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DIVISION OF HORTICULTURE.

OUTLINE OF GREENHOUSE LABORATORY WORK.

DECEMBER 1901.

OUTLINE

OF

GREENHOUSE LABORATORY WORK

SAMUEL B. GREEN,
PROFESSOR OF HORTICULTURE.

R. S. MACKINTOSH,
ASSISTANT IN HORTICULTURE.

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GENERAL DIRECTIONS.

A suitable note book must be provided for recording the work done in the laboratory. One about the size of this bulletin is best.

Give each exercise its number and title.

State briefly how the exercise has been performed; the results and any point of special interest to you in connection with it. Special note should be made of the care and growth of the plants which are handled in the greenhouse.

Do not copy the exercise from this bulletin.

Write up the results while they are fresh in mind and have note books ready for examination at any time.

In marking the note books special attention will be given to the following points: (a) Thoroughness, neatness and system in writing up the results of the work. (b) Spelling. (c) English. (d) Clear penmanship.

After being assigned a locker in the greenhouse laboratory, examine its contents carefully and see that all the proper apparatus is on hand and in good order. If incomplete have the matter remedied at once. Sign the apparatus list and return to the one in charge.

If apparatus or key is lost, missing or broken at the close of the term, no excuse will be taken, but it must be paid for.

OUTLINE OF GREENHOUSE LABORATORY WORK.

INTRODUCTION.

This bulletin is prepared especially as a guide for the use of the classes in the greenhouse laboratory work of the Minnesota School of Agriculture. It is one of the results of the development of our special School of Agriculture and of our efforts to meet the necessities of students.

As our school is in session during the autumn and winter months only, it is very desirable to illustrate by indoor exercises some of the principles that underlie the practice of horticulture and agriculture in this section. Many of the lessons here given could be illustrated much better by field practice and many other and perhaps more valuable lessons could be given, were it possible to have the school in session during the growing season. The development of this work has been greatly facilitated by the loyal and earnest attention of Mr. R. C. Carroll, for many years foreman of the Division of Horticulture, and my assistant, Mr. R. S. Mackintosh, who has been closely identified with this line of instruction from its inception.

THE GREENHOUSE LABORATORY.

The greenhouse laboratory is a one-story (26 feet by 50 feet) wing of the horticulture building. It has a large skylight, a cement tile floor, brick walls, benches on three sides, with ninety lockers. A supply room occupies one corner. On the walls are hung framed specimens of most of our troublesome weeds. Twenty-two students can easily work here at one time. Each working place is equipped with small watering pot, small shovel, three screens, smoothing board, dibber, etc. In addition, each student is furnished in his locker with two germinating pans com-

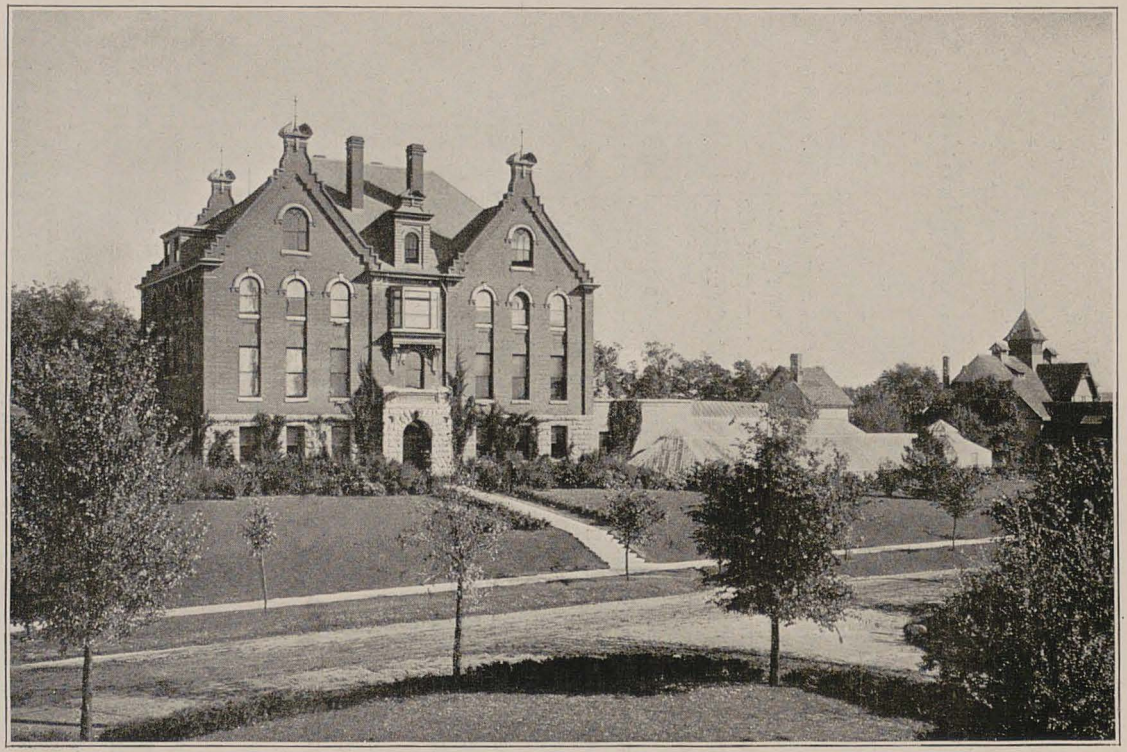


Fig. 1. The Horticulture Building.

Fig. 2. The Greenhouse Laboratory.

plete, a budding knife and a grafting knife. In the store room is other apparatus which is supplied as occasion demands.

The person having this work in charge, in order to obtain best results, must insist upon its being done carefully and thoroughly. The note book of each student must contain a full statement of the way the work is done and the results from it. If time can be found for it, some of the more important exercises should be re-

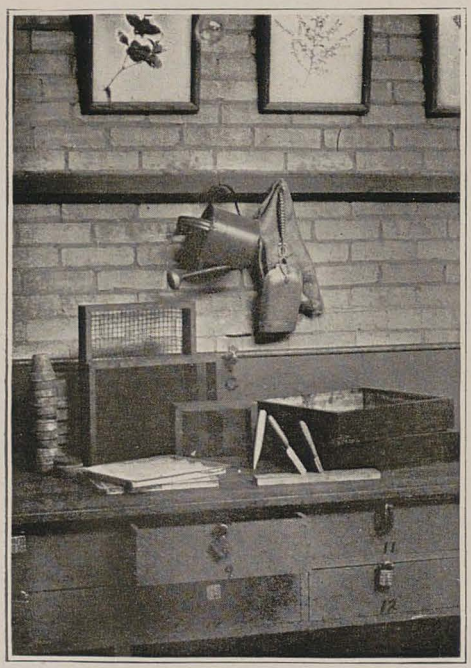


Fig. 3. Apparatus at Student's Bench in Laboratory.

peated. Many matters of interest in the same general line may often be introduced to advantage. These are quite numerous in all greenhouses, and may consist of some specially troublesome disease, such as club root of cucumbers and tomatoes, or leaf spot of roses, or of the common insects that are troublesome under glass, as the red spider, green fly, mealy bug and scale. Other methods of potting or shifting may be occasionally performed, or

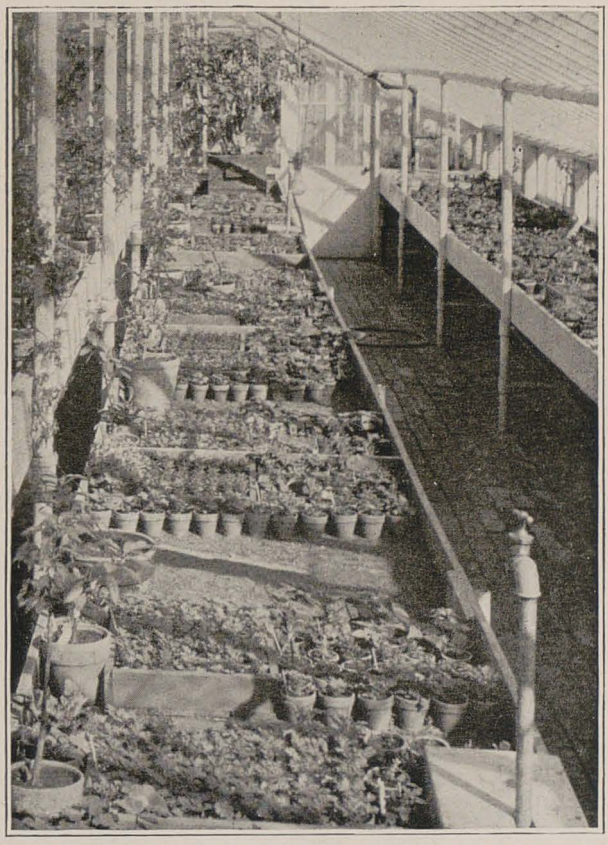


Fig. 4. Portion of Student's Greenhouse.

some bud variation shown before the class. In fact, it should be the aim of the instructor to have every period crowded with suggestions, and never lose sight of the fact that he is teaching principles. It is very important that the student label every plant he handles with its common name, and become familiar with its value. A good gardener, or other person used to the care of greenhouses, should be in charge of the daily routine work of watering and ventilating the greenhouses, as students have their time too closely occupied with other lines of work to assure good results when all the details are left entirely to them.

SAMUEL B. GREEN.

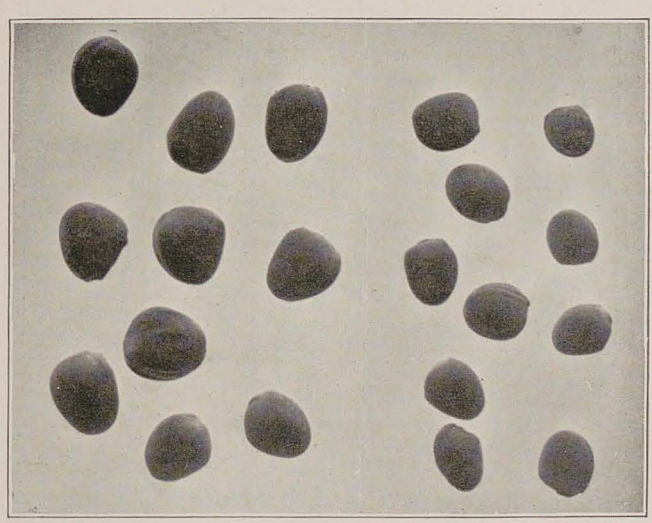
OUTLINE OF GREENHOUSE LABORATORY WORK.

SAMUEL B. GREEN, R. S. MACKINTOSH.

LESSON A.

LARGE SEEDS VS. SMALL SEEDS.

There is generally an advantage in sowing large seeds. In the case of the Radish the large seeds give larger and earlier radishes than the small seeds. At the Minnesota Experiment Station in 1901 the difference in the product was as follows:



Large. Small.

Fig. 5. Radish Seeds.

Large Seed	Marketable	57	per cent.
	Small	43	" "
Small Seed	Marketable	34	" "
	Small	66	" "

The product from the large seed was marketable four days earlier than that from the small seed.

MATERIAL NEEDED. One flat (box); potting soil; radish seed; smoothing board; two 4-inch pot labels.

Exercise 1. Count out 100 of the smallest and 100 of the largest radish seeds.

From large seed. From small seed

Fig. 6. Radishes—product from large and small seed.

The soil for the seed bed should consist of any good garden or potting soil. Potting soil is made by mixing together 2 parts good garden loam, 2 parts leaf mold, 2 parts rotted manure, 2 parts clean sand; screen through a one-half inch mesh screen. Level off and make depressions (see figure 8) for four rows the

long way of flat. Write labels as shown in figure 7—always begin at end that does not go into the soil. Never use a pen or indelible pencil, but rather a soft black lead pencil, well sharpened. Sow 50 seeds in a row. Water and put at your place in greenhouse.

