The So-Called Candle Cactus

No explanation is required as to how this cactus received its popular name. It is a species oft grown for ornament in regions suited to it. Mr. Burbank has utilized it, along with many others, in his experimental work, although not with directly productive results.
RECLAIMING THE DESERTS
WITH CACTUS

THE METHODS USED TO PRODUCE A SPINELESS
CACTUS

PLAINSMEN will tell you that in the old days
they have known the antelope and the
buffalo to come for many miles to feast on
cactus plants whose spines had been burnt off by
a chance fire.

The spines of the cactus burn like tiny tapers,
leaving the slabs nearly unprotected, and the succu-
ulent forage thus made accessible constituted a
treat that was precisely to the liking of the antelope
and the buffalo. Horses and cattle were found to
relish the plant equally under the same circum-
stances.

In the midst of the desert sands, with little else
eatable in sight that was more inviting than the
sagebrush with its dry and dusty foliage, the succu-
 lent cactus slabs, held out invitingly, offered juicy
herbage that the animals browsed on with avidity.

Even when the cactus still retained its spines,

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the antelope would sometimes try to find a way of getting at its juicy substance. I have heard plainsmen tell of seeing the antelope holding in its mouth a slab that had been dislodged, and twisting its neck this way and that in an effort to find an unprotected spot at which it could nibble.

Obviously the cactus had need of its spines if it was to escape the unwelcome attentions of the browsing animals that found such difficulty in securing sustenance among the dwarfed herbage of the plains and deserts.

But by the same token it appears that if a way could be found to take from the cactus its bristling array of spines, the plant might be made to supply forage in regions where other succulents cannot secure a foothold. So the problem of producing a spineless cactus was one that had but to be suggested to any one who knew the life of the arid regions to make instant appeal.

MATERIALS AND RESULTS

It was obvious, however, to anyone having any clear knowledge of plant development, that the task of removing the spines from the cactus would be a very arduous one.

It is true that there are small species of cactus that are spineless, or nearly so, that have been familiar for generations. One of the first pets of my childhood days was a thornless cactus, a beau-
The Quisco Cactus

This is a species from South America which is so thorny that it is impossible to touch the finger to it at any point. Mr. Burbank has given it a place in his garden, along with many others, to see whether it shows a tendency to variation, and thus gives promise of possible modification. It is viewed, however, more as a curiosity than as the probable progenitor of a plant of economic importance.
tiful little plant of the genus *Ephiphyllum*. There are also members of the *Cereus* family that are thornless, showing not a trace of spine on any part of the plant or fruit.

But the cactus plants that are thus unprovided with spines were without exception small and inconspicuous species, and also with a bitter principle so disagreeable that cattle generally refused to eat the plants. So the plants offered no possibilities of direct development through selection, that could promise the production of varieties that would have value as forage plants.

Meantime the large varieties, in particular the members of the genus *Opuntia*, which have peculiarly attractive qualities of size and succulence, are thickly studded with spines for the very reason, doubtless, that were they not thus protected they could never have maintained existence in regions inhabited by the jack rabbit, antelope and buffalo.

If the problem of securing a spineless cactus of value as a forage plant—to reclaim the deserts and supply succulent food for herbivorous animals where now little but sagebrush grows—was to be solved, it would be necessary, I thought, to hybridize the already well-known, partially spineless species of cactus with the large-growing, spiny ones. There seemed reason to hope that a reassortment of hereditary characters might be
ON THE SPINELESS CACTUS

brought about, such as we have seen, for example, in the case of thornless blackberry and stoneless plum among other plant developments.

Thus the qualities of size and succulence of the Opuntia might perhaps be combined with the smooth skin of the small, partially spineless species.

