I think you will see this is very, very important. Thank you very much.

PRESIDENT SNYDER: Thank you, John. We thought perhaps we might get some additional information from you while your ideas about the 12th program are still fresh.

This morning we have a symposium on Propagation of Plants by Budding and Grafting. The Moderator is David Leach from Brooksville, Pennslyvania.

MODERATOR LEACH: I see the session this morning is a *symposium*. *It occurred to me to look up and see what the defini*tion of symposium was. To my surprise I found it is a convivial meeting for drinking, conversation and intellectual matters. It is my observation there are symposiums going on constantly in the bar, but what we have got this morning is a plain old-fashioned meeting.

The first session this morning is on the Propagation of Plants by Budding and Grafting. Most of us believe that any plant is better off on its own roots, but a plant may not be sufficiently vigorous on its own roots or it may not be practical to propagate it commercially that way.

It is an interesting thought that this portion of the proceedings may become just a historical curiosity because it seems likely with the progress in research, the time will soon come when it will not be necessary to propagate plants by budding and grafting or some of the methods which are still needed today; but presently, without budding and grafting, some of the most valuable and some of the rarest and interesting of plants would never come on the market.

We have a distinguished panel this morning and the first speaker will talk on Anatomical Aspects of Budding and Grafting — Dr. Fred B. Widmoyer, Plant Science Department, University of Connecticut, Storrs, Connecticut.

ANATOMICAL ASPECTS OF BUDDING AND GRAFTING

FRED B. WIDMOYER
Department of Plant Science
University of Connecticut
Storrs, Connecticut

Graftage is the recognized means of propagating plant materials which are either difficult or impossible to obtain from seeds or cuttings. Propagators using grafting have unknowingly recognized plant anatomy when they speak of "compatabilities" and "incompatabilities." Most frequently, the reference is to the relationship of stock to scion.

Budding and grafting involve the same principles, differing only in the number of growing points on the scion. In all cases, wounding occurs in the process. Healing may be attributed to the activity of the cambial layer in some species, phloem, xylem and ray parenchyma in others. The basic phenomena occuring during the reestablishment of buds and grafts will be discussed.

Roberts (1949) has thoroughly reviewed the literature as it related to the techniques and physiology of graftage. More recently, Rogers and Beakbane (1957) discussed stock and scion relations. Of the histological research reported most of it has been on fruit varieties.

In order to better understand the problems of wound healing, certain basic botanical terms are required. Examination of the transverse (cross) section of the stems of the genus *Rosa* and *Chaenomeles*, show anatomical differences. In these stem sections certain regions stand out.

The outer covering of a young stem is a single layer of cells called epidermis. Later a periderm is formed beneath this which protects the inner tissues of the stem or root. The outer portion, cork, is composed of dead cells.

The cortex is composed primarily of parenchyma cells. These function in many ways — food manufacture, storage, and protection. This region may be from a few to many cells in thickness.

The vascular system is composed of phloem, cambium and xylem. The cambium is a meristematic layer which produces cells which become phloem externally and xylem internally. Each cambial cell divides to produce potential phloem and xylem cells alternately. Young phloem cells are more likely to retain or revert to meristematic conditions than are the xylem cells.

Radiating from the pith to the cortex are more or less parenchymatous strands called interfascicular, pith, or medullary rays. Within the vascular tissues are the fascicular rays composed of xylem and phloem rays.

The central portion of a stem is generally occupied by the pith. Most of the parenchyma of this region is specialized as storage tissue.

This completes the basic anatomy of the stem. Let us examine the process of wound healing. Several phenomena probably occur simultaneously. The most important is the early proliferation of parenchyma cells to form callus which preceeds other cellular activity. These thin walled, relatively large cells are easily torn and susceptible to desiccation. The propagator assists mother-nature by the type of graft selected (whip and tongue, being more rigid) and by tying and waxing techniques. Sanitary conditions and care reduce disease infections.