The seed for this purpose should be just as it comes from the winnowing machine after threshing, and before it has been screened. The ordinary radish seed of the stores has generally

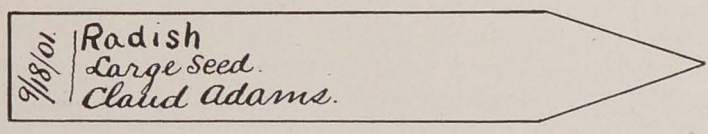


Fig. 7. Pot Label. Proper way of writing date, name, etc.

had all the small seeds taken out, and there is not as much difference in the seeds as is desirable.

LESSON B.

SEED SOWING IN BOXES.

Many kinds of plants must be started under glass in order to have them sufficiently large to get satisfactory results; such seeds are usually sown in boxes.

MATERIAL NEEDED. Flat; smoothing board; potting soil; lettuce, Golden Feather and Petunia seed; labels.

Exercise 2. Fill flat to within one-half inch of the top with good potting soil; screened through a half-inch screen; on top of this put one-fourth-inch potting soil screened through one-eighth-inch screen, to make a fine surface in which to sow the seed. This is not necessary in the case of large seeds like lettuce, but is very

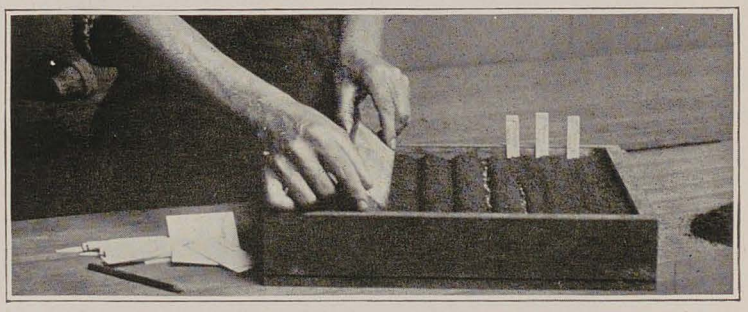


Fig. 8. Use of board in opening drills for seed. Rows at right are covered

desirable in the case of small seed, such as Golden Feather and Petunia. Smooth off the top of the soil with the smoothing board; make depressions for the seed two inches apart by pressing the edge of the smoothing board in the soil. Sow seed at the rate of about fifty to the inch; cover lightly by carefully pushing the soil over them with edge of smoothing board. Firm surface of soil with flat side of smoothing board; water and place in greenhouse.

When very fine or weak seeds are sown they are sometimes covered with moss which has been rubbed fine by working through a very fine screen.

LESSON C.

PLANT FEEDING WITH NITROGEN.

The special elements that enter into the composition of plants and are most often lacking in the soil are potash, phosphoric acid and nitrogen. Each of these elements acts somewhat differently on the plant. Potash and phosphoric acid encourage early maturity and seed production. This lesson shows how nitrogen acts.

MATERIAL NEEDED. Two six-inch flower pots; potting soil; spinach seed and two pot labels.

A
Without Nitrate of Soda.

B
With Nitrate of Soda.

Fig. 9. Spinach fertilized with Nitrate of Soda.

Exercise 3. Fill two six-inch flower pots with good potting soil to within one inch of the top of the rim; sow in each twelve spinach seeds, cover with one-half inch of soil and put in the greenhouse. If seeds are properly watered, the plants should show in five days. When the spinach is well started, thin out to three plants to each pot. Mark one pot A and the other B. Water A entirely with hydrant, rain or well water. Water B

three times per week with water in which nitrate of soda has been dissolved, at the rate of one ounce to the gallon. Make up a jar of this strength, so as to have it ready for use at all times. The dry nitrate could be put directly on the surface of the soil, but unless much care is used it is liable to burn the plant if it comes in contact with it.

After four weeks pot B should show marked increase in size and vigor of foliage. It is not uncommon in this experiment to get ten times as much foliage on the plants in pot B as in pot A. Nitrate of soda (called also Chili Saltpeter) is obtained from Chili. It resembles common rock salt in appearance and is one of the chief nitrogen fertilizers. It is especially valuable as a fertilizer for early leaf crops, and is often used by market gardeners. For special crops it should be applied at the rate of 150 pounds per acre in the field, at intervals of two weeks. Heavier applications are not desirable. Plants take up their nitrogen in the form of nitrates. The effect of large quantities of it in the soil is to cause an excessive growth of dark green leaves and wool. When applied to perennials in excess, it causes late maturing of the wood. Lettuce, cabbage or other leaf crop will give about as good returns as spinach.

LESSON D.

POLLINATION OF FLOWERS.

Most if not all flowers with conspicuous corollas are pollenized by insects which carry the pollen from one flower to the other on their bodies. Most plants are more productive when their flowers are pollenized by pollen from other plants. There are many ways in which this cross pollination is assisted by the form of the flowers. The Exercises 4, 5, 6, illustrate some of these forms and show how pollination may be done by hand.

PRIMULAS.

MATERIAL NEEDED. Long and short styled primroses, preferably the Chinese Primrose; white thread; black thread; raphia; labels.

Primulas have two kinds of flowers, known respectively by the terms (a) long-styled, (b) short-styled. All the flowers on each plant are the same kind.

Exercise 4. Make the following crosses when flowers are ready for pollination:

Short Style Long Style.

Fig. 10. Primula Flowers.

(A) Self-pollenized ten flowers, i. e., use pollen from the

same plant, but pollen from different flowers, and mark with a white thread tied around each flower stalk.

(B) Pollenize ten long or short styled flowers with pollen from other plants having the same form of flowers. Mark with black thread tied around each flower stalk.

(C) Pollenize ten long or short styled flowers with pollen from other plants having different form of flowers. Mark with a piece of raphia tied around each flower.

The corollas should be removed by carefully splitting them in two portions so as not to scatter any pollen on their own stigmas. The pollen in the anthers, attached to the corrollas may be used for pollenizing other flowers. Follow directions carefully and mark crosses as directed.

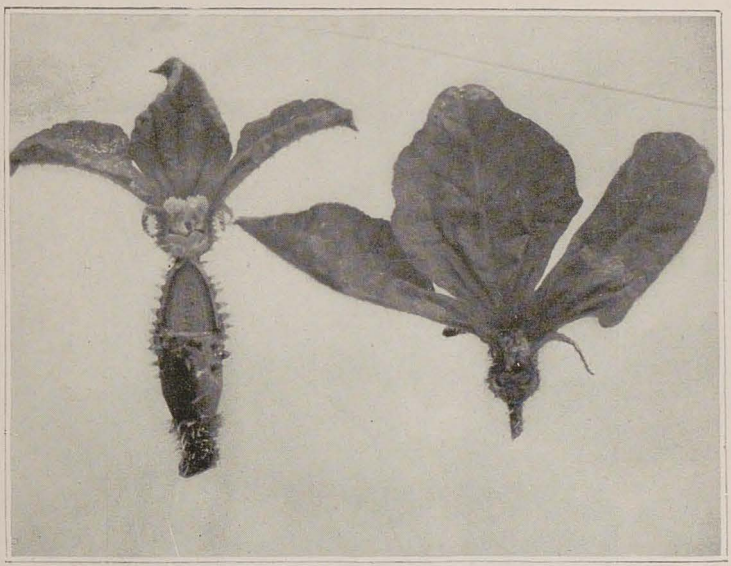
Darwin found that crosses between the different forms of flowers of primroses produced more and better seed than crosses between plants with the same kind of flowers, while self-pollenized flowers were sterile, or nearly so. If the exercise is carefully carried out, the results will show no seed formed from self-pollenized flowers, while good seed will generally be formed in the cross pollenized flowers. Since the work is done in the greenhouse in winter when there are very few insects present, there is practically no danger of the pollen being carried by insects. In manipulating the flowers, those for seed bearing should have opened only recently, and their stigmas should be fresh and slightly sticky.

CUCUMBERS.

MATERIAL NEEDED. One thrifty cucumber plant for each student; small paper labels.

Exercise 5. Note the two different kinds of flowers and that one is staminate and the other pistillate. Make an enlarged drawing of each flower in note book. To transfer the pollen take off a staminate flower which has the pollen grains showing on the stamens, draw back corrolla and dust the pollen onto the stigma of the pistillate flower. Mark each flower pollenized, with the date of the operation. Pollenize all the pistillate flowers as they arrive at the proper stage of development.

Select four flowers and pollenize only one lobe of the stigma of each, and note its effect upon the fruit. It will generally cause the fruit to be one-sided if the work is done carefully. In this case it will probably be best to transfer the pollen with a tooth-pick, as the work can generally be better done in this way than where the stamens are rubbed on the stigma.



Pistillate. Staminate.
Fig. 11. Cucumber Flowers.

Select three pistillate flowers and tie the corolla of each together the day before they are to open, with a light string so they cannot open. This will prevent pollination and probably will prevent the development of fruit.

STRAWBERRIES.

MATERIAL NEEDED. Two well-rooted strawberry plants in pots; these should be in flower when turned over to the students;

it is desirable that one plant shall have a perfect flower and the other a pistillate flower.

Exercise 6. Pollenize six flowers of the pistillate sort with pollen from perfect plant, and leave about as many more without being pollenized. Remove the stamens from one-half of the flowers of the plant having perfect flowers before they open; note the results in each case. The work should be carefully done and at-

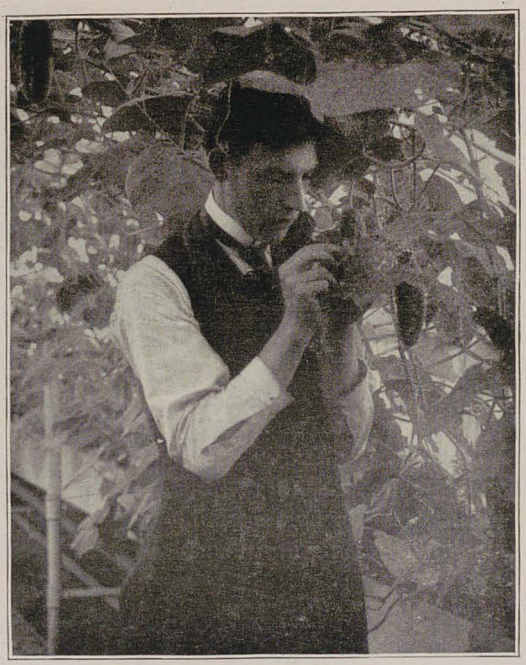


Fig. 12. Pollenizing Cucumber Flowers by Hand.

tention called to the appearance of the stamens when they are ready to receive the pollen. Notice that the pistillate flowers have abortive stamens.

Make drawing of flower from each plant.

LESSON E.

GROWING OF PLANTS FROM CUTTINGS.

A few plants increase, at least to some extent, naturally from cuttings. Good examples are willow whose small twigs will often root on overflowed land. The buds of the Tiger Lily are in effect but cuttings and root very easily.

Soft wood and leaf cuttings are terms applied to such cuttings as are here indicated. That is, they are made while the plant is still growing. The best condition of the wood for soft wood cuttings will vary more or less with the different plants. Wood that is very soft and succulent seldom roots very well and is quite liable to be injured by fungus. As a rule wood that is rather hard but yet in condition so that it will break in bending will root best. Very old wood is slow in rooting and the roots from it are not generally as vigorous as from that which is about half matured.

In the case of roses the right condition of the wood is that which is found in the wood just below an opening flower. The illustration shows cuttings in about the proper condition for rooting to best advantage.

Hard wood or dormant cuttings are terms applied to cuttings taken after the wood has ripened, usually after the leaves have fallen, as is the common practice in making cuttings of willow and currant.

Plant food in large quantities is stored up in the hard wood cuttings, so that, when put in the soil, it can form roots and top and generally take care of itself until it is a fully developed plant and able to continue its existence. On the other hand, the soft wood cutting has little if any plant food stored in its tissues, and must be carefully watered and protected, so as to preserve its foliage that it may be able to form plant food. This accounts

for the difference in the treatment of the two kinds of cuttings. If the leaves are cut off, or allowed to wilt, on soft wood cuttings, they will generally fail. Since the leaves assimilate plant food to the best advantage in direct sunlight, they should have all the sunlight they can stand, provided they do not wilt. Having no root system, they must have plenty of water.

