easily and profitably improve the grade of their cotton?

FIG. 76. Baled cotton being taken to market

References. DUGGAR, J. F. Southern Field Crops. The Macmillan Company. Cotton score card published by the State agricultural college; *Department Bulletin 62; Farmers' Bulletin 302, 364, 591.* Office of Experiment Stations Bulletin 33, pp. 351–360, 381–384; United States Department Agriculture, Office of Markets and Rural Organizations, S. R. A. 1.

EXERCISE 57

CROP ROTATION

Statement. Growing one kind of crop on the land year after year favors the accumulation of insects, plant diseases, and weeds injurious to that crop. Also some crops, as corn, are classed as "exhaustive," while other crops, as legumes and pasture grasses, to a limited extent, are considered to rest the land upon which they are grown and are classed as "restoratives." By alternating exhaustive and restorative crops the land is not so rapidly depleted as by growing exhaustive crops only. The labor load of the farm is better distributed throughout the year by growing a variety of crops instead of only one or two.

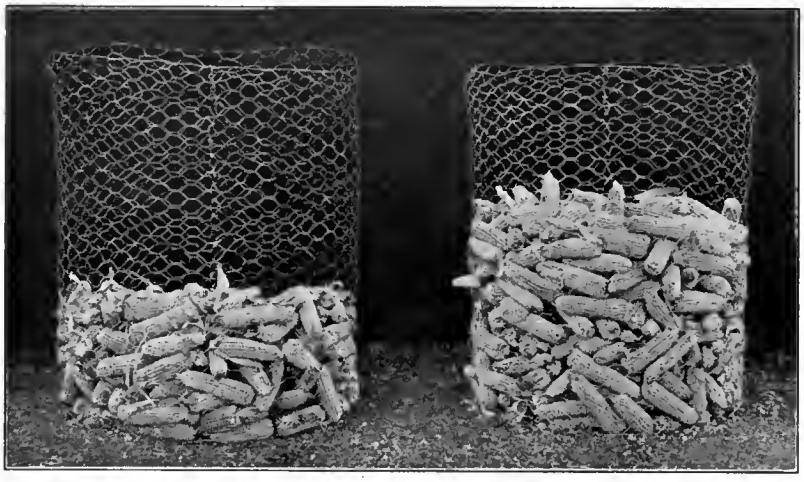


FIG. 77. The effect of crop rotation on the yield of corn

At the Missouri Experiment Station a test of the value of crop rotation has been in progress for twenty-five years. The crib at the left shows the average amount of corn (20.3 bushels) an acre produced when grown in corn continuously, and the crib on the right shows the amount of corn (34 bushels) produced by an acre in a rotation of corn, wheat, and clover. The figures give an average production for twenty-five years

Object. To study systems of crop rotation as applied to the community and to plan systems of rotation which will give a balanced agriculture.

Materials. A diagram of the home farm, or one in the neighborhood, showing the number of fields and area of each; a statement of the nature and type of soil and the kind of farming practiced.

Directions. 1. In planning a rotation decide first which are the main crops, and which secondary or restorative crops will best fit in with the main crops and produce a well-balanced cropping system. Study the most successful rotations of the neighborhood and apply one such to the farm for which you are planning a rotation. Make a drawing, dividing the farm into as many units as there are crops in the rotation chosen. For convenience each field should be numbered in laying out the system. Some such form as that shown on the opposite page may be helpful. The first column contains four units, the same as the number of crops in the rotation chosen. A unit may consist of any number of fields, but all units should be as nearly the same size as possible.

2. Plan two-, three-, four-, and five-year rotations respectively, using the crops grown in your community. Plan a desirable rotation for a general livestock farm, using corn, oats, and clover, and plan a rotation system for a grain farm, using corn, wheat, oats, and clover, in which only the grain and the seed of the clover are sold. Plan a rotation in which cotton, cowpeas, and corn are the principal crops. Fill in the forms on the opposite page. Discuss each rotation planned and explain the reason for the arrangement of crops.

Questions. In planning a crop rotation show how excessive spring plowing may be avoided. Explain how a crop rotation will help to control weeds. Explain how it will help to control diseases. Name two plant diseases that are controlled by crop rotation. Name the important restorative crops of the United States. Which of these are adapted to the locality in which you live?

References. WATERS, H. J. Essentials of Agriculture, pp. 86–87, 164, 287, 291, 310. Ginn and Company. HOPKINS, C. G. Soil Fertility and Permanent Agriculture, pp. 318, 362, 389. Ginn and Company. BURKETT, C. W. Soils, pp. 266–282. Orange Judd Company. WARREN, G. F. Farm Management, pp. 402–416. The Macmillan Company.

EXERCISE 57 (*Continued*)

CROP ROTATION FOR GENERAL FARMING

Unit Number	Fields Number	Total Acres	First Year	Second Year	Third Year	Fourth Year
1	1 and 2	34	Wheat	Clover	Corn	Oats
2	3, 4, and 5	41	Oats	Wheat	Clover	Corn
3	6, 9, and 11	41	Corn	Oats	Wheat	Clover
4	7, 8, and 10	36	Clover	Corn	Oats	Wheat

ROTATIONS PLANNED BY STUDENTS

1						
2						
3						
4						
1						
2						
3						
4						

EXERCISE 58

THE SILO AND SILAGE

Object. To understand the construction and function of the silo and the manner of preparing silage, and the method by which it keeps. Also to learn how this material is used.

FIG. 78. All classes of live stock eat silage with a relish

Materials. A neighborhood silo and apparatus for filling it; salesman's descriptions of the different kinds of silos; the textbook data upon quantities of corn and other material required to fill silos of given size, and upon the amount of silage needed to feed different kinds of farm animals.

Directions. The class should visit one or more good silos under the guidance of the teacher and the farmer who owns the silo, when the silo is being filled and later when the silage is being fed.

1. The points to be studied in the first visit should include the structure and size of the silo, its relation to the barn and to the stock to be fed, material used for silage, the stage of maturity when harvested, how cut and loaded, the arrangement of wagon racks, methods of unloading, cutting, and filling the silo. All the members of the class should be permitted to go into the silo and to help distribute the silage and tramp it around the edges. Make a complete record of all the above facts and note any particulars in which improvements might be made with profit.

FIG. 79. Before the silo came into general use, one of the principal drudgeries of feeding stock was digging corn fodder out of the snow

2. On the occasion of the second visit the points to be considered should include condition of silage, number of inches of silage used each day, amount of silage that is lost by decay, where the loss occurs, the changes in temperature, color, and odor which have occurred in silage between the time when the fresh material was placed in the silo and the time when it is fed. Note the relish with which the animals eat the silage. And how much each kind eats daily.

Questions. Ascertain the number of animals of each class on each farm visited and calculate the amount of silage required to feed them throughout the season; the dimension of the silo or silos necessary to contain the feed. Estimate the number of acres of corn, sorghum, or kafir required to supply this amount of fresh material. What would be the approximate cost of erecting such a silo or silos and what would it cost to fill them?

References. WATERS, H. J. Essentials of Agriculture, pp. 248–259. Ginn and Company. PLUMB, C. S. Beginnings in Animal Husbandry, pp. 298–300. Webb Publishing Company. WILSON and WARBURTON. Field Crops, pp. 91–92. Webb Publishing Company.

EXERCISE 59

HOW TO PLANT A TREE

Statement. Nature if let alone maintains a balance between the root area and the top area of growing plants. In transplanting trees this balance is disturbed, because most of the roots are cut off when the tree is removed from its growing place. Unless the top is cut back to correspond to the new root system the tree will usually die.

Object. To learn how to plant trees properly.

Materials. Trees to be planted; planting board; sharp knife; shovel or spade.

Directions. 1. Drive stakes at the exact place where each tree is to be planted. Before digging the hole stake the planting board in place as shown in Fig. 83. Remove the planting board and stake, marking the location of the tree, and dig the hole. The hole should be large enough to contain all the roots without crowding and deep enough to set the tree about an inch deeper than it grew in the nursery. Prune from the roots any broken, straggling, or interlacing parts, replace the board, and place the tree in the hole. One person should hold the tree in the proper position while dirt is filled in by another. Top soil should go in first and should be tramped firmly about the roots as the hole is filled. After the dirt is in place and has been firmed, a little loose soil should be spread over the top to prevent the surface from baking.

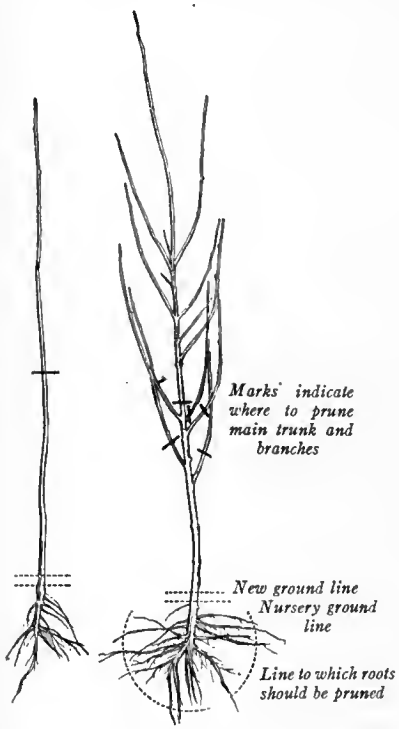


FIG. 80. Method of pruning trees before planting

The tree at the left is a one-year-old whip and is cut back to form the head; the one at the right is a two-year-old and needs to be top-pruned as well as root-pruned. The irregular curve indicates where the roots should be cut

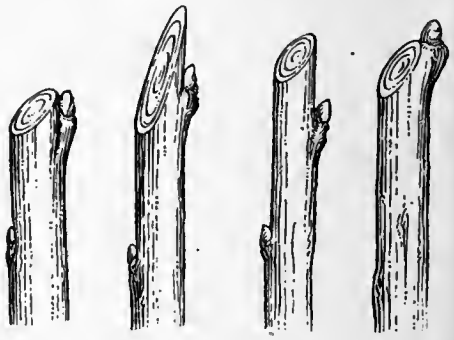


FIG. 81. The right and wrong ways of cutting off branches

At the left the right way; the next branch was cut too slanting; the next too far from the bud; the one on the right, too near the bud. Courtesy of the United States Department of Agriculture, Bureau of Plant Industry

The top of the tree needs to be cut back in proportion to the severity with which the roots are pruned, but the shaping of the top may be left until the first year's pruning.

FIG. 82. Planting board

The board is held firmly in place by stakes at the end notches; the middle notch indicates where to dig the hole and later just where to set the tree in the hole

2. One tree should be properly root-pruned and branch-pruned in the presence of the class, then the pruned tree and an unpruned one compared in order to make clear the problems which will face the two trees when they are planted. From the work and discussions write a statement of the proper procedure in planting a young fruit tree. Make diagrams showing depth of planting, preparation of hole for the tree, and appearance of the properly pruned tree.

3. Invite the local nurseryman or an experienced orchardist of the neighborhood to assist in the demonstration and if possible have each student plant fruit trees of different kinds and ages so as to bring out the essential points in root and top pruning and in the formation of the head best adapted to the local climate. Also require the students to plant a sufficient number of ornamentals to become familiar with the habits of this group of shrubs and trees.

4. An improvement project should be planned to follow this exercise in which the student will be encouraged to undertake the better planting of his father's home grounds, the school campus, a portion of the city park or some neglected part of the town. In such a project the practical details pertaining to the care of trees and shrubs after they have been planted, so that they may be carried safely through the critical period caused by a drought in the first or second summer, will be emphasized. Also the proper cultivation of the plants to insure their rapid development will be considered.

FIG. 83. The use of the planting board

The board was removed while the hole was being dug and was replaced. When the tree was placed in the notch it occupied the proper position. The dirt should be carefully worked among the roots. (Courtesy of Purdue University)

Questions. In what manner does it damage a tree to leave the roots exposed to the air before planting? How is such exposure largely prevented by the nursery men in shipping trees? What are the advantages of a planting board? Why is it important to pack fine soil firmly about the roots? Why is it advisable to cut back the top of a tree at planting time? How close together should apple trees be planted? peach trees? pear trees? How many trees of each are planted on an acre?

References. WATERS, H. J. Essentials of Agriculture, p. 268. Ginn and Company. WILKINSON, A. E. The Apple, pp. 71–75. Ginn and Company. WAUGH, F. A. The American Apple Orchard, pp. 40–41. Orange Judd Company.

EXERCISE 60

PRUNING THE APPLE TREE

Statement. All fruit trees require to be pruned from time to time for the production of fruit of the highest quality. It is by removing the excessive wood growth through judicious pruning that the fruitfulness of the tree is increased. Also the size and quality of the fruit are improved, and insects and diseases are more readily controlled.

FIG. 84. A two-year-old apple tree before and after pruning

The picture on the right shows the tree after pruning; note the even distribution of scaffold limbs; an excellent type of an open-headed tree

Object. To learn how to prune bearing apple trees.

Materials. A neglected orchard; a pruning saw; a pair of hand shears; a ladder; a pail of paint and a brush for each squad.

Directions. For this work a visit should be made to a neglected orchard or an orchard which is in need of being pruned. In working over old trees the dead and diseased limbs should be removed first. Then cut out all twisted, weak, and crossing or rubbing branches as well as those which grow back through the center. The ideal tree should have a low head, and an open top with the bearing wood distributed throughout. Old and neglected trees usually require heading back. Cut each upright limb in the top of the tree back to a strong limb spreading toward the outside of the tree. Thin the remaining limbs, so that the sunlight may have access to all portions of the tree, by removing the weaker limbs and leaving the best fruit-bearing wood. The removal of large limbs hastens the work of renovation, but the large scars are slower in healing than the small ones. If the trees are devoid of fruit-bearing wood along the main limbs, head back all healthy water sprouts to about three inches in length and in this way convert them into fruit spurs. In removing limbs cut close to the remaining limb, leaving a smooth surface, sloping so as to shed water. Paint all cuts larger than one inch in diameter to prevent infection of wood which is exposed.

FIG. 85. Before and after pruning

The tree at the left is a well-cared-for tree before being pruned; on the right is the same tree after it has been pruned. Notice the limbs on the ground at the left of the pruned tree which were removed. Note also how much more open the top is and that all interlacing limbs have been removed

If the same orchard can be used for several years, an excellent opportunity is offered for studying the effect of pruning on the character of the fruit and the vigor of the trees.

Questions. What are the objects of pruning? Do water sprouts have any value? Why is it necessary to remove the diseased wood? Why should the wounds be painted? How can excessive height growth be remedied? Describe in detail how to renovate a neglected orchard.

References. WATERS, H. J. Essentials of Agriculture, pp. 268–270. Ginn and Company. WILKINSON, A. E. The Apple, pp. 83–90. Ginn and Company. WAUGH, F. A. The American Apple Orchard, pp. 77–91. Orange Judd Company.

EXERCISE 61

HARVESTING AND GRADING APPLES

Statement. The proper time for picking fall and winter apples is when the fruit has reached full size and is well colored, but before it has begun to soften. Neither immature nor over-ripe fruit keeps well in storage, and its eating qualities are not up to standard. Success in orcharding will in considerable degree depend upon the skill and intelligence used in picking, grading, and packing the fruit.

Object. To learn how to harvest and grade apples.

Materials. Ladders; picking sacks; orchard crates; grading table; sizing board; a well-sprayed orchard laden with ripe fruit.

Directions. *Picking.* Divide the class into squads of four each and assign each squad to a block of trees. Have two students pick all the fruit that can be reached from the ground, have a third pick from the ladder, and the squad leader direct the work under the guidance of the teacher and the proprietor of the orchard. In picking the fruit raise and turn each apple slightly so as to avoid pulling out the stem or breaking off the fruit spur. If the stem is pulled out, the opening into the flesh of the apple is likely to become infected with the organisms which cause it to decay. The fruit spurs are the source of future crops and should be carefully guarded against injury. Handle the fruit carefully to avoid bruising, and as soon as a sack is filled its contents should be carefully emptied into boxes.

FIG. 86. Picking apples
No successful substitute for hand picking has been invented in harvesting apples, cotton, and corn. The sack is the best receptacle for the picked fruit

Grading. The apples are next placed on the grading table, where they are graded for size, color, and blemishes. First remove all injured or diseased fruits. Then, using the sizing board, which is graduated to one-eighth inch, separate the apples into the various sizes. Learn the standard of sizes demanded by the general market or for the special market for which you are grading and make the classification conform to their requirements. These should, in turn, be graded for color so that each lot will consist of perfect specimens that are uniform in size and color. After the student's eye is trained, the sizing board may be discarded and the grading be done by hand.

Questions. Why should the fruit be handled carefully? Of what value are the fruit spurs? What is the proper time for picking apples? Which separate from the spurs more readily, the ripened or the immature specimens? How does the grading for color affect the appearance of the apples? Why should the diseased and injured fruits be removed? Why should apples be graded into the different sizes?

References. WAUGH, F. A. The American Apple Orchard, pp. 149–165. Orange Judd Company. FLETCHER, S. W. How to Make a Fruit Garden, pp. 131–135 (old). Doubleday, Page Company. WILKINSON, A. E. The Apple, pp. 270–271. Ginn and Company. WATERS, H. J. Essentials of Agriculture, pp. 274–275. Ginn and Company.

EXERCISE 62

PACKING APPLES

Statement. Fruit which reaches the consumer in perfect condition demands the highest price. To obtain this price requires not only that good healthy fruit be grown but that it be so marketed that it is not bruised and that it is uniform in size, color, and quality. This means that apples must be carefully packed.

Object. To learn how to pack apples in boxes and barrels.

Materials. Several bushels of apples graded for size and color, as explained under *Grading*, and standard-sized apple boxes and barrels.

Directions. *Boxing.* First line the box with paper, folding it at the bottom to prevent tearing. Refer to the table for the style of pack that is adapted to the size to be packed. The 3–2 pack, which is adapted to the greatest number of commercial sizes, and the one best adapted to general requirements, is here described. The principles involved, however, are the same as for other diagonal packs. Place an apple, stem end down, in each of the two lower corners of the box. A third apple is placed midway between these two. The location of the third apple is important, since if incorrectly placed it will destroy the regularity of alignment. In the two spaces formed by the three apples of the first row two other apples are placed. These should slip part way between the first apples, but should not slip into line with them. The next rows are alternately comprised of three and two apples each until the layer is completed. These should fit snugly and the rows should be straight. Two apples are used for the first row of the second layer, and they should be placed in the open spaces in the first row of the first layer. The layer is then packed as described for the first. The first, third, and fifth layers are started with three apples, and the second and fourth are started with two. The last layer is packed stem end up since this end bruises less readily than the blossom end. A well-packed box should have regular rows that fit firmly. The apples at the ends should be even with the ends of the box and the apples in the middle should be slightly higher. This bulge aids in maintaining a tight pack. The papers should now be folded over and the cover nailed on, using a cleat at either end. The packed boxes should be turned over and the top removed to show the appearance of the pack.

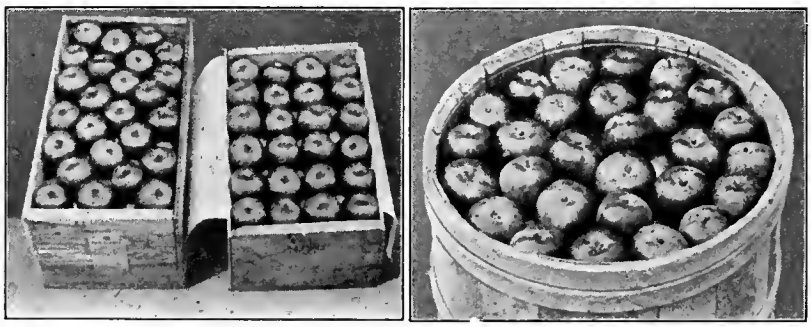


FIG. 87. The standard apple packs

At the left is shown the 3–2 box pack; in the center, a straight box pack; at the right, a good barrel pack

Barrelling. Follow the approved practices of the community and whenever possible work under the direction of an experienced fruit packer.

Questions. Why should the box be lined with paper? Why should the paper be folded? Is the location of the apples in the first row important? Why? How many apples in the first row of the first, third, and fifth layers? of the second and fourth layers? Why is there less injury in the diagonal than in the straight pack? How high should the apples be at the end of the box? What is the value of the bulge in the center? Describe the procedure in packing apples in barrels.

References. WILKINSON, A. E. The Apple, pp. 293–312. Ginn and Company. WAUGH, F. A. The American Apple Orchard, pp. 165–171. Orange Judd Company.

EXERCISE 62 (*Continued*)

BOX-PACKING TABLE

Diameter	Style	Position	Number
$2\frac{5}{8}$ inches	3–2 diagonal	Flat	163
$2\frac{3}{4}$ inches	3–2 diagonal	Flat	150
$2\frac{7}{8}$ inches	3–2 diagonal	Flat	125
3 inches	2–2 diagonal	Flat	112
$3\frac{1}{8}$ inches	2–2 diagonal	Flat	104
$3\frac{1}{4}$ inches	2–2 diagonal	Flat	96
$3\frac{5}{8}$ inches	2–2 diagonal	Flat	80
$3\frac{1}{2}$ inches	2–2 diagonal	Flat	72

PART IV. INSECTS AND PLANT DISEASES AND THEIR CONTROL

EXERCISE 63

THE STRUCTURE OF AN INSECT

Statement. Some insects are beneficial, others injurious, yet others are both helpful and harmful, and yet others are apparently of no direct importance. Man has been able to meet and utilize these relations largely by first learning how they carry on their life activities, such as feeding, breathing, and reproduction. Since all of these activities are directly related to certain structural features of the insect, a knowledge of its structure is essential.

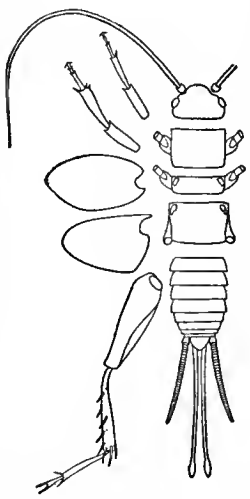


FIG. 88. Dorsal view of cricket

Object. To study the structure of the common grasshopper.

Materials. A common grasshopper; hand lens; drawing pencils and eraser.

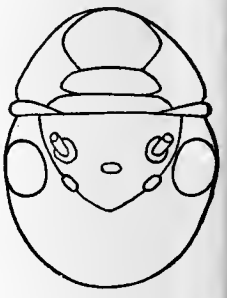


FIG. 92. Frontal view of head

Directions. Study the body covering and note that it is rigid and is composed of a series of ringlike units called segments. These segments differ in various parts of the body, but the similar ones are grouped together to form the three body regions, head, thorax, and abdomen.

1. The head appears to comprise but one segment, but in reality six are fused together to form it. Two slender antennæ extend from the upper part of the head. Two compound eyes and three simple eyes (ocelli) are also easily observed. The mouth parts are of the biting type and composed of four distinct superimposed sets, namely, upper lip, or labrum; a pair of jaws, or mandibles; a lower pair of more complex jaws or maxillæ; and the lower lip or labium. The maxillæ and the labium bear each a pair of jointed appendages known as palpi.

FIG. 89. Lateral view of head

2. The thorax, or middle-body region, is composed of three segments, each of which bears a pair of legs. The first segment (prothorax) is covered on the top and the two sides by a heavy, thickened, saddle-shaped shield. Each of the next two segments (mesothorax and metathorax) bears a pair of wings. A diagonal line (suture) extends across the side of each of these last two segments, making them appear to be four segments instead of two. Just above the base of the middle leg and in the

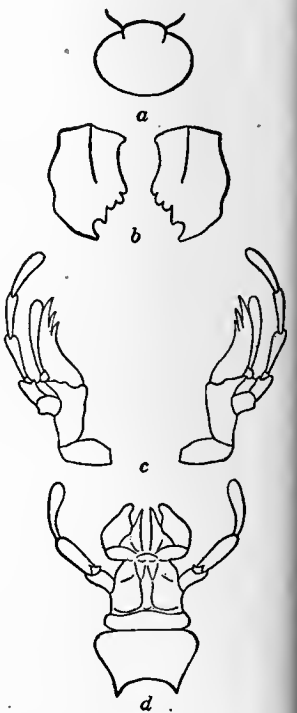


FIG. 93. Mouth parts

a, labrum; *b*, mandibles; *c*, maxillæ; *d*, labium

FIG. 90. Lateral view of thorax

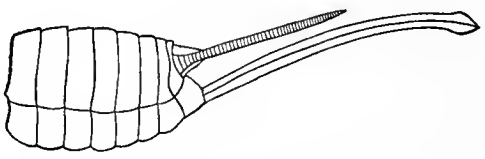


FIG. 91. Lateral view of abdomen

groove between the meso- and metathorax is a slitlike opening (spiracle), one of the breathing pores. Aside from certain inconspicuous basal parts, each leg consists of a femur (or thigh), a tibia, and a tarsus (or foot).

3. Ten segments are easily counted in the abdomen. The basal segment bears a pair of conspicuous, oval auditory organs, at the front edge of each of which is a spiracle. Each of the following segments bears a pair of lateral spiracles. In the female the abdomen terminates in two pairs of short, pointed organs which constitute the major part of the egg-laying organ (ovipositor), while in the male the end of the abdomen is rather blunt and bears a pair of short movable plates (claspers).

4. Make drawings of a grasshopper similar to those shown of the cricket.

References. SANDERSON, E. D., and JACKSON, C. F. Elementary Entomology, p. 372. Ginn and Company. COMSTOCK, J. H. Manual for the Study of Insects, p. 701. Comstock Publishing Company.

THE GRASSHOPPER

Make drawings of the parts indicated below, similar to the drawings of the cricket.

1. Face view: antennæ; compound eyes; simple eyes; mouth parts.
2. Mouth parts: labium; mandible; maxilla; labrum; palpi.
3. Lateral view of thorax with wings and legs removed: leg and wing attachments; spiracles; intersegmental grooves.
4. Abdomen, lateral view: ear; spiracles; abdominal segments.

EXERCISE 64

THE LIFE HISTORY OF AN INSECT

Statement. Before we can control insects we must learn something of their life history; that is, when and where they lay their eggs, when the eggs hatch, into what forms they develop, what they feed upon, where and in what stage they pass the winter, and how many generations are produced each year and what their natural enemies are.

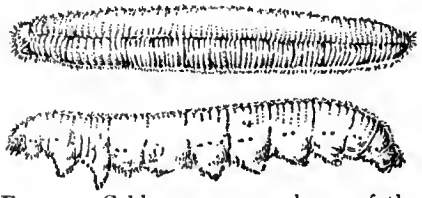


FIG. 94. Cabbage worm or larva of the cabbage butterfly
Dorsal and lateral view. (After Dean)

Object. To study the life history of the cabbage worm.

Materials. A flowerpot for each student in which a young cabbage plant is growing; a lantern globe, the top of which has been covered with cheesecloth; a number of breeding cages large enough to hold several of the potted cabbage plants; insect nets and cans or jars.

Directions. 1. A few days after the cabbage is set in the spring observe the white butterflies with black spots on the wings, which may be seen flying about near the ground. Observe how and where their eggs are deposited. Describe the eggs. With the insect net capture mating pairs of the butterflies and place each pair in a jar or can so they may be taken uninjured to the laboratory. In the laboratory one pair should be placed in each of a number of breeding cages. The pots containing the young cabbage plants can be placed in the cages and daily observations made for the presence of eggs. Make notes and drawings of where the eggs are deposited, how they are grouped, their color, size, and shape.

FIG. 95. Pupa or chrysalis of the cabbage butterfly
Dorsal and lateral view. (After Dean)

FIG. 96. Cabbage plant injured by the cabbage worms (After Dean)

2. After the eggs hatch, the potted plants should be removed from the breeding cage and the large lantern globe, the top of which has been covered with cheesecloth, should be placed over each plant to prevent the escape of the larvæ. Make notes and drawings describing the newly hatched larva, showing the number of molts and the length of time in the larval stage. If possible, observe the transformation of the larvæ to the pupal form.

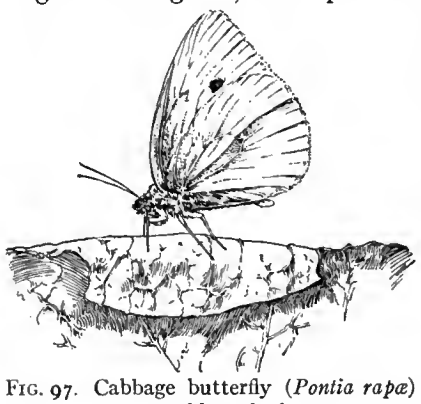


FIG. 97. Cabbage butterfly (*Pontia rapæ*) on cabbage leaf
(After Dean)

3. After pupation the pupæ that are wanted for immediate use should be placed in a light, warm room, where they will probably emerge in a few days. Determine and make notes of date and method of emergence. Describe the adult.