Parenchyma cells are produced by both the stock and scion, which are relatively unspecialized. Wound healing, regeneration, formation of adventitious roots and shoots and union in grafts are made possible through resumption of the meristematic activity by these parenchyma cells.

Some dicot wood has few to no parenchyma cells. The xylem area of angiosperm plants generally has considerably more parenchyma than do the coniferous plants. This perhaps is why plant propagators select certain graft types for certain clones. Parenchyma is primarily located in the phloem and cortical regions of the gymnosperm. If parenchyma is present in the wood it may have secondary walls or become otherwise specialized. At this stage of development, the ability to remain meristematic is reduced. However, the cells actually injured form a plate of dry necrotic tissue which cover the cut surfaces. The actual proliferation occurs adjacent to this layer. According to Buck (1952) these cells rupture the necrotic layer and produce callus strands from one to several cells wide on the graft interfaces. The production of callus is chiefly from the *ray* parenchyma (primarily phloem) although some does originate from any of the other living cells. The increased number of parenchyma cells force the necrotic tissue further into the graft interface, producing islands of dead, non-functional cells. By this time, the cells are intermingled in such a way that their origin is difficult to ascertain. The existing cambium of the graft pair probably contributes the least to wound healing.

Specialization of certain cells of the callus develops. Adjacent to the cambium layers of stock and scion cambia-like bands are produced. Divisions of these cells continue both tangentially and radially until the cambium layers are joined. The newly completed cambial layer begins to produce xylem cells to the inside and phloem cells to the outside. The early cells are usually smaller with a mass of dense protoplasm. These cells are oriented into "bridging" tissue, which insure continuity of the vascular tissues between stock and scion. According to Yeager (1944) even though stock and scion contributed to the callus formation, the new vascular tissues arise solely from the scion. *A successful graft union is accomplished by cells produced after the graft has been made.*

The time of healing varies, depending upon the accuracy in which the parts are aligned, vigor and growth activity of stock and scion, temperature, humidity, disease and insect control. Any condition which adversely affects vegetative growth also reduces the healing of a graft union.

Several examples of anatomical failures which are purely technical are as follows:

1. poor matching of stock and scion cambia
2. phloem specifically fails to unite
3. phloem degenerates and the graft does not survive
4. failure of the cambia to unite — producing instead of xylem and phloem, masses of undifferentiated parenchyma
5. components of the graft not differentiating xylem and phloem at a comparable rate
6. failure of xylem to unite.

From the following studies, many of these anatomical phenomena will be evident.

Show slides:

Slide 1 — Rose and *Chaneomeles* — comparative tissues and cells.

Slide 2 — This is a new whip and tongue graft. The stock is the lower part and the scion is the upper part. One of the prerequisites of a successful graft is closeness of fit. Even though cambial layers are not exactly aligned, the wound tissues may be produced, but at a much slower rate. At this point along the interfaces proliferation of some parenchyma is already occuring. The blue stained cells are parenchyma and other non-woody tissue. The red stained and black stained cells are woody cells which are no longer living.

Slide 3 — The stock is on the left and "bridging" cells are on the right. At this stage of development, it is impossible to determine the origin of the mass of parenchyma. These cells are the connecting strands between the stock and scion. By this time survival of the scion is assured if adequate bridging tissues have been produced. Stimulation of cell divisions occurs with increases of temperature, in the range of 45° - 90° F. The darkened cells are the remains of necrotic cells ruptured by the growth of the parenchyma cells.

Slide 4 — This shows more clearly the rapid proliferation of parenchyma cells on the graft interface. Remember, the blue stained cells are living parenchyma cells. This mass in the lower right is bridging tissue showing continuity between stock and scion.

Slide 5 — Further development of the stock-scion union of *Malus* on *Sorbus*.

Slide 6 — Cross sectional view of a whip and tongue graft which shows the completion of a graft union, continuous cambial layer xylem and a resumption of xylem and phloem cell production, all of which originated from callus tissue.