Fig. 13. Typical Cuttings of House Plants. 1.—Umbrella Plant (*Cyperus alternifolius* rooted.) 2.—Santolina (*Santolina chamæcyparissus*). 3.—Gnaphalium (*Helichrysum petiolatum*). 4.—Fuchsia (*Fuchsia sp.*) 5.—Cigar Plant (*Cuphea platycentra*). 6.—Crab Cactus (*Epiphyllum truncatum.*) 7.—Artillery Plant) *Pilea serphyllifolia*). 8.—Sea-grape (*Coccoloba uvifera*). 9.—Geranium (*Pelargonium hortorum.*)

MATERIAL NEEDED. Plants for cuttings (these should consist of at least six kinds that root easily, as coleus, fuchsia, bryophyllum, geraniums, artillery plant, tomato, chrysanthemum, leaf cactus) ; one flat full of sand ; a sharp knife, and pot labels.

Exercise 7. Make one or more cuttings as directed of each plant given out, as shown in figure 13, and insert them in rows in the flat of clear sand, close enough to economize space, but far enough apart so that they do not shade one another. Rows three inches apart is about right. Mark each kind with its common and botanical names and the date when they were made up, and, after

watering thoroughly, place in full sunlight in the greenhouse, but they must be shaded with paper or burlap if they show signs of wilting.

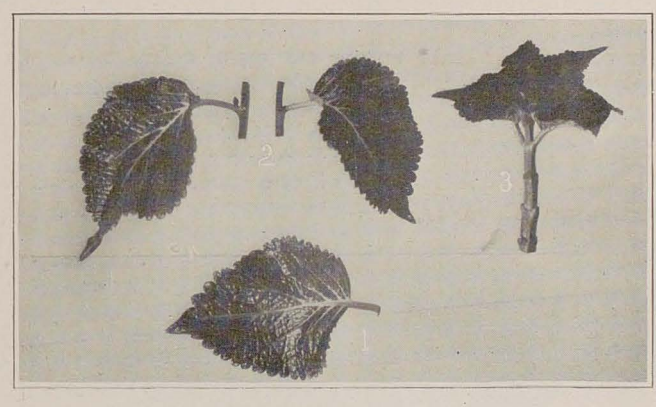


Fig. 14. Coleus. 1.—Leaf. 2.—Two split cuttings. 3.—Ordinary.

Clean sand is best for rooting cuttings, but if this cannot be had, nearly as good results may be obtained from clean moss or

Fig. 15. Coleus cuttings rooted. 1.—Leaf. 2.—Split. 3.—Ordinary.

sifted coal ashes. Sandy loam will answer, but it is not so good as the former, although most of the hard wood cuttings will root in loam. The probable reason why sand is best is that it is freer from disease germs, to the attacks of which the cuttings are liable until rooted.

Exercise 8. I. Make up one cutting of coleus, as shown in exercise 7, (see No. 3, figure 14.) II. Select a joint having two good, thrifty leaves and cut it out with piece of stem about one inch long, or less. Split it lengthwise, as shown in figure 14, No. 2, and insert in sand. III. Cut off one good, thrifty coleus leaf, and put in sand, figure 14, No. 1.

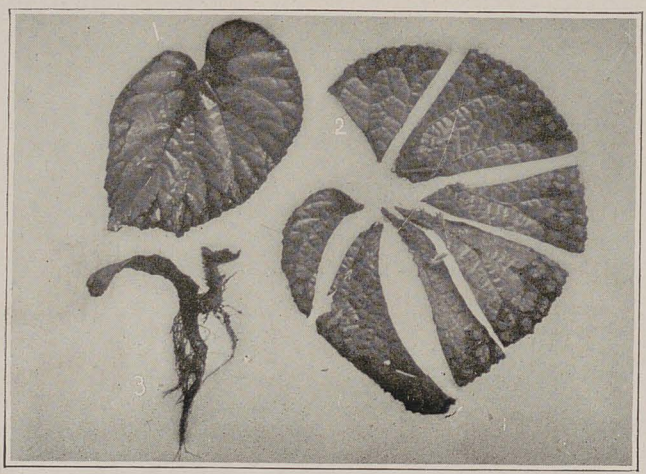


Fig. 16. Rex Begonia. 1.—Laf. 2.—Leaf made into cuttings. 3.—Cutting rooted.

Notice that all the coleus cuttings root readily. Pot off all when rooted and note that cuttings II and III produce plants, but leaf cutting I, while it greatly increases in size, fails to develop a bud, and hence no plant is formed.

Exercise 9. Cut up a full grown Rex Begonia leaf, as shown in figure 16, and place in sand, as described under exercise 7. Note that in a few weeks the pieces of leaves produce buds and from these the new plant starts.

Exercise 10. Pin up a full grown Bryophyllum leaf on the

wall of your desk or put in your locker. After several weeks note that it has the power of starting into growth and producing small plants from the edges of the leaf. After these have started, the leaf itself dies away, and the plants may be removed and potted.

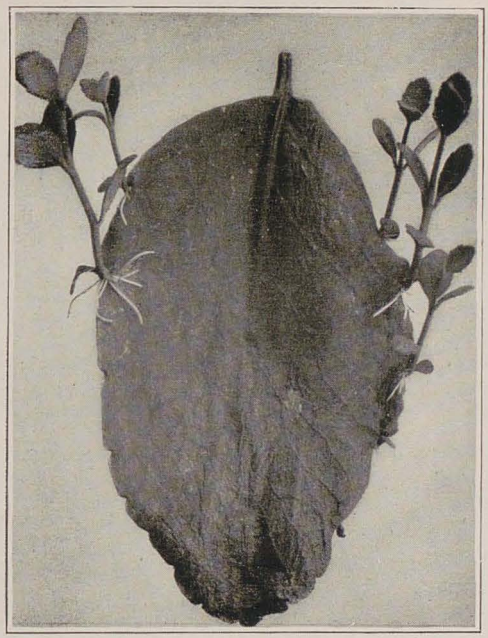


Fig. 17. Bryophyllum leaf with new plants starting from its edges.

This is a common method of propagation with this plant. No water is required for the plant in this experiment; it will grow just as well in a dry room as in a moist one.

Exercise 11. Rose cuttings. Use young vigorous wood; very soft wood is almost sure to fail; it is much better to have it too hard than too soft. Cut this wood into as many pieces as there are buds on it, as shown in figure 18, and insert in sand as directed for exercise 7. Note that in a few weeks the lower end of the cuttings become covered with a growth of white soft tissue

which soon sends out roots and that they do not send out roots from above this point. This soft white growth is known as callus.

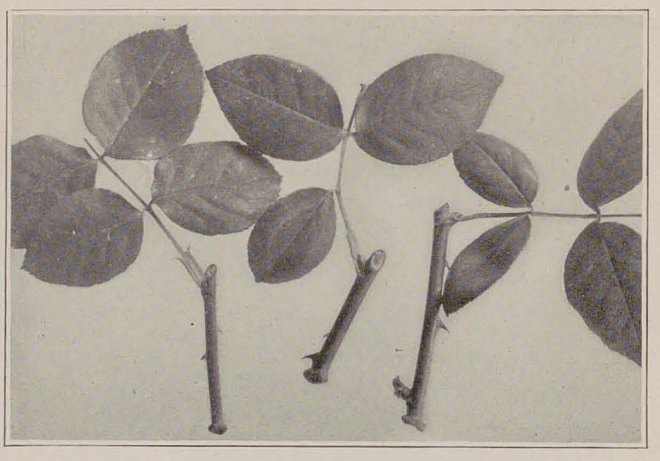


Fig. 18. Rose cuttings well calloused (i. e. healed over) at bottom.

CALLUS. Denotes the first growth made by plants in the healing over of their wounds.

LESSON F.

CORROSION OF MARBLE BY ROOTS.

Plants differ greatly in their power to obtain plant food from soils, and one of the reasons for it probably is that the roots of certain plants secrete fluids, which aid them in obtaining some of their food from the minerals in the soil. This lesson illustrates how a lime rock may be made to yield up its lime to roots.

MATERIAL NEEDED. Six-inch pot; marble block 2x2½ inches in size; polished on one side; old newspaper; moss; sand; Windsor Beans.

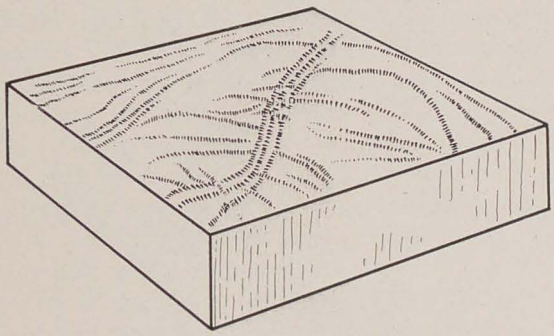


Fig. 19. Marble block corroded by bean roots.

Exercise 12. Fill a six-inch pot to within three inches of its rim with sand. Put in a marble block and imbed in sand; place a germinated bean at one corner of the marble block, so that its roots will grow across it; fix it in position with a little sand; cover with six thicknesses of newspaper and one-half inch of moss; water thoroughly; allow place at side of newspaper for

bean plant to push out. Examine the roots of the bean each day and see to it that they are in close touch with the marble block. The newspaper covering will allow of this being readily done. After plant is six inches high, pull it up and note that its roots have etched the polished surface of the marble where they have come in contact with it. Make drawing in note book to show the etched lines thus made.

The Windsor bean is used because it is so large that it is easily handled and its roots act strongly and give especially good results.

LESSON G.

GRAFTING.

Very few of our improved perennial plants come true from seed. To propagate those that do not root easily from layers or cuttings, they are usually grown by grafting or budding. No exact dividing line can be drawn between grafting and budding, but as usually practiced the cion in grafting contains more than one bud, while in budding the cion has only one bud.

Grafting and budding refer to the propagation of a plant by means of a cutting (cion) inserted in a rooted plant (stock) of the same or very closely related species. Thus the original Wealthy tree has been increased by inserting cuttings of its branches into seedling apples. The stock and cion grow together as one plant. The coin becomes the desired kind of plant, while the stock furnishes the root system which supports the cion. Success depends, first upon the perfect union of the wood of stock and cion. Second, the inner bark or cambium layer of both stock and cion must come together closely. It is impracticable always to have the stock and cion of the same size and it is the common practice to so fit the graft that the cambium layers are in close contact on one side. This means that the inner bark of both cion and stock are together on one side. Third, the wounds made must be covered to keep them in close contact and from drying out. Wax or waxed cloth is used in grafting, while in budding, tying with string or raphia to hold the bud firmly in place is the usual way and wax is seldom used.