Questions. What are the feeding habits of larvæ? Will the arsenical sprays kill them? When and how often should the sprays be applied? Is it practical to hand pick the larvæ from young plants? Where and in what position are the eggs laid?

References. WATERS, H. J. Essentials of Agriculture, pp. 300–312. Ginn and Company. SANDERSON, E. W. Insect Pests of Farm, Garden and Orchard. J. Wiley & Sons. *Farmers' Bulletin 766,* United States Department of Agriculture.

EXERCISE 65

THE STRUCTURE, HABITS, AND MANAGEMENT OF HONEY BEES

Statement. The honey bee produces more food for man than any other insect — directly by gathering nectar from the flowers and changing it to honey, and indirectly — by pollinating fruit blossoms. The bee gathers nectar, a natural product which would otherwise be wasted.

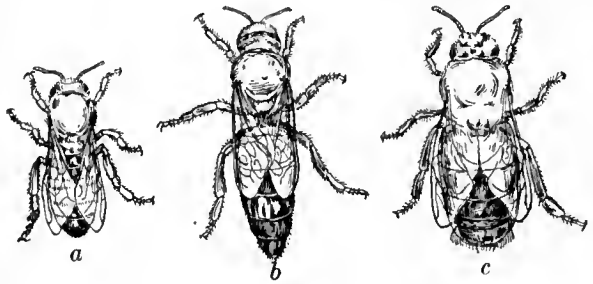


FIG. 98. The honey bee
a, worker; *b*, queen; *c*, drone

Object. To study the structure, habits, and management of the honey bee.

Materials. Hives of live bees; veil; smoker; hive-tool; queen; excluding board.

Directions. 1. For the first examination of the colony, select the middle of a warm spring day during the period when fruit trees are in bloom. Light the smoker, put on gloves, adjust veil. Blow a few puffs of smoke in the entrance and give a few sharp raps on the body of the hive, raise the cover, blow a few puffs of smoke over the tops of the frames, grasp the frame from the middle of the hive at each end and carefully lift it from the hive (Fig. 101). Hold it over the hive in such a way that the comb will be in vertical position. Study the brood, which is in concentric rings. Distinguish the queen, workers, and drones (Fig. 98), the eggs, larvæ, and pupæ (Fig. 99), and the different kinds of cells (Fig. 100). Note whether there are any insect enemies present, or any bee diseases.

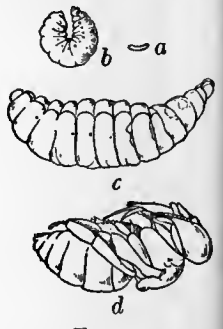


FIG. 99
a, egg; *b*, young larva; *c*, older larvæ; *d*, pupa

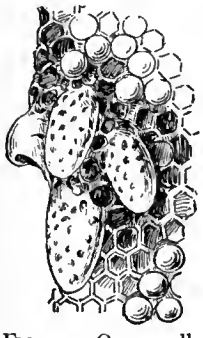


FIG. 100. Queen cells

2. Take to the classroom some dead workers and drones for further study. Notice the mouth parts, the brushes, and the pollen baskets on their legs. Tell how the bees gather pollen and make bee bread. Examine on the front leg the comblike device through which the bee draws its antennæ to clean them. Examine the rings on the under side of the body from which wax is secreted.

3. The last examination should be made in the fall of the year. Determine whether or not they have sufficient food to enable them to pass the winter successfully and if there are enough bees in the hive.

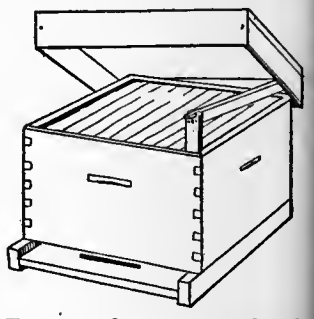


FIG. 101. One-story stand and hive with metal cover

Questions. Name the three kinds of bees in a colony. What is the relative number of each? What is the sex of each kind? What service in the colony does each kind render? What is nectar and where do bees obtain it? Into what is it made? What use do bees make of honey? What is bee bread, from what is it made, and to what use is it put by bees? What is the comb? From what is it made and to what use is it put? In what way do bees aid in fruit production? How many pounds of honey does a colony of bees usually produce in a season above their own needs? How may you know whether there is enough honey stored to support the colony during the winter? When should you make inspections for this purpose? If there is not enough, what is the remedy? Name the principal honey-producing plants of the community and state the season in which bees feed upon each. Which plants produce the best quality of honey? Which the poorest?

References. DADANT, C. P. 'First Lessons in Beekeeping," *American Bee Journal.* PELLET, F. C. Productive Beekeeping. J. B. Lippincott Company. ROOT, A. I. and E. I. "A B C and X Y Z of Bee Culture," 1917 ed. A. I. Root Company. WATERS, H. J. Essentials of Agriculture, p. 300. Ginn and Company.

EXERCISE 66

A STUDY OF FUNGI

Statement. Fungi are found on both living and decaying organic matter, and are present in abundance practically wherever there is dead organic matter. Many fungi attack plants and break down the living tissue, causing the plants to become diseased. The following fungi, some of which attack living plants, can usually be found: corn smut, wheat smut, soft rot of apple, brown rot of peach or plum, mold on peaches, cherries, or improperly preserved fruits, and mold on oranges or lemons.

FIG. 102. Corn smut

One of the best-known plant diseases. Common on Indian corn all over the United States. The black smut masses are composed of smut dust — a very great number of spores. (Photograph by L. E. Melchers)

Object. To grow and study fungi.

Materials. Stale wheat bread; tumbler; microscope; slides and cover glass; other fungi obtainable, as corn smut, wheat smut, or soft rot of apple.

Directions. 1. A typical fungus of bread mold may be obtained in from three to five days. Moisten a small piece of bread with water, place it in a large tumbler, and allow it to stand exposed to the air in the room for an hour or two. Add a few more tablespoonfuls of water and cover the tumbler with a saucer or a piece of heavy cardboard. Keep this in a warm room. Within a few days a white, threadlike growth known as mycelium will develop. Mount a very small portion of this in a drop of water on a slide, using a cover glass. Examine this under the low and high power of the microscope. When the spore cases appear make additional studies.

2. In a similar manner collect and mount small bits of the spore masses (black dust) of corn or wheat smut and examine them. Compare these black-dust spores with bread-mold spores for size. Compare various spores as to their color, shape, and size. Notice any particular markings on the walls of the smut spores and describe each of them.

FIG. 103. Mold on orange

This may easily be found on oranges and lemons in any grocery store. If a small portion is scraped off with a knife, mounted in water, and examined under the high power of the microscope, the spores are easily seen. (Photograph by L. E. Melchers)

3. Place an apple, peach, plum, orange, or lemon which shows signs of a soft rot or decay in a dish and cover tightly for a day or two. A fungus will develop sufficiently to be easily seen with the unaided eye. Often diseased fruit with the fungus cropping out will be found hanging on the tree. Frequently diseased fruit or vegetables can be found in the grocery store. Examine small portions of any of the fungi which are cropping out from diseased fruit under the low and high power of the microscope, just as the bread mold was examined.

EXERCISE 66 (*Continued*)

Questions. Of what does the mycelium consist? What do sporangia contain? What functions do these bodies have? Describe the spores as to their size, shape, and color. How do fungi reproduce? How does corn smut spread? How does wheat smut live over from one season to another? Name all the farm plants that you know to be attacked by smut.

References. WATERS, H. J. Essentials of Agriculture, pp. 288–289. Ginn and Company. DUGGAR, B. M. Fungous Diseases of Plants. Ginn and Company. STEVENS and HALL. Diseases of Economic Plants, p. 486. The Macmillan Company.

EXERCISE 67

A STUDY OF BACTERIA

Statement. Bacteria are microscopic single-celled plants living either singly or in groups. Under natural conditions they are present on almost every object and are exceedingly abundant in the air, soil, and water. Most bacteria are harmless, many are beneficial, while some cause disease. Tuberculosis, typhoid fever, and cholera, the wilt of melons and cucumbers, and the crown gall common to apples, alfalfa, and many other plants are common bacterial diseases.

Object. To study bacteria and observe the effects of bacterial action.

Materials. Four small bottles; boiling water; cotton; Bulgar tablets; microscope; cover glass and slide.

Directions. Secure four small bottles or tumblers holding approximately half a pint. These should be thoroughly cleaned by placing them in water and bringing it to the boiling point for a few minutes. Fill each half full with sweet milk (not pasteurized). Buy some Bulgar tablets or tube cultures at the drug store; these contain the living bacteria, *Bacillus bulgaricus*. Place half a tablet in each of two tumblers of milk. Do not put anything in the other samples. Insert in the mouth of each bottle a firm cotton plug made by rolling the cotton into a roll. Place one of the tumblers containing the Bulgar tablet, and one of the tumblers which was not inoculated with a tablet, in a refrigerator. The other two tumblers should be placed in a room where the temperature is about 80° F. At the end of twelve, twenty-four, and thirty-six hours compare the two samples of milk containing the bacteria with the other two untreated samples as to their odor and taste and record any difference that may be apparent. Describe what you have discovered. Note the appearance of the milk in each sample. Record any difference in the physical and chemical state of the samples. Return the bottles to their respective places and reëxamine samples at the end of forty-eight and seventy-two hours. Notice the differences between the souring of the various samples, the characteristic odor, and the physical changes in the milk. Examine a drop of sour milk under the highest power of your microscope. Can you see the bacteria? Describe what you see. In which sample are the bacteria most numerous?

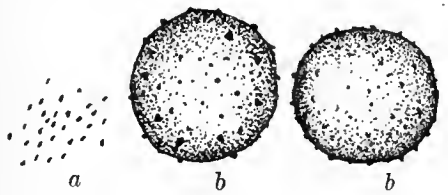


FIG. 104. A group of bacteria and two corn-smut spores

All are magnified 500 times, showing relative sizes

Questions. What was the effect of bacteria upon milk? How did the temperature at which the milk was held affect the action of bacteria? At what temperatures do bacteria grow most rapidly? What temperature is required to kill them? What are the common ways of holding bacteria in check or killing them? Why do we store perishable products in the ice box? Explain how low temperature retards the souring of milk. How does it retard the spoiling of meat and eggs? How does boiling and sealing while hot prevent spoiling in canned fruits and vegetables? Why was the cotton stuffed in the mouth of the bottles in the experiment above? Will dirty milk keep as well as clean milk? Will milk keep as well when placed in dirty vessels as in clean ones? What is meant by sterilization and how may it be accomplished? What is the effect of sterilization? What is meant by pasteurization and how may it be accomplished? What product is most generally pasteurized? Name some of the most common disinfectants. Why do we spray fruit trees? Name some common diseases of plants which are due to bacteria and describe the best method of preventing them. What are some of the common diseases of farm animals caused by bacteria?

References. CONN, H. W. Agricultural Bacteriology. P. Blakiston's Son and Company. LIPMAN, J. G. Bacteria in Relation to Country Life. The Macmillan Company.

EXERCISE 68

CONTROLLING PLANT DISEASES

FIG. 105. Oat smut

This is common in oat fields wherever oats are grown. It is easily controlled by disinfecting the seed. The illustration shows one good head and three diseased heads. (Photograph by L. E. Melchers)

Statement. Much of the great loss due to bacterial plant diseases may be controlled by disinfecting the seed. One of the most efficient substances for this purpose is formalin. This disinfectant is used successfully in the case of stinking smut of wheat, smut of oats, barley, sorghums, and potato scab.

Object. To treat seed by the formalin method for bacterial disease.

Materials. Pint of formalin; peck samples of wheat and oats which are smut infested; pails for immersing the seed.

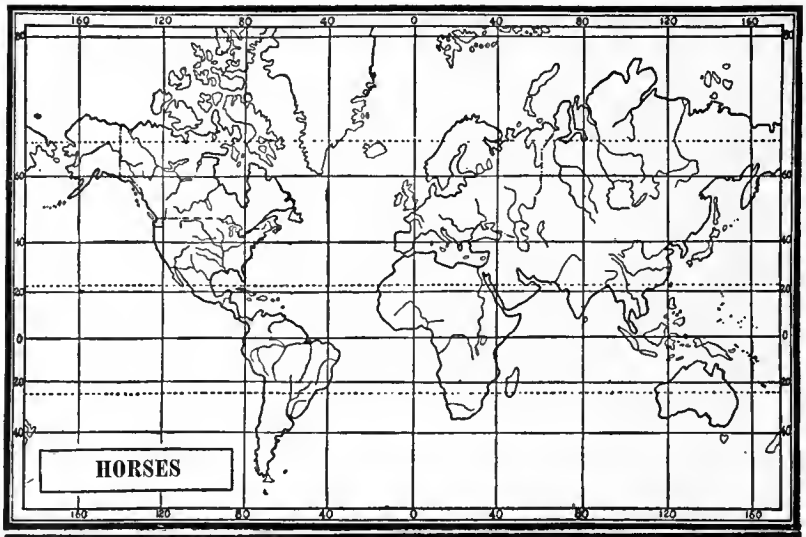
Directions. Buy a pound of formalin from the drug store, and secure samples of wheat and oats which contain smut from the elevator or from the farm and a sample of potatoes from a field which suffered from potato scab. Prepare the formalin mixture, using one pound of formalin in forty-five gallons of water. Place each sample to be treated in a cloth bag and immerse it in the formalin solution. Leave it immersed for ten minutes and then spread out to dry. Plant the seed as soon as possible after receiving the treatment. If you live on the farm apply treatments at home to seed to be used on the farm. It will be necessary to figure out the exact quantity of solution needed for treating a small lot of seed or potatoes. Do not use a stronger or weaker strength than recommended. After treating, plant the seed and observe results, as compared with the results from untreated seed planted alongside or in the fields of the neighborhood.

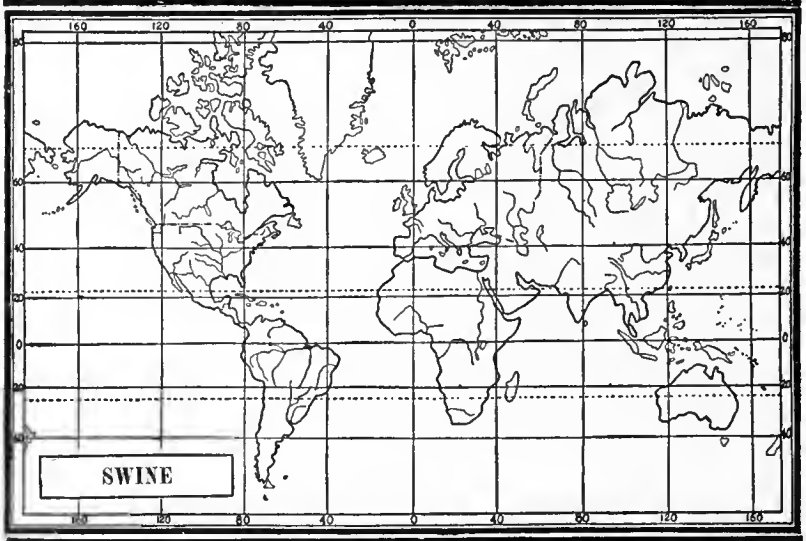
FIG. 106. Treating seed oats for smut prevention

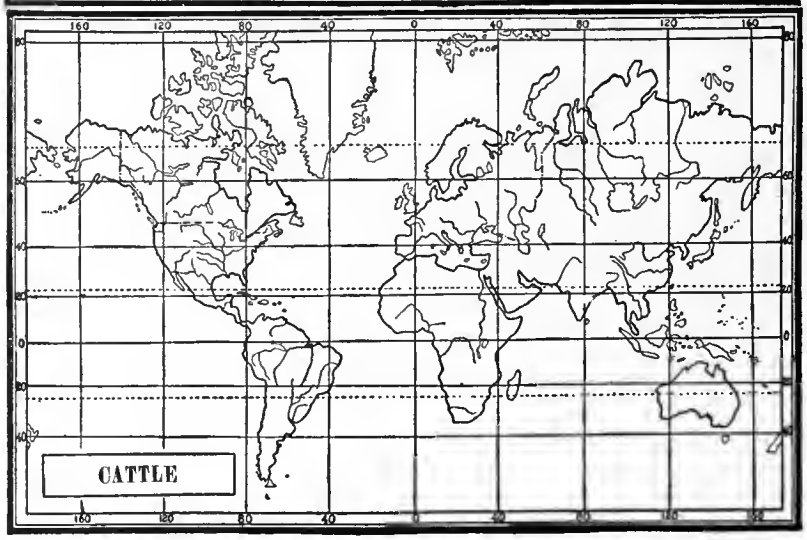
The method shown is the new "dry" method, concentrated formaldehyde solution being used. Every shovelful of grain is given one "shot" of very fine spray. (Photograph by L. E. Melchers)

Questions. What are the most destructive plant diseases in your community? How are bacteria and fungi distributed? Where may they be found? What is the value of treating seed for smut? In what form is smut present on seed? Name as many methods of control of plant diseases as you can. Is it much trouble to treat seed with formalin? Is it expensive? If 5 per cent of the crop is saved by treating the seed, does it pay?

References. WATERS, H. J. Essentials of Agriculture, pp. 287–298. Ginn and Company. DUGGAR, B. M. Fungous Diseases of Plants, pp. 372–380. Ginn and Company. STEVENS and HALL. Diseases of Economic Plants, p. 346. The Macmillan Company.







EXERCISE 69

WHERE OUR BREEDS OF LIVE STOCK ORIGINATED

Statement. In times when men, women, and children had to provide food, clothing, and shelter with their own hands and had to carry their burdens on their own backs, the people remained uncivilized. Those races of people which early learned to tame wild animals and make them help to provide food and clothing, and to bear burdens soon began to establish orderly ways of living. They soon had food all the year around, wore clothes instead of skins and lived in houses instead of caves or trees. Also those races which made the greatest improvement in the usefulness of their domestic animals have developed the highest forms of agriculture and have been the world's most intelligent farmers. Much of the history of man's progress from a state of savagery to the highest state of civilization is revealed by a study of the origin of our breeds of farm animals.

Object. To fix in the pupil's mind the countries which have contributed most to the improvement of the breeds of live stock that are common in the United States.

Materials. Outline maps of the world and text material showing where each of our common breeds of farm animals originated.

EXERCISE 69 (*Continued*)

Directions. 1. Indicate on one of the outline maps where each of our important breeds of horses originated, representing the draft and coach breeds by one color, the light horses by another, etc.

2. On another map indicate where our hogs originated, distinguishing between the lard hog and the bacon hog.

3. On a third map show by different colors the origin of our beef and dairy cattle.

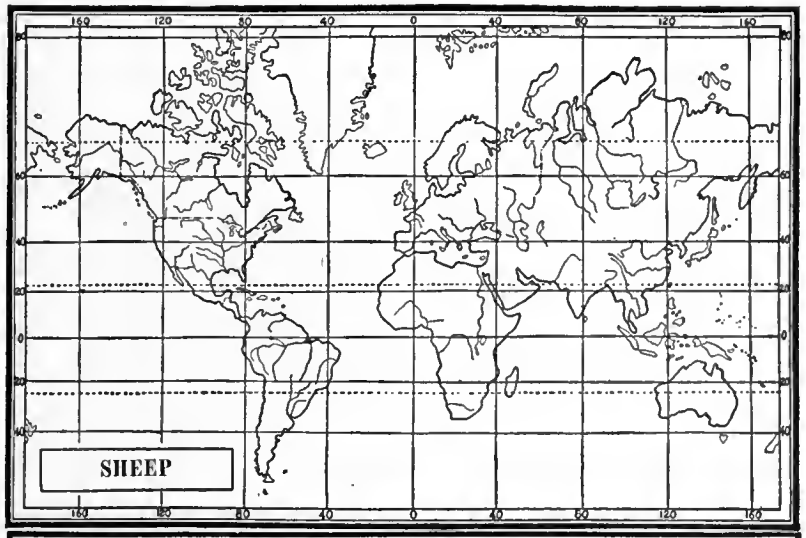
4. Indicate on another map the origin of our principal breeds of sheep, differentiating between the wool and the mutton breeds.

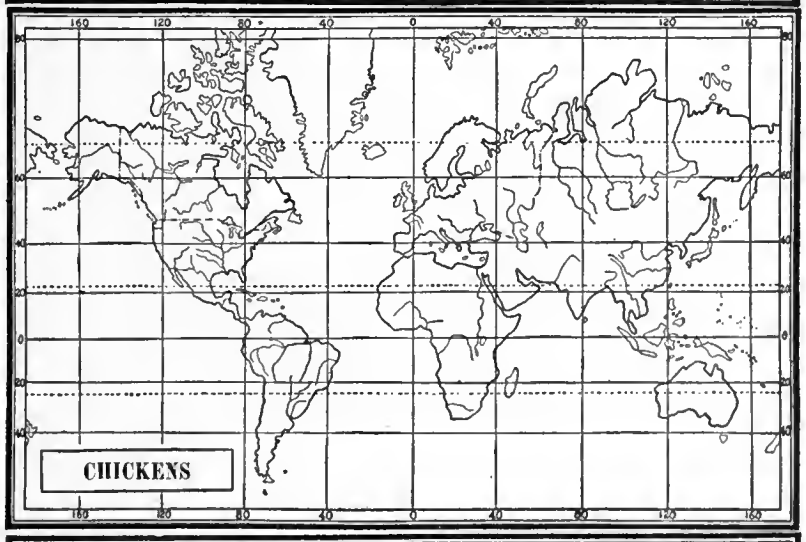
5. On another map show the origin of the important breeds of chickens, representing the heavy types by a different color from that of the light breeds.

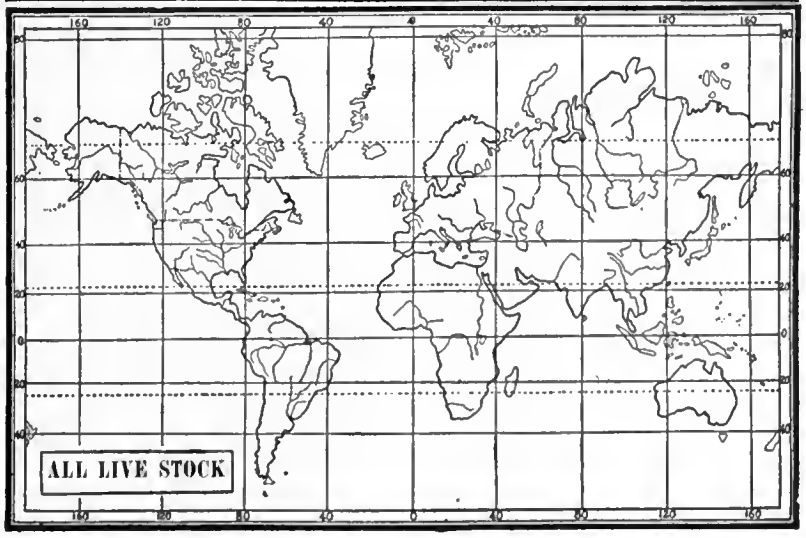
6. On a sixth map show the origin of all improved animals, indicating horses, cattle, and swine, etc., by different colors.

Questions. List the countries of the world and the improved breeds of live stock furnished by each. List the animals found on local farms. Where did each originate? Consult the yearbook of the United States Department of Agriculture and rank the countries as to the value of animal products. Rank the animals in the order of importance in your state; in your community. State why local farmers produce various classes of live stock.

References. WATERS, H. J. Essentials of Agriculture, pp. 330–339, 395–407. Ginn and Company. BAILEY, L. H. Encyclopedia of American Agriculture, Vol. 3, pp. 1–15. The Macmillan Company. SHALER, N. S. Domesticated Animals. Charles Scribner's Sons.







EXERCISE 70

JUDGING HEAVY HORSES

Object. To study in detail the points of importance in judging the value of a horse and to fix in mind the ideal market and breeding types. Also to train the eye in detecting weaknesses, defects, and blemishes, and to understand their importance in estimating the usefulness and selling value of horses.

Materials. Pictures of prize-winning horses clipped from live-stock journals and mounted on cards; stereopticon and slides; score card on opposite page; suitable animals for practice in judging.

Directions. The work should be begun by a study of the illustrations and by practice in locating on the living animal each of the most important parts. A study of the types and breed characteristics of horses is also necessary. Practice should be given in the use of the score card. Note how nearly each part conforms to the standard given; express judgment in writing of the worth of each part. It is well in the early exercises for the student to compare his score in detail with that made by his classmates and by the instructor.

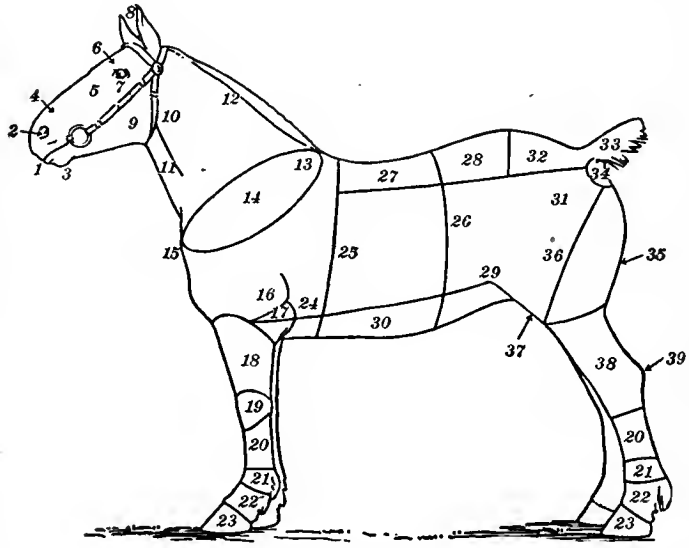


FIG. 107. The points in judging a horse

1, mouth; 2, nostril; 3, chin; 4, nose; 5, face; 6, forehead; 7, eye; 8, ear; 9, lower jaw; 10, throatlatch; 11, windpipe; 12, crest; 13, withers; 14, shoulder; 15, breast; 16, arm; 17, elbow; 18, forearm; 19, knee; 20, cannon; 21, fetlock joint; 22, pastern; 23, foot; 24, fore flank; 25, heart girth; 26, coupling; 27, back; 28, loin; 29, rear flank; 30, belly; 31, hip; 32, croup; 33, tail; 34, buttocks; 35, quarters; 36, thigh; 37, stifle; 38, gaskin or lower thigh; 39, hock

Comparative or competitive judging. The use of the score card is preliminary to the more practical method of judging — that of taking in with the eye, quickly and accurately, the general conformation of an animal and forming a sound judgment as to the comparative worth of a number of animals presented in competition. At the beginning of competitive judging it is well to limit the number to three or four animals and whenever possible to choose animals that have obvious differences in form and value. Students, working independently and without conversation, should be required to place the animals in the order of their worth and to give written reasons for their placings. After the work is completed the fullest discussion should be had and the teacher should offer constructive criticism of the work.

Judging contests. Contests between high-school teams in judging the principal classes of live stock, either at the farm of some prominent breeder or at the local or state fair, will be of much value in stimulating interest in live-stock production and in developing school spirit.

Questions. How do we measure the height of horses? What are the advantages of a medium sloping shoulder? or of a close back coupling? of a medium sloping pastern? Describe accurately the kind of foot desired on heavy horses, and why. Name the breeds of draft horses. Name and describe the market classes of heavy horses and state the uses of each. Has the use of the farm tractor and auto truck affected the use of this type of horses, and how? What breeds of draft horses predominate in your neighborhood?

References. WATERS, H. J. Essentials of Agriculture, pp. 330–352. Ginn and Company. GAY, C. W. Productive Horse Husbandry, pp. 139–144. J. B. Lippincott Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 301–325. R. G. Adams and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 92–97. Ginn and Company.

