Label on Tree Graft

This illustrates Mr. Burbank's method of labeling a graft, in order to keep track of his experiments. The label is of wood, and the inscription is made with paint or pencil. The wire attaching the label should of course be loosely applied to avoid restricting the plant.
EVERY ONE has heard the story of the distinguished professor who devoted his entire life to the study of a particular species of mite, and who, on his deathbed, regretted that he had not confined his attention to the study of the respiratory organs of this insect, instead of trying to comprehend its entire structure.

This specialist, like many another, felt that he had wasted his energy by attempting to cover too wide a field. He felt that his ten volumes or so on the anatomy of the mite could give but superficial treatment of a great subject.

Whoever sympathizes with the attitude of mind revealed by this doubtless apocryphal yet truly symbolic tale, will have scant patience with my method of plant experimentation. For, far from confining attention to a single species, or even to

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a single genus or order, I have extended my observations to almost every form of plant, testing species by thousands, and individual specimens by hundreds of thousands or millions, in my experimental gardens; and only by exception has complete record been kept of all details of any given series of experiments, beyond the more or less fallacious records of memory.

Yet I have had the good fortune to produce, I suppose, more forms of plant life that could justifiably be called new, than have been produced by any other single experimenter in our time. Had I stopped to make meticulous record of each experiment, I doubt if I should now know more than I do about even my less important products, and I surely should have been able to produce only a fraction of those that I have produced.

METHODS AND RESULTS

Yet it must not be supposed that I have altogether refrained from graphic recording of the progress of my tests. The fact is quite otherwise. I have kept in the aggregate a vast body of records, and have had them always at hand, under my eye from day to day, telling of the essentials of my hybridizing and other experiments.

My “plan books” have been a constant aid to memory, and guide to further effort.

My record books have set down in black and
Label on Greenhouse "Flat"

In working on a large scale, time-saving is imperative. Mr. Burbank finds this simple method of labeling his "flats" to serve an excellent purpose. The label is easily replaced, or the penciled inscription may be erased, and a new one substituted, when the "flat" is used for another experiment.
white the unequivocal evidence of progress—or of failure to progress. Few salient facts as to the precise parentage of important hybrids and the exact methods by which variation has been brought about have failed to find explicit record, notwithstanding the omission of multitudes of details that to some observers might have seemed worthy of transcription.

And if I have adopted in the field shortcut methods of recording selection, these have not lacked precision and accuracy, notwithstanding their time-saving character.

In point of fact, all along the line I have endeavored to strike a happy medium between the waste of time that would result from the keeping of unduly elaborate records, and the waste of effort that would necessarily result if no records at all were kept.

The reader who would clearly comprehend the nature of the compromise must bear in mind that I have, as a rule, had a practical object in view in conducting my experiments. It is true, as Professor Bailey has courteously said, that I constantly make experiments with plants for the mere love of the work. It is true also that my tests include hundreds of species from which I expect no very definite return. Yet it is further true that the main body of my experiments have
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been concerned with flowers or fruits that seem to offer opportunities for practical improvement.

I have usually been seeking, in the experiments to which most time has been given, to modify the plant in such a way as to make it a more beautiful and desirable garden ornament, or to modify a vegetable or fruit in such a way as to make it a more valuable food product.

Such being the case, it will be understood that, with regard to large series of experiments, I have been concerned with results rather than with methods. As to the latter, it often happens that numberless experiments might be described in substantially the same terms. Once the principles of hybridization and selection have been clearly mastered, they may be applied to almost every variety of plant life. There are differences in the detail, but the broad outline is the same for each.

ESSENTIALS VERSUS NON-ESSENTIALS

It would then be but a waste of time to record over and over details as to these broader outlines of plant experimentation. Where anything of interest has appeared, any point as to which a plant shows differences from its fellows, this has become a matter for recording.

Moreover, it has been my universal custom to make record of the first hybridizing or crossing
Diagram of Tree Grafts

This is a leaf from Mr. Burbank's plan book. It is a sort of shorthand or diagramatical record that condenses a large amount of information into small space, leaving room for additional records should they be called for. Such a page seems cryptic to the casual observer, but to Mr. Burbank himself it is full of meaning.
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through which any particular series of experiments is inaugurated. The parentage of the Shasta daisy, the white blackberry, the stoneless plum, the sugar prune, the pluncot, the thornless blackberry, the spineless cactus—these are matters of clearest and most unequivocal record. The results of the first crossing, through which matters of prepotency and of latency are determined, and through which the plant is given the impulse to variation, are also explicitly shown.