Terms. The part inserted is called the cion, and in common grafting, it must be of the preceding year's growth, but cions of older and also of young growing wood, are sometimes used, but must always have vigorous buds. The part in which the grafts are inserted is termed the stock. The operation of putting these

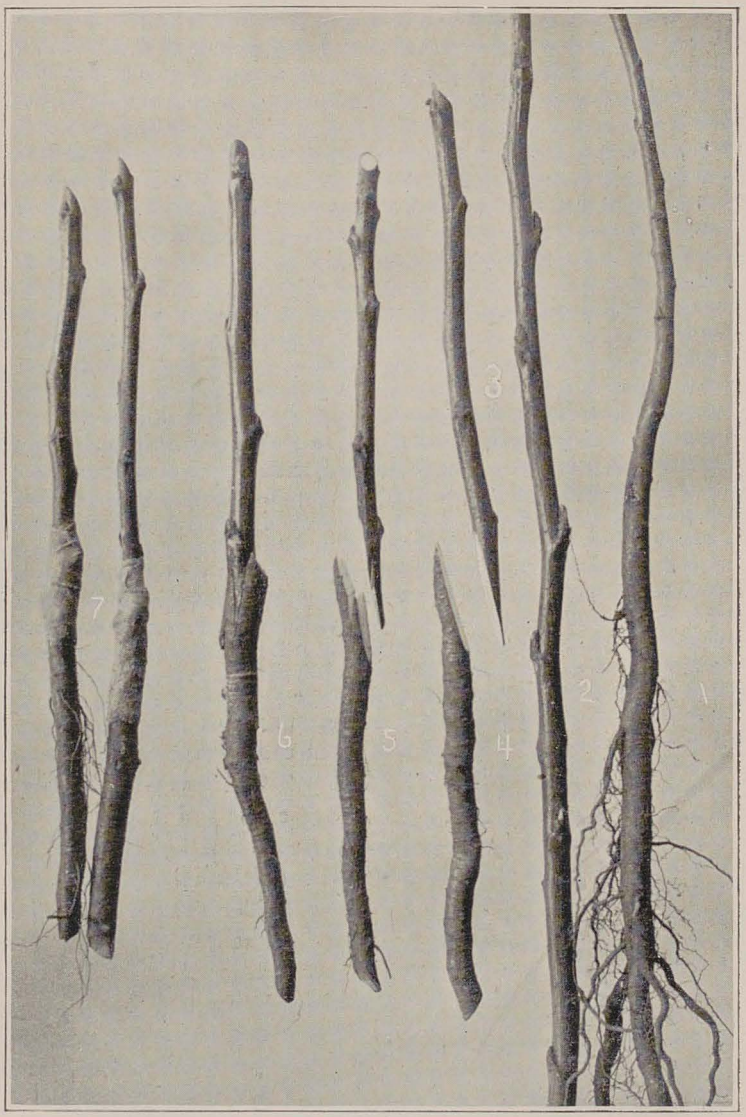


Fig. 20. Root Grafting. 1.—Stock (seedling apple). 2—Cion. 3—Cion cut. 4.—Stock cut. 5.—Cion and stock tongued. 6.—Pushed together. 7.—Wrapped with wax cloth.

parts together is termed grafting. Gardeners also use the term working; applying it to both budding and grafting.

PRACTICE WORK IN GRAFTING.

MATERIAL NEEDED. Moderate sized twigs of almost any kind of tree. The best would be apple twigs of the preceding year's growth for cions, wood three or four years old for top grafting and apple roots for root grafting. But as these materials are difficult to obtain in sufficient quantity for a large class, it has been our custom to use one year old willow twigs of large size, as these we can obtain very easily. A short thin knife, such as is commonly used by shoemakers, is very useful. Grafting wax and raphia.

Exercise 13. Four kinds of grafts should be made. A. Splice graft; B. Whip graft; C. Cleft graft; D. Side graft. These are all illustrated in figure 20. Students must use as much care in this practice lesson as in any other.

Grafting wax is made as follows: Melt together by weight four (4) parts resin, two (2) parts beeswax, one (1) part tallow. When melted, pour into water, grease the hands and pull until it is about the color of molasses candy. Make into balls and store for use. Such wax should be warmed when applied. When grafting wax is well made, it will not run in the summer nor crack in cold weather. If too hard, add more tallow; if too soft, add more resin. It is used for covering the union of cion and stock and for covering the wounds of trees generally.

Waxed cloth or paper is made by coating cloth or heavy manilla paper with hot wax, after which it is hung up to dry. It is used for binding grafts and covering tree wounds. When ready to use, tear or cut into long strips about five-eighths of an inch wide. Begin at botton of graft and wind around until wound is covered with one thickness from bottom to top. If the wax cloth does not fit tightly in all places, press between thumb and finger until it does.

REGULAR WORK IN GRAFTING.

MATERIAL NEEDED. Seedling apple trees, two or three years old, such as are commonly used by nurserymen for propagating the apple. These cost not more than one dollar per hundred for those of largest size, such as will make at least three stocks each. They should be obtained in autumn and be buried in sawdust or sand in a very cold cellar. A sharp knife; grafting wax; grafting cloth; raphia.

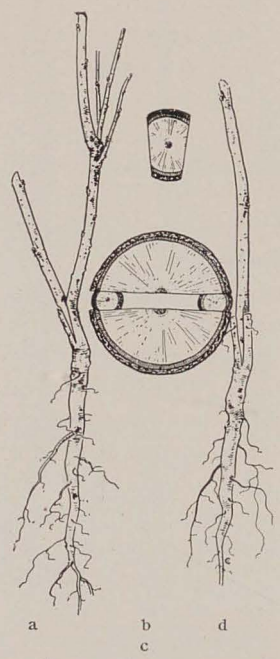


Fig. 21. (a) Side Graft. (c) Cross section of cleft graft with two cions in stock. (b) Cross section of cion showing wedge shaped cut. (d) Cleft Graft.

Cions of any variety of apple may be used. These should consist of shoots of the preceding year's growth, not less than 12 inches long. Such shoots may be cut when wanted, but generally they should be gathered late in autumn and be stored as recommended for the roots. When using, cut to about five inches long and use all the firm wood.

Root grafting may be done in the house at any time after the leaves have fallen and before the trees start into growth again in the spring, but perhaps the best time is between the middle of December and the middle of March. After they are made up they should be stored in cellars, in sand, soil, moss, sawdust or similar material for planting out in the spring. When thus stored the cion and stock should grow together by callousing before planting in the open ground, and that, too, with scarcely the starting of the buds.

Exercise 14. Make the following grafts:

A.—2 splice grafts and tie only with raphia.

B.—3 cleft grafts.

C.—2 side grafts.

D.—1 whip graft.

Wrap all with waxed cloth except A. Lay grafts on bench in greenhouse and cover with two inches of moist sand. Allow them to remain thus for one week and then notice that the wounds have calloused, i. e., have begun to heal over. The buried grafts must not be allowed to get dry. When well calloused plant in a six-inch pot in good soil, water and set in greenhouse. This is done that the results may be seen in the course of the term's work.

E.—Make 10 whip grafts, and pack in sand in a box, to be stored in cold cellar until spring. Label each variety with its name and the date it was made. Students can have these whip grafts sent to their homes in the spring, if they leave ten cents for postage and packing.

The splice graft is made by cutting the upper end of stock and lower end of cion with a long bevel, then tying both together with the bark even on one side. This form is only used in cases where the wood is pithy, as in rose wood. (See figure 20, Nos. 3 and 4.)

The tongue or whip graft differs from the above only in there being a slit cut in both stock and cion, so that when pushed together the tongue of one is in the slit of the other, thus they are held together firmly and have more surface in contact than in the splice graft. This form is commonly used in root grafting the apple, plum, etc., and on small stocks. (See figure 20.)

The cleft graft (at D, figure 21) is commonly used in stocks of large size, but may be used on those that are small. In common practice stocks over three-quarters of an inch in diameter are cleft grafted. The stock is cut off square on top and slit down through the center for about one and one-half inches. The cion is cut with a long bevel on both sides; the faces (in cross section) should not be parallel to one another, but rather wedge shaped, as shown at B, figure 21. If the stock is large enough, two cions are put in as shown in figure 21. This form of graft is used chiefly in top working old trees, etc. The wounds are covered with wax.

The side graft is used principally in grafting such stocks as it is not desirable to cut back until the cion has started, and for root grafting the cherry, where for some unknown reason it gives best success. It is made by cutting a slit downward, far enough into the wood so that when the cion is inserted it is held in place. The cion is cut with a long bevel on one side, but on the other the cut should only be about one-half as long. The long cut is placed next to the stock. Tie in place with a little raphia and then cover all with wax cloth.

In making all grafts select a place on stock and cion where the bark is healthy, smooth and even.

HERBACEOUS GRAFTING.

Most plants can be grafted more surely when their wood is quite hard but sometimes it is quite practicable to graft very immature wood as in this exercise.

MATERIAL NEEDED. A potato plant eight inches high; tomato plant for cion. An early potato will be best to use for winter practice, as it will start into growth more easily than a late kind. Raphia; moss.

Exercise 15. The potato stem should be cut off square about four inches from the ground and the stem split about one and a half inches down. The cion should be about four inches long from the growing end of a tomato plant. This should be cut wedge

shaped sufficiently to fit into the cleft in the potato stalk, which should then be tied together and the whole union surrounded with a bunch of damp moss. The plant should then be protected from the sun for a few days and the moss about the union should at all times be kept wet. If the work is properly done, the cion and stock will soon unite and very likely the cion will send out roots

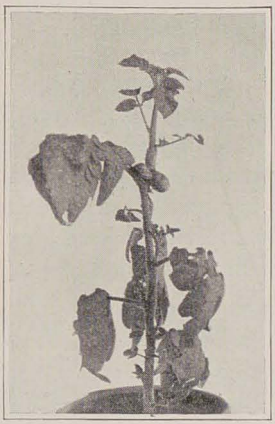


Fig. 22. Herbaceous Grafting—potato on tomato.

into the moss, which does no harm. The tomato should grow and produce fruit, and the potato will produce tubers. The reverse of this operation may be as successfully performed on thrifty tomato plants and small green tubers will be produced at the base of the potato cion at the union, figure 22. But the latter is not so successfully performed as the former.

LESSON H.

BUDDING.

Budding, as the term is commonly used, applies to the operation of setting a bud into a growing tree. Budding of the plum and apple is usually done in July and August with a bud of the current season's growth. Buds inserted at this time should not start until the following spring. Figure 23 shows the different stages of the operation, and it is quite distinct from the methods of grafting described in lesson G, and yet, as previously stated, there is no difference in the principles involved in the two forms and the terms used are the same.

Fig. 23. Budding 1.—Stock with cross and longitudinal cuts. 2.—Buds cut partly off. 3.—Bud. 4.—Bud inserted. 5.—Tied with raphia. 6.—Bud started and stock cut off.

PRACTICE WORK IN BUDDING.

MATERIAL NEEDED. Willow wood or elm wood; a sharp, round pointed, thin knife.

Exercise 16. In this exercise for practice we use willow wood, which has been buried in moist warm sand until the bark will separate readily. We have also resorted to inserting the buds under the outer bark of the common elder. The buds for insertion may be from apple, plum, elm or others, and they should be carefully and firmly bound in place with cotton warp, yarn, raphia or similar material. It is also a good plan to nail the sticks that are to be used for stocks to a plank on the floor, so that they can be worked the same as if they were in the ground.

Insert and tie in a neat and workmanlike manner at least six buds or until work is well done.

REGULAR WORK IN BUDDING.

MATERIAL NEEDED. Some thrifty growing apple seedlings or rose bushes in pots. We prefer two year old seedlings of Siberian crab (*Pyrus baccata*), as they start more quickly than the common apple (*Pyrus malus*), in the winter and have given us excellent results. Any variety of thrifty rose will also answer. We have found Gloire de Dijon the most satisfactory of the roses for our purpose.

TWO FORMS OF BUDDING ARE USED:—

Exercise 17. Budding with a dormant bud. This work is adapted to use in the spring after the foliage has started, say as late as the latter part of May. The cions in such a case must be kept dormant by cold storage until used. The *Pyrus baccata* may be budded at any time after they get to growing nicely, using buds from apple cions which are kept in the cellar, but when short of named varieties, the buds from the tops of dormant apple seedlings are used. The buds are inserted as shown in the processes illustrated in figure 23. Six buds are inserted in one plant.

As soon as they are grown fast, the top of the plant is shortened back severely so as to throw the growth back into the inserted buds, which will soon begin to push and make a new top for the

Fig. 24. Budded plant with six buds growing.

plant. As soon as the inserted buds start, all other pushing buds are removed from the stock.

Exercise 18. Budding with a pushing bud. This is performed by cutting off a bud from a growing rose branch, and after removing all but one-half inch of the stem, inserting the bud

under the bark of some other rose bush. The further treatment is as for exercise 17. We also use the buds from the new wood of our potted apple seedlings to illustrate this lesson. This form of budding is adapted to use in June.

