gation of specialized stems, and tissue culture. The intent of all these laboratory projects and demonstrations is to acquaint students not only with the skills necessary to perform the task, but also to be sure they understand the terminology, the type of plant material used, the time of the year the task is performed, and the success rates that might be achieved.

It must be understood, however, that students completing a plant propagation course in 10 to 16 weeks are in no way highly skilled propagators. These laboratory projects are meant to acquaint them with the art and science of plant propagation, and to give them the knowledge that years of hard work lie ahead to become a highly skilled propagator.

As we do our job of teaching plant propagation, we hope more young men and women are encouraged to become involved in plant propagation as their life's vocation and avocation. There is, of course, no more noble profession!

TEACHING HERBACEOUS PLANT PROPAGATION LABORATORIES

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IMPORTANT PRELIMINARY CONSIDERATIONS

In teaching plant propagation laboratories, or for that matter, teaching laboratories of any sort, the objectives of the exercise must be clearly stated. Does the exercise teach a practical propagation technique? Does the exercise teach important priniciples of propagation? It is important that these objectives be clearly stated and that evaluation of the results be assessed in relationship to these objectives at the conclusion of the experiment.

Another important consideration is the students' preparation prior to beginning the exercises in question. It is important that they have adequate opportunity to learn fundamentals of plant science, including plant structure and functions. They should also have a reasonable knowledge of the equipment and materials required for completion of the exercise. These fundamental concepts can be taught through the vehicle of prerequisite courses or through the preliminary parts of the propagation course that precede these exercises.

For any exercise that is to be used, it is important that the instructor test it him/herself. It is important that the exercise

work successfully, and the best way to know that it will work successfully is to have tested the excercise prior to presenting it to the students. This may seem to be an obvious concept, but in the hustle and bustle of the academic world it is easy to overlook such details or to allow oneself to be rushed into a situation of teaching a technique that is not tested prior to giving it to the students. Together with this testing, the instructor must also give strong consideration to careful preparation and planning before the exercise. Just as in a commercial operation, such as a nursery, it is important to plan carefully in teaching. I feel that this is an important concept for students to acquire and one of the best ways to acquire it is to have had it demonstrated by instructors who are well organized. An appropriate approach is to plan a timetable of operations. For many exercises this may mean purchasing plants or growing plants well in advance of the beginning of the semester (quarter). Of course it's also important to order equipment and plant materials with plenty of time allowed for delivery. "Backorder" problems can often cause serious delays in implementing an otherwise well thought out laboratory exercise.

HERBACEOUS PROPAGATION EXERCISES

Special propagation techniques, such as division and separation, are important methods of propagating numerous kinds of herbaceous materials. Such species as iris, peonies, daylilies, dahlias, rhubarb, and cannas are normally propagated by one of these methods. Although relatively simple processes, knowledge of plant structure and where new shoots arise is important. In a species such as dahlia, a knowledge of the necessity for taking a portion of the crown, along with the tuberous root division in which the crown piece includes an "eye" or bud, is important as well. Many of the division and separation techniques and examples are well illustrated in laboratory manuals or textbooks such as those listed in the bibliography for this discussion.

THREE SUCCESSFUL HERBACEOUS LABORATORIES

I will use three successful herbaceous propagation laboratory examples to illustrate different principles and uses that are of a practical nature to the propagator.

Lily Scaling. In this exercise either Easter or garden lily bulbs may be used. This exercise demonstrates organ regeneration adventitiously from modified leaves. It is important to use plump healthy bulbs and to remove any outer scales which are dry, shriveled or damaged. These should be discarded and the next several layers of plump firm scales removed individually. These scales will be placed to approximately one half their length vertically in a moist medium in flats. They may then be placed in a moderate temperature greenhouse (approximately

20°C, or 70°F). A medium which is commonly used for this technique is moist sphaghum peat, but a comparison of media such as vermiculite, peat, perlite, and sand makes this a more interesting exercise if sufficient lily bulbs are available. An alternative procedure is to place the scales in moist (not wet) peat or other medium in polyethylene bags. The medium should only be about half of the volume of the bag and the scale embedded in the medium and the bags securely closed with a twist tie type closure or similar method.

Normally this technique produces tiny bulblets on the cut or broken surface at the base of the scale within three to four weeks time. One beauty of this exercise is that it is predictably successful every time. We have tested this exercise in various ways for 13 years in our laboratories and it has always worked successfully. It should be noted that now, through use of tissue culture techniques, rapid bulblet increase can be achieved much more efficiently than through this method. However, this method is one which can be accomplished with a minimum of equipment by the beginning propagator or the propagator who does not have a tissue culture laboratory facility available.