The hope that it might be possible to effect such a transformation through hybridization was abundantly justified. In due time such a new race was developed, a gigantic cactus, overtopping all its known ancestors in size, and surpassing them all in succulence of flesh, producing fruit of unpredicted excellence in almost unbelievable quantity, and having a surface as smooth as the palm of your hand. Such a plant was produced as the result of hybridizing experiments, followed up and supplemented by the usual methods of rigid selection. But the result was not achieved with the small cacti referred to. Meantime I was carrying on extensive experiments with all the half-spineless ones which had been well known for centuries.

A SOUL-TESTING EXPERIENCE

But the work through which this result was achieved constituted in some respects the most arduous and soul-testing experience that I have ever undergone.

In carrying out the experiments, from the initial
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pollenizing through stages that involved the handling of seed and the constant handling of seedlings, I was obliged to associate intimately with the cactus plants, and it was impossible to avoid their spicules. Particularly after the work had advanced to a stage where the larger spines had been removed and the remaining spicules were in little bundles on the older leaves, did it become impossible to handle them without filling one’s fingers with the irritating prickles.

For five years or more the cactus blooming season was a period of torment to me both day and night. Time and again I have declared from the bottom of my heart that I wished I had never touched the cactus to attempt to remove its spines. Looking back on the experience now, I feel that I would not have courage to renew the experiments were it necessary to go through the same ordeal again.

Not only would the little spicules find lodgment everywhere in my skin, but my clothing became filled with them, and the little barbs would gradually work their way through the cloth and into my flesh, causing intense irritation.

At first I devoted much time to the endeavor to remove the very inconspicuous but exceedingly irritating and pain-producing little spicules with the aid of a magnifying glass and forceps. But I
Vestigial Leaves

The spine-like projections here shown on the slab of the cactus are vestigial leaves. An account of them, with reference to their evolutionary meaning, is given in Volume I. They are all that remain of the leaves that the cactus once bore; and these reminiscent spikes drop off shortly after coming out.
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learned ultimately that the only satisfactory expedient was to shave off the spicules with a sharp razor, or to sandpaper them off, which can readily be done where a great quantity is to be dealt with. When thus reduced in size they would not farther enter the flesh, and gradually the pain would subside.

But the recollection of the torture in connection with the development of the spineless cactus will always remain the most painful one associated with any of my plant developments.

No other complication comparable to this has been encountered in connection with the considerably over ten thousand species of plants with which I have experimented.

But possibly it will appear in the end that no other series of experiments that I have undertaken can be compared in importance to the production of the race of spineless giants which tower to almost treelike proportions, and grow with such rapidity as to produce on good agricultural land from one hundred and fifty to three hundred tons of new forage to the acre annually by the third season after planting, besides nearly one-half as much fruit, yet which are as tender and succulent as grass, affording forage of fine quality in unprecedented quantity, and which can send their roots far into the earth and gain a supply of water
Giants and Dwarfs

These cactus seedlings show amazing variation. Though grown from the same lot of seeds, some of them are mere pigmies, while others rise to proportions that, by contrast, are colossal. The child is father to the man; and the big children of this lot of seedlings will make big mature plants, while the little ones will always be dwarfs.
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for their sustenance from subterranean sources in regions where the surface of the country is that of the desert; economizing this for long seasons of drought which may follow.

HEREDITARY TRAITS

These new races of spineless cactus are of many varieties, in token of their varied ancestry.

In producing them I followed my usual custom of securing material from every available source.

The main supply came, naturally, from the arid regions of the Southwest; the original home of the cactus. But I received also plants from Minnesota, Montana, Dakota, New England, Missouri, and Colorado, South America, North and South Africa, and regions around the Mediterranean. It could not be known at the outset just what crosses would be most effective, and so experimented on every species on which I could lay hands. I pollenized the giant Tunas with pollen of the little trailing cactus, and with such inconspicuous cousins of the giant as the little hardy Opuntia vulgaris.

There were several small more or less spineless species available, and others that produced a comparatively small crop of spines, and of course it was recognized from the outset that these must be our main reliance. Just as the little French partially stoneless plum had been the foundation for building the stoneless plums and prunes of to-day,
ON THE SPINELESS CACTUS

it was thought that the little cactus that was smooth skinned might furnish the element of spinelessness in all the future races of spineless cactus, however varied the other elements of their heritage.