Conditions necessary for success in budding are similar to those in grafting, (1) a congenial stock and cion; (2) stock in thrifty growing condition; (3) buds well developed on the cion; (4) tied firmly in place until grown fast. The ties should be examined occasionally and if found too tight, loosened so that they will not injure the stock.

LESSON I.

POTTING.

Potting is a term used to indicate the setting of plants in pots. It is done on a large scale in greenhouses and sometimes for hot beds and cold frames. It is also an important part of the management of house plants. Poor potting is responsible for many failures in growing plants.

MATERIAL NEEDED. Plants that are easily grown as seedlings of common Golden Feather or Lettuce. They should be quite small and only large enough to go easily into a 2½-inch pot. Good garden loam, leaf mold; rotted manure; sand; 2½-inch pots; labels.

Exercise 19. Mix together thoroughly the various ingredients of potting soil as follows:

2 parts good garden loam.
2 parts leaf mold.
2 parts rotted manure.
2 parts sand.

Sift through a quarter-inch mesh screen to remove stones, roots, etc., and to break up the lumps. Good potting soil must be rich, yet open and retentive. The formula given will make a good potting soil for general use. For ferns it is desirable to use more leaf mold or thoroughly rotted wood. Where neither leaf mold or rotted wood can be obtained, rotted sod and sand will do fairly well. For roses the soil should consist largely of clay, and the leaf mold and sand should be left out. In selecting the manure, that which is well rotted is preferred, and generally cow manure is most desirable; but well rotted horse manure is excellent and some florists prefer sheep manure.

Standard pots are made in the same style by the various potteries in this country. The sizes are designated by their inside diameter measure, which is the same as their depth.

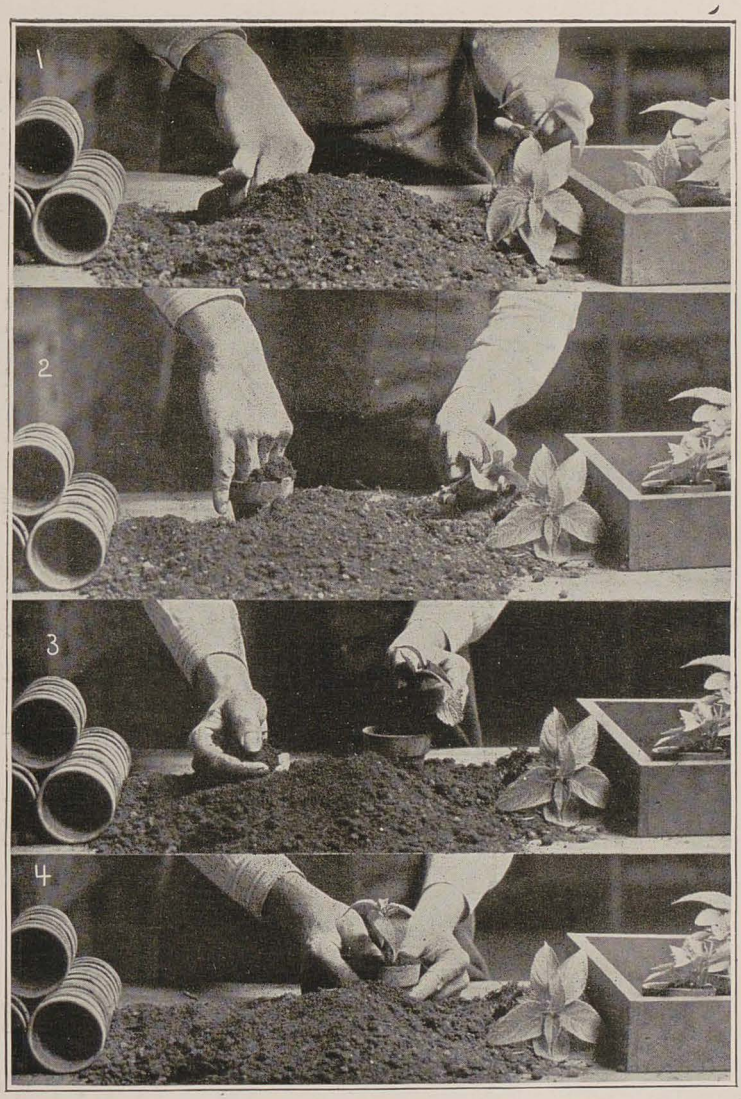


Fig. 25. Potting plants—four successive positions of the hands.

POTTING OF CUTTINGS.

Of the cuttings which were put in the cutting bench in Lesson E, the larger part should be rooted in three weeks' time and this exercise is to complete the work then begun. The cuttings should

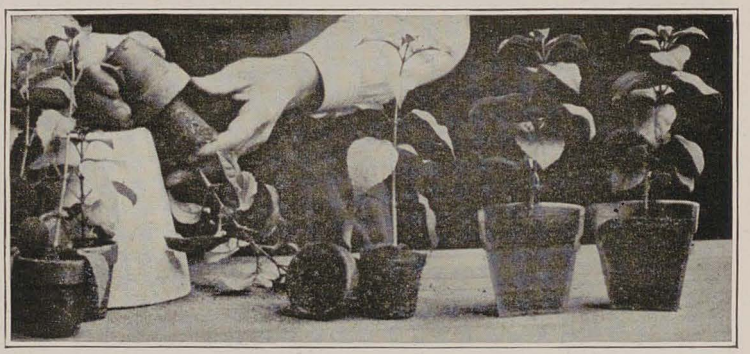


Fig. 26. Knocking a plant out of pot and repotting into a larger pot.

have good roots before they are potted, but they should not be allowed to grow a long time in the cutting bench, as roots produced under such conditions are not of the best.

Exercise 20. The material needed and method of operating is the same as above. Any cuttings that are not well rooted and are still fresh should be put back into the sand.

LESSON J.

VIABILITY OF SEEDS.

A clear idea of the amount of good seed contained in that sown is most desirable. For no matter how much seed is used, only that which grows is of any value, and the rest as far as the crop is concerned, is only so much dirt.

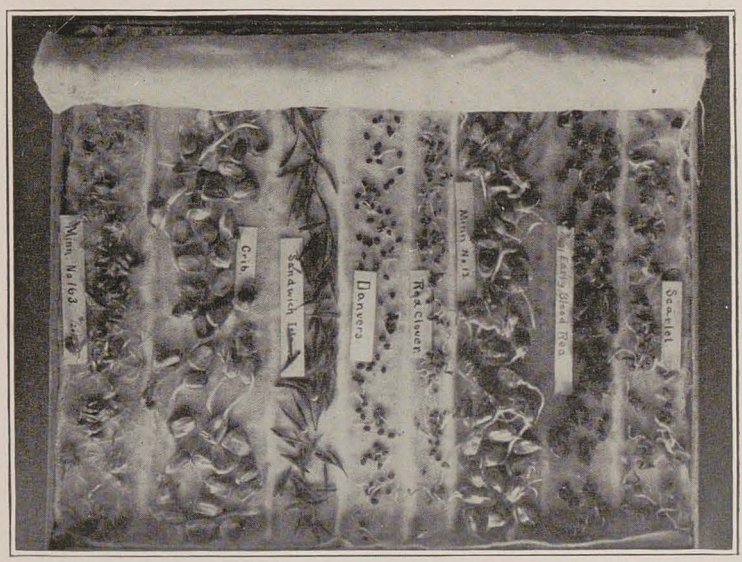


Fig. 27. Seed testing pan with germinating seeds—the cover cloth rolled to one side.

MATERIAL NEEDED. One or more germinating pans; two pieces of cotton flannel for each pan; glass to cover germinating pans; small paper labels and record blank; seeds of various kinds mentioned.

Exercise 21. Count out 100 each of the following seeds: (a) Carrot, (b) salsify, (c) onion, (d) pigeon grass, (e) red

clover, (f) timothy, (g) parsnip. Wet the cloths, allowing them to get thoroughly soaked, and wring out the surplus water. Spread one cloth in the bottom of the pan, wooly side down, draw cloth together into seven folds, between which the seeds may be sown. When seeds are in, cover with the other cloth woolly side up, cover with glass and set away in a warm place, as in a greenhouse or living room.

Exercise 22. In second pan sow in the same way, and treat the same, 50 seeds each of (a) corn taken from the crib, (b) corn properly cured, (c) 100 fruits of beet, and (d) 100 radish seeds.

The pans should be kept moist and examined once in two days, and all seeds that have made a good start should be removed and a record made of them in the note book. When all have germinated that will, count those remaining and state whether they appear rotten or simply dormant.

The following table shows the viability of good merchantable

Kind of Seed	Purity	Germination	Kind of Seed	Purity	Germination
	p. c.*	p. c.		p. c.	p. c.
Alfalfa	98	85-90	Melon, musk	99	85-90
Asparagus	99	75-80	Melon, water	99	80-85
Barley	99	90-95	Millet, com. *Chaetochloa italica*	98	85-90
Beans	99	90-95	Millet, hog *Panicum miliaceum*	99	85-90
Beet	99	100-150†	Millet, pearl	99	85-90
Blue grass, Canadian	90	45-50	Oats	99	90-95
Blue grass, Kentucky	90	45 50	Okra	99	80-85
Brome, awnless	90	70-75	Onion	99	75-80
Buckwheat	99	90-95	Parsley	99	70-75
Cabbage	99	90-95	Parsnip	95	70-75
Carrot	95	80-85	Peas	99	90-95
Cauliflower	99	80-85	Pumpkin	99	85-90
Celery	98	60-65	Radish	99	90-95
Clover, alsike	95	75-80	Rape	99	85-90
Clover, crimson	98	80-85	Rye	99	90-95
Clover, red	98	85-90	Salsify	98	75-80
Clover, white	95	75-80	Sorghum	98	85-90
Corn, field	99	90-95	Spinach	99	75-80
Corn, sweet	99	85-90	Squash	99	85-90
Cucumber	99	85-90	Timothy	98	85-90
Eggplant	99	75-80	Tomato	98	85-90
Fescue, meadow	95	85-90	Turnip	99	90-95
Lettuce	99	85-90	Tobacco	98	75-80
Kafir corn	98	85-90	Wheat	99	90-95

* Impurity allowed refers to inert matter and one per cent (only) of weed seeds other than those practically prohibited, as above noted.

† Each beet fruit, or "ball," is likely to contain from 2 to 7 seeds. One hundred balls should yield 150 sprouts.

seed as determined by the Department of Agriculture, but Dr. A. J. Peters, the botanist in charge of the seed laboratory, adds: The quality of seed depends so much upon the season in which it is

raised that it is scarcely possible to say that under all circumstances good seed should germinate so and so much.

Name.....

Date..... *190* ....

Record of Viability Test of Seeds.

KIND OF SEED	Per Cent Germinated

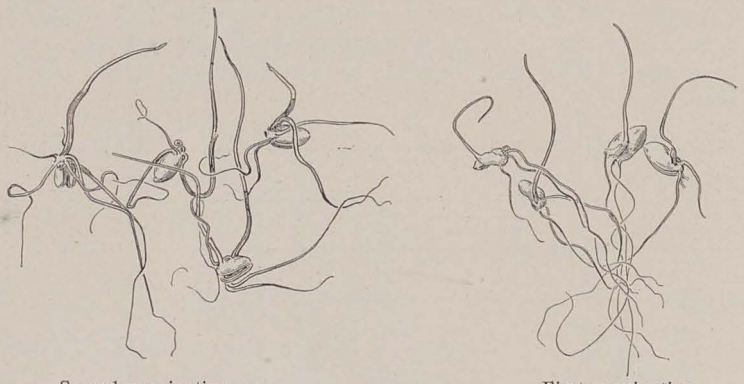
Fig. 28 Blank used for recording viability.