EXERCISE 70 (*Continued*)

SCORE CARD FOR DRAFT HORSES

Scale of Points	Score		
	Possible	Student's	Corrected
Age, estimated..... yr., actual..... yr.			
GENERAL APPEARANCE — 26 Points			
Height: estimated..... hands; actual..... hands	1		
Weight: over 1600 lb. in good condition; estimated..... lb., score according to age	5		
Form: broad, massive, symmetrical, blocky	4		
Quality: refined; bone clean, large, strong; tendons clean, defined, prominent; skin and hair fine; "feather," if present, silky	4		
Action: energetic, straight, true, elastic; walk, stride long, quick, regular; trot free, balanced, rapid	10		
Temperament: energetic; disposition good	1		
Style: stylish and graceful carriage	1		
HEAD AND NECK — 8 Points			
Head: proportionate size, clean-cut, well-carried; profile straight	1		
Muzzle: neat; nostrils large, flexible; lips thin, even, firm	1		
Eyes: full, bright, clear, large, same color	1		
Forehead: broad, full	1		
Ears: medium size, tapering, well-carried, alert	1		
Lower jaw: angles wide, space clean	1		
Neck: medium length, well-muscled, arched; throatlatch fine; windpipe large	2		
FORE QUARTERS — 23 Points			
Shoulders: long, moderately sloping, heavily and smoothly muscled, extending into back	3		
Arms: short, heavily muscled, thrown back, well-set	1		
Forearm: long, wide, clean, heavily muscled	2		
Knees: straight, wide, deep, strong, clean, well-supported	2		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: moderate slope and length, strong, clean	3		
Feet: large, even size, sound; horn dense, waxy; soles concave; bars strong, full; frog large, elastic; heels wide, strongly supported	7		
Legs: viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot; from the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and the back of the hoof	2		
BODY — 10 Points			
Withers: moderate height, smooth, extending well back	1		
Chest: deep; breastbone low; girth large	2		
Ribs: deep, well-sprung, closely ribbed to hip	2		
Back: broad, short, strong, muscular	2		
Loin: broad, short, heavily muscled	2		
Underline: long, low; flanks well let down	1		
HIND QUARTERS — 33 Points			
Hips: broad, smooth, level	2		
Croup: long, wide, heavily muscled, not markedly drooping	2		
Tail: attached high, well-carried	1		
Thighs: deep, broad, heavily muscled	2		
Quarters: deep, heavily muscled	2		
Stifles: clean, strong	2		
Gaskins (lower thighs): long, wide, heavily muscled	2		
Hocks: large, strong, wide, deep, clean	6		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: moderate slope and length, strong, clean	2		
Feet: large even size, sound; horn dense, waxy; soles concave; bars strong, full; frog large, elastic; heels wide, strongly supported	6		
Legs: viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, and foot; from the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle, and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	3		
Total	100		

EXERCISE 71

JUDGING LIGHT HORSES

Object. To fix clearly in mind the conformation peculiar and desirable to each type of harness horse, and of the saddle horse. To accomplish this the student must first learn the history of the development of each type, and know the uses of each.

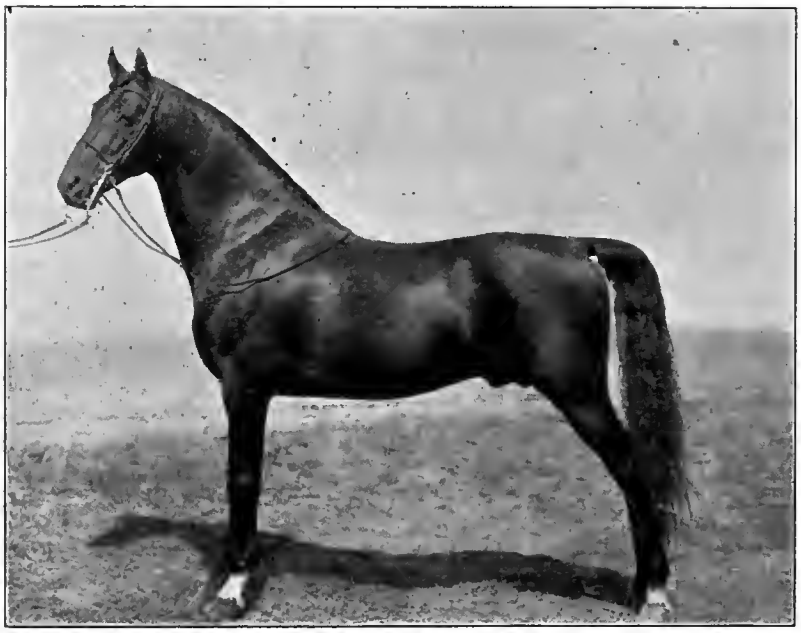


FIG. 108. A grand champion saddle horse

Materials. Charts showing the names of the parts of a horse; pictures of prize-winning animals of each class clipped from live-stock journals; stereopticon and slides; score card on opposite page and suitable animals for judging.

Directions. After a careful study of the draft horse, it will be less difficult to judge the other classes of horses. The parts are named the same, defects occur in common, and indications of constitution and quality are similar. The differences are those which fit the animals for their particular work: in the draft horse, pulling power; in the heavy horse, style, action, and conformation; in the light harness horse, style, action, speed, and endurance; in the saddle horse, gaits, style, temperament, and carrying strength; in ponies, style and tractable disposition.

Score the animals of the different classes according to the points which are outlined in the score card. Compare your own score card with the score cards of your classmates, and also with that of your instructor. Does your score differ from theirs?

Discuss fully the points wherein your score varies with that of the instructor or of the other students.

Questions. Name the breeds of light horses and write a brief sketch of the origin, distribution, and present uses. How has the automobile affected the use and value of light horses? What are the factors of first importance in light horses? How many light horses are there in your neighborhood, and to what use are they being put? Are there fewer or more than there were ten years ago? Why?

References. WATERS, H. J. Essentials of Agriculture, pp. 330–350. Ginn and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 7–92. Ginn and Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 352–372. R. G. Adams and Company. GAY, C. W. Productive Horse Husbandry, pp. 144–148. J. B. Lippincott Company.

FIG. 109. The Shetland pony, Locust, which sold for over $2000, the highest price in the history of the breed

EXERCISE 71 (*Continued*)

SCORE CARD FOR LIGHT HORSES[1]

Scale of Points	Score		
	Possible	Student's	Corrected
Age: estimated..... yr., actual ..... yr.			
GENERAL APPEARANCE — 28 Points			
Weight: estimated..... lb.; actual ..... lb.			
Height: estimated ..... hands; actual ..... bands	2		
Form: symmetrical, smooth, stylish	4		
Quality: refined; bone clean, fine; tendons clean, defined; hair and skin fine	4		
Action: energetic, straight, true, elastic; walk, stride long, quick, regular; trot, free, balanced, rapid	15		
Temperament: active; disposition good; carriage stylish	3		
HEAD AND NECK — 8 Points			
Head: proportionate size, clean-cut, well-carried; profile straight	1		
Muzzle: neat; nostrils large, flexible; lips thin, even, firm	1		
Eyes: full, bright, clear, large, same color	1		
Forehead: broad, full	1		
Ears: medium size, tapering, well-carried, alert	1		
Lower jaw: angles medium wide, space clean	1		
Neck: long, well-muscled, arched; throatlatch fine, clean; windpipe large	2		
FORE QUARTERS — 23 Points			
Shoulder: long, sloping, smoothly muscled, extending into back	3		
Arms: short, strongly muscled, thrown back, well-set	1		
Forearm: long, wide, clean, strongly muscled	2		
Knees: straight, wide, deep, strong, clean, strongly supported	2		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: long, sloping, strong, clean	3		
Feet: medium and even size, sound; horn dense, waxy; soles concave; bars strong, full; frog, large, elastic; heels wide, strongly supported	6		
Legs: viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot; from the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and the back of the hoof	3		
BODY — 10 Points			
Withers: moderate height, smooth, extending well back	1		
Chest: deep, wide; breastbone low; girth large	2		
Ribs: deep, well-sprung, closely ribbed to hip	2		
Back: broad, short, strong, muscular	2		
Loins: broad, short, strongly and smoothly muscled	2		
Underline: long, low; flanks well let down	1		
HIND QUARTERS — 31 Points			
Hips: broad, smooth, level	2		
Croup: long, wide, muscular, not markedly drooping	2		
Tail: attached high, well-carried	1		
Thighs: deep, broad, strongly muscled	2		
Quarters: deep, heavily muscled	1		
Stifles: strong, clean, muscular	2		
Gaskins (lower thighs): long, wide, strongly muscled	2		
Hocks: large, strong, wide, deep, clean	6		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: long, sloping, strong, clean	3		
Feet: medium and even size, sound; horn dense, waxy; soles concave; bars strong, full; frog, large, elastic; heels wide, strongly supported	4		
Legs: viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, and foot; from the side, a perpendicular line from the hip joints should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	3		
Total	100		

[1] For saddle horses the light-horse score card should be used, including, under Action, the five gaits; namely, walk, canter, rack, fox trot, and slow pace or running walk. For coach horses it should be remembered that high and stylish action are preferable to speed.

EXERCISE 72

BLEMISHES, UNSOUNDNESSES, FAULTS, AND VICES IN HORSES

Statement. In judging a horse both unsoundness and conformation are vitally important and largely determine the placing the animal receives. Horses have many defects which lessen their value to a greater or less degree. Some of the important defects are listed below.

1. *Blemish.* A healed injury of the skin or of the parts immediately underlying it. Example: Scars as a result of wire cuts.

2. *Unsoundness.* Any condition that interferes with the animal's usefulness or which will make the animal less useful in the course of time. The following forms are recognized:

a. Temporary unsoundness. A condition amenable to treatment and without leaving after-effects. Example: Lameness as the result of a nail puncture.

b. Permanent unsoundness. A condition which interferes with, or may at any time interfere with, the natural usefulness of the animal. Example: a bone spavin.

c. Serviceably sound. This means that the animal is sound, but may carry a blemish, such as a scar, which does not and will not interfere with its usefulness.

3. *Defect.* This term refers more to a bad form with which the animal was born, though at times it may be an acquired condition. Two varieties are usually recognized:

a. Absolute defect. This may be as serious as an unsoundness and decrease the value of an animal for all forms of service. Example: very narrow chest or small nostrils.

b. Relative defect. Such a defect disqualifies for certain forms of service only. Examples: a straight shoulder on a horse intended for speed, or a sway-back on a horse intended for carrying heavy loads.

4. *Vices.* These are mental rather than physical defects. The term "fault" is sometimes used to designate a mild vice, as halter pulling, while a true vice, such as kicking or running, makes the animal more or less unserviceable or dangerous.

Object. To recognize the above defects readily.

Materials. Horses showing examples of the various unsoundnesses and blemishes.

Directions. Invite the local veterinarian to hold a clinic at the school and ask him to secure typical examples of as many important blemishes and unsoundnesses as possible for student practice in locating and recognizing them. Classify all unsoundnesses as temporary, permanent, and serviceably sound. Classify all defects as absolute or relative. Use the following outline in making your classification:

FIG. 110. Types of blemishes, defects, and unsoundness

From left to right defects are indicated by x: bog spavin; bone spavin; splint; thoroughpin; curb; ringbone; sidebone. (Courtesy of the Bureau of Animal Industry, United States Department of Agriculture)

EXERCISE 72 (*Continued*)

LOCATION AND CLASSIFICATION OF COMMON UNSOUNDNESSES

The name of the unsoundness is given opposite the place where it occurs, and in addition, in so far as possible, all blemishes are indicated by the abbreviation "bl."; temporary unsoundnesses by "t. un."; permanent unsoundness by "p. un."; serviceably sound by "s. s."; absolute defects by "ab. d."; relative defects by "rel. d."; faults by "f."; and vices by "v." The list deserves careful study, in the beginning of judging work, both with the aid of charts and diagrams and with animals.

WHAT TO LOOK FOR
I. Head
1. Region of the poll:
a. Poll evil (t. un.)
b. Scars of previous operations (bl.)
2. Eyes:
a. Blindness (p. un.)
b. Blue-eyed
3. Ears:
a. Overmobile indicates
(1) Viciousness (v.)
(2) Nervousness (f.)
(3) Blindness (ab. d.)
b. Immobile indicates
(1) Deafness (p. un.)
(2) Sluggishness (rel. d. or f.)
(3) Lockjaw (t. un. or p. un.)
4. Nostrils:
a. Discharge indicates
(1) Catarrh (t. un.)
(2) Glanders (p. un.)
(3) Diseased molars (t. un.)
b. Signs of
(1) Roaring (p. un. or s. s.)
(2) Heaves (p. un.)
5. Muzzle and lips:
a. Bit sores (bl.)
6. Teeth:
a. Diseased molars (bl. or p. un.)
b. "Bishoped" (bl.)
c. "Parrot" mouth (ab. d. or rel. d.)
d. Undershot jaw (ab. d. or rel. d.)
7. Tongue:
a. Mutilation — end cut off to prevent lolling (bl. or p. un.)
II. Neck
1. Upper border:
a. Broken crest (bl.)
b. Braided mane
2. Lower border:
a. Roaring (p. un. or s. s.)
b. Broken windpipe (bl. or p. un.)
3. Sides:
a. Unilateral functionless jugular vein (bl.)
b. Bilateral functionless jugular vein

WHAT TO LOOK FOR
III. Back
1. Withers:
a. Fistula (t. un. or p. un.)
IV. Tail
1. Tail:
a. Unhealed docked end (bl.)
b. False tail attached
c. Lateral curvation (a.)
d. Limp or paralyzed tail (rel. d. or p. un.)
V. Fore limb
1. Shoulder:
a. Collar boils (bl. or t. un.)
b. Sweeney (bl. or t. un.)
c. Abscess or fistula (t. un. or p. un.)
2. Elbow:
a. Shoe boil (bl. or t. un.)
3. Knee:
a. High splint (p. un.)
b. Broken knee
c. Buck knee (ab. d.)
d. Calf knee (ab. d.)
e. Capped knee (bl., t. un., or p. un.)
4. Cannon:
a. Splints (bl., t. un., or p. un.)
b. Thick tendons (bl., t. un., or p. un.)
c. Grease heel or scratches (bl. or t. un.)
d. Scars of unnerving to prevent lameness due to ringbone (s. s.)
5. Fetlock:
a. Windgalls (bl. or s. s.)
b. Interfering sores (bl.)
c. Cocked ankles (ab. d.)
d. Grease heel or scratches (bl. or t. un.)
6. Pasterns:
a. High ringbone (p. un. or s. s.)
b. Scars or unnerving, to prevent lameness due to navicular disease (s. s.)

WHAT TO LOOK FOR
7. Coronets:
a. Sidebone (p. un. or s. s.)
b. Quittor (t. un.)
c. Low ringbone (p. un. or s. s.)
8. Feet:
a. Navicular disease (p. un. or s. s.)
b. Founder (t. un. or p. un.)
c. Toe cracks (t. un.)
d. Quarter cracks (t. un.)
VI. Hind limbs
1. Hips:
a. Broken ilium (t. un.)
b. "Knocked down" hips (p. un.)
2. Stifle:
a. Dislocated petells or stifle (t. un. or p. un.)
b. Dropsical swelling (p. un. or s. s.)
3. Hocks:
a. Thoroughpin (p. un. or s. s.)
b. Curb (bl., t. un., p. un., or s. s.)
c. Spavin:
(1) Bone (p. un. or s. s.)
(2) Bog (p. un. or s. s.)
d. Capped hock (bl., t. un., or p. un.)
VII. General diseases
1. St. Vitus' dance (p. un.)
2. Crampiness (t. un. or p. un.)
3. Stringhalt (t. un. or p. un.)
4. Roaring (p. un. or s. s.)
5. Heaves (p. un.)
VIII. Faults
1. Cribbing (f.)
2. Wind sucking (f)
3. Halter pulling (f.)
4. Shying (f.)
5. Rolling in stall (f.)
IX. Vices
1. Balking (v.)
2. Biting (v.)
3. Kicking (v.)
4. Running away (v.)

Questions. Upon what will the importance of an unsoundness depend? What defects may a horse show and still render excellent service? What is the relation of conformation to the possible occurrence of unsoundness? What will be likely to occur to a draft colt having a narrow, light-boned hock?

References. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 298–394. R. G. Adams and Company. How to Select a Sound Horse, *Farmers' Bulletin 779*, United States Department of Agriculture. CRAIG, R. A. Common Diseases of Farm Animals, pp. 143–200. J. B. Lippincott Company.

EXERCISE 73

JUDGING MULES

Object. To study systematically the conformation of the mule; to develop ability to select animals that are efficient machines, and to detect and evaluate imperfections.

Materials. Illustrations and charts showing the parts of a mule; pictures of good individuals clipped from live-stock journals; score card on opposite page, and available animals for judging.

Directions. Since the mule is essentially a draft animal for use under conditions which require both strength and agility, the chief points in judging relate to size, weight, and action. Mules should be somewhat more rangy than horses. Plenty of bone is an essential point and a clean cut head and neck is to be looked for. Note carefully the temperament of mules as it is quite important for the comfort and convenience of those who are to use them. Study the parts of the animal and score the various animals available in accordance with the rules given in the score card on the following page. Note that the work is very similar to scoring horses and should occasion but little difficulty if the horse has been carefully studied. Judge two or more animals in competition and place them according to their worth. Give reasons in each case. Opportunities for comparative judging are present at almost any time, as a team of animals will do for the work and can usually be found. The eye should be trained to see the excellences and the deficiencies of an animal almost at a glance. Such skill can only be acquired by constant practice in comparative judging. The habit of "sizing up" every animal one sees should be formed early. The degree to which the members of work teams match in size, color, conformation, and action should be observed. The animals which show evidences of thrift should be noted and compared with those which are always unthrifty.

FIG. 111. A champion pair of mules

Questions. What are the market classes of mules? What are the specifications as to height, weight, and type of each? To what uses is each adapted? What is the relative value of each class in your local market? Where are the principal mule markets of the United States? In what condition are mules most readily salable, and why? What is the predominant type of mule produced and used in your neighborhood? At what age is the mule put to work? At what age is he at his prime? At what age does he usually begin to decline in value? How does the mule compare with the horse in its capacity to withstand hardship?

References. WATERS, H. J. Essentials of Agriculture, pp. 339–349. Ginn and Company. GAY, C. W. Productive Horse Husbandry, pp. 309–314. J. B. Lippincott Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 413–418. R. G. Adams and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 161–167. Ginn and Company.

EXERCISE 73 (*Continued*)

SCORE CARD FOR MULES

Scale of Points	Score		
	Possible	Student's	Corrected
Age: estimated ..... yr., actual ..... yr			
GENERAL APPEARANCE — 26 Points			
Height: 16 hands or over; estimated .... actual	3		
Weight: 1200 to 1600 lb. in good condition; estimated ..... lb., score according to age	3		
Form: broad, massive, symmetrical, blocky	4		
Quality: bone clean, large, strong; tendons defined; skin and hair fine	6		
Action: energetic, straight, true, elastic; walk, stride long, quick, regular; trot, free, balanced, rapid	8		
Temperament: active, good disposition; stylish carriage	2		
HEAD AND NECK — 9 Points			
Head: proportionate size, clean-cut, well-carried; profile straight or slightly Roman-nosed	1		
Muzzle: neat; nostrils large, flexible; lips thin, even, firm	1		
Eyes: full, bright, clear, large, same color	1		
Forehead: broad, full	1		
Ears: large, tapering, fine texture, well-carried, alert	2		
Lower jaw: angles wide, space clean	1		
Neck: medium length, well-muscled, arched; throatlatch fine; windpipe large	2		
FORE QUARTERS — 22 Points			
Shoulders: long, moderately sloping, heavily and smoothly muscled, extending into back	2		
Arms: short, heavily muscled, thrown back, well-set	1		
Forearm: long, wide, clean, heavily muscled	2		
Knees: straight, wide, deep, strong, well-supported	2		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: moderate slope and length, strong, clean	3		
Feet: large, even size, sound; horn dense, waxy; soles concave; bars strong, full; frog large, elastic; heels wide and strongly supported	6		
Legs: viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot; from the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and the back of the hoof	3		
BODY — 10 Points			
Withers: moderate height, smooth, extending well back	1		
Chest: deep, wide; breastbone low; girth large	2		
Ribs: deep, well-sprung, closely ribbed to hip	2		
Back: broad, short, strong, muscular	2		
Loin: broad, short, heavily muscled	2		
Underline: long, low; flank well let down	1		
HIND QUARTERS — 33 Points			
Hips: broad, smooth, level	2		
Croup: long, wide, heavily muscled, not markedly drooping	2		
Tail: attached high, well-carried	1		
Thighs: deep, broad, strong, heavily muscled	2		
Quarters: deep, heavily muscled	2		
Stifles: strong, clean, muscular	2		
Gaskins (lower thighs): long, wide, clean; tendons large, heavily muscled	2		
Hocks: large, strong, wide, deep, clean	7		
Cannons: short, wide, clean; tendons large, clean, and well-defined, set back	2		
Fetlocks: wide, straight, strong, clean	1		
Pasterns: moderate slope and length, strong, clean	2		
Feet: large, even size, sound; horn dense, waxy; soles concave; bars strong, full; frog large, elastic; heels wide and strongly supported	5		
Legs: viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, and foot; from the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	3		
Total	100		

EXERCISE 74

JUDGING BEEF CATTLE

Object. To study the factors determining the value of beef cattle from the standpoint of the breeder, feeder, and butcher; to study the proportion and general symmetry of an animal so as to form an accurate judgment regarding its size, weight, condition, quality, and general conformation.

FIG. 112. Poor type of feeder

This steer is lacking in depth of body and expanse of stomach characteristic of the better type of feeder

FIG. 113. Shorthorn steer — Merry Monarch

Grand champion steer at the International Livestock Exposition in 1917. Fed and exhibited by Purdue University

Materials. Pictures of good types of animals clipped from live-stock journals and mounted on cards; stereopticon and slides; score card on opposite page; suitable animals for judging.

Directions. Observe carefully the illustrations showing the parts of a beef animal and be able to locate the parts on the animal before beginning the judging. Beef cattle are judged by both the eye and the hand. The eye determines the form, symmetry, size, color; the hand determines the thickness

FIG. 114. Hereford steer — California Favorite

Grand champion steer at the International Livestock Exposition of 1916. Bred, fed, and exhibited by the University of California

FIG. 115. Aberdeen Angus steer — Victor

Grand champion at the International Livestock Exposition in 1911. Fed and exhibited by the Iowa State College

of flesh, pliability and looseness of the skin, and the texture of the hair. In judging the covering run the tips of the fingers along the backbone, the loin, shoulder top and side, and the tail-head, which are the parts least likely to be well covered. Test the quality of the skin by picking up a roll over the back rib while the animal's head is held directly forward.

In judging a beef animal the standpoint from which it is judged is of much importance. Check the ten most important items in the score card from the standpoint of the breeder; of the feeder; of the

butcher. Give a verbal description of how a good feeder should appear. Contrast it with the type that makes a poor feeder in stomach capacity, hair coat, mellowness of the skin, etc.

The score card is not a set of rules. It is intended to help pupils to form an opinion and make their judgment of the worth of an animal correct. After a pupil has become familiar with the points to be considered and their relative worth he should undertake comparative judging. Constant observation and practice in comparative judging will enable a student to place an exhibit of animals without recourse to the score card. Practical judging resolves itself into the problem of weighing one fault against another and comparing one virtue with another and quickly estimating values. Place an exhibit of animals and give oral reasons for your placings.

Questions. Name the qualities in a beef animal which the butcher most desires; those which the cattle producer emphasizes most. What is meant by quality in beef cattle? How may it be detected? What does a lustrous hair coat denote? What part of the carcass brings the highest price? What the lowest price? What part of the body is last to be covered with fat? How do you determine the degree of fatness in beef cattle?

References. WATERS, H. J. Essentials of Agriculture, pp. 381–392. Ginn and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 169–175. Ginn and Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 19–51. R. G. Adams and Company.

SCORE CARD FOR BEEF CATTLE

STANDARD OF EXCELLENCE	SCORE				
	Possible	Student's		Corrected	
		No. 1	No. 2	No. 1	No. 2
Weight: estimated ..... lb., according to age	10				
Form: straight top line and underline; deep, broad, low-set; compact, symmetrical	10				
Quality: hair fine; bone firm but strong; skin pliable; mellow, even covering of firm flesh, especially in region of valuable cuts; absence of ties and rolls	10				
Condition: prime; flesh deep; evidence of finish especially marked in cod, at tail-head, flank, shoulder, and throat; absence of ties or rolls	10				
Head: clean-cut, symmetrical; quiet expression; mouth and nostrils large, clear, and placid; face short; forehead broad, full; ears medium size, fine texture, erect	5				
Neck: thick, short, tapering neatly from shoulder to head; throat clean	2				
Shoulder vein: full	2				
Shoulder: well covered with flesh; compact	3				
Brisket: full, broad but not too prominent; breast wide	1				
Dewlap: skin not loose and drooping	1				
Chest: deep, wide, full	1				
Crops: full, thick, broad	3				
Ribs: long, arched, thickly fleshed	8				
Back: broad, straight, thickly and evenly fleshed	8				
Loin: thick, broad; thickness extending well forward	8				
Flank: low and full	2				
Hooks: smoothly covered; width in proportion to other parts, but not prominent	3				
Rump: long, level, wide, and even; tail-head smooth, not patchy	2				
Pin bones: not prominent, width in proportion with other parts	1				
Thighs: full, fleshed well down to hock	4				
Twist: deep, full; purse full	4				
Legs: straight, short; arm full; shank fine, smooth	2				
Total	100				

Animal .....

Student ..... Date .....

EXERCISE 75

JUDGING THE DAIRY COW

Object. To learn how to select a profitable dairy cow by her form, temperament, and handling qualities. It is possible with proper education and experience to determine by these means, and with very few mistakes, whether a cow is a good, medium, or poor dairy cow. Fine distinctions can be made only by weighing and testing the milk for a year.

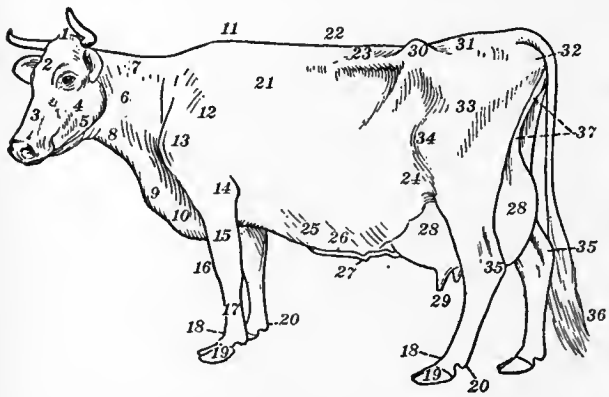


FIG. 116. Outline of a dairy cow with parts named

1, poll; 2, forehead; 3, bridge of nose; 4, cheek; 5, jaw; 6, neck; 7, crest of neck; 8, throat; 9, dewlap; 10, brisket; 11, withers; 12, shoulder; 13, point of shoulder; 14, elbow; 15, arm or forearm; 16, knee; 17, shank; 18, ankle; 19, hoof; 20, fetlock; 21, crop; 22, chine (back); 23, loin; 24, flank; 25, milk well; 26, mammary vein or milk vein; 27, navel; 28, udder; 29, teats; 30, hook (or hook bone) hips; 31, pelvic arch; 32, pin bone or rump bone; 33, thigh; 34, stifle; 35, hock; 36, switch or brush of tail; 37, escutcheon

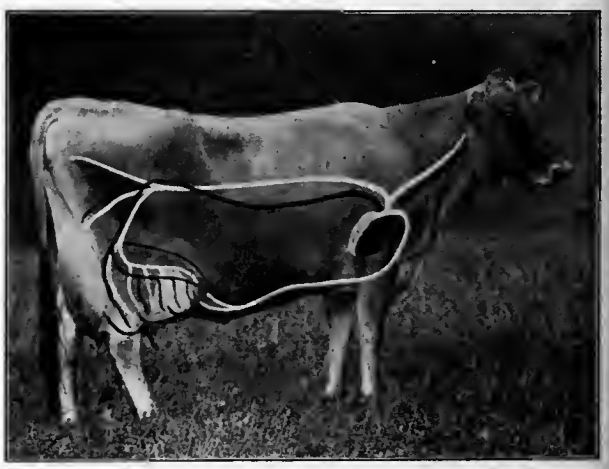


FIG. 117. Arteries (in white) leading from the heart to the udder, and veins (in black) leading from the udder to the heart

Materials. Charts; pictures; score cards; dairy cows. Whenever possible, cows whose milk or butter records are known should be used so that a check may be had on the student's judgment.

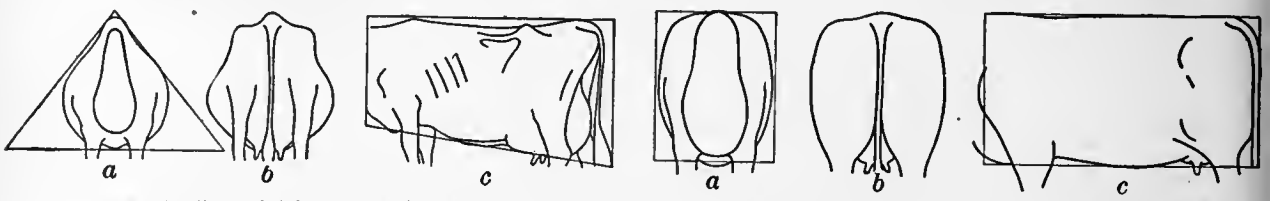


FIG. 118. Outlines of dairy and beef types compared *a*, front view; *b*, back view; *c*, side view. U. S. Dept. of Agriculture

Directions. First become acquainted with the parts of the cow mentioned in the score card and be able to locate them on the animal. A study of the illustrations followed by a study of the conformation of the animals will be helpful.