These slides were furnished through the courtesy of Dr. Mahlstede and Dr. Buck of Iowa State University and Drs. Watson and Davidson of Michigan State University and George Evans, who is currently teaching at the University of Montana.

REFERENCES

Buck, G J. 1953. The Histological Development of the Bud Graft Union in Roses. Proc. ASHS 62·497-502.

Esau, Katherine. 1960 Anatomy of Seed Plants. New York. John Wiley and Sons.

Evans, George, Donald P. Watson and Harold Davidson. 1961. Initial Evaluation of Grafting Some Species of the Rosaceae. Proc. ASHS 78:580-585.

Hartmann, Hudson T. and Dale E Kester. 1959. Plant Propagation: Principles and Practices New Jersey. Prentice-Hall, Inc.

Mahlstede, John P. and E. S. Haber 1957. Plant Propagation. New York. John Wiley and Sons.

Roberts, A. N. 1962. Scion-Bud Failure in Field-Grown Roses. Proc. ASHS 80:605-614.

Roberts, R. H. 1949. Theoretical Aspects of Graftage. Bot. Rev. 15 (7) :423-463.

Rogers, W. S. and A. Beryl Beakbane. 1957. Stock and Scion Relations. Ann. Rev. Pl. Physiol. 8:217-236.

Yeager, A. F. 1944 Xylem Formation from Ring Grafts. Proc. ASHS 44:221-222.

MODERATOR LEACH: Thank you, Dr. Widmoyer, for one of the best talks on anatomical aspects of budding and grafting that the Society has ever had.

Next we are to hear some Unusual Methods of Budding and Grafting from Dr. J. C. McDaniel, Department of Horticulture, University of Illinois.

DR. McDANIEL: I will depart a little bit from the announced title of the program and will call on two men to talk briefly on some successful methods of budding and grafting which they have used recently.

One is Mr. Ben Davis of the Ozark Nurseries at Tahlequah, Oklahoma, on his method of performing the modified patch bud. This is used particularly with such thick-barked species as walnut, pecan and some of the other nut trees, persimmons. It is applicable to thick-barked hardwood tree species generally.

THE MODIFIED PATCH BUD

BEN DAVIS II
Ozark Nurseries Company
Tahlequah, Oklahoma

This method of budding was developed by Mr. Hoyt Cockrell of Cockrell's Riverside Nursery at Goldthwaite, Texas. I have never heard of this method being used anywhere else until we adopted it two years ago. Mr. Cockrell tells me that they are nearly always 90 to 95 percent successful in their Pecan budding using this method.

The outstanding characteristic of this method of patch budding is that a single blade knife is used, while in other method of patch budding, special knives are required. Another advantage of this method is its speed. Our budding crew was averaging 260 buds per man per 8 hour day, by the end of the season, and for most of them it was the first time to use this method. Some individuals who had done some of this type budding the year before were putting in 400 to 500 buds per 8 hour day. About half of the crew consisted of high school boys who had never done budding of any type. This method is fairly easy to teach, provided the student is reasonably adept at handling a knife.

We used this method of budding on Pecans, Japanese Persimmons, English Walnuts and Black Walnuts. We were especially pleased with the results obtained on budding English Walnuts. We have been grafting these for several years with very poor results. Last summer we decided to try patch budding them, and obtained a 78 percent stand. Because of this, we have decided to quit grafting English Walnuts altogether and use the modified patch bud exclusively.

This method was also highly successful on Japanese Persimmons, although we budded a limited amount of these.

The results we obtained on Pecan budding were not nearly as successful and we got only a 33 percent stand. I think that this was due to the fact that the budding crew was not familiar with the method, and also their lack of understanding of the importance of a *perfect match.* This is especially important in Pecan budding, as it is a very difficult item to propagate at best. On the limited amount of Pecan budding which I did myself, being very careful to match at the top and one side, I obtained something like a 90 percent stand.