The seed must be true to name, and practically free from smut, bunt, ergot, insects or their eggs or larvæ, and the seeds of dodder (*Cuscuta spp.*), wild mustard (*Brassica spp.*), wild flax

(*Camelina spp.*), Russian thistle (*Salsola kali tragus*), Canada thistle (*Carduus arvensis*), cockle (*Agrostemma githago*), chess (*Bromus secalinus*), quack grass (*Agropyron repens*), penny cress (*Thlaspi arvense*), wild oat (*Avena fatua*), and the bulblets of wild onion (*Allium vineale*). It must not contain more than one per cent of other weed seeds, and should come up to the percentages of purity[1] and germination given in the table.

REGERMINATION OF SEEDS.

Seeds of many kinds have the power of germinating more than once. This power is of much assistance to plants in overcoming adverse conditions.



Second germination. First germination.

Fig. 29. Regermination of Wheat.

MATERIAL NEEDED. The same as above.

Exercise 23. Germinate 200 grains of wheat in a germinating cup as in exercise 21; when the sprouts are about one inch long take one-half of them out of the germinator and put in the drawer of the laboratory where they will be perfectly dry and allow them to remain for one week, by which time the sprouts will be so brittle that they can be easily rubbed off. The seed should then be sowed in the germinating cup as before and the vigor and size of the sprouts noted. The second germination often starts very much quicker than the first.

1 This means purity of grain, not purity of stock.

LESSON K.

PURITY TEST OF SEEDS.

An acquaintance with the seeds of weeds may often prevent the sowing of them. It is well known that practically all the bad weeds of this section are of European origin, and they have been distributed through this country by becoming mixed with grass, flax and other seeds, and have been planted unknowingly by farmers, who have since suffered.

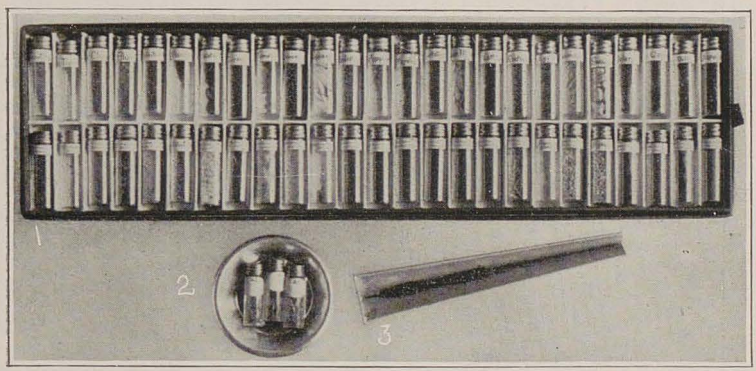


Fig. 30. 1.—Seed sample case. 2. Samples for analysis. 3.—Tray to aid in counting seeds.

MATERIAL NEEDED. Record blanks and hand lenses; clover, grass and weed seeds with which to make suitable mixtures; a named collection of the seeds of our principal weeds, Fig. 30. A collection numbering about twenty-five species can be made to include about all that is necessary for this exercise. These should be in a case in small bottles with screw caps, and correctly labeled with their common and botanical names. Several different samples should be used in the class at one time. A small tin pan for

holding the seed, and an angle trough for use in counting the seed. It is very desirable in winter to have pressed specimens of the dif-

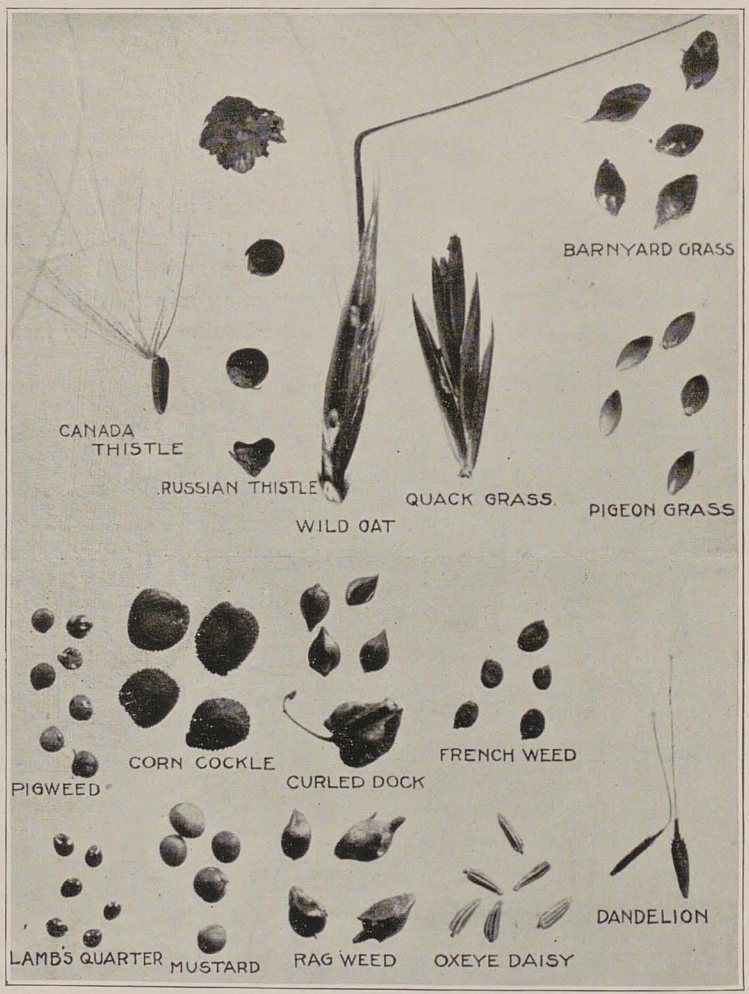


Fig. 31. Weed seeds (enlarged x 3).

ferent weeds and plants used in the exercises, so that students may become more familiar with them. These should be mounted

and framed and hung in a conspicuous place in the laboratory.

Exercise 24. Give out samples of clover, bluegrass or timo-

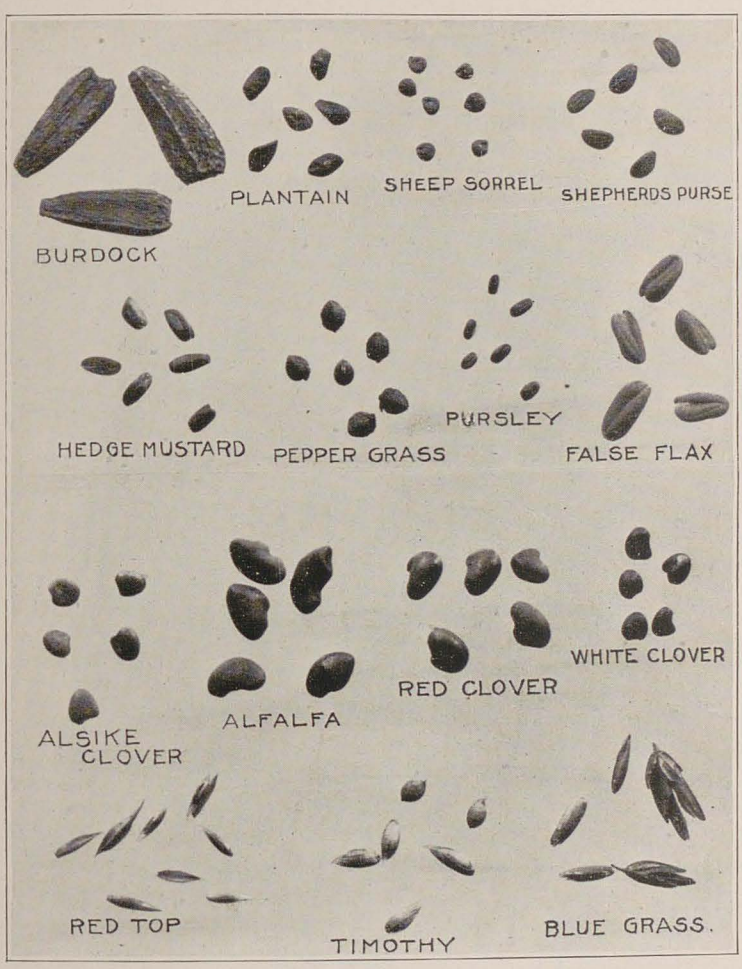


Fig. 32. Weed, Grass and Clover seeds (enlarged x 3).

thy, etc., with known adulterations and require all seeds to be identified and described in note book, with enlarged drawings of the same. Determine the per cent of good and poor seed by

Name.....

Date..... *190*.....

Record of Purity Test of Seeds.

Sample..... *Bottle No* .....

Per cent. of Pure Seed.....

LIST OF IMPURITIES FOUND	
INJURIOUS	INDIFFERENT
	INERT MATTER, Etc

Fig. 33. Blank used for recording purity test of seeds.

counting out 100 seeds just as they come, and then counting the respective kinds found in the sample. Fill out blanks furnished and return to instructor.

The weed seeds and other adulterants found should be classified as injurious seed, i. e., those of troublesome weeds, such as Russian Thistle, Canada Thistle, French Weed; indifferent seeds, such as clover in a timothy sample, and other harmless adulterations; and inert matter, such as chaff and other dirt.

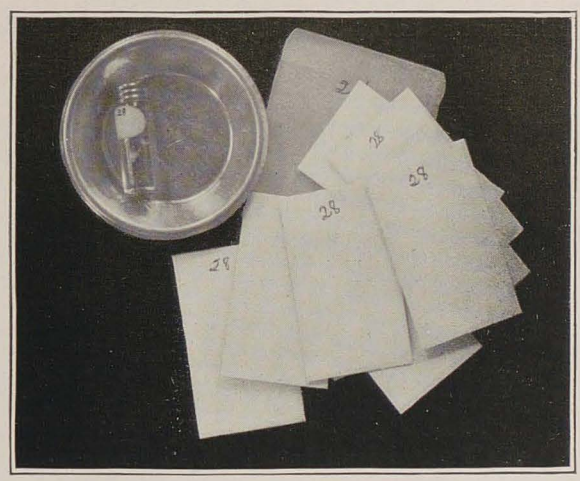


Fig. 34. Materials for examination in purity test of seeds.

When this exercise is completed give examination as follows: In the class room give out to each student a bottle containing a small quantity of mixed grass and weed seeds and one envelope for each kind of seed in the mixture and require the seeds to be separated and put in envelopes with the name of the seed plainly marked on the outside. Of course no helps should be allowed in such work.

LESSON L.

PRICKING OUT.

This lesson in transplanting shows the proper way to handle many small seedlings that it is not desired to pot off. Many small plants do just as well in a flat as if potted, and they do not take up so much room as in pots, and the operation of transplanting in flats is quicker than potting.

Fig. 35. Pricking out of seedling plants.

MATERIAL NEEDED. Flat; dibber; smoothing board; potting soil and plants grown in Lesson B.

Exercise 25. Transplant 63 plants of either Petunia or Golden Feather, setting the plants 7 in a row one way and 9 the other way of flat. To do this, the plants must be taken up with considerable soil. Take great care in separating them so as to preserve a good root system, and in setting them out be sure to get the root system fully as deep as it grew before. Use dibber to open holes and to firm the soil around roots when plant is in place. When finished the surface of the soil should be even and the rows of plants straight both ways.

LESSON M.

TREATMENT TO PREVENT POTATO SCAB.

The disease known as potato scab may be largely prevented by planting clean seed and even diseased seed may be used, provided it is treated as indicated in this lesson. When the seed and soil is free from the scab germs the crop will be free from scab.

MATERIAL NEEDED. ½ bushel of potatoes; 2 sacks; two 30-gallon barrels; one ounce commercial corrosive sublimate in crystals; 4 fluid ounces of 40 per cent formaline or formaldehyde.

Exercise 26. Treatment with corrosive sublimate. Dissolve one ounce corrosive sublimate in hot water, in wooden or earthen vessel. When dissolved add water to make up to 7½ gallons. Put potatoes into sack and submerge in the solution in the barrel. Let soak for 1½ hours. As this is a deadly poison, great care must be taken that none is taken internally. This strength is not at all harmful to the hands.