Score a number of dairy cows, then weigh and test the milk produced by each. Compare your judgment with that of the owner of the cows. Follow carefully the score card given on the next page.

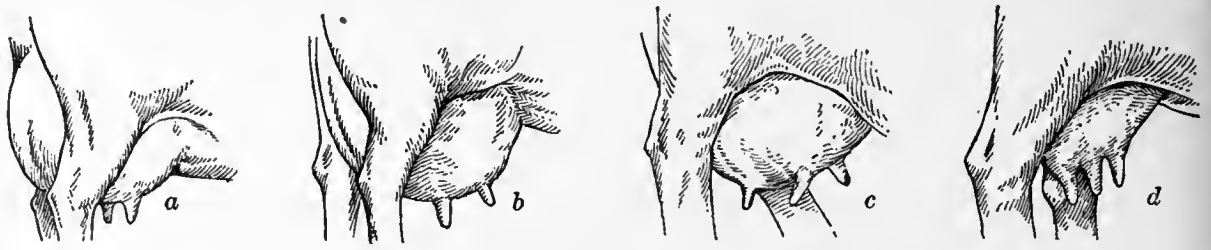


FIG. 119. Types of udders *a*, type of good udder; *b*, *c*, and *d*, types of poor udders. U. S. Dept. of Agriculture

References. WATERS, H. J. Essentials of Agriculture, pp. 353–364. Ginn and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 243–249. Ginn and Company. VAUGHAN, K. W. Types and Market Classes of Live Stock, pp. 113–131. R. G. Adams and Company.

EXERCISE 75 (*Continued*)

SCORE CARD FOR DAIRY CATTLE

Scale of Points	Score		
	Possible	Student's	Corrected
GENERAL APPEARANCE — 18 Points			
Form: inclined to be wedge-shaped	6		
Quality: hair fine, soft; skin mellow, loose, medium thickness; secretion yellow; bone clean, fine	6		
Temperament: nervous, indicated by lean appearance when in milk	6		
HEAD AND NECK — 7 Points			
Muzzle: clean cut; mouth large; nostrils large	1		
Eyes: large, bright, full, mild	1		
Face: lean, long; quiet expression	1		
Forehead: broad	1		
Ears: medium size, yellow inside, fine texture	1		
Horns: fine texture, waxy	1		
Neck: fine, medium length; throat clean; light dewlap	1		
FORE QUARTERS — 5 Points			
Withers: lean, thin	1		
Shoulders: light, oblique	2		
Legs: straight, short; shank fine	2		
BODY — 26 Points			
Chest: deep, low; girth large, with full foreflank	10		
Barrel: ribs broad, long, wide apart; large stomach	2		
Back: lean, straight, open-jointed	10		
Loin: broad	2		
Navel: large	2		
HIND QUARTERS — 44 Points			
Hips: far apart, level	2		
Rump: long, wide	2		
Pin bones: high, wide apart	1		
Tail: long, slim; fine hair in switch	1		
Thighs: thin, long	4		
Udder: long, attached high, and full behind, extending far in front and full, flexible; quarters even and free from fleshiness	22		
Teats: large, evenly placed	5		
Mammary veins: large, long, tortuous, branched, with double extension; large and numerous milk wells	5		
Legs: straight; shank fine	2		
Total	100		

SCORE CARD FOR DAIRY HEIFER CALVES

Scale of Points	Score		
	Possible	Student's	Corrected
Age————			
GENERAL APPEARANCE — 40 Points			
Weight: proportionate to age and breed Estimated ..... Actual	10		
Form: deep, long, wide; ribs well sprung; top and bottom lines parallel; rump long, level, and wide	10		
Quality: hair fine, bone clean and smooth and proportionate to body in size	10		
Disposition: active and alert	8		
Color: distinct and characteristic of brood	2		
CONSTITUTION AND HEALTH — 20 Points			
Skin: clean, pliable, and oily	6		
Nostrils: open	2		
Eyes: prominent and bright	2		
Heart girth: large, full at crops and fore flank	6		
Backbone: straight and strong	4		
CONDITION — 20 Points			
Body: medium well fleshed, indicative of dairy form	15		
Hair: fine, soft, and straight	5		
MILK ORGANS — 20 Points			
Well-developed indications of large and symmetrical udder	10		
Teats: good and even size and well placed	8		
Mammary veins: extending well forward as determined by wells	2		
Total	100		

EXERCISE 76

THE PRODUCTION RECORD OF A DAIRY HERD

Statement. Some dairy cows return a substantial profit to their owners. Others, receiving the same care, are kept at a loss. The one is a success, the other a failure. As we have already learned, we may judge the producing power of cows with considerable accuracy by their physical characteristics. However, it is not sufficiently accurate to discover to the owner which of his cows are most successful and which are failures. It is only by weighing and testing the milk of each cow for three days in the middle of each month for a year that this information can be obtained. This record may be kept by the farmer himself, by the agricultural student of the high school, or through the cow-testing association of which the farmer may be a member.

Object. To ascertain by means of an accurate milk, butter fat, and feed record the dairy value of each cow.

Materials. Cows to be tested; Babcock tester; scales; blank on opposite page.

Directions. A farmer had his herd tested by the high-school students, and the records of two of his cows were as follows:

One cow produced 16,355 pounds of milk, which contained 691.7 pounds of butter fat in a year. She consumed during the year 6590 pounds of silage, 1760 pounds of clover hay, and 2428 pounds of mixed grain. She was on pasture six months. Another cow produced in the same year 2466 pounds of milk, which contained 83.3 pounds of butter fat. She consumed in the year 5040 pounds of silage, 1494 pounds of clover hay, and 1328 pounds of mixed grain. She was also on pasture six months.

Compute, at the local market prices, the cost of the feed consumed by each animal, and the value of the milk and butter fat produced. Compute the return each cow made for each dollar invested in her feed. Compare the gross returns and gross profit from a herd of twenty such cows as the first one; from twenty such cows as the second one.

Questions. Is there a wide difference in the efficiency of the two cows tested as regards their ability to convert feed consumed into milk and butter fat? What did cow No. 1 do with a part of her feed that cow No. 2 did not do? How did cow No. 2 use the feed which did not go for milk production? Which of the two cows, No. 1 or No. 2, would you select as the better beef type of animal? Which is the better type of dairy animal?

Reference. ECKLES, C. H. Dairy Cattle and Milk Production, pp. 132–149. The Macmillan Company.

FIG. 120. The patriot and the slacker cow

The cow whose picture is shown at the left produced 691 pounds of butter fat in a year; the one whose picture is shown at the right, in the same herd and given the same care as the others, produced only 83 pounds of butter fat in one year. (Courtesy College of Agriculture, University of Wisconsin)

EXERCISE 76 (*Continued*)

RECORD FOR THE MONTH OF _____

		Cow No. 1	Cow No. 2	Cow No. 3	Cow No. 4	Cow No. 5	Cow No. 6
14	A.M. . . .						
	P.M. . . .						
15	A.M. . . .						
	P.M. . . .						
16	A.M. . . .						
	P.M. . . .						
Total							
Per day							
Total for month							
Per cent fat							
Total fat							
Value							

FEED RECORD

Cow Number	Date	Kinds of Feeds	Amounts	Value	Total Value per Month
1					
2					
3					
4					
5					

Fig. 121. Holstein Aaggie Acme of Riverside 2d, No. 164467

Fig. 122. Guernsey cow Langwater, *Dairymaid*

The cow shown in Fig. 121 had a record in three hundred and sixty-five days, of 24,682.7 pounds milk and 1331.41 pounds butter — the world's record in butter production for one year.

EXERCISE 77

JUDGING SWINE

Object. To learn the characteristics of the different breeds and types of hogs; to learn the adaptability of each to different conditions, and to acquire skill and accuracy in choosing those animals which most nearly conform to the ideal of their class and which will produce the greatest profit on the farm.

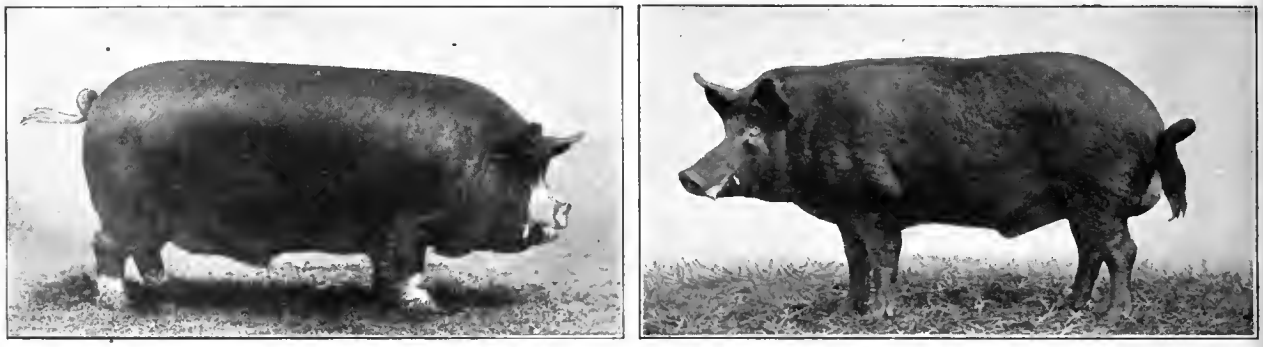


FIG. 123. The lard and bacon types compared

At the left a typical Berkshire boar which sold for $10,000. At the right a champion Tamworth boar

Materials. Pictures of prize-winning hogs clipped from live-stock journals and mounted on cards; stereopticon and slides; score card on opposite page; suitable animals for practice in judging.

Directions. A study of the type and breed characteristics of swine and of the score card and charts showing location of the different parts of the animal should be made before beginning judging practice. The student should be able to recognize readily the leading breeds of swine, and special emphasis should be placed upon those types and breeds which are of greatest importance in the community. Score several animals of each class.

One specimen should be as nearly perfect and in as nearly finished condition as possible, to serve as a type. The others may be of inferior type in one or more important particulars, to emphasize not alone the valuable qualities to be sought for but also to fix in the pupil's mind the more important deficiencies to be met with in judging swine.

At first the score card on the next page should be carefully followed and the ideals described applied to as many different animals as opportunity will permit. Later, opportunities for practice in competitive judging should be provided.

Questions. What are the principal differences in the type and uses of lard and bacon hogs? Sketch briefly the history, characteristics, and uses of the breeds of hogs common to the United States. What

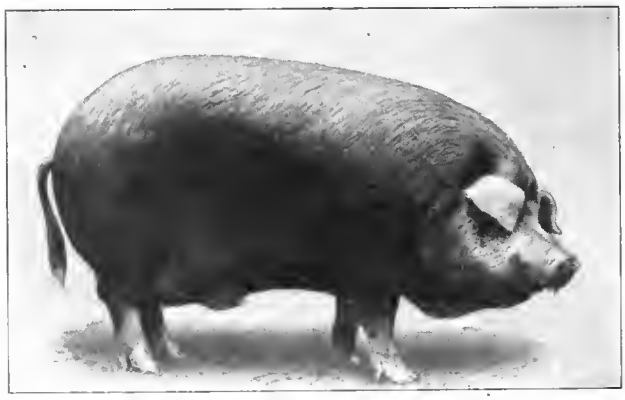


FIG. 124. Champion Duroc Jersey barrow at the International Livestock Exposition

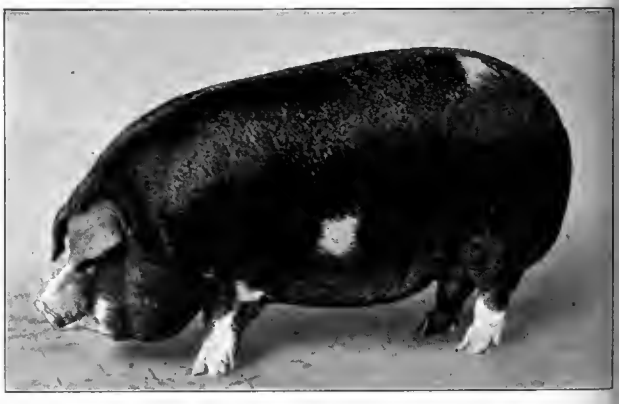


FIG. 125. Grand champion Poland China barrow at the International Livestock Exposition

is the approximate territory of each in the United States? At what age are pigs usually weaned, and at about what weight? At what age and at what weight are hogs usually marketed? What are the common diseases of swine in your locality, and how are some of the most important ones controlled?

References. WATERS, H. J. Essentials of Agriculture, pp. 395–401. Ginn and Company. DAY, G. E. Productive Swine Husbandry, pp. 9–22. J. B. Lippincott Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 467–554. Ginn and Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 237–256. R. G. Adams and Company.

SCORE CARD FOR FAT, OR LARD, HOGS

Scale of Points	Score		
	Possible	Student's	Corrected
GENERAL APPEARANCE — 32 Points			
Weight: according to age	2		
Estimated . . . . . Actual . . . . . pounds			
Form: deep, broad, low, symmetrical, compact, standing squarely on legs	10		
Quality: bone clean; hair silky; skin fine	10		
Condition: deep, firm, even covering flesh, giving smooth finish			
HEAD AND NECK — 6 Points			
Snout: medium to short, not coarse	1		
Eyes: full, mild, bright, large	1		
Face: short; cheeks, full; without wrinkles	1		
Ears: fine, medium size; soft, neatly attached	1		
Jowl: strong, neat, broad, full to the shoulders	1		
Neck: thick, short, broad on top	1		
FORE QUARTERS — 11 Points			
Shoulders: broad, deep, full, smooth, compact on top	5		
Breast: wide, roomy	2		
Leg: straight, short, strong, wide apart, well set	2		
Pasterns: strong, straight, upright	2		
BODY — 32 Points			
Chest: deep, broad, large girth	3		
Sides: full and smooth from hams to shoulders, close ribbed	6		
Back: broad, straight, thickly and evenly fleshed	9		
Loin: wide, thick	8		
Belly: straight, wide	4		
Flank: even with underline	2		
HIND QUARTERS — 19 Points			
Hips: smooth	2		
Rump: long, wide, level, well filled out	3		
Hams: heavily fleshed, deep, wide, thick	10		
Legs: straight, short, strong, wide apart, well set	2		
Pasterns: strong, straight, upright	2		
Total	100		

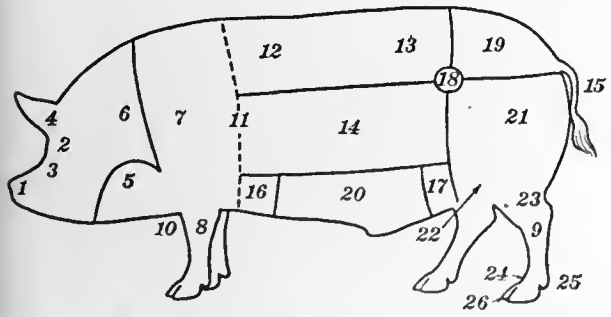


FIG. 126. A chart for teaching names of the parts of the hog

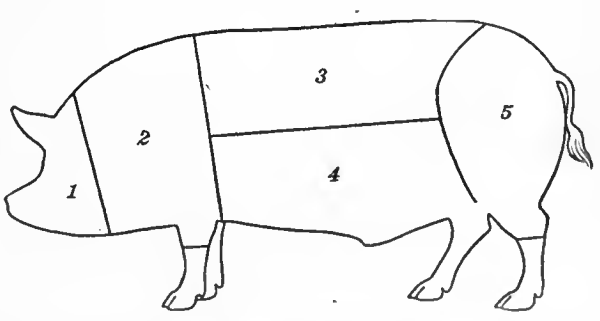


FIG. 127. Outline for chart for teaching wholesale cuts of pork

In Fig. 126, 1 denotes the snout; 2, eye; 3, face; 4, ear; 5, jowl; 6, neck; 7, shoulder; 8, foreleg; 9, hindleg; 10, breast; 11, chestline; 12, back; 13, loin; 14, side; 15, tail; 16, fore flank; 17, hind flank; 18, hip; 19, rump; 20, belly; 21, ham; 22, stifle; 23, hock; 24, pasterns; 25, dewclaws; 26, foot. In Fig. 127, 1 represents the head; 2, shoulder; 3, loin; 4, belly; 5, ham

EXERCISE 78

JUDGING SHEEP

Statement. Sheep may be classified according to type and breed or according to how they are sold on the market. According to types or breed, sheep are classified either as fine-wool type or as mutton type. According to market demands, sheep are classified as fat or mutton, feeders, or breeders.

Object. To become familiar with the classification of sheep and to be able to judge quickly and accurately the value and comparative worth of an animal.

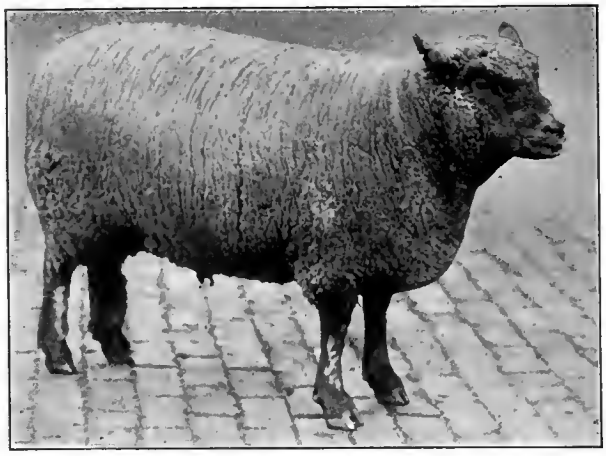


FIG. 128. The mutton type

The champion college-bred Southdown wether at the International Livestock Exposition. Bred and exhibited by the University of Obio

Material. Pictures of pure-bred sheep clipped from live-stock magazines and mounted on cards; stereopticon and slides; score card on opposite page; suitable animals for scoring.

Directions. In handling live sheep, seize them by the leg; never catch them by the fleece. The fleece is examined for quality over the heart, where the wool fibers are finest, on the lower outside part of the thigh, where the wool is coarsest, and at the mid-ribs, where the fiber is of medium fineness. Select a natural seam in the fleece, opening it with the backs of the two hands and pressing the fleece back so as to expose the fiber its full length and also to expose the skin, which should be inspected for color and condition.

Score animals at first according to the score card given on the next page and later judge a number of animals, in each case giving reasons for your placings.

Questions. Why has the sheep been called the animal with a "Golden Hoof"? In what important ways did the sheep help man on his way toward a civilized life? What are the distinctive types of sheep, in what respects do they differ, and where is each principally found? Of what service is the sheep in a system of clean farming? What pet animal most seriously interferes with the development of the sheep industry? What is the remedy? About how much wool is produced by a sheep in a year? What is its worth at your local market? What is the approximate live weight of the mutton sheep when mature? of the wool type? What breeds of sheep are most common in your neighborhood? Which is best adapted to local conditions? In what respects might the methods of handling sheep in the neighborhood be improved? Contrast the methods and results of one or two of the best sheep raisers of the neighborhood with those of the average, and write a statement showing the particulars in which general improvement of the average might be made.

FIG. 129. The fine-wool type. Rambouillet Ram "Laramie" and his world record fleece which weighed 46¼ pounds at fifteen months' growth

Owned by the Oklahoma Agricultural and Mechanical College

References. WATERS, H. J. Essentials of Agriculture, pp. 409–417. Ginn and Company. PLUMB, C. S. Types and Breeds of Farm Animals, pp. 333–455. Ginn and Company. VAUGHAN, H. W. Types and Market Classes of Live Stock, pp. 159–179. R. G. Adams and Company. GAY, C. W. The Breeds of Live Stock, pp. 327–380. The Macmillan Company.

EXERCISE 78 (*Continued*)

SCORE CARD FOR MUTTON SHEEP

Scale of Points	Score		
	Possible	Student's	Corrected
GENERAL APPEARANCE — 38 Points			
Weight: according to age	8		
Form: long, level, deep, broad, low-set, stylish	10		
Quality: bone clean-cut; hair silky; skin pink; offal light	10		
Condition, or Finish: covering deep, even, firm, free from patches; dock thick; purse and flank full; neck thick	10		
HEAD AND NECK — 6 Points			
Head: short, clean-cut; forehead broad and full; eyes large, clear; ears fine, alert; muzzle large; lips thin; nostrils large, open	4		
Neck: short, thick, free from folds; shoulder vein full	2		
FORE QUARTERS — 6 Points			
Shoulders: smooth, evenly covered, compact on top	4		
Brisket: broad, neat	1		
Legs: short, straight, wide apart; forearm full; shank smooth, fine	1		
BODY — 23 Points			
Chest: wide, deep, full	5		
Back: broad, long, straight, thickly covered; ribs well-sprung, close together	10		
Loin: broad, thick, long, strong	8		
HIND QUARTERS — 15 Points			
Hips: wide, level, smooth	2		
Rump: long, level, wide	4		
Thighs: deep, wide, full	4		
Twist: deep, full	4		
Legs: short, straight, wide apart; shank smooth, fine	1		
WOOL — 12 Points			
Quantity: long, dense, even	4		
Quality: pure, fine, uniform, free from dead or black fiber; crimp close, regular	4		
Condition: clean, bright, lustrous, sound, soft, light color; yolk plentiful	4		
Total			

FIG. 130. Yearling Shropshires

Winners of first prize at the Panama Pacific International Exposition. Bred and exhibited by San Ramon Rancho, San Ramon, California

EXERCISE 79

A STUDY OF THE CONSTITUTIONAL VIGOR IN FOWLS

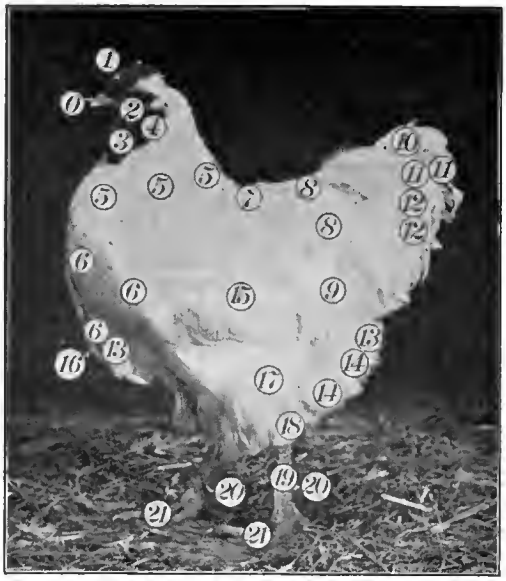


FIG. 131. A White Wyandotte cock, showing constitutional vigor

The points of a fowl are marked and are as follows: 0, beak; 1, comb; 2, face; 3, wattles; 4, ear lobe; 5, hackle; 6, breast; 7, back; 8, saddle; 9, saddle feathers; 10, sickle feathers of tail; 11, lesser sickles; 12, tail coverts; 13, body and fluff section; 14, fluff; 15, wing; 16, point of heel which is the division between the breast and the body and fluff sections; 17, thigh; 18, hack joint; 19, shank; 20, spur; 21, toes

Statement. Only fowls which have much constitutional vigor are good producers. All the organs of the body, especially those which have to do with digestion, respiration, and reproduction, and the nervous system which controls these organs, must be healthy.

Object. To learn to judge fowls in respect to their constitutional vigor.

Materials. Fowls to be judged; score card on page 159.

Directions. In accordance with the instructions given score a number of fowls. Indicate in the proper blank space the cuts given each part and explain by underlining the corresponding words, under Remarks.

1. Make a careful study of the actions and movements of the fowls to be judged, as these are probably the best indications we have of their physical condition. Fowls that are weak are likely to be inactive and dull, and more likely to sit than to stand. They seldom range to any extent in search of forage and do not scratch in search of feed.

The loudness and frequency of the crow of the male and the cackle of the female are indications of physical strength and superiority. Weak fowls seldom crow or sing.

2. Observe the form of the body for evidences of strength or weakness. The strong bird has a bright, prominent eye, a well-developed, blocky body, bright plumage, an erect carriage, bright comb and wattles, and should be active and sprightly in movement. A long neck, thin beak, narrow head, long, slender body, long legs and thighs, or a stilted appearance indicate lack of constitutional vigor.

3. In the young chick low vitality is indicated by a stunted growth, by slow feathering, a pronounced crowlike beak, drooping wings and head, and a low-squatting walk.

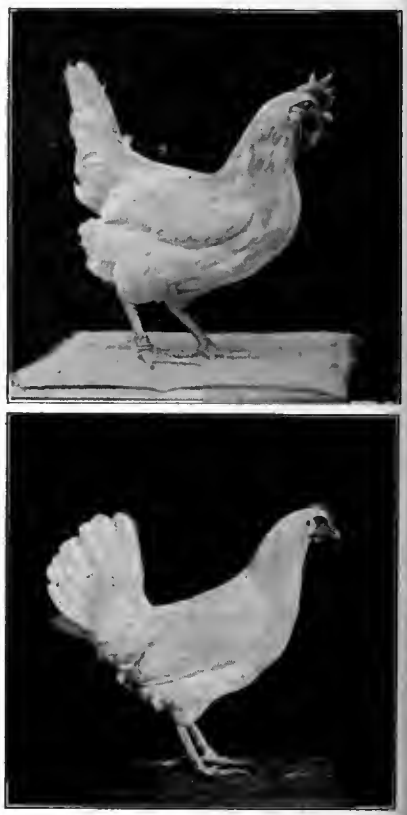


FIG. 132. A heavy- and a light-laying bird compared

The hen shown above is Lady Eglantine. She laid 314 eggs in one year and holds the world's record. The hen shown below laid 56 eggs in a year when well cared for. Notice the long straight beak of the poor layer as compared with the stout curved beak of Lady Eglantine; also the comparatively undeveloped comb and wattles of the poor layer and the lack of body capacity as compared with the world's record hen

Questions. Define and give the advantages of selection. What are some of the causes for lack of vigor in fowls? What are some of the signs of vitality and the lack of it? What does the action of a fowl indicate and how may it be judged?

References. LIPPINCOTT, W. A. Poultry Production, pp. 128–138. Lea and Febiger. LEWIS, H. R. Productive Poultry Husbandry, p. 256. J. B. Lippincott Company. *Bulletin 45*, Cornell Reading Course.