But when, particularly in case of a fruit having complex characters, the experiment passes to stages of the third and fourth generations, involving tens of thousands or hundreds of thousands of seedlings, it is no longer possible to make detailed and explicit record, with exact count of the different combinations and variations developed, for two very explicit and sufficient reasons.

One reason is that the numbers of seedlings involved are so great that it would be physically impossible for any one carrying on hundreds of different series of tests at the same time to make numerical count in accordance with the statistical method adopted by workers who are experimenting on a limited scale.

The second reason is that even if such a count, showing the exact number or percentage of seedlings with different combinations of traits, were
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attempted, it would be unavailing unless vast companies of seedlings were preserved for the term of years necessary to bring them to fruitage.

When one is concerned solely with numbers, or with such tangible qualities as color of hair in the case of Professor Castle’s guinea pigs, or color of feather with Professor Davenport’s fowls, it is an easy matter to check results, because the creatures under investigation manifest the qualities that are being tested from the moment of birth, or develop them at a very early age.

But with plants the case is obviously different. Whereas we may judge something as to the character of fruit that a seedling will ultimately bear from observation of the seedling itself, yet for purposes of scientific record such predictions would be considered as worse than worthless. To know what percentage of seedlings of a given generation have really progressed toward the ideal of a sugar prune that will ripen August 1st instead of September 1st, let us say, it would be necessary to let all the seedlings grow for several years, or at the very least to wait two or three years for the grafted cions from each seedling to come to fruitage.

The practical experimenter, seeking results, cannot possibly work in this way when he works on a large scale.

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Record of Blooming

Facsimile of another page from Mr. Burbank’s record books. This one has to do with the time of blooming of various fruit bearers,—a matter of great importance, because blossoming time is correlative with the time of fruiting, which often has important bearing on the value of a new fruit. It is a little surprising to learn that varieties that bloom early ripen their fruit relatively late, and vice versa.
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He must be content to select from among thousands of seedlings the one or five or ten or fifty that appear to him most promising. To these he must pin his faith, and all the rest must be destroyed to make room for other plants.

Otherwise he would require not twenty odd acres, which make up the total area of my experimental farm, but hundreds or even thousands of acres.

And to keep track of the multitudinous seedlings would require the aid not of the half dozen or so assistants whose coöperation makes my experiments possible, but of a small army of equally industrious workers.

SYSTEMATIC WORK IMPERATIVE

But, having thus outlined the limitations that necessarily attend work conducted on a large and comprehensive scale, let me now proceed to elaborate somewhat the other side of the story.

Let me outline the various practical methods of recording experiments that have been developed in the course of my years of experience. Let me in particular point out some of the shortcuts that have made it possible for me to record the essentials, and even in important cases the details, of progress, with a minimum expenditure of time and labor.

Among the essentials that cannot be overlooked
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by any systematic and successful experimenter are
the following:

A general plan of the ground occupied by all
the experiments must be made, and there must be
clear record of each plant, shrub, or tree planted.
It is important also to record the time when each
one was grafted or budded; the date of all experi-
ments in crossing any particular tree or plant;
observations as to any anomalies of development;
and finally, as a matter of course, the results
obtained.

As to these things, the memory, no matter how
tenacious, must prove more or less untrustworthy.
It is only the black and white record that can be
depended upon. But plans may be outlined so
simply that all these essentials may be recorded
at the expense of very little time or labor.

It is not much trouble, for example, to keep a
plan book at hand, each page of which is devoted
to a certain planting, its location on the grounds,
and all other matters that are worthy of record.
It will facilitate matters in such a book to have
the records of planting arranged somewhat in
the order in which the plantings have occurred
during the season.

If these records are made on large sheets of
paper so plotted as to show the location of the
various beds of plants, this will be an added
Grafting Record

Yet another page of Mr. Burbank's record books, this one dealing with grafting. It will be seen that the records of different years are associated, and it will be obvious that the records were intended for Mr. Burbank's own eye, to supplement the records of memory. When thousands of experiments are being performed simultaneously, it is imperative that the recording should be done with the least possible loss of time.
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convenience, as it will enable any particular lot of plants to be located, even if through some inadvertence the label stakes, which are an absolute necessity, have been removed or lost by careless workmen.

Often when planting in the field, letters or numbers are used on the stakes, corresponding with similar letters or numbers in the record book.

LABEL STAKES AND LABELS

As to the label stakes themselves, the ones that I habitually use for general field culture are about 20 inches long, 2 inches wide, and \( \frac{3}{4} \) of an inch in thickness. They are smoothly planed and painted about half way down on both sides with common white lead paint.