Exercise 27. Treatment with formaline. Formaline is not as deadly a poison, hence is safer to use than corrosive sublimate. Pour the 4 ounces of formaline into 7½ gallons of water; follow directions as in exercise 26 as to time and method of treating potatoes.

LESSON N.

BORDEAUX MIXTURE.

As a general fungicide for fungous diseases on plants this is the most useful. It is especially useful in preventing mildew of grapes, blight of potatoes, plum rot and pockets, apple scab, and other diseases.

MATERIAL NEEDED. Commercial copper sulfate or blue vitriol; strong, fresh lime; one thirty gallon barrel; two fifteen gallon kegs; one cotton sack; two wooden or graniteware pails, and a saucer.

Exercise 28. Make up twenty-five gallons of the mixture before the class, following the standard formula.

Copper sulfate	5 pounds
Fresh lime	5 pounds
Water	50 gallons

Put 2¾ pounds of copper sulfate in the cotton sack and suspend in twelve gallons of water in one of the fifteen gallon kegs.

Fig 36.

Fig. 36. Making Bordeaux mixture. Pouring milk of lime and copper sulphate solution together.

This allows the sulfate to dissolve faster than if the material is put at the bottom of the keg. Put 2½ pounds of the lime into the other 15 gallon keg, just cover with water at first, and allow it to slack. Add water when necessary to keep it from burning while slacking. When slacked, add water to make twelve gallons.

This is termed milk of lime. Just before using, the sulfate and milk of lime are poured together into the barrel, as shown in figure 36. Keep the mixture well stirred. The mixture, when properly made, should be of a sky-blue color and have an excess of lime. Before using, one of the following tests should be made, to be sure that there is an excess of lime; when there is not enough lime present, the copper sulfate is apt to burn the foliage on which it is sprayed. 1st test. Put a little of the mixture into a saucer and, holding it between the eyes and the light, blow into it gently for half a minute. If properly made a thin pellicle

Fig. 37.

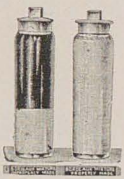


Fig. 38.

Fig. 37. Testing Bordeaux mixture. The saucer or plate method.

Fig. 38. Improperly and properly made Bordeaux mixture after standing one hour. The properly made mixture has just begun to settle. After U. S. Department of Agriculture.

of carbonate of lime will form on the surface, caused by the chemical action between the lime and carbonic acid in the breath, thus showing that there is an excess of lime and it is safe to use. 2nd test. Hold a clean knife blade in the mixture for at least half a minute. If a copper deposit appears on the blade, it shows that there is an excess of copper sulfate, and it is dangerous to use unless more lime is added.

LESSON 0.

SPRAY PUMPS.

Spray pumps are now largely used to distribute insecticides and fungicides. There are many kinds offered by dealers, some of the best should be in the hands of every cultivator of the soil.

MATERIAL NEEDED. Some of the best spray pumps, with their attachments, including knapsack sprayers and several kinds of spray nozzles.

Exercise 29. By pumping water illustrate that spraying is quite different from sprinkling and it is better and more economical of the material. Show attachments for spraying under the foliage, and also for raising the nozzles to the tops of trees by small iron pipes or by means of bamboo poles.

LESSON P.

PACKING NURSERY STOCK.

This refers to the packing of live or dormant plants for transportation. Care has to be taken that they do not dry out, become broken or suffer from heat or frost. To save expense, cheap, light packing materials must be used. Some of the common methods are:

Packing growing plants to go by mail.

Packing growing plants in basket or light box to go by express.

Packing bale of dormant plants to go by express or freight.

Box packing of nursery stock.

Exercise 30. Packing of growing plants to go by mail.

Fig. 39. Successive stages in packing growing plants to go by mail.

MATERIAL NEEDED. Sphagnum moss: i. e., florists moss; oiled or paraffine paper, heavy express paper; stout twine; tree and pot labels; shipping tags; strawberry or other growing plants.

Conditions necessary for success: Plants must have soil washed off roots and as little packing about them as possible, to save postage; they must be moist, but not wet, and outside of package must be dry, or it will be thrown out of the mail. The rate of postage on seeds or nursery stock is eight cents per pound.

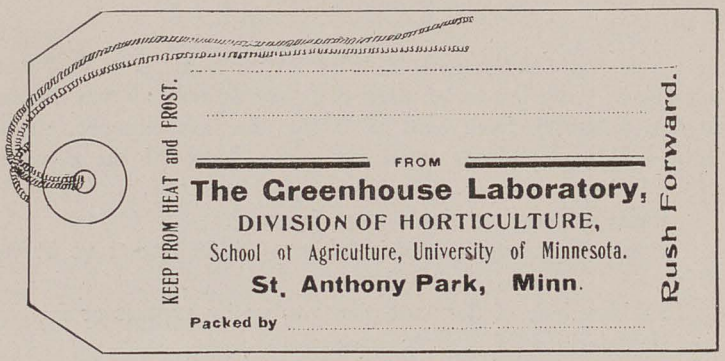


Fig. 40. Shipping tag.

METHOD. Select a number of plants so as not to exceed four pounds, the legal limit of weight of a mail package. Straighten out their roots and lay them in a close pile, with the roots together, putting a very little moss among them if the plants make a bundle more than three inches in diameter. Cover the roots on the outside of the bundle with one-half inch of sphagnum moss, and tie it on with string; next cover bundle with oiled paper, turning it carefully around both ends; then cover over all with manilla paper and tie securely. Write address on covering and also on a shipping tag. Put stamps on back of tag.

After package is made up, it should be put away in the locker to remain for one week, when it should be taken out and examined and condition of contents noted. If work was well done, it will be in good condition.

Exercise 31. Basket package to go by express containing growing plants, and weighing not over twenty pounds.

MATERIAL NEEDED. Cabbage or strawberry plants and potted plants; Sphagnum moss; newspaper or other cheap paper; light weight split wood basket; strong twine. Light boxes may also serve the same purpose.

METHOD. If the plants to be packed are loose plants, such as those of cabbage and strawberry, they should be tied together in bundles four to six inches in diameter, with a little wet moss in the middle of each bundle. If they are in pots, water freely, and when the surplus water has drained off, knock out of the pots

Fig. 41. Successive stages in packing growing plants in basket to go by express.

and roll each ball up separately in paper. Select a basket or box of proper size and deep enough to protect the tops of the plants, and leave the handle free. Place a layer of moss one inch thick in the bottom and then place the bundles or single potted plants uprightly close together in the basket until it is filled. Pack moss in between plants and the side of the basket. In the case of cabbage or strawberry plants, cover the top of the basket with burlap, well sewed or tied on. In the case of tall potted plants, draw the tops of the plants together and cover around sides with burlap, leaving the tops out in warm weather, but when sending tender plants in cold weather, it would be necessary to cover the whole of the tops of plants, in which case a box is a better package.

Exercise 32. Bale package to go by freight or express. This is adapted to sending dormant plants, such as apple, plum, elm and other trees, currant and raspberry bushes, and shrubs and trees generally. When properly packed, such nursery stock should keep well for two or more weeks in cold weather.

MATERIAL NEEDED. Burlap or other cloth or matting; strong

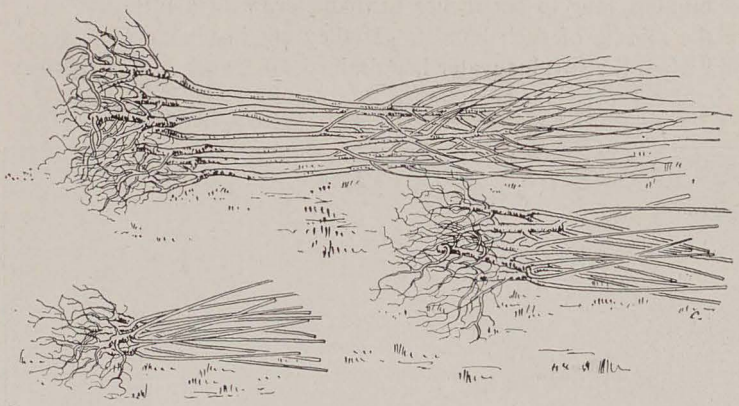


Fig 42. Trees and shrubs for packing into bale

rope yarn or binding twine; moist straw or chaff or shavings; a tub to hold mud for puddling the roots before packing. The mud

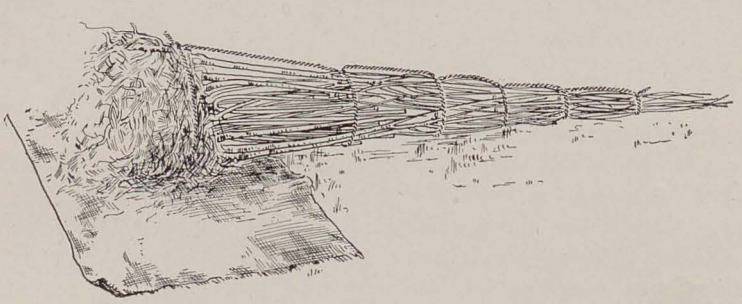


Fig. 43. Trees and shrubs tied together ready to be wrapped with burlap.

for this should be made of clay and water, and thin enough to barely run. Twelve apple trees, twelve currants, twelve raspber-

ries, two eight-foot street trees and six grape vines; shipping tags; labels.

METHOD. Tie each variety of plants in a small bundle by itself, and label each with its correct name. Then dip roots of each bundle in the mud until the roots are covered; tie all together in one big bundle, putting the roots all together and tying tightly.

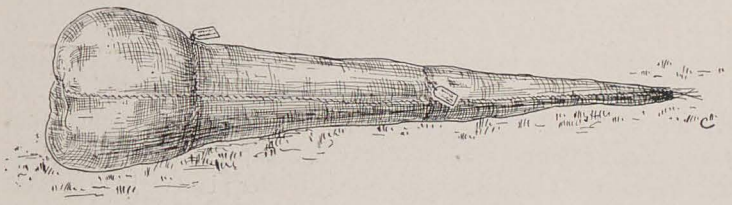


Fig. 44. Bale completed.

Select a piece of burlap big enough to cover the bundle, and lay it spread open on the floor; on this put three inches of a mixture of coarse wet chaff or moss or sawdust where roots are to come, and then lay on bundle; draw cloth over, put in packing where needed, so as to make a three-inch covering of packing over all the roots; sew together firmly about and under the roots, and close about top with bagging twine. Write two shipping tags plainly with name and address of purchaser, and tie on different parts of bundle.

Exercise 33. Box packing for cold weather. This method is especially adapted to sending trees and plants in frosty weather, but is an excellent method for any season of the year.

MATERIAL NEEDED. Wooden box large enough to hold the stock; heavy soft paper similar to carpet paper; quite dry moss and excelsior; twelve apple, six plum trees, twenty-four currants; six raspberries; twenty-four blackberries; twenty-four gooseberries; one hundred strawberries; twelve dormant roses; fifty coleus; fifty verbenas; twenty cannas; forty geraniums and one palm two foot high.

METHOD. Tie the apples, plums, raspberries, currants, blackberries, gooseberries and strawberries in bundles and dip in the mud described under exercise 32. Allow the mud to dry off a little; knock the coleus, geraniums and verbenas out of the pots

they are in, and wrap the ball of earth of each plant with paper to hold it together. Wrap the cannas and palm likewise in paper.

Line the box with paper thoroughly and cover the bottom of the box with three inches of moist chaff. Place the bundles of apple and plum trees and fruit plants in the bottom, making a smooth and compact job. Nail a few one inch boards across the box inside to hold the trees and fruit plants in place; cover with about two inches of hay or broken straw. Lay in the coleus, verbenas and other plants evenly, so that the box will be full after two inches of hay and the paper is on. If not full when all are in, put in enough hay or other dunnage to make the plants solid when cover is on. Cover with hay and paper and nail cover on tightly. Packed in this way even very tender plants will keep well for two weeks or more in cool weather. The most danger is from heating, but if the plants and the packing are only moist, not wet, there is very little danger from this.