EXERCISE 79 (*Continued*)

STANDARD AND SCORE CARD FOR JUDGING CONSTITUTIONAL VIGOR IN FOWLS

	Value	Cut	Remarks
General appearance. The bird shall give the impression of strength and vigor. It shall be stylish in carriage and active in movement. The body must be compact and well balanced . .	15		Not strong, lacks style in carriage, not active, gangling, not symmetrical
Condition. The fowl shall be free from diseases or deformity and the plumage smooth, clean, and glossy	10		Diseased, deformed. Plumage rough, dirty, lacks luster
Head. Shape (4) The head should be carried well up and be broad, deep, and of medium length for the breed			Poorly carried, narrow, shallow, long
Beak (4) The beak shall be strong, stout, medium in length, well curved, and broad at its base			Beak wide, long, straight, narrow
Eyes (2) The eyes shall be strong, large, full, brilliant, and clear			Eyes weak, dull, sunken
Face (3) The face shall be full and bright red in color			Face lacks fullness, poor color
Comb and Wattles (6) The comb and wattles must be well developed, firm, smooth in texture, and bright red in color	19		Comb and wattles poorly developed, poor color, coarse, flabby
Neck. The neck should give the appearance of strength and be well arched and well feathered .	3		Weak, straight, poorly feathered
Back. The back shall be long and broad for the breed. It shall be flat at the shoulders and the width carried well back towards the tail. The oil gland at the base of the tail shall be well developed	10		Short, narrow, rounding. Oil gland not well developed
Wings. The wings shall be medium in size, well folded, and carried close to the body	2		Large, poorly folded, poorly carried
Tail. The tail shall be well feathered, well spread, and not drooped	2		Not well feathered, poorly spread, drooping
Breast. The breast shall be broad, full, and rounding	10		Narrow, peaked, sharp
Body and Fluff. This section shall be wide, deep, and long, showing evidence of capacity. The abdomen shall be well tucked up and firm. The keel shall be straight	14		Narrow, shallow, short, crooked keel. Abdomen flabby
Shanks. The shanks shall be stout, straight, and smooth	5		Rough, crooked, weak
Thighs. The thighs shall be stout, straight, well muscled and set well apart at the hip and hock joints	5		Weak, not parallel, poorly muscled, set too close together
Toes. The toes shall be stout, straight, and smooth. The nails shall be short, strong, and well worn .	5		Crooked, weak, rough. Nails long
Total	100		

EXERCISE 80

JUDGING EGGS

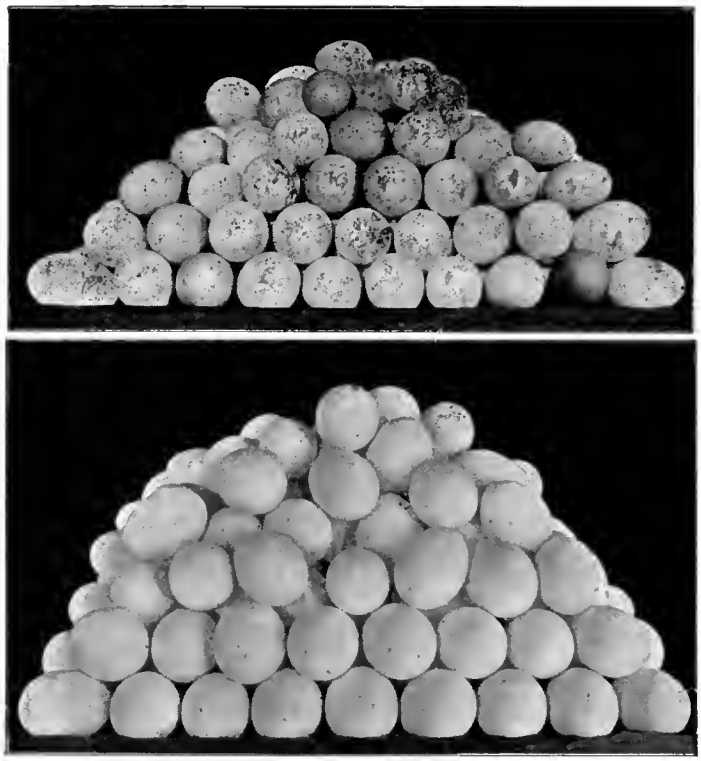


FIG. 133. Comparison of ungraded and graded eggs

Those shown above (ungraded) are not uniform in size, shape, or color, and many of them are soiled; those shown below (graded) are standard in size, color, form, and condition

Statement. Several million dollars are lost each year in the United States through the improper handling of eggs. It is only recently that we have begun to sell eggs according to grade and quality. This method of marketing eggs, together with the critical judging of eggs, will do much to educate people in the proper care of this important food material.

Object. To determine the market classifications and value of commercial eggs.

Materials. Eggs of different sizes, colors, shapes, and degrees of cleanliness and freshness for detailed study; a number of selected exhibits of a dozen eggs each, for comparative judging; a candling device.

Directions. 1. Study the explanations given in the score card on the following page and score exhibits in accordance with the plan given. After scoring exhibits compare your score with that of the instructor and fill out the corrected score column. Discuss fully the points wherein your score varies from that of the instructor.

2. Skill may be acquired in determining the freshness of eggs by means of the candling device. In the newly laid egg the contents completely fill the shell. When the egg has cooled a small air space is observable at the large end. As the egg grows older the space grows larger.

Questions. Why does the air space in an egg enlarge with age? What does this show regarding the porosity of the eggshell? At what temperature should eggs be kept? Can eggs be properly kept in contact with musty or unpleasant odors? Explain. In judging exhibits why is uniformity of size, shape, and color important? What happens if an egg is kept at a high temperature (100° F.) for a few days? for three weeks? Should eggs be washed? Explain what portion of the eggshell is removed by washing and how this affects the keeping quality of the egg.

FIG. 134. A convenient candling device

References. LIPPINCOTT, W. A. Poultry Production, pp. 463–480. Lea & Febiger. WATERS, H. J. Essentials of Agriculture, p. 431. Ginn and Company.

EXERCISE 80 (*Continued*)

SCORE CARD FOR EGGS

	Value	Cut				Remarks
Weight. One dozen eggs should weigh between twenty-four and twenty-six ounces	18					Too light, too heavy
Uniformity. The whole dozen shall be uniform in size and shape and color	6					Not even in color, size, or shape
Shell shape. The shell should be symmetrical with reference to the longitudinal axis. It shall be oval in general outline but distinctly more pointed at one end than at the other. It shall be free from ridges or roughness .	6					Same size at both ends, ridged, too long, too short, too round, uneven, unsymmetrical
Shell color. The color should represent the respective breed. If white, the shell is to be free from gloss or creaminess, showing what is ordinarily spoken of as "dead white." If brown, it shall be of such shade as represents a fair average of the respective breed. It shall show the bloom of a new-laid egg. Each egg in the dozen of whatever color shall be free from spots and even in color throughout	4					Too light, too dark, uneven, not clear, spotted
Shell condition and texture. The shell shall be sound, perfectly clean, and unwashed. It shall be smooth and fresh from excrescences of any sort. It shall be of such strength and thickness as to afford reasonable protection to the contents	18					Washed, dirty, cracked, shiny, lacks bloom, tough, thick, thin, rough
Contents, fullness. The contents of the egg shall nearly fill the shell. The air cell shall be barely visible at the large end of the egg and stationary	12					Shrunken, air cell too large, misplaced, or movable
Contents, yolk. The yolk shall be dimly visible before the candle. It shall be free from spots, clots, or bloodrings, and show no signs of heating or incubation. It must float freely in the white when the egg is revolved before the candle	18					Heated, bloodrings, incubated, stuck clots, spots
Contents, white. The white shall be viscous, clear, and free from spots. The tendency to be weak and watery shall be severely discriminated against	18					Weak, watery, off color, mold
Total	100					

EXERCISE 81

MICROSCOPIC EXAMINATION OF MILK

Statement. Whole milk after having most of the butter fat removed as cream is called skim milk. Skim milk is valuable as feed for calves, pigs, chickens, etc., as well as exceedingly nutritious for man. It should be more generally used as a human food. Skim milk contains all the food materials found in the whole milk except the small percentage of butter fat, averaging less than 4 per cent. The removal of butter fat changes the physical characteristics of the resulting products.

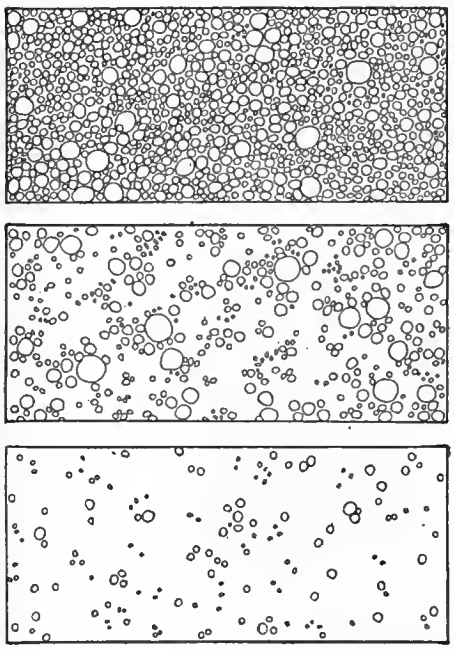


FIG. 135. Butter-fat globules

Reading from above downward, samples are shown of cream, milk, and skimmed milk under the same magnification. Proportionate numbers of fat globules are shown

Object. To determine the physical characteristics of skim milk, whole milk, and cream.

Materials. Three test tubes or shallow vessels; samples of skim milk, whole milk, and cream, respectively.

Directions. Study the appearance of each sample and describe the differences. Place a slide showing skim milk under the microscope and observe the size, shape, and number of the fat globules. Also note the presence of any foreign materials, as dirt or bacteria. In like manner observe the slides showing whole milk and cream. Compare the three and explain the reasons for the differences noted.

Examine under the microscope milk just drawn from a cow recently fresh. Examine milk from a cow of the same breed which has been in milk for several months. Compare the two samples as to size, number, and color of the fat globules. Also compare the fat content of milk samples from different breeds of cattle.

Make drawings on the opposite page of what the microscope shows in the case of skim milk; in the case of cream.

Questions. Describe the fat globules. What is their average size? Does the length of time a cow has been in milk influence in any way the fat globules? If bacteria are present in the sample, explain from what sources they might have come. Which is the heavier, skim milk, whole milk, or cream? Which material contains the greater proportionate number of fat globules, whole milk or cream? Explain the reason for the difference and how the concentration of globules occurs when milk is set, and how it is brought about when the centrifugal separator is used. Did you observe any difference in the size of the fat globules in a given sample, or were they all of uniform size? Did you find that the globules were uniformly larger in some samples than in others? Are they larger in the milk of some breeds than in that from others? Which breed produces milk containing the largest globules, which the smallest? State what difference there is between the size of the globules of skim milk and cream. As a rule, which globules are left in the skim milk, the smaller or the larger ones, and why? What is the relation between the size of fat globules and the rapidity and completeness of creaming either by the gravity or the centrifugal method? Name two methods by which cream may be removed from milk.

References. WATERS, H. J. Essentials of Agriculture, pp. 372–375. Ginn and Company. ECKLES and WARREN. Dairy Farming, pp. 168–172. The Macmillan Company. WING, H. H. Milk and its Products, pp. 16–35. The Macmillan Company.

NOTE. Slides of skimmed milk, whole milk, and cream should be prepared previous to the class period and adjusted in the microscope.

EXERCISE 82

MILK TESTING

Statement. Before the Babcock method of testing milk was discovered milk was purchased by the gallon or pound without regard to its richness. Thus, for example, milk which contained a small amount of butter fat brought as much as that which contained a great amount of fat. Now most of the milk sold on the market is tested for fat, and its value is determined by its fat content and its freshness and cleanliness. In a word, milk is now sold on its merits. The dairyman who takes the pains necessary to produce rich, clean milk is rewarded, and the careless dairyman is penalized.

Object. To test different milk samples and milk products.

Materials. Babcock tester, milk-testing bottles, and cream-testing bottles; sulphuric acid (commercial, Sp. Gr. 1.82); 17.5-cubic-centimeter, 18-cubic-centimeter, and 17.6-cubic-centimeter pipettes; milk, cream, and cheese to be tested.

Directions. To test for butter fat in milk proceed as follows: Clean a milk-test bottle (graduated from 1 to 10) and a 17.6-cubic-centimeter pipette. By suction draw into the pipette 17.6 cubic centimeters of milk to be tested. In securing the sample be careful that the milk is well stirred, so that the sample tested will be representative of the entire amount. Holding the milk-test bottle at an angle let the milk run from the pipette into the bottle. In like manner, with the 17.5-cubic-centimeter pipette add commercial sulphuric acid. Let it run down the neck of the bottle so as to wash down any milk that may be in the neck. Holding the bottle by the neck give it a gentle rotary motion until the acid and milk are mixed. When mixed properly they should have a rich chocolate-brown color. Repeat for other samples. Place the bottles in the tester and whirl for five minutes at the speed indicated on the tester. Fill each bottle to the neck with warm water and whirl again for two minutes. Add warm water until the butter fat stands in the bottle neck and whirl again for one minute. Remove and read the test.

For testing skim milk, where it is desirable to read the small fractions of 1 per cent, two forms of bottles have been devised. In one two pipettes full of milk are used and the graduations have half the ordinary value; in the other the bottle has two necks, one for the introduction of milk and acid, and the other, extremely narrow in size, in which the fat is measured. The ordinary milk-test bottle may be used if neither of these can be had.

1. Test a milk sample taken from the first milk drawn from a cow and a sample taken from the milk last drawn.
2. Test milk from a Jersey cow, a Holstein, a Guernsey, an Ayrshire, a Shorthorn, a Hereford.
3. Test a sample of buttermilk.
4. Test a sample of skim milk taken (1) from milk skimmed by hand and (2) from separated milk from different separators in the community.
5. Test cream in the same manner as milk, only use an 18-cubic-centimeter pipette and a cream-test bottle, which is graduated to 35 per cent or more.
6. Test butter and cheese for butter fat, only weigh out 18 grams instead of measuring. Place it in the bottle, add a little water and then add acid to dissolve it. Proceed as in the case of milk.

Questions. In what way does the acid affect the milk? What should a good sample of milk test? What is the value of testing milk? How does the creamery determine the value of the cream purchased? Is there any advantage in the farmer's allowing a large amount of milk to go to the creamery with the cream? Does he lose the milk? How might he save a part of it?

References. WATERS, H. J. Essentials of Agriculture, pp. 372–379. Ginn and Company. ECKLES and WARREN. Dairy Farming, pp. 59, 196–199. The Macmillan Company. STOCKING, W. A. Manual of Milk Production, pp. 109–136. The Macmillan Company.

EXERCISE 82 (*Continued*)

MILK TESTING

Kind of Material	Source of Sample	Date Sample Was Taken	Butter Fat Test

EXERCISE 83

METHODS OF PRODUCING SANITARY MILK

Statement. The souring of milk is due to the growth of bacteria in the milk. The more numerous the bacteria in the milk the more rapidly it sours. Bacteria which sour milk are not generally present in the milk before it is taken from the cow, but enter the milk in dirt, from the air, etc. There should be as little dust as possible in the air of the barn at milking time, and no dirt should be permitted to gain access to the pail.

Object. To determine some of the factors which influence the keeping quality of milk.

Materials. Cows which the pupils may milk; open and covered milk pails; place for cooling milk; a number of one-half-pint bottles.

Directions. 1. Milk one cow, using for the milk container an open pail. Milk another, using a partly closed pail. Have both pails sterilized immediately before using them. At once take samples of milk from each pail, keeping the samples in clean, sterilized milk bottles, well sealed. Place the two samples under the same conditions of heat and light. Observe the results.

FIG. 136. Types of milk pails
The pail at the left is the better, because the hood helps to keep the dirt out of the milk

2. Let sour milk stand for a while in each of two milk bottles. Later wash one bottle and sterilize it with boiling water. Drain the water and do not dry with a cloth. Pour the milk out of the other bottle but do not wash it. Fill the two bottles with fresh milk from the same pail, seal and set aside under the same conditions. Observe results.

3. Obtain two samples of fresh milk; cool one sample immediately after milking and leave the other sample to cool gradually at room temperature. Otherwise, keep the samples under the same conditions and observe results as to the rate at which each sours.

At the end of twelve hours, observe each sample taken above as follows:

a. Taste each sample and record whether it is sweet or sour to the taste.

b. Place a definite portion (20 cubic centimeters) of each sample in a white dish and add phenolphthalein solution, drop by drop from a burette, with constant stirring. Note and record the number of cubic centimeters of solution added before the milk changed color. Since phenolphthalein solution turns red in the presence of acid, this test tells which milk is the sourer.

Questions. How do bacteria gain access to milk? Mention several methods by which the number of bacteria in milk may be lessened. Does cooling milk at once after milking decrease the number of bacteria entering the milk or does it decrease the rapidity with which they multiply? Might dirty milk be kept sweet for a reasonable length of time if kept at a low temperature? How should milking utensils be treated to keep them clean and also free from bacteria? How may dirt largely be prevented from gaining access to milk? What precautions should the dairyman take with regard to his clothing when milking cows or handling milk? What precautions should he take regarding his hands? With regard to the cleanliness of the cow's body, udder, and teats? What is the objection to feeding hay to cows in the milking barn just before milking time? What are the objections to sweeping the barn at that time? Can you state the grades of market milk and what are the qualities required in each? What is the relative market price of each? Describe the conditions under which grade A milk may be produced.

References. WATERS, H. J. Essentials of Agriculture, p. 374. Ginn and Company. HARPER, M. W. Animal Husbandry for Schools, pp. 157–159. The Macmillan Company. ECKLES and WARREN. Dairy Farming, pp. 177–183. The Macmillan Company.

EXERCISE 83 (*Continued*)

SANITARY MILK PRODUCTION

Sample Number	How Treated	Taste of Sample	Amount of Phenolphthalein Solution Used	Amount of Acid		
				Large	Medium	Small
1						
2						
3						
4						
5						
6						

PART VI. FEEDING FARM ANIMALS

EXERCISE 84

PLANTS AS FOOD FOR ANIMALS

Statement. Plant substances are the original source of nourishment for animals. The science of feeding rests upon our knowledge of these substances and of the needs of animals. Animal food compounds are classified as water, ash, protein, fat, nitrogen-free extract, and crude fiber.

Object. To determine the presence of some of the food compounds in plant and animal substances.

Materials. Potato; white of an egg; balances; evaporating dish; nitric acid; concentrated hydrochloric acid; ammonia; iodine solution; ether or gasoline; Fehling's solution; a-Naphthol solution; sulphuric acid; substances containing grape sugar or cane sugar; other plant and animal substances to be tested.

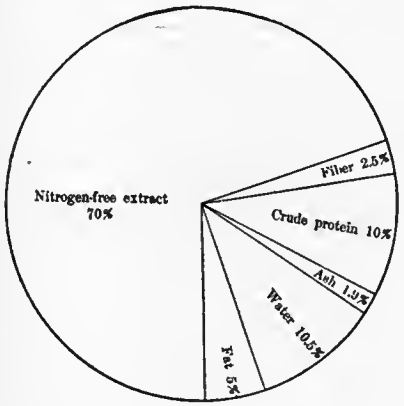


FIG. 137. The food components of shelled corn

Directions. 1. *Water.* To determine the amount of water in a plant substance weigh out a ten- or twenty-gram sample and dry it for two or three hours in an oven at the temperature of boiling water. Reweigh the sample, place it in the oven, and heat again. Reweigh and continue heating and weighing until the weight becomes constant. The loss in weight is water. Compute and record the percentage of water lost. Compute the percentage of dry matter in the fresh sample.

2. *Ash.* The sample after being dried is burned to a white ash. Weigh and compute the percentage of ash on the basis of dry substance; on the basis of fresh sample. Compute by difference the percentage of organic matter in the dry substance; compute the percentage in the fresh substance. Compare results with those given in Appendix.

3. *Protein.* Place some white of egg in a dish or test tube and add a few drops of nitric acid. Note the color which appears. Heat the mixture slightly, rinse off the acid, and add ammonia. Note again the color. The colors which appear indicate the presence of protein. Place a little nitric acid on a piece of finger nail. A yellow color indicates protein. Test such substances as wheat flour, meat, and milk for protein.

4. *Nitrogen-free extract.* Nitrogen-free extract consists in part of sugars and starches. Sugars may be detected by the taste in those substances which contain a large amount. To test for grape sugar place a raisin or crystals of grape sugar in a test tube or dish and add water. Shake the mixture and to a little of it add a drop of Fehling's solution and heat. Note the change in color. A yellow to red color indicates the presence of grape sugar.

To test for cane sugar or glucose proceed as follows: Place a piece of cane sugar or glucose not larger than a pin head in a test tube. Add 4 or 5 drops of water and 2 drops of a ten per cent solution of a-Naphthol in chloroform. Add 2 c.c. of concentrated sulphuric acid in such manner as to allow the heavy acid to form a separate layer at the bottom of the tube. Note the color of the ring which forms. After a few minutes add 5 c.c. of water. What colored precipitate forms?

To test for starch place a few drops of iodine solution on the cut surface of a vegetable such as the potato. The blue color indicates the presence of starch. Test corn kernels, wheat, flour, rice, etc., for starch.

5. *Crude fiber.* Remove the seed coat from a bean or kernel of corn. Examine the outer layer of a mature corn stalk. This hard, woody material is principally crude fiber. Cotton and flax are examples of crude fiber that may be readily examined.

6. *Fats.* Fats are extracted with ether. Cover a little cottonseed meal, linseed meal, or corn meal with ether; stir about a minute and pour off the ether. Set aside until the ether evaporates, as indicated by the absence of the odor of ether. The substance remaining is fat. (Gasoline may be used if ether is not obtainable.) Test wheat bran, castor beans, peanuts, cottonseed, flaxseed, and sunflower seed for fats.

Questions. Mention two plant products from which starch is obtained for commercial purposes. Mention two plant products from which oil is obtained for commercial use. From your examination of crude fiber would you consider it a very valuable part of the plant? Is it easily digested?

References. WATERS, H. J. Essentials of Agriculture, p. 25. Ginn and Company. HENRY and MORRISON. Feeds and Feeding Abridged, pp. 11–16. The Henry Morrison Company. JORDAN, W. H. The Feeding of Animals, pp. 7–9. The Macmillan Company.

EXERCISE 85

HOW THE ANIMAL DIGESTS ITS FOOD

Statement. Just as the plant is unable to take food from the soil until it is dissolved, so the animal is unable to use food for its nourishment until it has been digested. Digestion begins with mastication and continues up to the time the undigested part of the food leaves the body. The mineral matter, crude protein, fat, sugar, starch, and fiber, each undergoes digestion in the alimentary tract.

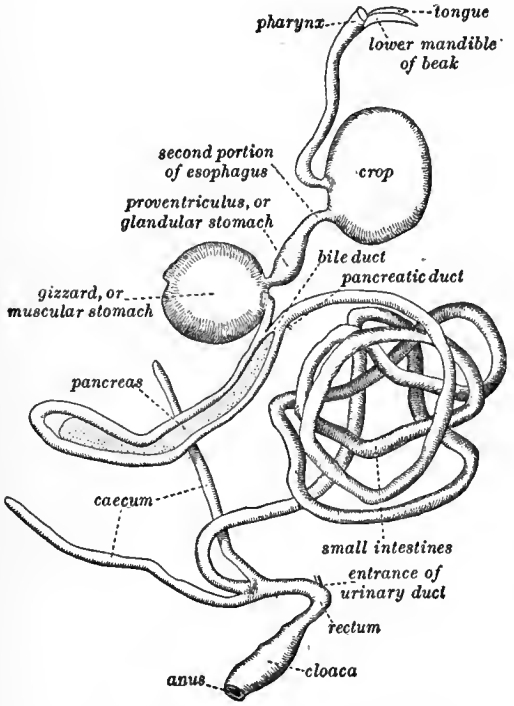


FIG. 138. The digestive tract of a chicken
Diagram from Iowa State College

Object. To learn the processes of digestion and where in the alimentary tract each food is digested.

Materials. Colored pencils and pictures of the digestive tracts of animals to be studied.

Directions. 1. Using different colored pencils or ink to represent mineral matter, crude protein, fat, sugar, starch, and fiber, respectively, trace their passage through the digestive tract to the place where each is largely changed into another product. Indicate in writing the manner in which each change is brought about. Note in what organ of the body each change takes place. Explain where and how the digested food is absorbed into the circulatory system. Determine where and for what purpose each kind of digested food is used by the animal.

2. Make a careful study of the digestive tracts of the chicken, the horse, and the ox as shown in the diagrams and described in reference books. Also state in writing the important particulars in which each differs from the other. Show how fowls masticate their food, and how in detail the ox masticates food, and what is meant by the expression, "chewing its cud." To what class of animals is the expression applied? Indicate the difference in their systems with respect to their ability to handle coarse fodders.

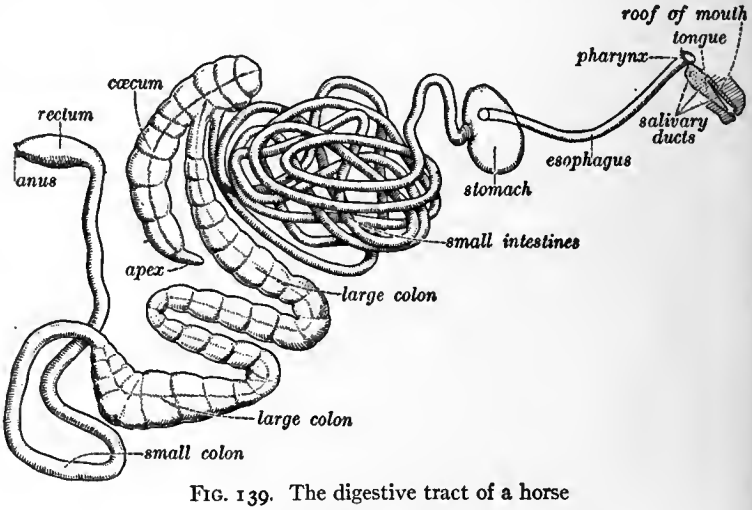


FIG. 139. The digestive tract of a horse
From Iowa State College

3. Describe the digestive processes which go on in the mouth and name the compounds which are active in bringing about the changes which occur there. Describe the changes which take place in the simple stomach, and name the juices which are active. State what changes occur in the small intestines. Indicate the action of the pancreas and the liver. What processes take place in the large intestines? State where and how each part of the digested material is assimilated by the body. Explain how the fats, carbohydrates, and protein are digested. Mention the part which bacteria play in the digestive process and in which class of animals they are the most important.

Questions. In what respects does the alimentary canal of an ox differ from that of a pig? In what respects does the digestive tract of a chicken differ from that of the ox? of the pig? Which of these animals is most capable of handling coarse food, and why? Why does the chicken need gravel or crushed stone? Explain the effect of grinding grain upon the ease and rapidity with which it is digested. Is a foodstuff containing much crude fiber more or less readily and completely digested than one containing little fiber, and why? How many stomachs has the ox? What is meant by the term "ruminant" and to what class of animals is it applied? Consult the tables in the Appendix and state what proportion of corn and other common feeds is digested.

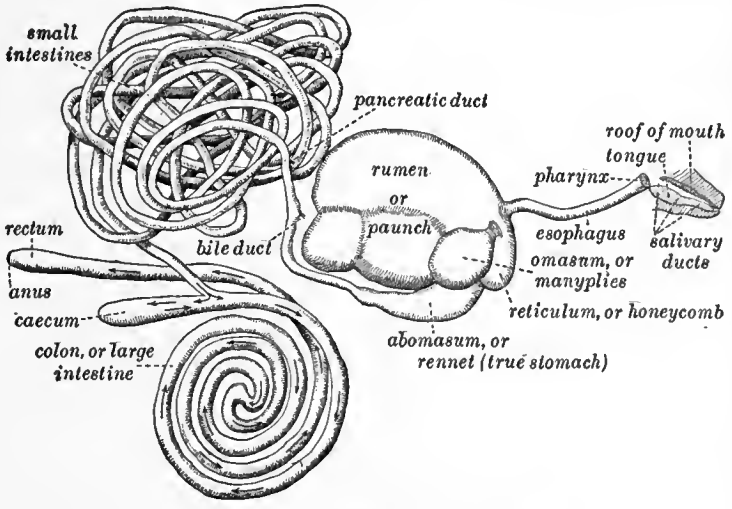


FIG. 140. The digestive tract of a cow
Diagram from Iowa State College

References. WATERS, H. J. Essentials of Agriculture, pp. 320–329. Ginn and Company. HENRY and MORRISON. Feeds and Feeding Abridged, pp. 18–33. The Henry Morrison Company. JORDAN, W. H. The Feeding of Animals, pp. 98–126. The Macmillan Company. HARPER, M. W. Animal Husbandry for Schools, pp. 58–63. The Macmillan Company.

EXERCISE 86

COMPUTING THE NUTRITIVE RATIO OF STOCK FEEDS

Statement. The successful stockman gives his animals feeds containing protein and carbohydrates in the proportions in which they require these materials for their best development, just as the skilled mechanic mixes sand and cement in the proper ratio to make good concrete. The ratio between the digestible protein and digestible carbohydrates in a foodstuff is called the nutritive ratio of that material.

Object. To determine the nutritive ratio of feeds and to compare different feeds as to their value in compounding rations.

Materials. Pencil and paper, and tables giving the composition of feeding stuffs. (See Appendix, Table I.)

Directions. In computing the nutritive ratio only the digestible portion is usually considered. Included in the carbohydrates are the starch, sugar, crude fiber, and fat. As the fat contains about two and one fourth times as much energy as starch or sugar, the amount of digestible fat in the feeding stuff is multiplied by two and one fourth before it is added to the other carbohydrates. This process is termed converting fat into carbohydrate or starch equivalent. The nutritive ratio is obtained by dividing the per cent of total digestible carbohydrates by the per cent of digestible protein contained in the foodstuff. In stating the nutritive ratio the protein is expressed as 1 and the carbohydrates as the quotient obtained. As an example, corn (according to Table I, Appendix) contains 7.5 per cent of digestible protein, 67.8 per cent of digestible carbohydrates, aside from fat, and 4.6 per cent of fat. Multiplying the fat by $2\frac{1}{4}$ ($4.6 \times 2\frac{1}{4}$) and adding the product (10.4) to the carbohydrates (67.8), we have as the total carbohydrates 78.2. Dividing this amount (78.2) by the amount of protein (7.5), we have as the quotient 10.4. Thus the nutritive ratio of corn is one part digestible protein to 10.4 parts digestible carbohydrates, written 1 : 10.4. This means that for every pound of digestible protein in corn there are 10.4 pounds of digestible carbohydrates. Feeds in which the difference between the amount of protein and carbohydrates is small are said to have a narrow nutritive ratio, as 1 : 3, while those feeds in which the difference is large, as in the case of corn, are said to have a wide ratio.