The most curious feature about the crossing of the giant Opuntias with the small species, in particular with the little cactus of the Eastern United States known as *Opuntia vulgaris* was that the hybrid was intermediate between the parents as to every characteristic but one. In size, stem, and manner of growth and form of pads, it made a complete blend of the traits of the two totally dissimilar parents.

But its blossom was a relatively enormous flower, very much larger than that of either parent.

As to the blend of traits of this hybrid of giant and dwarf forms of cactus, the phenomena observed were obviously comparable to those that we have seen in sundry other connections. The Primus Berry, the Sunberry, and the Plumcot, will be recalled as illustrating the production of new forms, unlike either parent yet breeding true to the new type in a single generation.

The hybrid between the giant and dwarf Opuntias furnishes another illustration of the same thing. This intermediate type, strikingly dissimilar to either parent yet obviously blending the characteristics of both, bred true to form, showing
Cactus Seedlings

Ready For Inspection

Here are some cactus seedlings of very different types, undergoing observation. From among them, the ones that show the rudimentary leaves, rather than spines will be selected for further use. They represent a stage in the development of the spineless cactus.
ON THE SPINELESS CACTUS

nothing of that tendency to racial variation in the second generation that marks hybrids in general, and that, as will appear in a moment, marks the hybrids of the other cactuses very conspicuously.

But there is an added element of great interest in the fact that the blossoms of the new hybrid so markedly differs from the flowers of either parent and so conspicuously excels either of them in size and beauty.

It would seem that the floral envelope occupies a position in the hereditary scale somewhat different from that of the main stem of the plant. And this is perhaps not strange, when we reflect that the flower is a relatively recent development in the history of plant life.

We have already noted that flowering plants are of comparatively recent origin, geologically speaking.

We have seen evidences here and there of the relative adaptability of the floral envelope as compared with the stem and leaf structure of the plant. So this new illustration of that phenomenon need not surprise us, however much it may interest us.

It would appear, if we may interpret the phenomena just presented, that the giant and dwarf Opuntias have diverged so widely that they are practically at the limits of affinity that permit crossbreeding. The stems and main structures of

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the plant, therefore, refuse to conform to the principles of Mendelian segregation, and hit upon a compromise in which the traits of each plant find representation.

But the flower, somewhat less fixed as to its characteristics, and indeed somewhat less widely divergent in the two species, accepts a compromise of a different order, and, under stimulus of that strange influence which we do not well understand but which we see constantly illustrated, it takes on a new vigor of growth.

It surpasses the flowers of either one of its immediate ancestors somewhat as the hybrid Royal Walnut tree surpasses its parents in growth.

This phenomenon of great vigor or tendency to excessive growth developed through hybridization, is, as we have seen, a very common one; its peculiarity in the present instance is merely that here it applies to the flower of the plant alone, whereas elsewhere we have usually seen it apply to the entire structure of the plant, including at least in some cases (for example the Primus Berry, the Phenomenal Berry, and the Royal Walnut) the fruit as well.

Let me add that when the Opuntias not quite so diverse in form as the giants and dwarfs were hybridized, the progeny showed the tendency to increased vigor of general growth, not merely to
Spineless and Spiny of the Same Fraternity

These plants were grown from the seeds of a single cactus fruit. Three of them are perfectly spineless, while one is unusually spiny; but all have the long rounded form of the parent, which differed in this particular from most other plants of the same variety.
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increase of the flower, although productivity was also emphasized.

Indeed, it is to the fact of such stimulus of growth by hybridization that my success in developing the gigantic races of spineless cactus is due.

HYBRIDIZING MATERIALS AND METHODS

The hand pollinating of the cactus, which was the foundation of these experiments in the producing of the new spineless races, presents no technical difficulties yet requires to be carried out in a particular way.