Potato Tubers from Leaf-Bud Cuttings. This is a method that is of practical use to the potato breeder who wishes to increase a seedling line prior to field planting. A simple procedure, it is necessary to start the potato plants in large pots or containers approximately three months prior to use. This is normally done in a greenhouse. For winter classes in northern latitudes, the growth of these plants can be enhanced by use of high intensity discharge (HID) lamps. The procedure involves removing mallet type leaf-bud cuttings with approximately 2 cm of stem attached to a healthy leaf. The stem length should be equal (1 cm) above the node and below the node. The entire stem segment including the bud is then embedded in the medium to be used. Depth is important and normally, depending on the size of the stem segment, a depth of 2 to 3 cm is recommended. It is important that light be excluded or the bud will grow as a normal axillary shoot rather than forming tiny tubers. Exclusion of light, and possibly oxygen relationships, probably interact with hormones to stimulate tuber formation rather than the shoot that one might expect.

Although moist sand is the recommended medium for this procedure, variations for experiments would include comparison of other media with sand, such as vermiculite, peat, perlite, etc. Another comparison that could be run instead of a medium comparison would be application of growth regulating chemicals such as benzyladenine (BA), gibberellic acid (GA_3), B-nine (Alar, daminozide), or compounds more familiar to the propagator of cuttings such as indolebutyric acid (IBA). Another interesting modification one can incorporate into this experiment is for dif-

ferent students to have different cultivars of potato. Use of unusual cultivars such as 'All Blue' or red skinned types like 'Pontiac' adds color and interest to the experiment. Results will be observed in 3 to 4 weeks.

This exercise also illustrates regeneration of a new structure in an unusual location, or adventitiously. Tiny tubers form in the leaf axil. Usually only one forms at this location but occasionally 2 or even 3 may form. In addition it is common for the cutting to have rooted. The tubers normally reach marble size in this period of time. They can then be broken off from the cutting for planting or storage prior to planting at a later date. Even the smaller tubers (pea size) can be used successfully.

Petunia Leaf Piece Culture. This exercise deals with an extremely simple and nearly always successful tissue culture technique. Since tissue culture is really in many cases just employment of minute or tiny cuttings, some of the principles of propagating by cuttings apply. This exercise demonstrates the influence of hormones (hormone-like growth regulators) on control of root production and shoot production. I particularly like this exercise because it works well and can be done in an open laboratory. It teaches fundamental concepts of asepsis and of hormone effects and interactions.

Procedure involves growing petunia seedlings to the 4th or 5th true leaf stage (or older) and this means starting them one to two months in advance of the exercise depending on the growing facilities and techniques employed. The leaves to be cultured are excised from the stock plants so grown and are surface disinfected in bleach solution (0.5% sodium hypochlorite) for 10 minutes. The leaves are then removed from the disinfecting solution and are rinsed thoroughly in two successive rinses of 5 minutes each in sterile distilled water. They are then transferred carefully into sterile petri dishes and cut into 4 mm wide sections transversing the midrib of the leaf. Instruments for all of these procedures should be surface sterilized, usually by dipping in alcohol and flaming them. The leaf sections are then transferred into sterile petri dishes which have been prepared in advance with modified Lindsmaier-Skoog medium with 0.5 mg/liter benzyladenine (BA), 1.0 mg/liter naphthaleneacetic acid (NAA) or both BA and NAA. The petri dishes are then sealed with parafilm or tape and placed on a lighted laboratory bench or in a growth chamber.

Results are obtained in a relatively short period of time, with some activity visible within 1 to 2 weeks. Small shoots on the BA medium, roots on the NAA medium, and usually callus on the BA plus NAA medium are visible within 3 to 4 weeks. Students can then record their observations and relate the results to principles of hormonal physiology. Ideas for variations to try in this experiment include comparing indoleacetic acid vs. naphthalene-

acetic acid and/or a splitting of the experiment and placing part of the cultures in dark and part in light.

RECAP OF IMPORTANT CONSIDERATIONS

It is imperative that the instructor make sure that the exercise teaches a practice, skill or principle. It is also extremely important that the instructor know that the exercise work successfully The best way to know that, is to have practiced it oneself. Organizing the exercise well in advance of the implementation of the exercise by the students will also enable students to have a successful learning experience from these laboratory exercises. Finally, observations of results should be evaluated and discussed for maximum understanding of the value of these exercises.

Numerous other exercises such as scooping or scoring hyacinths, herbaceous cutting exercises, herbaceous grafting techniques and similar exercises could be handled in a manner similar to the three exercises discussed in this presentation. Such exercises can be developed by the instructor or they can be found in available laboratory manuals.

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ASPECTS OF A TEACHING PROGRAM FOR PLANT TISSUE CULTURE

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Tissue culturing of plants as a means of asexual propagation is an example of a tool which was developed and refined by the research community long before it gained acceptance as a technology for use in industry. This lack of concomitant development by industry and university researchers has led to communication gaps in the implementation of techniques and applications. Since most plant propagation teaching programs cover tissue culture briefly and from a theoretical perspective, most students are