The importance of such a calculation is based on the fundamental principle that no other constituent of feeds can take the place of protein in forming new tissue or replacing old, or in making milk, eggs, wool, feathers, etc. Therefore we must begin the building of a ration with a certain minimum of protein. It is true that there are three sources of carbohydrates, fat, starch and sugar, and crude fiber. For the purposes of calculating the nutritive ratio we convert these values into that of carbohydrates, but later we shall learn that they have widely different values.

Problems. Compute the nutritive ratio of each of the following feeds and classify them as narrow, medium, and wide. Cottonseed meal, linseed meal, wheat, bran, wheat middlings, oats, kafir grain, alfalfa hay, clover hay, cowpea hay, corn silage, wheat straw, and corn stover. (See Appendix, Table I.)

Questions. What are the principal uses which the animal makes of protein? What common foodstuffs supply protein most abundantly? What are the principal sources of protein in your locality? What are the principal uses to which animals put carbohydrates? What are the principal sources of carbohydrates in your neighborhood? What are some of the foodstuffs in your neighborhood which have a narrow nutritive ratio? Name six feeds possessing a wide nutritive ratio. Name some of the common feeds which have a medium nutritive ratio.

References. PLUMB, C. S. Beginnings in Animal Husbandry, p. 272. Webb Publishing Company. HENRY and MORRISON. Feeds and Feeding Abridged, pp. 37–38. The Henry Morrison Company. JORDAN, W. H. The Feeding of Animals, p. 283. The Macmillan Company. HARPER, M. W. Animal Husbandry for Schools, p. 359. The Macmillan Company.

EXERCISE 87

COMPUTING A BALANCED RATION

Statement. The nutritive ratio required by young and rapidly growing animals is narrower than that for grown animals. A dairy cow in full flow of milk needs a ration containing more protein than does a steer that is being " roughed " through the winter. A ration with a nutritive ratio which is adjusted to the needs of the animals to which it is being fed is said to be a balanced ration. One which does not supply the nutrients in the proper proportion is said to be an unbalanced ration. The needs of all classes of farm animals have been carefully studied and what constitutes a balanced ration for each has been approximately determined. The nutritive ratio required by most of such classes is shown in column five of Table II of the Appendix.

Object. To learn how to compound a balanced ration for different classes of farm animals.

Materials. Paper; pencil; Table II, Appendix.

Directions. Assume that weanling pigs are fed corn meal 20 pounds and skim milk 80 pounds. Computing the nutrients in this ration we have:

Amount of Feed	Protein (in Pounds)	Carbohydrates (in Pounds)	Nutritive Ratio (in Pounds)
Corn, 20 pounds	1.5	15.64	
Skim milk, 80 pounds . . .	2.88	4.44	
Total, 100 pounds	4.38	20.08	1 : 4.57
Wolff-Lehmann Standard . .			1 : 4.5

This ration is properly balanced. In a like manner work out the following problems:

1. Pigs weighing 100 pounds are being fed corn meal 80 parts, and wheat middlings 20 parts. Are they receiving a balanced ration? If not, what change would you make in the proportion of corn to middlings to balance the ration?

2. A cow giving milk is receiving a ration consisting of corn chop 6 pounds, cottonseed meal 2 pounds, wheat bran 2 pounds, corn silage 30 pounds, and timothy hay 10 pounds daily. Is the ration balanced? What changes would you make in the proportions? What would be the effect of substituting alfalfa for timothy?

3. A pen of laying hens weighing between 5 and 8 pounds each are being fed a ration of 3 pounds cracked corn, 1 pound wheat, 1 pound corn meal, 1 pound oatmeal, 1 pound bran, and $\frac{1}{2}$ pound meat-scrap. What is the nutritive ratio of this ration? What is the proper ratio for hens of this size? (See Appendix, Table II.) Change the proportions so as to give the proper ratio.

4. A calf is being wintered on timothy hay and corn stover. Is the ration balanced? Show what the effect of substituting half clover, alfalfa, or cowpea hay for timothy would have on the ration.

5. Ascertain what rations are most commonly used in the neighborhood in feeding work horses; weanling colts; calves; dairy cows; fattening steers; wintering cattle; pigs weighing 50 pounds, 100 pounds, and 200 pounds, respectively. Compute the nutritive ratio of those rations which are most important to the neighborhood and ascertain how far they deviate from a balanced ration. Suggest how their deficiencies may be corrected, using home-grown feeds whenever possible.

References. Waters, H. J. Essentials of Agriculture, pp. 328, 392–393. Ginn and Company. Henry and Morrison. Feeds and Feeding Abridged, pp. 106–116. The Henry Morrison Company. Plumb, C. S. Beginnings in Animal Husbandry, pp. 274–288. The Webb Publishing Company. Harper, M. W. Animal Husbandry for Schools, p. 65. The Macmillan Company.

EXERCISE 87 (*Continued*)

1. FOR PIGS WEIGHING ONE HUNDRED POUNDS

Kind of Feed	Amount of Feed	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Corn meal	80			
Wheat middlings	20			
Total				
Standard				

2. FOR A COW IN MILK

Kind of Feed	Amount of Feed	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Corn chop				
Cottonseed meal				
Wheat bran				
Corn silage				
Timothy hay				
Total				
Standard				

3. FOR LAYING HENS

Kind of Feed	Amount of Feed	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Cracked corn				
Wheat				
Oatmeal				
Bran				
Meat scrap				
Total				
Standard				

4. MAINTENANCE RATION FOR CALF

Kind of Feed	Amount of Feed	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Timothy hay				
Corn stover				
Total				
Standard				

EXERCISE 88

COMPUTING A STANDARD RATION[1]

Statement. A ration which supplies nutrients in proper amounts as well as in proper proportions is called a standard ration.

Object. To learn how to compound a standard ration for different classes of farm animals using, as far as possible, the common feeds of the farm.

Materials. Paper; pencil; table of feeding standards. See Table II of Appendix.

Directions. Compute a standard ration for pigs weighing from 50 to 75 pounds each, and assume that one feed most convenient to use is corn. Pigs of this age require 45 to 52 pounds of dry matter, 6.3 pounds of digestible protein, 32.96 pounds of digestible carbohydrates, and a nutritive ratio of 1 : 5.2 daily per 1000 pounds of live weight of animal. The table of feeding standards is designed to show the pounds of each nutrient required for 1000 pounds of animal. When the feeds for 1000 pounds of weight are determined, the amount required for the animal or animals under consideration may be readily computed.

Using corn alone the ration would contain 67.8 pounds of digestible carbohydrates and 4.6 pounds of fat in 100 pounds. Multiplying the fat by 2.25 and adding it to the carbohydrates gives 78.2 pounds of carbohydrates in 100 pounds of corn. Therefore, to furnish 32.96 pounds of carbohydrates would require 42.15 pounds of corn. This amount of corn contains only 3.16 pounds digestible protein, which is too small an amount. The nutritive ration of corn, 1 : 10.4, is entirely too wide.

1. Instead of feeding corn alone, make the ration of corn 20 pounds and wheat middlings 20 pounds daily per 1000 pounds of live weight. Compute the pounds of dry matter, protein, and carbohydrates contained in this ration and compare with the standard.

2. Assume that the ration consists of corn 27 pounds and skim milk 87 pounds per 1000 pounds, live weight. Calculate the pounds of dry matter, digestible protein, and digestible carbohydrates supplied and the nutritive ratio of the ration. Compare this with the standard.

3. In a similar manner compute a standard ration for pigs of this age, using corn, wheat middlings, and meat-meal or tankage. Place all figures in the blank on the following page.

4. Compute a standard ration for growing yearling steers, using corn silage and wheat straw as the basis, and purchasing cottonseed meal. Compute a standard ration for fattening two-year-old steers with corn, sorghum silage, and alfalfa hay as the basis, and the privilege of purchasing cottonseed cake or old process linseed meal. Make up a ration for fattening steers with corn stover, oat straw, cowpea hay, and cottonseed meal as the basis.

Questions. How does the local farm practice compare with the feeding standards? Are the farmers using too much or too little protein? How may the farmers of the community secure additional protein without purchasing it? Which is the more costly to buy in feedstuffs, protein or carbohydrates? How many farmers are feeding their pigs on corn alone or on corn and pasture grass? Which class of animals requires the greater quantity of protein or the narrower rations, growing or grown animals, working or idle horses, milking or dry cows, laying or barren hens? What is the effect of an ample supply of protein on the quantity and luster of the hair coat of animals? Which shed or molt the earlier, those which are liberally or those which are sparsely supplied with protein?

References. Henry and Morrison. Feeds and Feeding Abridged, pp. 423–433. The Henry Morrison Company. Plumb, C. S. Beginnings in Animal Husbandry, pp. 281–287. Webb Publishing Company. Jordan, W. H. The Feeding of Animals, pp. 280–295. The Macmillan Company.

[1] In farm practice it is frequently advisable to depart somewhat from the accepted feeding standard. For example, when feeds rich in protein are high priced and those rich in carbohydrates, like corn, are cheap, it will pay to feed a wider ration than the standard prescribes. The successful feeder, however, conforms as nearly to these standards as the cost of his feed and the value of the products will allow.

EXERCISE 88 (*Continued*)

Kind of Feed	Amount of Feed	Amount of Dry Matter	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Corn					
Wheat middlings . . .					
Total					
Wolff-Lehman Standard					

Kind of Feed	Amount of Feed	Amount of Dry Matter	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Corn					
Skim milk					
Total					
Wolff-Lehman Standard					

Kind of Feed	Amount of Feed	Amount of Dry Matter	Digestible Crude Protein	Carbohydrates	Nutritive Ratio
Corn					
Wheat middlings . . .					
Meat meal or tankage .					
Total					
Wolff-Lehman Standard					

EXERCISE 89

COMPUTING A STANDARD RATION FOR PIGS

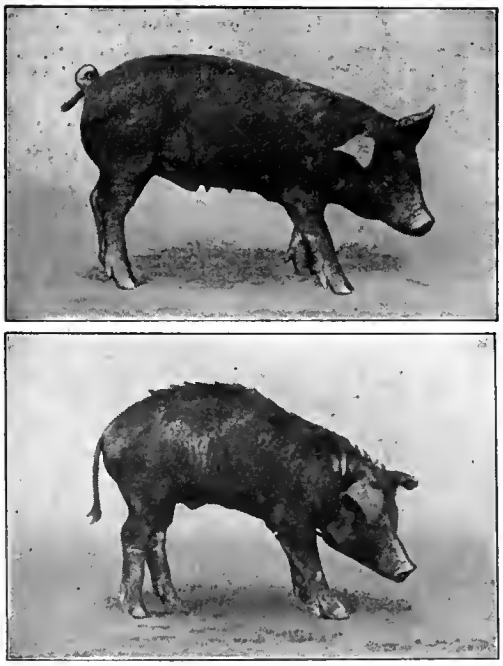


FIG. 141. The effect on the growing pig of feeding an unbalanced ration

The upper picture shows how the pig looked at the beginning, weight 28 pounds. The lower picture shows its appearance at the end — after having been fed all the corn it would eat for six months, weight 31 pounds

Object. To ascertain what combinations of common feeds will fatten young and growing hogs most cheaply.

Materials. Paper; pencil; table of feeding standards in Appendix.

Directions. Assume that pigs weighing 150 pounds each are to be fed until they weigh 200 pounds, or through the second feeding period, which is a period of growth as well as of fattening. The feeding standard for pigs in this period requires daily for each 1000 pounds of live weight from 36 to 45 pounds of dry matter, which should contain 6.4 pounds of protein, 30 pounds of carbohydrates, and 1.6 pounds of fats, and should have a nutritive ratio of 1 : 5.2.

1. Suppose wheat middlings and corn are combined in the proportion of 32 per cent middlings to 68 per cent corn, or 9 pounds of middlings to 27 pounds of corn. What is the nutritive ratio and how does it compare with the standard?

2. Let us suppose that tankage is added to make a ration of 25 pounds of corn, 8 pounds of wheat middlings, and 2 pounds of tankage, or corn 62 per cent, wheat middlings 32 per cent, and tankage 6 per cent. Compute nutrients, and compare with the standard.

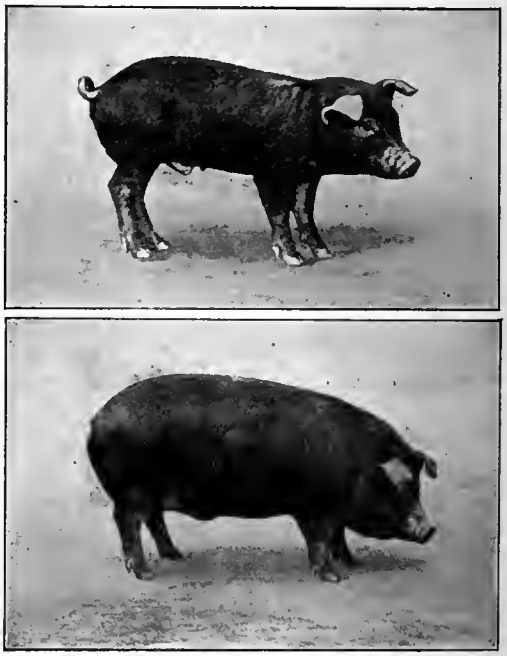


FIG. 142. Effect on the growing pig of feeding a balanced ration

The upper picture shows the appearance of the pig at the beginning of the test, weight 17 pounds. The lower picture shows how it looked after having been fed for six months on a balanced ration, weight 200 pounds. This pig is full brother to the one shown in Fig. 141

Compute, and compare with the standard, rations made up of the following feeds offered in the proportions named, estimating the amount of each which should be fed daily: shelled corn, 100 pounds; sweet potatoes, 100 pounds; peanut meal, 50 pounds. Also shelled corn, 100 pounds; cassava, 100 pounds; peanut meal, 50 pounds.

Questions. What rations are most commonly used in your community for brood sows, for mothers and young pigs, for weanlings, for fattening hogs? What are the most common hog pastures in your neighborhood? Which is the best? With clover or alfalfa pasture, is as much protein required in the grain as when the hogs are confined to a dry lot? Is as much required when hogs are running on bluegrass or bermuda grass? What are the most common commercial proteins available for swine feeding? What is the principal source of carbohydrates in swine feeding?

References. WATERS, H. J. Essentials of Agriculture, pp. 402–406. Ginn and Company. HENRY and MORRISON. Feeds and Feeding Abridged, pp. 347–350. The Henry Morrison Company. DAY, G. E. Productive Swine Husbandry, pp. 142–185. J. B. Lippincott Company.

EXERCISE 89 (*Continued*)

COMPUTING STANDARD RATIONS FOR HOGS

Kind of Feed	Amount of Feed (in Pounds)	Dry Matter (in Pounds)	Digestible Protein (in Pounds)	Digestible Carbohydrates (in Pounds)	Nutritive Ratio
Standard . .					

Kind of Feed	Amount of Feed (in Pounds)	Dry Matter (in Pounds)	Digestible Protein (in Pounds)	Digestible Carbohydrates (in Pounds)	Nutritive Ratio
Standard . .					

Kind of Feed	Amount of Feed (in Pounds)	Dry Matter (in Pounds)	Digestible Protein (in Pounds)	Digestible Carbohydrates (in Pounds)	Nutritive Ratio
Standard . .					

EXERCISE 90

COMPUTING STANDARD RATIONS FOR DAIRY COWS

Object. To learn the requirements of cows giving milk and the most economical sources of the nutrients required.

Materials. 1. Assume that the cow is producing 24 pounds (three gallons) of milk containing 4 per cent butter fat daily, and that she weighs 1000 pounds; assume that corn and timothy hay are the most convenient feeds to use.

The requirement of such a cow according to the feeding standards is 29 pounds of dry matter, 2.5 pounds of protein, and 14.1 pounds of carbohydrates daily. Ten pounds of corn and 15 pounds of hay daily would supply approximately the amount of carbohydrates required. Ascertain whether this ration furnishes the required amount of digestible protein and dry matter. Ascertain also how the nutritive ratio of this ration compares with the standard. Substitute alfalfa, clover, or cowpea hay for timothy, giving 10 pounds of grain and 25 pounds of hay a day, and compute the amount of each group of nutrients supplied and compare them with the standards. Reduce the corn to 7 pounds daily, the clover or alfalfa hay to 20 pounds, and add 2 pounds of cottonseed meal. Compute, and compare with the standard in quantity of nutrients and nutritive ratio.

2. Make a study of the rations most commonly fed in the neighborhood and compare them with the standard. Suggest improvements in the amount or kind of grain used; in the amount and kind of roughage used. Ascertain to what extent the legumes are used as the principal hays and to what extent silage is the principal source of non-legume roughage.

3. Compute the nutrients contained in the rations for milk cows suggested in the text and compare them with the accepted standards. Suggest other rations which might be profitably used in your locality.

Questions. Should all the cows in a herd be given the same amount of feed? How may the proper amount of grain for a cow be ascertained? How much roughage should be fed to cows giving milk? How may one know when a cow is being underfed? overfed? At what season of the year is milk produced at the least cost for feed, and why? Ask an experienced dairyman of the neighborhood whether it is practicable " to bring a cow back to her milk " after the milk flow has been allowed to decline. Record these answers.

References. HENRY and MORRISON. Feeds and Feeding Abridged, pp. 247–279. The Henry Morrison Company. ECKLES, C. H. Dairy Cattle and Milk Production, pp. 260–287. The Macmillan Company. WATERS, H. J. Essentials of Agriculture, pp. 364–367. Ginn and Company.

EXERCISE 91

COMPUTING STANDARD RATIONS FOR LAYING HENS

Statement. The problem of supplying a proper ration for poultry of all classes is one of the most important considerations in the practical handling of birds. The breed, age, housing, season, and range must all be taken into account in compounding the ration.

Object. To learn the requirements of the laying hen and the most profitable sources of the nutrients required.

Materials. Paper, pencil, table of feeding standards, and digestible nutrients for chickens.

Directions. 1. Assume that the hens are in full laying and weigh 3 to 5 pounds each, and that the feeds available are corn, wheat, oats, bran, shorts, and meatscrap.

2. According to the feeding standard the requirements of such hens per hundred pounds live weight, are 5.5 pounds of digestible dry matter, 1 pound of protein, 4.53 pounds of carbohydrates daily. If we fed 2 pounds corn, 2 pounds wheat, 1 pound oats, 2 pounds bran, 1 pound shorts, and .5 pound meatscrap, we should supply approximately the amount of carbohydrates required. Determine whether this amount of feed furnishes the required amount of digestible protein and dry matter. Ascertain also how the nutritive ratio of this ration compares with the standard. Substitute 1 pound of kafir and 1 pound of corn meal for the wheat, compute the amount of each group of nutrients supplied, and compare with the standards. Drop the oats from the ration and add 1 pound of corn meal and substitute oil meal for the meatscrap. Compute nutrients supplied and compare with the standard in quantity of nutrients and in nutritive ratio.

FIG. 143. Influence of a balanced ration on egg production

In the basket at the left are 110 eggs, the average first-year production of ungraded hens fed on a balanced ration. In the basket at the right are 65 eggs, the average first-year production of ungraded hens receiving an unbalanced ration. (Courtesy of the Kansas State Agricultural College)

3. Make a study of the rations most commonly fed in the neighborhood and compare them with the standard. Suggest improvements in the amount or kind of grain used; in the amount and kind of high protein feed used. Ascertain to what extent carbohydrates and fattening feeds are used.

4. Compute the nutrients contained in the rations suggested in the text and compare with the standard. Suggest rations which you could profitably use in your locality.

Questions. What should the relative proportion of grain and mash be? Why do we feed the flock instead of the individual? Why is it difficult to feed a flock of mongrels, or a mixture of breeds that vary in size and temperament, with good results? At which season of the year are eggs produced at least expense? Why isn't it profitable to limit the amount of feed below normal at times when feed is scarce and high in price? What is a scratch feed and of what may it be composed? What is a dry mash and of what may it be composed? At what time of day is a scratch feed given and how is it fed? At what time of day is the dry mash given and how is it fed? Of what advantage is green feed in winter and how may it be obtained?

References. LIPPINCOTT, W. A. Poultry Production, pp. 359–376. Lea & Febiger. WATERS, H. J. Essentials of Agriculture, pp. 427–428. Ginn and Company.

PART VII. FARM EQUIPMENT AND MACHINERY

EXERCISE 92

THE GAS ENGINE AND AUTOMOBILE

Statement. There is no machine that has been so widely and rapidly introduced on the farm as the gas engine. Probably no other machine can be put to so many uses or can save so much human energy.

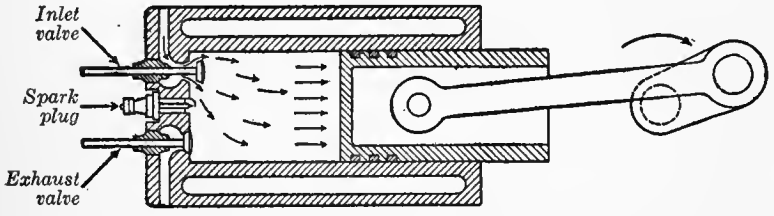


FIG. 144. Suction stroke

Suction of the mixture of air and gas through inlet valve takes place during the complete outward stroke of the piston, the exhaust valve being closed

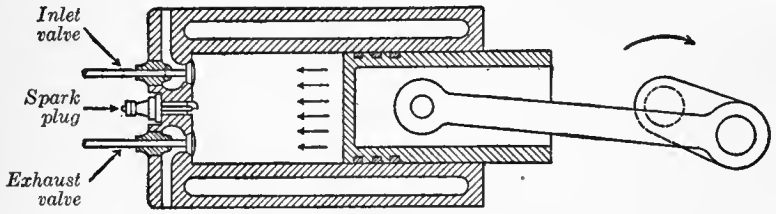


FIG. 145. Compression stroke

On the return stroke of the piston both valves remain closed and the mixture of air and gas is compressed between the piston and the closed end of the cylinder

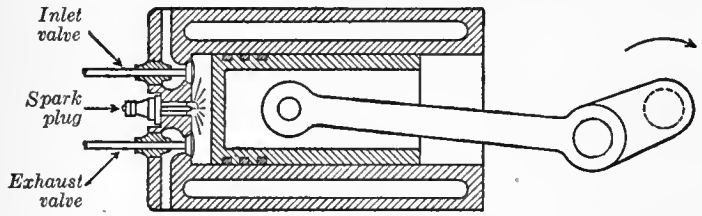


FIG. 146. Ignition and explosion

Just before the compression stroke is completed the compressed mixture is ignited by a spark and rapid combustion or explosion takes place

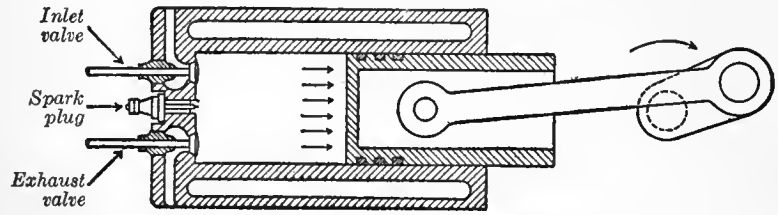


FIG. 147. Explosion or power stroke

The increased pressure within the cylinder due to rapid combustion of the mixture drives the piston on its second forward stroke. This is the only stroke in the cycle in which power is generated. Both valves remain closed during this stroke

Object. To study the important parts of a four-stroke-cycle gasoline engine, its operation, and the essential parts of an automobile.

Materials. Gasoline engine and an automobile which may be examined.

Directions. 1. Examine a gas engine and learn the function and location of the following parts: fuel tank, fuel-regulating valve, carburetor, inlet valve, exhaust valve, ignition system, engine cylinder, piston, connecting rod, crank, crank shaft, flywheel, valve gear shaft, two-to-one gears, governor, cylinder jacket, cooling system, lubricators.

Explain in writing the action of the four-stroke-cycle gasoline engine, indicating the function of each of the above parts.

2. Before attempting to start the engine examine the fuel supply, try out the ignition system, see that the lubricators are working properly, retard the spark to the starting position, open the fuel-regulating valve, and crank the engine, always pulling upon the crank. As soon as the engine picks up adjust the fuel valve for best fuel economy and advance the spark to the running position. Stop and start the engine until you are familiar with the operation. Explain in writing causes for a gasoline engine's failing to start. Give directions in writing for operating gasoline engines.

3. Examine an automobile and learn the location and function of the following parts: motor, clutch, transmission gearing, differential, universal joint, steering system, control system, service

brake, engineering brake, fuel system, ignition system, carburetor, and starter. Give directions in writing for starting, stopping, oiling, cleaning, and handling an automobile. If farm tractors are used in the neighborhood either bring one to the school for detailed study or take the class to the store or farm where a tractor is and give the students the opportunity to go over the machine in detail and at least to witness it in operation. Get catalogues of the principal types and standard makes of tractors and explain the advantages and disadvantages of each. Assign the class the problem of listing all the ways in which a tractor may be profitably used on the farm the year round.

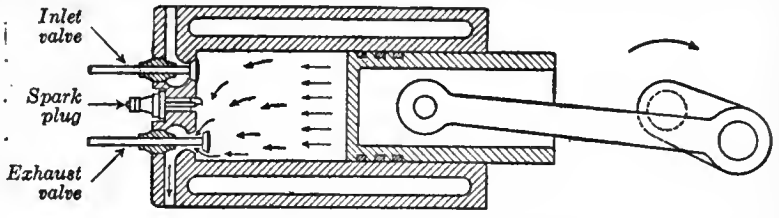


FIG. 148. Exhaust or scavenger stroke

During the fourth stroke the exhaust valve remains open and the burned gases are driven from the cylinder into the air by the return of the piston

References. POTTER, A. A. Farm Motors, Chaps. V and VI (Second Edition). McGraw-Hill Book Company, through whose courtesy the cuts used in this exercise were obtained. HARSHFIELD and ULBRIGHT. Gas Engines for the Farm, pp. 6–28. John Wiley & Sons.

EXERCISE 93

THE ADJUSTMENT AND USE OF FARM MACHINERY

Statement. With large machinery the farmer has been able to use the strength of animals such as the horse and the ox, and also the power of wind, water, steam, gas, and electricity. This has multiplied his efficiency many times. With hand tools a man can cultivate scarcely more than two acres of land. With modern labor-saving machinery, he can cultivate one hundred and sixty acres or more. Machine agriculture develops a much more intelligent farmer than hand agriculture. He must understand the construction and uses of the machines he operates and must know how to keep them properly adjusted and repaired.

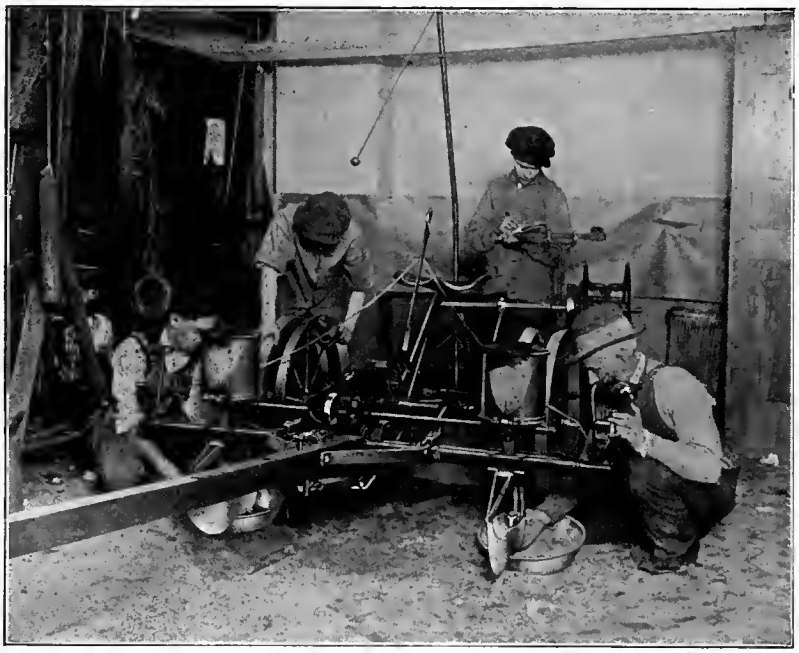


FIG. 149. Adjusting the drop of the corn planter
(Courtesy of the International Harvester Company)

Object. To learn the structure, adjustment, use, and management of farm machinery in common use.

Materials. Catalogues of the leading farm machinery manufacturers; posters; charts and photographs; machines in stock at the local dealers or owned by neighboring farmers.