The cactus flowers open only in the very hottest part of the day, and within fifteen minutes after the pollen-bearers are exposed there is probability that the wind or bees will have accomplished self-fertilization of many of the flowers. It is necessary, therefore, for the experimenter to be on the spot, to anticipate the opening of the flower.

Our method was to collect pollen in watch crystals, and, if necessary, keep it until the flowers we wished to pollinate were matured. As the different varieties of cactus bloom at different seasons, it was sometimes necessary to keep the pollen for a considerable period.

When the plant to be pollinated is ready to bloom, nothing more is necessary than to remove its stamens just before they are matured, and to dust pollen from watch crystal with a camel’s hair
Mr. Burbank Selecting Cactus Seedlings

Remember that most of these little fellows are covered with spicules. Mr. Burbank's hands are also covered with spicules; and his clothes are full of them. He asserts that the task of dealing with these tiny citizens, in the effort to educate them into spinelessness, was the most painful one in his experience.
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brush over the receptive stigma, being careful not to allow the brush to become smeared with pollen from the stamen, lest the next pollinating be vitiated.

Each blossom thus pollenized is of course tagged to make permanent record of the cross, in accordance with the method detailed in an earlier chapter.

It was customary, wherever possible, to make the cross reciprocal, although with the Opuntias as with other plants, it appears to make little if any difference as to which is the staminate and which the pistillate parent. Here as elsewhere in the plant world the factors of heredity appear as a rule to be distributed impartially between pollen grains and ovules.

The cactus plants that served as material for my comprehensive experiments aiming at the development of a spineless race of economic value were very numerous as to species and very widely diversified as to form and habit. More than one thousand species of cactus are listed by the botanist, and there is the greatest amount of variability, so that no two botanists are agreed as to the precise classification of all the forms.

Of course I have not had every species of cactus at my disposal, but the number with which I have worked is very large indeed.

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ON THE SPINELESS CACTUS

For years collectors in all parts of the world have gathered specimens for me, and as knowledge of my work went abroad, even collectors who knew me only by reputation have sent specimens of one kind or another, until my experiment garden may be considered the great gathering place of the varied clans of the cactus family.

In addition to the specimens received from private collectors, I received also a collection that had been gathered at Washington for botanical classification. Most of these were curious thorny specimens, and I think none of them was used in my successful experiments, although all of them were tested.

Some of the most important acquisitions were sent by my friend, David C. Fairchild, including slabs gathered in France and Sicily. I received also specimens from Mexico, South America, and Hawaii, as well as almost numberless varieties from all regions of the United States where any form of cactus grows. The so-called Smith Cactus, a variety introduced into California by Professor Emery E. Smith, about forty years ago, proved of value as a hybridizing agent.

MANY SPECIES, BUT MORE NAMES

But it is almost impossible to gain a really accurate conception of the materials employed, because of the great confusion of the classifiers,
How Cactus Plants Are Propagated

Nothing more is necessary than to put one end of the slab in the ground. Indeed, the slab will probably germinate and send down roots even if it is merely laid on the ground. The cactus is a hardy plant and it takes a lot of rough usage to discourage it. Each of these slabs will grow presently into a large, robust plant.
ON THE SPINELESS CACTUS

which has led to the ascribing of different names in many cases to the same species.

For example, the variety which I received under the name “Anacantha” (meaning “without spines”) from Fairchild, is identical with specimens received from the Department of Agriculture bearing only a number, and with others received from Italy on one hand, and from my collector in South America on the other, one of the numerous specimens coming under the name “Gymnocarpa.”

It was often only by careful inspection and observation under hybridizing experiments that we could identify the various specimens as being of the same species, or same variety.

Again the so-called Morada, another species that proved of value, was first received under the name Amarillo, meaning yellow, from near Vera Cruz, Mexico, it having been sent me by the late Walter Bryant, formerly of Santa Rosa. This I found to be practically identical with another specimen that had come from southern Europe, under the name of Malta.