LESSON Q.

USE OF GARDEN SEED DRILLS AND HAND CULTIVATORS.

MATERIAL NEEDED. Box of soil, or portion of greenhouse bed or floor, which is covered with at least eight inches of good garden soil; one or more of the best drills and garden cultivators, with a full set of attachments; one hundred willow or other cuttings, to take the place of plants in the exercises; wheat, or other medium sized seed.

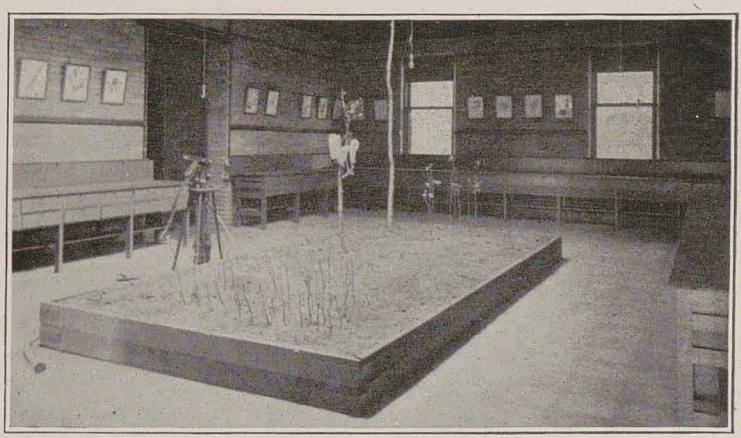


Fig. 45. Laboratory fitted with soil box for exercises with seed drills, hand cultivators and in transplanting.

Exercise 34. Plant out two rows of cuttings of any kind that will take the place of plants, and allow them to stick up four

inches above ground. Each student is to work seed drill, regulate flow of seed, and arrange cultivators as follows:

To open furrows.

To close furrows.

To cut weeds from both sides of the row at one operation.

To cut weeds from one side of each of two rows at one operation.

To loosen the soil between the rows for a dust blanket.

LESSON R.

HEELING IN.

Heeling in is a term that denotes a common method of caring for nursery stock after it has been dug and before it is planted out. Serious losses of trees and plants often occur for lack of knowledge of this simple matter.

MATERIAL NEEDED. Apple trees; plum trees; currants; gooseberries; raspberries; strawberries; spade.

Exercise 35. (1) Dig trench six feet long, twelve inches deep and wide, place one row apple roots in it, in upright position; cover roots firmly with earth; place in another row of trees, and repeat with apple and plums, until all are covered. Then in front of trees heel in small fruit shrubs, and in front of these put in strawberries.

Fig. 46. Heeling-in trees for winter.

(2) Heel in the same material in the same way, except place them in a slanting position as shown in figure 46. When all are in, bend tops of trees and shrubs to the ground and cover with six inches of soil. Put a stake at each end of the rows of strawberries, and cover them likewise with six inches of earth. This method of heeling in is best for plants that must be kept over winter. It is a good plan to cover with four inches of mulch in addition to soil.

LESSON S.

PLANTING OUT.

This lesson comprises illustrations of the following subjects:
Transplanting strawberry plants.
" suckering raspberry plants (sets).
" apple root grafts.
" forest tree seedlings.
" apple tree.
" street tree.
Planting willow cuttings.

MATERIAL NEEDED. A small plat of garden soil as in lesson Q. Strawberry plants; suckering raspberries; apple seedlings; large apple tree; street tree; willow cuttings; spade, rake; line, etc.

GENERAL DIRECTIONS. Set trees or plants at the same depth at which they formerly grew, or a very little deeper. Always firm the soil about the roots, or, in the case of cuttings, about the part below ground.

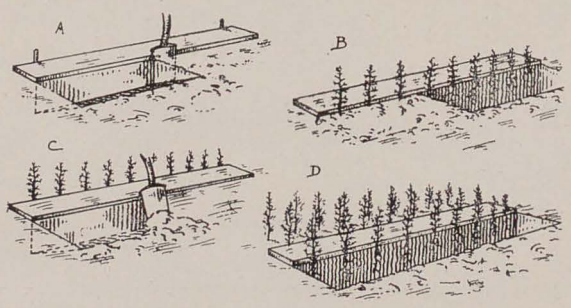


Fig. 47. Successive steps in planting young evergreen or other very small seedlings. (a) Board in place and trench partly opened. (b) Seedlings in place and partly covered. (c) New trench with seedlings in place at (d).

Exercise 36. Twenty-five strawberry plants should be set out by each student. In doing this, much care should be taken to spread the roots and to set the crown of the plants at the same

depth that they grew in the soil. If roots are very long, they should be shortened to five inches.

Exercise 37. Transplant ten suckering raspberry sets, setting them in a trench made like a furrow. Shorten tops to ten inches.

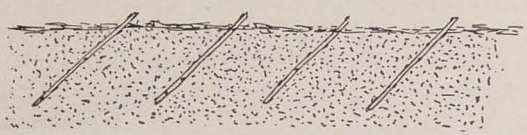


Fig. 48. Position in the soil of willow cuttings when properly set.

Exercise 38. Plant out ten apple root grafts, setting them with the upper bud of the cion just at the surface of the ground. Use spade or dibber in planting them. Be especially sure that the soil is packed firmly about the root and union.

Exercise 39. Plant out the forest tree seedings, preferably

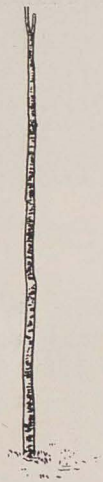


Fig. 49. Elm street tree pruned to a bare pole when planted out. The best method.

small conifers, setting them six inches apart in rows eight inches apart, using for this purpose a board, as shown in figure 47.

Exercise 40. Plant one apple tree of ordinary planting out size, after removing any cut or broken roots. The top soil should be put in a pile separate from the subsoil, so that in filling in again the top soil should be put around the roots.

Exercise 41. Plant out fifty 12-inch willow cuttings. First cut along the line with a spade where the cuttings are to be set, and then push the cuttings into the ground at an angle of 45 degrees, as in figure 48, and leave only one inch sticking out above the surface soil.

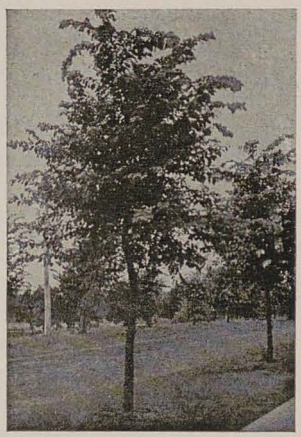


Fig. 50. Elm street tree five years from planting. It was pruned to a bare pole when set, as in figure 49.

Exercise 42. The soil in the bed should be increased to at least thirty inches in one portion, and when hole in made plant out one two-inch elm street tree, after first removing broken roots and all the branches, leaving it as a bare pole, as shown in Figure 49.

LESSON T.

PRUNING.

The subject of pruning is of much importance and rather a difficult one for the beginner. We here illustrate only a few of the more important principles.

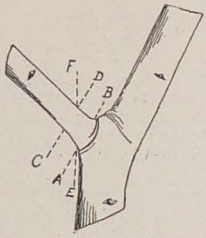


Fig. 51. Showing the proper place to make the cut, in pruning. A wound made on the dotted line A—B will be promptly healed One made on the line C—D or E—F will not. In figure 52, the lower branch was cut off too far from the trunk. (After Goff.)

MATERIAL NEEDED. Street trees two inches in diameter. (If the trees are a little brushy, so much the better will they illustrate the subject.) A sharp knife; a pair of pruning shears and

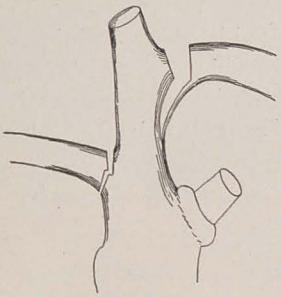


Fig. 52. Showing how to make the cut in pruning large branches. The upper cut, all made from above, permits the branch to split down. The left cut, first made partly from below, prevents splitting down. (After Goff.)

a fine saw; grafting wax, or white lead for covering the wounds. Specimens should also be at hand showing how the wounds of

plants heal over; the effect of poor pruning in allowing rot to get started in the trunks, etc.

Exercise 43. If the work must be done indoors, each student should prune at least one apple tree, and two or three street trees should be pruned by members of the class before the class.

Fig. 53. Pruning to an outside or inside bud Cut as in the figure, the uppermost bud would form a shoot that tends to vertical. Cut on the dotted line, the uppermost bud would form a shoot tending to the horizontal. (After Goff.)

The wounds should be covered with grafting wax or white lead paint; call attention to the various ways in which the buds point and the effect of their position on the branches that come from them; the proper place to cut off branches and the way to do it to prevent the bark splitting down. These points are illustrated in figures 51, 52 and 53. Make a special point of covering most carefully the fresh wounds on apple wood more than one year old, as apple wood more than one year old is often hurt by pruning, while young wood is seldom so injured.

This subject should always include observations on the effect of pruning on near-by trees, as regards its effect on form, and the healing over of wounds. In the trimming back of the plants used for budding, there are numerous minor observations that can be made as to effect of pruning on growing plants.

LESSON U.

METHODS OF WINTER PROTECTION.

In this climate trees and plants often require extra protection to enable them to do well. Many methods are used, but those here given illustrate the forms in common use.

MATERIAL NEEDED. Apple trees of ordinary transplanting

Fig. 54. Apple trees protected from sun scald by tying corn stalks on trunks and branches.

size; spade; cornstalks; hay rope; heavy paper; wooden box; lath screen; wire screen; whitewash; Paris green and soft soap.

Exercise 44. Protection from winter killing. Plant apple tree and raspberry and currant bushes, and protect by laying flat on the ground and covering with six inches of soil. This method is adapted to small fruit plantations and to small trees, and is es-

pecially useful for protecting apple and plum trees planted in autumn.

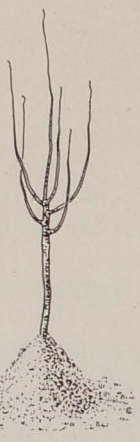


Fig. 55.

Fig. 56

Fig 55. Earth banked around a fruit tree for winter.
Fig. 56. Wooden box around tree trunk to protect from sun scald.

Fig. 57.

Fig. 58

Fig. 57. Lath frame around tree trunk to protect from sun scald
Fig. 58. Tree protected by tying hay around trunk.

Exercise 45. Protection from sunscald. Protect trunk of planted apple tree with (a) constalks tied on the southwest side,

(b) hay rope wound around tree trunk, (c) lath screen, (d) with wooden box filled with soil.

Exercise 46. Protection from mice. Protect trunk of apple tree from mice by banking up to the height of 16 inches with earth; also by wire netting put around trunk. Note also that the wooden box put on to protect from sunscald will protect from mice and rabbit injury.

Exercise 47. Protection from rabbits. Spray trees with lime or cement wash containing Paris green. Paint trunks with soft soap paint.

DEFINITIONS.

FLAT.—A shallow box used for various purposes as growing plants and for transplanting plants. For our work it is 14x17 inches and 3 inches deep.

DIBBER.—A small wooden pin used for transplanting. The size and shape depends on the kind of holes to be made.

SCREEN.—A box made like a flat, but the bottom covered with wire netting. Three sizes are furnished, one with ½-inch mesh, one with ¼-inch mesh and one with ⅛-inch mesh.

RAPHIA.—Tying material for budding, etc. Product of the palm, Raphia ruffia from the tropics.

PUDDLING.—The operation of covering the roots of nursery stock with mud to enable them to withstand the changes incident to packing and removal.

LABELS.—Pot labels refers to those without wire and intended to be pushed into the soil. Tree or swing labels are those pierced or notched and held in place on a tree by a small copper or iron wire.

CAMBIUM.—The row of cells of new growing tissue between the bark and the wood.

CALLUS.—The first growth made by plants in healing over of their wounds.