Directions. 1. Arrange with one or more local implement dealers to let the students help in the work of setting up and adjusting for use their binders, mowers, gang plows, disks, cultivators, corn and cotton planters, and wheat drills. Have them study the methods of adjusting each machine for effective work with the least friction or wear. Study the construction and regulation of the knotter in the binder, the dropping parts of the planters, and the feed of the drill. If feasible, arrange through a local dealer for the traveling representatives of some of the more important implements to demonstrate their proper care and use.

2. Test a corn planter for regularity of drop with graded and ungraded seed corn.

3. Learn how to thread a binder and test the adjustment by running some bundles of straw through the machine.

4. Look over the repair parts of a binder, planter, and seeder and make a list of those which are most frequently needed and what they cost.

5. With the aid of the dealer have each member of the class make a list of the machines and tools required for a typical farm of the locality, the retail price of each, and the total cost of the complete equipment.

Questions. What are the principal sources of power on the farms of the community? Name the half dozen principal labor-saving machines used on the farms of the neighborhood. Write a brief history of the invention and development of each. How did the farmer perform the operations which these machines perform before they were invented? Where does the farmer obtain repairs for his implements?

References. WATERS, H. J. Essentials of Agriculture, pp. 449–455. Ginn and Company. WIRT, F. A. Farm Machinery. John Wiley and Sons. RAMSOWER. Equipments for the Farm. Ginn and Company.

EXERCISE 94

THE CARE OF FARM MACHINERY

Statement. After land, buildings, and live stock, the largest investment of the American farmer is in machinery. Unless the complex and costly machines are properly used and cared for, great loss results. The average life of a wheat binder, perhaps, does not exceed six years. There are many cases in which a binder has rendered regular service for twenty-five or thirty years. A mower is usually rusty, worn, and discarded at the end of six or seven years. Many such machines have been made to last more than twenty years.

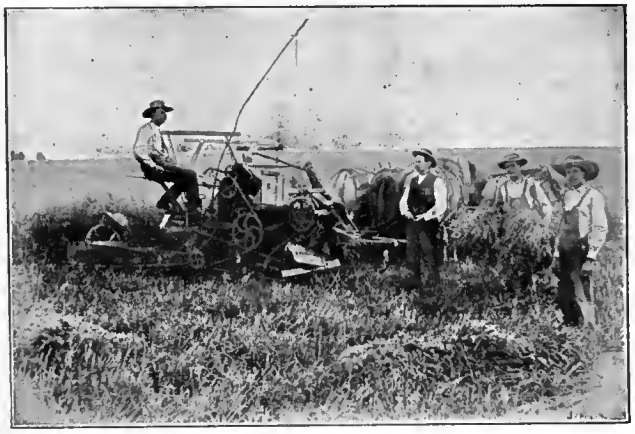


FIG. 150. A long-lived binder

This binder has harvested an average of nearly a hundred acres of grain a year for 28 years in Michigan and is still in use. The canvas has been removed and the machine kept under cover when not in use

Object. To learn the proper care of farm machinery and to study conditions under which they will give the greatest service.

Materials. Notebook; pencil; access to the implements of several representative farms.

Directions. 1. Take the class to two or three representative farms and have them make a study of the use and care of the farm machinery on each. Have them make a list of the machines and tools and record the uses to which each is put, the average number of days each year each machine is used, the number of crops on which it is used yearly, and its average period of service. If the machines and tools are housed when not in use, estimate the cost of the shed required. Estimate the annual cost of providing such shelter. If no shelter is provided, make the plan of a suitable shed and estimate the cost of erecting it.

FIG. 151. Such neglect of machinery as is shown in this picture is common on the American farm

2. Assume that a farmer grows 30 acres of wheat a year and owns a binder for his exclusive use, how many days a year will the binder be used? Assume that the binder lasts six years, how many days of service will it give? At the local price of a binder, allowing interest at 6 per cent, estimating the cost of repairs at $5.00 a year, and assuming that the machine lasts six years, what is the annual cost to the farmer of his binder? What has been the binder cost for each acre of wheat

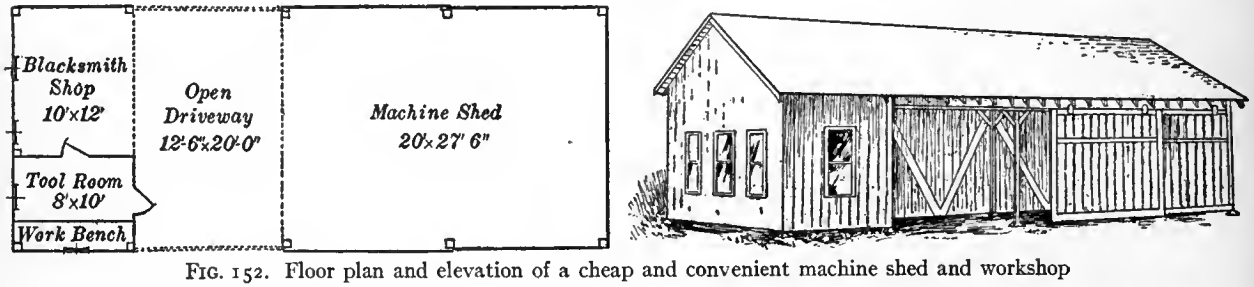


FIG. 152. Floor plan and elevation of a cheap and convenient machine shed and workshop

(Courtesy of the Oregon Agricultural College)

harvested? Assuming that the binder lasts twenty years and the other charges are the same as given above, what has been the annual cost of a binder? What the acre cost?

3. Ascertain if there is any feasible plan of coöperation among the farmers of the locality in the use of expensive machinery so that its yearly use may be increased.

4. Ascertain if the life of the machinery might be substantially increased, and suggest definite ways in which it may be accomplished.

Questions. How should binders, mowers, silage cutters, corn planters, and plows respectively be cared for so as to give the maximum length of service?

References. WATERS, H. J. Essentials of Agriculture, pp. 449–455. Ginn and Company. POTTER, A. A. Farm Motors. McGraw-Hill Book Company. WARREN, G. F. Farm Management, pp. 355–364. The Macmillan Company.

EXERCISE 95

MAKING A FARM INVENTORY

Statement. A farm inventory is a detailed list of farm property and debts with values assigned. Its purpose is to determine the actual worth of the farm business and what progress has been made in accumulating property. The values should be conservative and are usually about what the property would bring at a forced sale. The resources consist of all property belonging to the farmer. The liabilities are his debts. The difference between his resources and liabilities is the net worth of the farm, or what he would have if all of his property were sold at the values given and his debts paid.

Object. To ascertain the net worth of the farm business and to determine the gain or loss from year to year.

Materials. Access to a farm, from which a statement of all resources and liabilities may be obtained.

Directions. On the home farm or on a farm in the neighborhood, with the owner's consent, take an inventory of the property at the beginning and at the end of the year. The winter is the best time in which to make an inventory, as the work is not so urgent at that time and the crops are harvested so that their quantity can be more accurately determined.

The resources are classified as: real estate, which consists of the farm with all buildings, fences, and other improvements; live stock, including horses, cattle, hogs, poultry, and any other live stock; machinery and tools, including wagons, harness, conveyances, all farm machinery, and all small tools; feeds and supplies, including all hay, feeds, and grains on hand, and all supplies such as posts, lumber, cement, and twine; growing crops, or all crops planted and not yet harvested; accounts receivable, or all debts of others to the farmer; and cash on hand.

The liabilities should include all the farmer owes to others.

Note that an inventory shows only the gain or loss for the year, with no consideration of the labor or capital involved. It does not show which crops made profit and which ones were produced at a loss, nor the reason for the results obtained. To obtain these facts a detailed, day-to-day accounting of the business is required. If the time permits, a detailed account should be kept for the year on the home farm and a summary compiled from this account.

Questions. Explain the meaning of an inventory. How often should an inventory be made? In addition to the inventory what accounts should be kept on the farm? The inventory shows how much the farmer has made. What shows how he made it?

References. WATERS, H. J. Essentials of Agriculture, pp. 442–447. Ginn and Company. WARREN, G. F. Farm Management, pp. 428–494. The Macmillan Company. KYLE and ELLIS. Fundamentals of Farming and Farm Life, pp. 432–436. Charles Scribner's Sons.

EXERCISE 95 (*Continued*)

INVENTORY SUMMARY

Inventory of Farm Property of ____________________

Resources	Date ________ (Beg. of Year) No.	Total Value			Date ________ (End of Year) No.	Total Value		
Total resources		$________				$________		

Liabilities						

Total liabilities $________ $________

Net worth $________ $________

Gain or loss for the year $________

(If the *net worth* at the beginning of the year is greater than at the end of the year, then the difference is a loss. In such a case use red ink to record loss for the year.)

EXERCISE 96

THE COMMUNITY BUSINESS

Object. To determine where the people of the community get their living. To ascertain if the people of the community are as nearly self-sustaining as they should be or if they are buying things away from home which they might more profitably produce.

Directions. Make a survey of the local community to ascertain:

1. What proportion of the food, such as meat, bread, vegetables, and fruits consumed in the community is produced locally?

2. Examine the stock of one or two groceries in town and interview the merchants, to ascertain what proportion of their stock and their yearly sales was produced in the locality and what part was shipped in. Ascertain where the canned goods, butter, cheese, fruit, and meats were produced.

FIG. 153. The travels of a beef steer

One reason why meat is so high in price is that the live animal travels so much on the train and visits the city so often. The steer whose picture is shown above was born in Texas and was sent to Fort Worth to market as a calf; was wintered in Kansas, and sent to Kansas City to market as a yearling. Grazed in Missouri during the summer, again sent to Kansas City, then to Indiana to be fattened and to Chicago to be slaughtered. The beef was shipped in a refrigerator car to Louisiana to be consumed

3. How can the local farmers produce profitably a larger part of the products they consume and more of what the people in the town use?

4. How could the farmers cure their own hams, bacon, and dried beef and supply their own fresh meat through a local coöperative beef club? Ascertain the formulæ for curing meats on the farm and suggest plans for a beef club.

5. Suggest plans whereby the people of the town and country can work together and keep a larger share of the business of the community at home.

6. If there are local manufactories in the town, ascertain where the products are marketed, and if the local demand for such goods is fully supplied or whether similar products are shipped into the community from distant cities while a portion of the product of the local factory is shipped to distant markets. Make an estimate of the saving that would result if the products of the factories were marketed at home.

7. Consult the freight agents of the railway and the local merchants to ascertain if cattle, hogs, sheep, eggs, and poultry are shipped out of town to market and if similar products are shipped into town to be consumed. Is this an economical or a wasteful way of doing business? Would not the farmer receive a higher price for his products and the consumer secure his food at a lower price if the two classes worked in close coöperation through the local retail dealer?

8. Make an estimate of the number of hands a beefsteak passes through from the time it leaves the shipping station of the cattle producer until it reaches the table of the consumer.

9. Ascertain if the farmers of your locality so grade and pack their butter, eggs, fruit, vegetables, poultry, and meat, that it is uniform in quality, standard in grade, and attractive to the purchaser, or is it necessary for the merchant to rework, regrade, or repack these products before they are sold?

EXERCISE 96 (*Continued*)

10. How could the farmers of the locality improve upon their present methods of marketing their products?

11. How could the consumers improve upon their present ways of buying, so as to keep the money at home?

12. Who would profit most by a closer coöperation between farmers and the townspeople?

13. Write a theme on the wastes of the present system of doing business in your community and how it may be improved. State what you think are the obligations of the townspeople and the country people in this matter.

References. WATERS, H. J. Essentials of Agriculture, pp. 436–442. Ginn and Company. COULTER, J. L. Coöperation among Farmers. Sturgis and Walton Company. HUNT, T. F. How to Choose a Farm, pp. 62–66. The Macmillan Company.

OUTLINE OF TYPICAL HOME PROJECTS

I. PRODUCTION PROJECTS

PROJECT 1

GROWING CORN FOR PROFIT

Materials. Selected seed; an acre or more of land; the use of the necessary tools; machinery.

Directions. Consult all the literature available on corn production. Confer with the best corn growers of the community regarding the variety to use, sources of seed, methods of manuring and preparing the land, time and method of planting and cultivating the crop. Make and keep a record of everything you do; keep an accurate account of the time required, and the cost of each operation. Use only such methods as are practicable in commercial corn growing, but leave nothing undone that is practicable that will increase the yield. Enter a full statement of your operations in the blanks which follow.

SOIL RECORD

NOTE. A record of the soil will furnish a basis for determining what sort of fertilizer, if any, to use, as well as the nature of the cultivation that will prove the most desirable. The references will give specific information and should be studied. Others may be obtained that will prove valuable.

Bottom or Upland	Acres in Field	Crops grown on Soil Last Year	Crops grown on Soil Year before Last	Number of Years Field has been in Cultivation	When Legume Crop was last grown on Field	Fertilizers		
						Year before last and amount	Used last year and amount	Used this year and amount

SEED RECORD

Variety of Seed	Where Obtained	How Seed was tested for Germination	Result of Germination Test	Date of Planting	Date of Replanting if any	Final Stand		
						Good (95 per cent)	Medium (90 per cent)	Poor (85 per cent)

PROJECT 1 (*Continued*)

CARE AND HARVESTING RECORD

What is the exact size of the plot?
Explain what was done in the way of preparing the ground for the corn crop.
When and how did you give your ground its first cultivation after seed was planted?
How many times did you cultivate the ground after planting?
Just what kinds of tools did you use in cultivating your plot?
When and how was the crop laid by?
Give date and method of harvesting the crop.
Explain how the grain was weighed or measured to determine the yield.

COST, YIELD, AND PROFIT FOR THE YEAR

NOTE. In making up cost of your plot, figure rent at 5 per cent on the value of your plot as farm land; your time at 10 cents per hour (your father's time or hired help at 20 cents per hour); each horse at 10 cents per hour; barnyard manure at 50 cents per load (approximately one ton) whether applied this year or last; commercial fertilizers, at actual cost to you.

FILL OUT THE FOLLOWING ITEMS CAREFULLY	TOTAL NUMBER OF HOURS	TOTAL COST
a. Disking, manuring, or other work before planting, self and two horses 30 cents per hour, 10 cents per hour for each additional horse		
b. Planting the plot (self and team), 30 cents per hour		
c. Hoeing, weeding, or thinning (self), 10 cents per hour		
d. Cultivating (self and team), 30 cents per hour		
e. Harvesting crop (self and team), 30 cents per hour		
f. Estimated rent (5 per cent of value of the plot)		
g. Cost of barnyard manure at 50 cents per load		
h. Cost of seed (if you did not purchase it, figure its market value at the price of good seed)		
i. Total		
j. Total yield, bushels		
k. Market value December 1		
l. Net profit from the plot		

PROJECT 2

GROWING A VEGETABLE GARDEN FOR PROFIT[1]

Material. A suitable plot of land; seeds; tools; fertilizers; hotbed; cold frame.

Directions. 1. Locate the site of your garden, but before determining its size or the vegetables you will grow, read the required references, make such investigations as you can, and write answers to the following questions. Submit your answers to your parents and teacher for criticism and approval.

a. Is this community noted for good gardens?
b. Enumerate in order of importance the six most valuable garden vegetables.
c. Can you sell all your garden products in the local market?
d. Will you sell to stores or direct to consumers?
e. What kind of soil is best for a vegetable garden?

2. Determine the size of your garden and the amount of space to be given to each kind of vegetable. Determine just what vegetables you will grow, giving varieties of each.[2]

3. Make a drawing of your garden according to scale, showing the exact location and area of each proposed crop.

4. Study the life history of each vegetable you will attempt to grow.

5. Make a list of all the tools you will need and make arrangements to get them as needed.

6. Purchase the necessary seeds.

7. Prepare your garden for planting and start your hotbed and cold frame.

8. In a book provided for the purpose keep a daily account of all receipts and expenditures.

9. On blank forms similar to those below keep a full and exact account of the entire project.

SOIL RECORD

Bottom or Upland	Area of Plot	Crops grown on Soil Last Year	Crops grown on Soil Year before Last	Number of Years Field has been in Cultivation	When Legume Crop was last grown on Plot

[1] This project may be used as an individual home project or as a coöperative project on the school farm. It should follow, or be taken with Hotbeds or Cold Frames.

[2] These are very important and difficult problems. Read "Vegetable Gardening and Canning," by Nolan and Greene.

PROJECT 2 (*Continued*)

PLANTING RECORD

NOTE. Do not include in this any vegetables started in a hotbed or cold frame. Make an entry for each variety.

VEGETABLE	VARIETY	DATE PLANTED	DEPTH IN INCHES	DISTANCE IN INCHES	DISTANCE APART OF ROWS IN INCHES	DATE OF FIRST HARVEST	DATE OF LAST HARVEST

HOTBED AND COLD-FRAME RECORD

VEGETABLE	VARIETY	DATE PLANTED IN HOTBED	DATE PLANTED IN OR TRANSPLANTED TO COLD FRAMES	DATE TRANSPLANTED IN GARDEN

SUMMARY INVENTORY

NOTE. Insert all items, receipts, and disbursements.

ITEM	CHARGE	CREDIT

PROJECT 3

FINDING THE HIGH YIELDING EAR FOR SEED

Material. Twenty or thirty ears of seed corn of the variety to be tested for each student, and an equal number of corn rows 125 feet long. It is desirable to have different students test different varieties. The best local varieties should be tested and also the varieties recommended by the State Agricultural College.

Directions. Select twenty or thirty seed ears of the variety or strain best adapted to the neighborhood or that your father grows as his main crop and plant one row, 125 feet long, from the seed of each ear. This will require about four rows of kernels from the ear. Number each ear to correspond to the row in which the kernels are planted, ear No. 1 being planted in row No. 1, etc. The remainder of each ear should be tagged, wrapped, and put away for use after the results of the experiment have been determined. Plant the same number of kernels in each row and give all rows the same treatment.

At harvest ascertain the percentage of a perfect stand in each row; the number and percentage of barren stalks; the date on which the plants of each row begin to mature, observing which rows are early, which are late, and the number of days between maturity of the earliest and latest rows. When the corn is mature, husk each row separately and weigh the ears of each. Record the weight of corn in each row. Fill in the blanks on the following page.

Select thirty or forty of the best ears from the ten highest-yielding rows for seed for the next year's ear-row test and save all the other good ears from these rows as seed for the main crop. It is not safe to restrict the choice of seed to one or two of the highest-yielding rows, because the corn would become too closely inbred.

The ears of corn from which the seed came that produced the highest-yielding rows are to be planted in the seed plot, and the corn thus produced used for seed the next year.

PROJECT 3 (*Continued*)

THE EAR-ROW TEST

Row Number	General Character of Plant	Maturity	Type	Color	Grain	Germ	Yield per Acre
	Coarse or leafy	Late, medium, or early	Variable or mixed	Pure or mixed	Deep, medium, or shallow	Large, medium, small	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							

PROJECT 4

GROWING POULTRY FOR PROFIT

Material. Not less than twelve dozen selected eggs; poultry houses; pens; incubators; brooders; and the necessary chicken feed.

Directions. Give not less than six months to this project. Before beginning the project review all that you have learned about poultry. Study the following very carefully: (1) building poultry houses and pens; (2) the construction, care, and use of incubators; (3) the feeding and care of chickens.

Having completed the required reading, determine the number of eggs with which you will begin. Prepare your poultry house and pens from plans approved by your teacher. Procure an incubator of proper size and design approved by your teacher. Make all necessary arrangements for the proper kind and amount of food. Purchase your eggs and begin the project. Be sure to purchase only fresh fertile eggs.

On blank forms like those below keep a full and complete record.

HATCH RECORD

Day	Fertile	Infertile	Dead	Broken	Remarks
1st					
7th					
14th . . .					
21st . . .					
Total . . .					

INCUBATION RECORD

Total eggs	
Per cent of eggs (total) hatched	
Total number of chicks	
Total egg cost per chick	
—— eggs at —— cents per dozen	
—— gallons kerosene oil at —— cents per gallon	
—— hours labor at —— cents per hour	
Interest and depreciation	
Total cost of hatch	
Total cost per chick	

PROJECT 4 (*Continued*)

BROODING RECORD

Chicks started with	
Chicks lost	
Cockerels sold —— cockerels —— pounds ——	
Pullets reared	
Cocks reared	
—— gallons of fuel at —— cents per gallon	
—— hours labor at —— cents per hour	
Feed	
Interest and rent	
Total cost of brooding	
Cost per bird	
Incubation	
Brooding	
Total cost of flock	
Total cost per bird	

SUMMARY AND FINANCIAL STATEMENT

Month	Feed Consumed			Cost of Feed				Eggs Sold		Fowls Sold		Labor, Self
	Pounds Grain	Pounds Mash	All Else	Grain	Mash	All Else	Total	Number Dozen	Value	Number	Value	
Total												

FINAL SUMMARY

Note. Include a full and complete statement of all receipts and expenditures, showing totals and net profit.

Inventory	Items	Charges	Credit

PROJECT 5

KEEPING TWO DOZEN HENS FOR EGG PRODUCTION

Material. Two dozen selected hens; poultry house; pens; feed.

Directions. Make all needed preparation in advance so that when the time comes to start the project you will know just what to do and how to do it. Do all the required reading; talk with your teacher concerning all doubtful points; make complete plans and arrangements.

Having prepared the poultry houses and pens and made all necessary arrangements for feed and proper care, select and purchase your hens. Feed them an egg-producing ration, care for them daily, collect and market the eggs. Keep a full account of all receipts and expenditures for a period of three months. Supplementary to the tabulated information required below, write up the project in composition form. In writing your composition include such items as the following: breed of hens, period of greatest egg production, health of flock, effect of climatic changes, how the poultry house was kept clean, and general conclusions drawn from project. Compare your conclusions with those found in standard references; with results obtained by your classmates.

FINANCIAL SUMMARY

Month	Feed Consumed			Cost of Feed			Eggs Sold	
	Pounds Grain	Pounds Mash	All Else	Grain	Mash	All Else	Dozen	Value
Totals								

RATIONS USED

Month	Pounds Corn	Pounds Wheat	Pounds Mixed Grain	Pounds Meat Scraps	Pounds Mash	Pounds Shell	Pounds All Else
Totals							

PROJECT 5 (*Continued*)

SUMMARY INVENTORY

NOTE. Insert all items, receipts, and disbursements.

DATE	ITEM	CHARGE	CREDIT

II. SOIL PROJECTS

PROJECT 6

PREPARATION OF A SEED BED FOR WHEAT

Statement. The wheat plant makes a part of its growth during the fall, winter, and early spring, when the chemical and bacterial actions in the soil are at their lowest point of activity. These actions which liberate food for the growing plant are most active when the season is moist and warm. As a consequence land that will produce fairly well of crops which are cultivated and which grow only through the spring and summer, may not produce wheat well unless the farmer takes steps to assist nature in unlocking the plant food in the soil. He accomplishes this by plowing the land a month or two before the seed is sown and by harrowing the land frequently enough to keep down the weeds. By this means also moisture is accumulated and conserved, because land, when plowed, absorbs the moisture which falls as rain, and it is conserved because the weeds are kept down so that they do not rob the soil of moisture as they do on unplowed land. Available plant food is conserved also, as the weeds are not allowed to grow to use up the food as rapidly as it becomes available.

FIG. 154. How the yield may be increased by timely plowing

Material. Plot of ground which may be seeded to wheat; seed wheat.

Directions. 1. Divide the plot selected into three sections. Prepare the first section by plowing, disking, and harrowing it at least two months before time for seeding. Prepare the second section by plowing and harrowing it just before seeding time. Prepare the third section by disking to a depth of three inches and harrowing, just before seeding time. At seeding time harrow the first section, leave the other two sections as they are, and seed them all to wheat. Plant the wheat about an inch deep. Observe the differences in growth from time to time.

Test by pulling up different plants. If the seed bed was properly prepared, the plants will break off instead of being pulled out by the roots. If they leave the soil, it is because the seed bed has not been compacted sufficiently. Notice the methods used in preparing soil for wheat on different farms. Fill in the blank on the opposite page. Observe the growth and yield of wheat sown on unplowed corn land as compared with the three plots described above. Explain why farmers do not plow corn stubble land when sowing it to wheat.

Grow a field of wheat for market. Choose seed of a variety that is known to be well adapted to your locality. Prepare the land according to the best information you have, and keep a strict account of the cost of seed and all operations until the crop is marketed. Record the results and strike a balance to show the profit or loss in the operation. Compare your results with those of the best farmers of the neighborhood; with some of the poorest farmers. Note the particulars in which your methods differ from theirs. Explain wherein your method excels theirs.

NOTE. This project may be used as an individual project or as a group project.

PROJECT 6 (*Continued*)

PREPARING A SEED BED FOR WHEAT

Name of Farm	Date Plowed	Number of Cultivations	Date of Last Cultivation	Nature of Soil	Yield in Bushels

PROJECT 7

DETERMINING WHAT THE SOIL NEEDS

Material. Plot of land and different fertilizers.

Directions. Lay out twelve plots of ground exactly 2 rods wide and 8 rods long, marking the boundaries of each by stakes driven well into the ground. Each plot will contain $\frac{1}{10}$ of an acre. Plow all the entire plots and add fertilizers as follows:

Plot Number	Substance to be Used	Plant Food	Amount Needed for $\frac{1}{10}$ A.
1	Nothing		
2	Barnyard manure	10.0 per cent N	135.0 pounds
3	Sodium nitrate (or) dried blood (red) (or) cottonseed meal	16.0 per cent N 12.0 per cent N 6.7 per cent N	4.5 pounds 5.6 pounds 10.0 pounds
4	Acid phosphate (or) steamed bone meal	7.0 per cent P 10.0 per cent P	77.0 pounds 54.0 pounds
5	Muriate of potash (or) sulphate of potash	42.0 per cent K 43.0 per cent K	13.0 pounds 12.6 pounds
6	Nothing		
7	One substance from each of Nos. 3 and 4 combined		
8	One substance from No. 3 and one from No. 5 combined		
9	One substance from No. 4 and one from No. 5 combined		
10	One substance from No. 3, one from No. 4, and one from No. 5 combined		
11	One substance used in No. 4 and the material used in No. 2 combined		
12	Calcium carbonate (or) slaked lime	40.0 per cent Ca. 71.4 per cent Ca.	33.5 pounds 18.6 pounds

Work the fertilizer well into the ground and be careful that the fertilizer on one plot is not dragged on to another by cultivation.

At the proper time plant the entire plot to the same crop — wheat, potatoes or cotton. Plant in rows running lengthwise of the plot. As the growing continues throughout the summer give all the plots the same cultivation in case potatoes or cotton is planted and observe the differences due to fertilizers on the color, vigor, time of maturing, and yield of the crop.

Record the results, using blank forms like those on the following page.

PROJECT 7 (*Continued*)

SOIL RECORD

Bottom or Upland	Acres in Plot	Crops Grown on Soil Last Year	Crops Grown on Soil Year before Last	Number of Years Field Has Been in Cultivation	When Legume Crop Was Last Grown on Field

Plot Number	Substances Used	Amount	Plant Food Furnished		
			N.	P.	K.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

In the blank form place the amount of the plant food elements furnished each of the test plots. Describe the soil on which this test has been conducted.

Problem. 1. Compute the value of the crop on each separate plot at the local market price.

2. Compute in like manner the value of the fertilizer used. Which plot shows the best investment?

3. Rank the plots in order of the value of their gross returns, in the order of the return after deducting the cost of the fertilizer.

III. DEMONSTRATION PROJECTS

PROJECT 8

DEMONSTRATING THE VALUE OF A BALANCED RATION FOR GROWING HOGS

Material. One or two pigs weighing 40 to 50 pounds at weaning time; dry lot, securely fenced; corn, pasture, and other feed as required.

Directions. Select one or two thrifty pigs at weaning time, weighing 40 to 45 pounds each, and confine them in a dry lot. Feed the pigs on corn alone and keep water and ashes before them constantly.

In a similar lot confine an equal number of thrifty pigs of the same age and weight, feed them on a balanced ration, and allow them to have access to water, salt, and ashes regularly.

Put a third lot of similar pigs in a clover, alfalfa, or rape pasture and feed a grain ration in which the digestible protein is reduced one fifth from that of a balanced ration.

Feed in all cases just the amount of grain the pigs will eat without waste. It is best to keep them hungry enough to eat the feed promptly and to clean the trough. Let the feeding period extend from weaning time, about July 1, to the end of November. Weigh the pigs every thirty days. Keep an account of the amount of feed consumed by each lot.

At the end of the trial compute the gain of each lot, the average daily gain of each lot, the number of pounds of grain required to make a pound of gain, the value of the hogs of each lot, and the value of the feed consumed by each. Strike a balance and determine the profit or loss returned by each lot. Invite the hog growers of the neighborhood to inspect the hogs before they are marketed or butchered and report to them the results of the test.