One coat of paint is far better than two, for if a pencil is used the lightly painted surface takes the lead to advantage, and by bearing down heavily with the pencil, indentations are made in the wood that will resist the weather more effectually and thus give greater permanence to the record.

It is desirable to make the label stakes of soft, smooth redwood or other durable wood. In the East the locust is an excellent substitute. It is advantageous to dip the end of the stake in car- bolic acid or in a solution of sulphate of copper to prevent decay. These stakes may be used over
and over again for many years, being planed off as the occasion requires and repainted.

Many thousands of these label stakes are used each season on my experimental grounds. For smaller beds I use a stake usually 1 inch wide, from \( \frac{1}{8} \) to \( \frac{1}{4} \) of an inch thick, and from 10 to 14 inches in length. These smaller plant stakes may be purchased of dealers, and are prepared for use in the same way as the larger ones.

For use on trees a special label is employed, to make records of budding, grafting, and variation. This label is usually 5 or 6 inches long, and from 3-16 to \( \frac{1}{4} \) of an inch thick. It is notched at one end and attached to the branch of a tree with a piece of pliable galvanized iron wire. The wire should be loose enough to avoid any danger of strangling the branch.

The labels are painted with white lead. They sometimes remain upon the trees for five, ten or even fifteen years. To inscribe these permanent labels, I use a thick black paint, composed of a mixture of lamp black, linseed oil, and a little turpentine, applying the mixture with a small camel's hair brush. The names of varieties, the parentage, and other important matters are thus recorded. Then, while the paint is still wet, some fine dry sand is sifted over the label so as to protect the paint from the weather.

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Ripening Record

This may be regarded as a companion record to the one shown on page 257. It records the highly important matter of the time of ripening of various fruits. This particular page shows among other things that a seedling Japan raspberry ripened April 25th, and a new hybrid blackberry May 1st. Some of Mr. Burbank's finest new fruits, including the Burbank cherry and the Sugar prune are made doubly valuable by the fact that they ripen several weeks earlier than similar fruits of other varieties. Mr. Burbank is constantly encouraging fruits, by selective breeding, to modify or lengthen their season of fruiting.
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In addition to the labels and stakes I have just described, a small cardboard label of light weight is needed for making record of the hybridizing experiments. The common cardboard shipping tag about 1½ inches by 3 inches in size with a reinforced eyelet hole, is generally used on plants with tender stems; and where the wind is likely to disturb larger labels, half or two-thirds of the cardboard may be cut off, leaving barely space to inscribe the record.

Where these tags are used in extensive pollinations of many varieties on a single tree, it is not always necessary to write the record, for the same object may be accomplished by cutting off one corner of the card to indicate a certain variety of pollen, and a second corner to indicate another variety; additional varieties being represented by series of notches. Or the same end may be attained by punching holes in the card with a pocket steel punch. This plan saves much time, and the record is more permanent than if it were made with pencil. A large number of tags may be prepared at once with punch or scissors.

Tags of this character are less likely to have their records erased by wasps and hornets, which often partially destroy labels when securing material for their paper homes.

Conspicuous tags such as these are also of aid
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later in the season when the seed is to be gathered; because they make known at a glance the facts as to parentage, and make it possible to keep separate the seeds of different varieties. The labels are tied to the plants with common twine, as wire or other hard substances would be likely to injure the tender stems when the wind moves the tags about.

When numerous varieties of plants are grown in a single bed, we often nail a common tree label opposite each row on the board that borders the bed, instead of using a stake, as there is less danger of the label being displaced. It will be advantageous to place this label at the side of the bed away from that from which the prevailing winds and storms come. In this section of California the summer winds and winter storms come from the South, East, and Southwest, and in conjunction with the hot sunshine, they are very destructive to paint. So it is advantageous to face the labels toward the North.

All of these are matters of minor detail, yet not without their importance.

RECORDING RESULTS

In making selection of individual plants that are to be preserved, or from which seed is to be gathered, the most convenient, and at the same time the most accurate method is the simple one
It has sometimes been supposed that Mr. Burbank depends entirely on his memory, and makes very few written records of his experiments. This facsimile page, taken in connection with the others that have just been shown, will serve to dispel that erroneous notion. It will be seen that records are kept of the essentials of each different type of experiment, including not only methods, but results. In point of fact, although Mr. Burbank adopts many shortcuts, his records of essentials are surprisingly comprehensive and complete, considering the enormous range of his experiments.
of tying a small strip of cloth about the stem of the plant.