Another useful variety that came from various regions under different aliases was the form that has been grown in Florida and in California for the last thirty or forty years and which goes by the common name of White Fruit.

There are marked variations in the color and
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quality of the fruit of this cactus, the pulp sometimes being white and again variegated with yellow.

Specimens from different parts of the world might at first sight be thought to represent different species or at least different varieties; but I have found the various kinds of fruit growing on contiguous branches of the same plant.

The large species of cactus that grows commonly in the Mediterranean region, known there as Indian Fig or Barbary Fig, is closely similar if not identical with the species called Tuna in Mexico, although the fruit of the Mexican variety is usually somewhat smaller than that of the Old World form. The name tuna is applied indiscriminately in Mexico to cultivated and wild species of the tribe, but the varieties are sometimes recognized by different names, as Tuna Amarillo, Tuna Colorado, Tuna Blanca, etc.

Another quite common Mexican form known as Tapuna, appears to be entitled to recognition as a distinct species of Opuntia.

It produces flat leaves that are generally circular or heart-shaped. The plant does not grow as rapidly as others of the large-fruit Opuntias, and the fruit ripens late in the season. The leaves have a somewhat white appearance, as if dusted with flour, which distinguishes them readily from
Cactus Plants in the Nursery

Here the slabs originally planted have put forth several new slabs, showing that they have taken root and are thriving. The plants here are much too close together for permanent growth. At the end of the first year, the new slabs are used for transplanting at wider distances for forage or frutiting purposes.
the others. The fruit is rarely edible except for stock.

The Tapuna is also of rather exceptional compactness of growth and has high nutritional value as a forage plant. Moreover it is a much hardier species than many others, resisting both cold and wet better than most of the best Opuntias.

So this species has characteristics of obvious value from the standpoint of the plant developer.

THE QUESTION OF SPINELESSNESS

But what about the matter of spines?

This, of course, from the standpoint of the present investigation, is the vital question.

The question might be answered categorically, with the statement that not a single one of the Opuntias received from any source was altogether spineless. Spineless forms of some of the other genera are familiar, but it was early discovered that the Opuntias must be looked to for the development of a race of cactus that would have economic value. And, as I said, no form of Opuntia was received, among all the hundreds of specimens from various parts of the world, that was altogether spineless and spiculeless.

The form already referred to as the Anacantha, of which specimens were received from Fairchild and from others, came as near to spinelessness as any other form of true Opuntia.

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ON THE SPINELESS CACTUS

There is a very small and very tender species that is allied to the Opuntias, but is generally classified as a Nopalia, which was received from various parts of California and Mexico, as well as from the Hawaiian Islands, the Philippines, and from Europe, under various names, which is altogether spineless.

But this species is very sensitive to frost or to excessive heat, and in general succumbs to any untoward conditions so readily as to be valueless for this purpose, besides not being relished by any stock.

We have already referred to the fact that there are absolutely spineless forms of the genera *Epiphyllum* and *Cereus*.

These, indeed, have been well known to me for fifty years, and are familiar to all students of plant life. But, as just noted, investigations showed that the genus Opuntia must be depended on for material with which to build an economic race of spineless cactus.

My experiment, it will be understood, was intensely practical in its aim from the outset.

It was not at all my thought merely to produce an interesting race of spineless cactus of diversified forms.

The spineless cactus of my ideal was one that would have practical value as a forage plant; one,
Spineless Cactus
Slabs Ready for Shipment

These are selected slabs of some of Mr. Burbank's new spineless varieties of cactus. Simply laid in a tray, and given protection against rough usage, they may be shipped anywhere in the world, practically without regard to the time required. They seem to germinate even better when somewhat thoroughly dry. Such plants as these, for nursery purposes, command a price as high as $5.00 each.
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therefore, that would grow luxuriantly in arid places, would be reasonably hardy and resistant to extremes of temperature, and would produce an abundance of succulent forage as well as a supply of palatable fruit.