Questions. Which lot made the most rapid gain? Which lot required the least feed for a pound of gain? Which showed the smallest money cost for a pound of gain? Which lot brought the highest price per pound? Which lot brought the lowest price per pound? After deducting all cost, which produced the greatest net profit? Assuming that a farmer marketed fifty hogs a year, what would be his return from this source in twenty years by each method of feeding? Suggest other rations which will make profitable returns on hogs in your neighborhood.

RECORD OF RESULTS

Lot Number	Ration Used	Weight of Hogs at Beginning (in Pounds)	Weight of Hogs at Close (in Pounds)	Weight Gained (in Pounds)	Cost of Grain Consumed	Value of Grain	Profit or Loss

PROJECT 9

FINDING THE FAILURE COW IN THE HERD

Material. Milk cows selected from one or more herds in the community; feed; balances; milk tester; other equipment as needed.

Directions. Feed each cow the same kind of a ration. On the same three days of each month weigh each kind of feed consumed by each animal and record the weight. On the same days weigh the milk produced by each animal, night and morning. Make a composite sample of the milk from each cow and test it for butter fat by the Babcock method, using a separate blank form for each cow. Record all the data in order. At the end of the period of lactation of each make a summary of each cow's cost, production, and profit.

Questions. Is there a wide difference in the efficiency of the cows tested as regards their ability to convert feed consumed into milk and butter fat? How do you explain any difference found? Which of the cows tested shows the greatest profit? Which least? Which one, if either, would you select as the best beef type of animal? Which is the best type of dairy animal?

SUMMARY OF RESULTS

(Use separate blank for each cow)

Cow No. _____

Month	Kind of Feed	Weight of Feed	Value of Feed	Pounds Milk	Per Cent Fat	Value
Total						

IV. IMPROVEMENT PROJECTS

PROJECT 10

THE USE OF CONCRETE ON THE FARM

Material. Clean coarse sand, gravel, or crushed stone; cement; measuring cup; trowel; spirit level; screen; measuring box; materials for forms; reënforcing wire; tools for constructing forms.

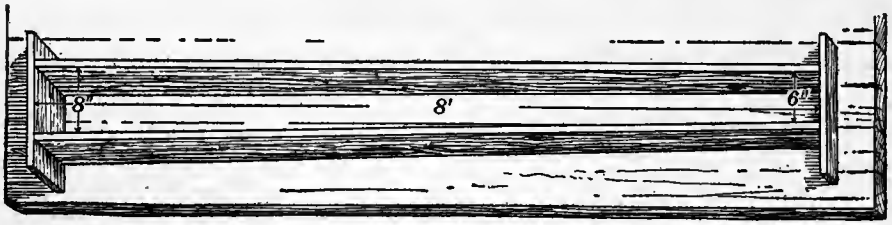


FIG. 155. Mixing board with full-sized post form in place

Directions. 1. *Fence post.* Concrete fence posts should ordinarily be 5″ or 6″ square. The length is determined by the height the post is desired above ground. Construct a mold as shown in Fig. 155, using 1″ dressed lumber. After the mold is assembled give the inside a thin coating of soft soap or crude oil to prevent concrete from sticking. Make a mixture of 1 : 2 : 4 concrete; mix thoroughly while dry and then add sufficient water to make the concrete mushy after being well mixed.

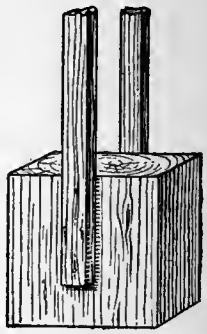


FIG. 157. A wooden tamper

At once place concrete evenly in the form to a depth of $\frac{3}{4}$″, and place two reënforcing wires (No. 9) the length of the post and $\frac{3}{4}$″ from each edge. Pour in concrete until the molds are filled within $\frac{3}{4}$″ of the top, and place two more reënforcing wires. Fill the mold, tamp lightly, and level across the top. To provide for fastening fence wire to posts take two pieces of No. 12 copper wire, 6″ long, and twist the halves together, leaving the ends free for about 2″. While the concrete is being placed in the form, set two or three of these wires in the concrete the proper distance apart for stringing wires, as shown in the illustration. The posts should not be disturbed for at least ten days, to give the cement time to set.

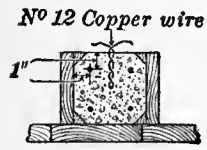


FIG. 156. End of a post showing how to place reënforcing wires and copper wire

2. *Concrete walks and steps.* Excavate to a depth of about 6″ and to a width of 3″ more than desired for the walk. Fill the space excavated with broken stones, coarse gravel, or cinders, to within 4″ of where the top of the walk is to be. Tamp the material thoroughly, using water to help pack it.

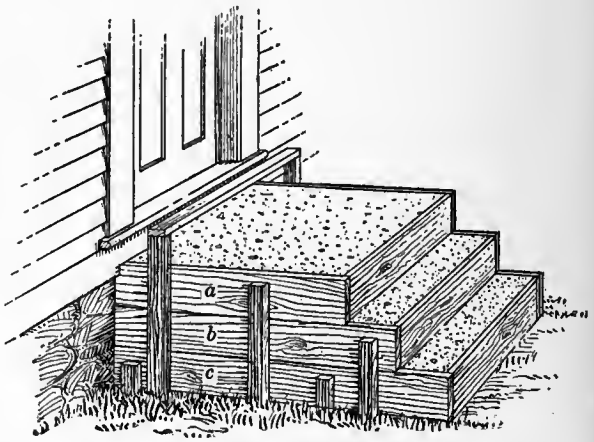


FIG. 158. Concrete steps

Place the form for the walk (2″ × 4″ pieces smooth on the inside) on the foundation. Make one side from $\frac{1}{4}$″ to $\frac{1}{2}$″ lower than the other, so the water will not stand in pools on the walk after a rain. Prepare a mixture of 1 : 3 : 5 concrete and fill the forms to within 1″ of the top. Tamp this mixture until water stands on the surface and at once place the finishing coat, consisting of one part of cement to one and one half parts of sand mixed to a mushy mortar. Smooth the finishing coat, but do not trowel too long and do not allow the walk to be exposed to intense sunshine, freezing temperature, rain, or dust while it is hardening. The walk should be divided into sections to prevent bulging when it expands in

warm weather or cracking when it contracts in cold weather, and it may be divided by building a section at a time, or by cutting the walk into sections while "green," by means of a trowel.

3. To make steps of concrete proceed as above for the foundation. Make frames for each step desired as shown in Fig. 158.

4. *Hog troughs.* A hog trough may be made by making a narrow box frame for the outside form and using a small straight section of a log for the inside form. Grease the inside of the forms and pour full of concrete made by mixing one part of cement to three parts of coarse sand moistened until it is a thick mortar. Tamp the concrete gently until water rises on the top, level with a straightedge, and smooth with a float or trowel. In about ten days remove the forms and soak the trough with water. While it is wet, paint the inside with a coat of pure cement mixed with water to the consistency of heavy paint. Keep the mixture thoroughly moistened for some time after applying, for unless it dries very slowly it will crack and peel off.

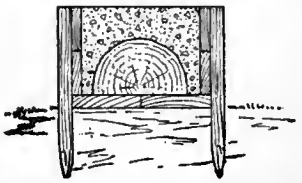


FIG. 159. Cross section of hog trough

PROJECT 11

THE CONSTRUCTION AND USE OF HOTBEDS AND COLD FRAMES

Materials. Window sashes and lumber; spade; soil thermometer; manure prepared as explained below, and angle irons and bolts.

Directions. The hotbed should be 6′ wide, located on the south side of a building and on high ground. In the fall, before the ground is frozen, dig a pit 18″ deep and a few inches larger than the outside dimensions of the frame. If the bed is to be set early, that is, before the middle of March, it is better to dig the pit 2′ deep. Construct the frame as shown in Fig. 160. Window sash may be used to cover the frame. Double glass sash is best, as it avoids the necessity for extra coverings during cold nights.

Gather fresh horse manure, mix it with one fourth its bulk of straw or leaves, and put it in a compact pile to heat. After it has heated for three days fork the heap over. On the fifth day repeat this opera-

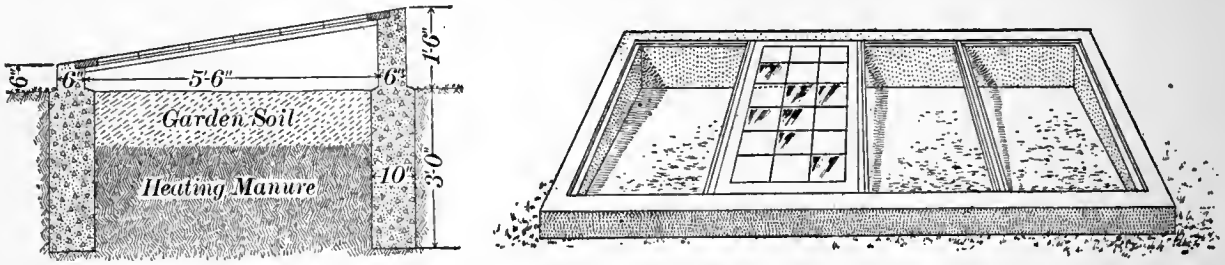


FIG. 160. Concrete hotbed

tion, and on the eighth day place the manure in the pit, tamping thoroughly as it is placed, and wet it thoroughly. Fill the pit to within an inch of the surface. Put the frame in place and bank earth or heating manure around the outside to retain the heat and shed surface water.

Supply a layer of rich garden soil about 6″ deep in which the plants are to be grown. Moisten the soil and place the sash on the bed. There will be a gradual rise in temperature at first, and later the temperature will slowly drop. When the temperature of the soil falls below 90° F., plant the seeds. From this time keep proper temperature by ventilation and water the plants as needed.

Plant such crops as later may be transplanted in the school or home garden.

Record all results as: variety and number of plants produced; daily temperature of the hotbed; and length of time required for the germination of the different kinds of seeds and the rate of growth of the plants of each.

After serving its purpose the hotbed may be used as a cold frame. A cold frame is like a hotbed except that there is no manure pit and no source of heat except the sun. The soil layer should be the same, and the covering may be sash, as in the hotbed, or it may be cloth if the season is well advanced. Record the crops produced and the results obtained, and compare the value of a cold frame with that of a hotbed.

APPENDIX

TABLE I. DIGESTIBLE NUTRIENTS AND FERTILIZING CONSTITUENTS IN COMMON AMERICAN FOODSTUFFS

Name of Feed	Total Dry Matter in 100 Pounds	Digestible Nutrients in 100 Pounds			Nutritive Ratio	Fertilizing Constituents in 1000 Pounds of Material			
		Crude Protein	Carbohydrates	Fat		Nitrogen	Phosphorus	Potassium	Calcium
Concentrates: Grains, Seeds, Etc.:									
Corn (No. 2 Grade)	86.0	7.8	66.8	4.3	1 : 9.6	16.05	3.00	3.22	0.20
Corn cob	86.0	1.4	44.8	0.4	1 : 32	3.90	0.26	3.39	0.10
Corn-and-cob meal	84.9	4.4	60.0	2.9	1 : 15.1	13.60	2.50	2.66	...
Gluten meal	90.5	29.7	42.5	6.1	1 : 1.9	54.80	1.40	0.28	...
Gluten feed	90.8	21.3	52.8	2.9	1 : 2.8	40.00	1.60	0.23	...
Wheat	89.5	8.8	67.5	1.5	1 : 8	20.80	3.40	4.30	0.40
Wheat middlings	88.8	13.0	45.7	4.5	1 : 4.3	27.00	11.30	7.64	...
Wheat bran	88.1	11.9	42.0	2.5	1 : 4	24.60	11.60	7.64	...
Rye	91.3	9.5	69.4	1.2	1 : 7.6	17.60	3.70	4.80	0.40
Rye middlings	88.2	11.0	52.9	2.6	1 : 5.3	22.90	5.30	5.42	...
Barley	89.2	8.4	65.3	1.6	1 : 8.2	16.00	3.40	3.90	0.40
Oats	89.6	8.8	49.2	4.3	1 : 6.7	17.60	3.00	4.00	0.70
Buckwheat	86.6	8.1	48.2	2.4	1 : 6.6	18.10	3.01	2.49	0.50
Rice	87.6	6.4	79.2	0.4	1 : 12.5	10.50	0.80	0.70	0.08
Canada field pea	85.0	19.7	49.3	0.4	1 : 2.5	37.90	3.61	5.71	1.00
Cowpea	85.4	16.8	54.9	1.1	1 : 3.4	35.42	4.56	14.00	1.00
Soybean	88.3	29.1	23.3	14.6	1 : 1.9	53.60	4.47	7.12	1.10
Kafir grain	90.1	5.2	44.3	1.4	1 : 9.1	16.90	2.39	2.54	0.12
Sorghum grain	87.2	4.5	61.1	2.8	1 : 14.1	14.80	3.54	2.66	...
Milo grain	91.0	4.9	44.8	1.3	1 : 9.7	17.10	2.40	2.66	0.10
Millet seed	87.9	7.1	48.5	2.5	1 : 7.6	17.40	2.80	1.86	...
Flaxseed	90.8	20.6	17.1	29.0	1 : 3.9	32.80	5.70	8.00	1.80
Linseed meal (old process)	90.2	30.2	32.0	6.9	1 : 1.6	52.10	7.08	10.38	3.62
Linseed meal (new process)	91.0	31.5	35.7	2.4	1 : 1.3	60.00	7.48	7.57	...
Cottonseed	89.7	12.5	30.0	17.3	1 : 5.4	29.40	4.50	6.16	...
Cottonseed meal	93.0	37.6	21.4	9.6	1 : 1.1	69.00	13.28	13.12	2.66
Cottonseed hulls	88.9	0.3	33.2	1.7	1 : 123	6.70	1.85	5.88	...
Sunflower seed	91.4	14.8	29.7	18.2	1 : 4.7	26.10	5.25	3.16	...
Peanut kernels	93.0	26.7	12.6	46.7	1 : 4.3	44.60	5.33	7.17	0.65
Peanut shells	89.9	2.6	9.2	2.8	1 : 5.9	...	...	...	...
Dried brewer's grain	91.3	20.0	32.2	6.0	1 : 2.3	40.00	6.92	1.13	...
Wet brewer's grain	23.0	4.9	9.4	1.7	1 : 2.7	10.70	1.81	0.28	...
Malt sprouts	90.5	20.3	46.0	1.4	1 : 2.2	42.10	7.48	11.24	...
Dried distiller's grain	92.4	22.8	39.7	11.6	1 : 2.9	49.90	2.58	0.96	...
Wet beet pulp	10.2	0.5	7.7	...	1 : 15.4	1.40	0.13	6.44	...
Dried beet pulp	91.6	4.1	64.9	...	1 : 15.8	12.90	0.95	1.75	...
Sugar beet molasses	79.2	4.7	54.1	...	1 : 11.5	14.50	0.22	20.51	...
Cow's milk	12.8	3.4	4.8	3.7	1 : 3.8	5.70	0.83	1.41	1.25
Cream	...	...	...	...	...	4.00	0.64	0.65	...
Cow's milk (Colostrum)	25.4	17.6	2.7	3.6	1 : 0.6	28.20	2.84	0.62	...
Skimmilk	9.4	2.9	5.3	0.3	1 : 2.1	5.20	0.92	1.66	1.28
Buttermilk	9.9	3.8	3.9	1.0	1 : 1.6	6.40	0.73	0.90	1.30
Whey	6.2	0.6	5.0	0.2	1 : 9.0	1.00	0.47	1.13	0.44
Fat hogs	...	...	...	...	...	17.60	3.14	0.50	...
Meat scrap	89.3	66.2	...	13.4	1 : 0.4	114.00	34.87	...	...
Dried blood	91.5	70.9	...	2.5	1 : 0.8	135.00	5.80	4.35	...
Tankage — 60 per cent protein	93.0	58.0	4.0	9.0	1 : 0.4	96.00	16.27	5.45	29.48
Tankage — 40 per cent protein	92.0	38.0	5.0	11.0	1 : 0.8	...	...	...	...

APPENDIX

TABLE I. DIGESTIBLE NUTRIENTS AND FERTILIZING CONSTITUENTS IN COMMON AMERICAN FOODSTUFFS (*Continued*)

Name of Feed	Total Dry Matter in 100 Pounds	Digestible Nutrients in 100 Pounds			Nutritive Ratio	Fertilizing Constituents in 1000 Pounds of Material			
		Crude Protein	Carbohydrates	Fat		Nitrogen	Phosphorus	Potassium	Calcium
Dried Roughage and Hay:									
Corn fodder, ears remaining	57.8	2.5	34.6	1.2	1 : 14.9	7.2	2.32	5.03	...
Corn stover, ears removed	59.5	1.4	31.2	0.7	1 : 23.4	8.00	1.00	6.16	4.72
Corn husks	49.1	0.8	33.8	0.2	1 : 42.8	4.10	...	...	...
Corn leaves	70.0	2.8	37.8	0.8	1 : 14.1	9.80	...	...	...
Timothy	86.8	2.8	42.4	1.3	1 : 16.2	9.40	1.42	8.02	1.77
Barley	85.0	5.7	43.6	1.0	1 : 8.0	14.10	...	...	...
Oats	86.0	4.7	36.7	1.7	1 : 8.6	14.20	2.88	14.35	...
Barnyard millet	86.0	5.2	38.6	0.8	1 : 7.8	16.90	1.85	16.27	...
Cat-tail millet	89.0	7.2	41.6	1.0	1 : 6.1	18.50	...	...	...
Hungarian grass	86.0	5.0	46.9	1.1	1 : 9.9	12.10	1.85	8.70	...
Prairie grass	90.8	3.0	42.9	1.6	1 : 15.5	9.90	...	...	...
Red clover	84.7	7.1	37.8	1.8	1 : 5.9	19.70	2.50	15.00	11.42
Mammoth red clover	78.8	6.2	34.7	2.1	1 : 6.3	19.90	...	...	...
Alsike clover	90.3	8.4	39.7	1.1	1 : 5.0	20.50	2.15	7.85	...
Crimson clover	90.4	10.5	34.9	1.2	1 : 3.6	24.30	1.72	7.40	...
Japan clover	89.0	9.1	37.7	1.4	1 : 4.5	22.10	...	...	...
Sweet clover	90.8	10.0	37.0	1.5	1 : 4.0	27.70	2.45	15.19	11.00
Soybeans	88.2	10.6	40.9	1.2	1 : 4.1	23.80	2.12	15.86	12.32
Cowpeas	89.5	9.2	39.3	1.3	1 : 4.6	21.50	2.53	7.80	18.14
Alfalfa	91.9	10.5	40.5	0.9	1 : 4.0	23.00	2.21	7.70	10.46
Peanut vine	92.4	6.7	42.2	3.0	1 : 7.3	17.10	1.38	6.55	...
Velvet bean	90.0	9.6	52.5	1.4	1 : 5.8	22.40	...	...	...
Sanfoin	85.0	10.4	36.5	2.0	1 : 3.9	23.70	2.15	8.30	...
Oat and pea	89.5	7.6	41.5	1.5	1 : 5.9	16.50	2.62	10.23	...
Straw:									
Wheat straw	90.4	0.8	35.2	0.4	1 : 45.1	5.00	.95	3.56	1.90
Rye straw	92.9	0.7	39.6	0.4	1 : 57.9	4.00	1.10	7.10	2.20
Oat straw	90.8	1.3	39.5	0.8	1 : 31.8	5.80	1.29	10.00	3.00
Barley straw	85.8	0.9	40.1	0.6	1 : 46.0	6.40	0.80	8.80	2.30
Field bean straw (pods)	95.0	3.6	39.7	...	1 : 11	...	...	...	...
Soybean straw	89.9	2.3	40.1	1.0	1 : 18.4	6.80	1.08	5.88	...
Green Roughage:									
Corn fodder	20.7	1.0	11.9	0.4	1 : 12.8	2.90	4.7	2.20	...
Kafir	17.5	0.9	9.0	0.5	1 : 11.2		...	...	...
Yellow milo	16.8	1.1	9.3	0.3	1 : 9.1	2.70	0.47	3.22	...
Sorghum	20.6	0.6	11.6	0.3	1 : 20.5	2.10	0.3	1.92	...
Sugar cane	15.8	0.5	9.5	0.3	1 : 20.4	1.90	0.39	2.49	...
Roots and Tubers:									
Potato	20.9	1 .1	15.7	0.1	1 : 14.5	3.40	0.70	4.80	0.20
Common beet	11.5	1.2	7.9	0.1	1 : 6.8	2.40	0.34	2.71	...
Mangel	9.1	1.0	5.5	0.2	1 : 5.9	1.90	0.39	3.15	0.15
Sugar beet	13.5	1.2	9.8	0.1	1 : 7.7	1.60	0.40	3.20	0.30
Flat turnip	9.9	0.9	6.4	0.1	1 : 7.3	2.10	0.39	1.92	...
Carrot	11.4	0.8	7.7	0.3	1 : 10.5	1.80	0.39	1.47	...
Rutabaga	11.4	1.0	8.1	0.2	1 : 8.5	1.90	0.52	2.77	...
Artichoke	20.5	1.3	14.7	0.2	1 : 11.6	4.20	0.61	2.66	...
Sweet potato	28.9	0.8	22.9	0.3	1 : 29.5	2.40	0.34	2.09	...
Chufa	20.5	0.6	9.1	5.6	1 : 35.7		...	...	...

APPENDIX

TABLE I. DIGESTIBLE NUTRIENTS AND FERTILIZING CONSTITUENTS IN COMMON AMERICAN FOODSTUFFS (*Continued*)

Name of Feed	Total Dry Matter in 100 Pounds	Digestible Nutrients in 100 Pounds			Nutritive Ratio	Fertilizing Constituents in 1000 Pounds of Material			
		Crude Protein	Carbohydrates	Fat		Nitrogen	Phosphorus	Potassium	Calcium
SILAGE:									
Corn	31.53	1.4	18.1	0.7	1 : 14	4.30	0.48	3.07	1.40
Sorghum	23.9	0.1	13.5	0.2	1 : 139	1.30	0.66	1.58	...
Kafir	...	...	...	...	...	...	...	...	...
Soybean	25.8	2.7	9.6	1.3	1 : 4.6	6.60	0.51	4.24	...
Cowpea vine	20.-	1.5	8.6	0.9	1 : 7.1	4.30	0.65	2.60	...

TABLE II. PLANT FOOD CONTAINED IN COMMON FERTILIZERS

Name of Fertilizer	Fertilizing Constituents in 1000 Pounds of Material			
	Nitrogen	Phosphorus	Potassium	Calcium
Barnyard manure	5.00	1.50	4.00	0.60
Dried blood	140.00	0.80	1.60	0.40
Sodium nitrate	155.00	...	...	...
Ammonium sulphate	200.00	...	...	...
Steamed bone meal	10.00	125.00	...	...
Raw bone meal	40.00	90.00	...	...
Raw rock phosphate	...	125.00	...	...
Acid phosphate	...	62.50	...	...
Basic slag	...	80.00	...	...
Wood ashes (unleached)	...	5.00	50.00	200.00
Kainit	...	...	100.00	...
Potassium chloride	...	...	480.00	...
Potassium sulfate	...	...	500.00	...
Raw limestone	...	...	...	400.40
Burned lime	...	...	...	774.60
Water-slaked lime	...	...	...	540.00

APPENDIX

TABLE III. FEEDING STANDARDS [1]

	Dry Matter Per 1000 Pounds Live Weight	Digestible Nutrients			Nutritive Ratio
		Protein pounds per 1000 pounds	Carbohydrates pounds per 1000 pounds	Fat pounds per 1000 pounds	
Swine, Growing:					
Pigs, first period	45–52	6.3	29.0	1.8	1 : 5.2
Early fattening	36–45	6.4	30.0	1.6	1 : 5.2
Late fattening	28–35	3.2	21.0	1.4	1 : 7.5
Swine, well Grown					
Brood sows	12–16	1.5	9.0	.5	1 : 6.7
Gilts	13–17	1.7	8.8	.6	1 : 6.0
Fattening	25–35	2.6	21.0	1.4	1 : 9.3
Cattle, Dairy:					
Maintenance	13–22	.6	6.6	.1	1 : 11.4
10 pounds of milk	21–28	1.1	9.0	.2	1 : 8.6
40 pounds of milk	27–35	2.6	15.0	.8	1 : 6.1
Cattle, Beef:					
Maintenance	12–21	.6	6.6	.1	1 : 11.4
Early fattening	26–32	3.0	15.0	.7	1 : 5.51
Late fattening	24–30	2.5	16.0	.7	1 : 7.0
Horses:					
Light work	18–23	1.5	9.5	.4	1 : 6.9
Heavy work	24–28	2.4	13.6	.8	1 : 6.4
Sheep, Lambs:					
Weaned	25–27	3.2	15.0	.7	1 : 5.2
Fattening	27–31	3.0	16.5	.5	1 : 5.9
Sheep, Full Grown:					
Maintenance	18–22	1.0	9.5	.2	1 : 9.9
Fattening	23–31	2.7	16.5	.8	1 : 6.8

[1] Computed on the basis of the amount of the different constituents required daily for each 1000 pounds of live weight. After Wolff, Lehmann, Kellner, Armsby, Haecker, and Evvard.

APPENDIX

TABLE IV. SUGGESTED LIST OF TYPICAL HOME PROJECTS

[Those marked with an asterisk are outlined in the manual.]

I. PRODUCTION PROJECTS

Field Crops

1. *Growing Corn for Profit
2. Growing One-half Acre of Potatoes
3. Growing One-half Acre of Cotton
4. Finding the High Yielding Ear for Seed
5. Growing an Acre of Alfalfa

Orchard and Garden Crops

6. *Growing a Vegetable Garden for Profit
7. A Home Fruit Garden
8. Planting and Caring for Fruit Trees
9. Managing Bearing Orchards
10. Renovating a Neglected Orchard
11. Strawberry Production
12. Commercial Vegetable Garden

Animal Husbandry

13. The Care of a Sow and a Litter of Pigs
14. Feeding Weanling Pigs for Market
15. Raising Baby Beef
16. Raising a Calf
17. Raising a Group of Lambs
18. Raising Dairy Calves
19. Dairy Cow Management
20. Keeping a Yearly Record of Dairy Cows
21. *Keeping Two Dozen Hens for Egg Production
22. *Growing Poultry for Profit
23. *Managing Incubators and Brooders
24. Managing Half-dozen Stands of Bees

II. SOIL PROJECTS

1. Renovating Worn Soil by Means of Crop Rotation, the Use of Green or Barnyard Manure or Commercial Fertilizers
2. The Value of Legumes as a Preceding Crop
3. Preventing Surface Erosion by Means of Terracing, Dams, and Tiles or Underdrainage
4. *Preparation of a Seed Bed for Wheat
5. *Determining What the Soil Needs

III. IMPROVEMENT PROJECTS

1. Making a Self-feeder for Swine
2. Making a Farrowing House for Sows
3. Making a Brooder for Chickens
4. Making Chicken Houses
5. *Construction and Use of a Hotbed or Cold Frame
6. *The Use of Concrete on the Farm
7. Planting the Home Grounds
8. Planting and Care of Trees and Ornamentals on the School Grounds

IV. COÖPERATIVE SCHOOL PROJECTS

1. Making an Exhibit at the County or State Fair of the Farm and Garden Products by the Students in Their Home-project Work, together with Itemized Statements of the Yields, Cost of Production, and Profits of Each Product
2. Maintaining a Similar Exhibit in the County Agent's Office or in Some Other Public Place, but on a Smaller Scale and Changed Periodically so as to Bring in All the Students and All Important Products during the Year

V. CONTROL PROJECTS

1. Hog Cholera
2. Texas Fever
3. Chinch Bugs
4. Grasshoppers
5. Hessian Fly
6. Gypsy Moth

VI. MANUFACTURING PROJECTS

1. Curing Meat, Pork, and Beef
2. Making Butter
3. Making Cheese
4. Making Ice Cream

VII. MARKETING PROJECTS

1. Distributing Milk
2. Distributing Fruit and Vegetables
3. Distributing Poultry Products
4. Distributing All Farm Products

VIII. RECLAMATION PROJECTS

1. Reclaiming Wet Land by Drainage
2. Converting Waste Brush Land into Pasture
3. Renewing Worn-out Land by Means of Green Manuring
4. Reclaiming Sour Land by the Use of Lime or Ground Limestone
5. Reclaiming Arid Land by Means of Irrigation or Dryland Farming

IX. DEMONSTRATION PROJECTS

1. *Demonstrating the Value of a Balanced Ration for Growing Pigs
2. Finding the Failure Cow in the Herd