Visitors to my gardens are sure to notice that each bed of flowers has a half dozen or so plants that are thus decorated. In some cases two or three strings may be attached to a single plant, indicating degrees of excellence. Selection having been made in this way, the plants may be allowed to ripen their seeds, and in due course the workmen may gather them without further direction, placing them in labeled boxes to be stored for the winter.

As regards new fruits, there is particular need of great accuracy, and here it is impossible to avoid a good deal of detail. It will not do at all, in dealing with a valuable addition to the list of fruits, to leave anything to memory as to its season of ripening, size and form, color, flavor, aroma, size of core or stone, length of stem, or any other essential quality.

An exact record must be kept of these items, and for this purpose a book with removable unruled leaves is the most satisfactory.

The fruit should be cut in half with a sharp knife. The incised surface may then be placed directly on the paper, and the outline of the fruit traced with pencil. The specimen may similarly be outlined in cross-section. This preserves a
Stakes to Mark
Divisions of a
Verbena Bed

Here penciled records are kept in the field, on stakes from which Mr. Burbank can tell at a glance the antecedents of the particular varieties of plants he is dealing with. Here there are seeds of many varieties sown in a single bed, but the label-stakes serve as an immediate guide to all of them.
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graphic record of the exact size and form of the fruit. The main character of the inside of each fruit may be indicated, and by adding the date of ripening, the time of its earliest and medium ripening, the number of days it will remain in good condition upon the tree, its keeping quality when packed for shipment, and its susceptibility to the ravages of insect pests and fungoid disease, we have on a single sheet a fairly complete and very valuable record, together with a graphic representative of the size and form of the fruit itself.

Record will be made in the same way in successive seasons of fruit from the same tree, with additional record of the appearance of any new characters or qualities. Comparison of the records will show whether the fruit on the young trees has increased in size, improved in quality, or varied in time of ripening from year to year. Not unfrequently the record of the third year shows a very considerable increase of good qualities over the first.

After a record has been kept for four or five seasons, a fair estimate may be made of the general value of this particular fruit. If in addition we know the characteristics of the parent forms—whether the ancestors were hardy or tender, and the like—we are now in position to form a clear judgment as to the probable value of the fruit.
Punched Labels

These labels are important time-savers. Each set of holes represents a specific plant or a different type of experiment, the key to the labels being found in the record books. The upper left hand label here shown might indicate, for example, that the branch on which it is tied bears blossoms of the Sugar prune (one hole at base of label), fertilized by pollen of the Conquest stoneless prune (three holes at center of label). Such labels as this are loosely attached to the stem of the plant that has been pollenized or grafted. They are permanent, and they minimize mistakes.
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Such a record as this is essential to actual progress. It is important, if for no other reason, to prevent the experimenter from deceiving himself. It is very easy to imagine that a certain product that has caused one much trouble is better than some other; or that a fruit of a given tree is larger than some rival variety. But the record book enables one to put the matter to a precise and definite test; it makes self-deception impossible; and it affords an invaluable guide to further experimentation.

There are thousands of graphic records such as these on the shelves of my library.

I would not think of attempting to conduct an intricate series of experiments looking to the development of a new fruit without the aid of these plan books.

When the experiment is finally completed, a series of these loose leaves, properly collated, furnishes a complete record of the various hybridizings and selections—resulting sometimes in better and sometimes in worse fruits—through which success has finally been achieved. These records are in themselves sufficient answer to anyone who imagines that the plant experimenter works haphazard, merely because he does not always adopt a biometric method.

After all, from the standpoint of the consumer
Notched Labels

This is another type of short-hand label similar in its use and interpretation to the ones shown on page 270. Each series of notches tells a different story, and the key to their interpretation is found in the record books. Two notches, for example, might represent the Alaska daisy and three notches the variety named Westralia. The top label above would then record the hybridizing of these two varieties. (The small notches for the string are not counted.) Mr. Burbank finds this method of keeping track of experiments highly satisfactory.
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who makes up the main bulk of the population, and whose tastes and needs are the criterion by which the plant experimenter’s results will be judged, it is the final product rather than the precise method by which it is attained that is important. But the ideal at which the plant experimenter aims would probably never have been realized had he not given himself the aid of some such system of quick and accurate records as my plan books present.

—Once the principles of hybridization and selection have been clearly mastered, they may be applied to almost every variety of plant life. There are differences in detail, but the broad outline is the same for each.