I repeat that I have still to see a form of Opuntia that is of good size and suitable for forage and yet that is altogether free from spines and spicules, except the ones that have been developed in my experiment gardens, and their progeny; and no such variety has yet been reported, although the authorities of the Agricultural Department of Washington scoured the earth to find such a variety.

These, indeed, are Opuntias fulfilling every specification of spineless forage plants of reasonable hardiness, great adaptability as to soil and easy culture, and enormous productivity; and they are wonderful fruit producers as well. But they are the result of a most arduous series of experiments in plant development, and they constitute new races, entitled to the rank of new species if ordinary botanical standards are to be accepted, that have been developed here, and that, so far as there is any evidence, had never previously existed anywhere in the world.

Their descendants have gone forth to begin the reclamation of the arid places of many lands, and
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also to be grown with profit even in the most expensive agricultural lands, especially for feeding with other forage crops. But in no land will they come upon a cactus from any other region that closely resembles them in their combination of entire spinelessness and inviting forage qualities.

PARTIALLY SPINELESS MATERIAL

Yet it must be understood that the various specimens of cactus that have been sent me from all over the world, many of which were utilized in crossing and hybridizing and selective experiments, were often forwarded under the supposition that they were specimens of spineless races.

And many of them were relatively spineless.

Some of them showed individual slabs that were almost free from spines.

But without exception these plants, notwithstanding their relative smoothness, would be found to have inconspicuous spicules or bristles, which constituted an armament almost as offensive as the larger spines; or else would soon demonstrate that their spinelessness was an individual peculiarity rather than a trait of the race to which they belonged, by developing spines on new slabs.

Yet the fact that partially thornless Opuntias exist in many regions demonstrates a tendency on the part of this plant to give up its spines partially under some circumstances.

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Spineless Cactus Showing Two Months' Growth

This picture shows the rapidity of growth of some of Mr. Burbank's improved varieties of spineless cactus. The central slab originally planted has put forth several off-shoots, and these of course have sent out numerous branches; so that now, only two months after the time of planting, the plant begins to take on the aspect of a cactus colony. Of course rapid growth was one of the important factors which Mr. Burbank had constantly in mind in making his selections.
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It shows that in the heredity of the plant there are strains of spinelessness that might presumably be utilized by the plant developer in the production of a spineless race.

In particular it was learned that there is in the Hawaiian Islands cactus that develops specimens that are partially thornless when grown on mountain sides in positions absolutely inaccessible to browsing animals. Also in California, Mexico, Colorado, New Mexico, and Texas, as I learned from various reports, small patches of half thornless cactus are sometimes found, always in inaccessible crevices among the rocks. These all appear to be species of Nopalia and not Opuntia.

In some of the South Sea Islands where vegetation is abundant, and where browsing animals are few, the Opuntias have either reverted to a spineless condition, or have retained spines that have become merely hairlike appendages.

This tendency to produce partially spineless races when the plant is grown under conditions that make it inaccessible to browsing animals, seems clearly to demonstrate that there are obscure factors of thornlessness in its prehistoric heredity. Our general studies in the effects of hybridizing give adequate clues as to the way in which these submerged factors may be brought to the surface.

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A Thrifty Yearling

Here is a year-old plant of one of Mr. Burbank’s improved varieties of spineless cactus. So thrifty is this youngster that it will need to be considerably thinned by the removal of numerous slabs, if it is to attain symmetrical growth. But of course each discarded slab may serve as the basal slab of a new plant just like the parent.
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The open secret, of course, is to blend the different strains of heredity by hybridizing the various Opuntias, and to select for propagation the seedlings that reveal the spineless condition in combination with other desired qualities.

A SPINELESS RACE ACHIEVED

From the outset I had been making hybridizing experiments, in which I utilized in particular the hardiest races of Opuntias that I could find, choosing, of course, at the same time, those that showed a tendency to produce relatively sparse crops of spines.

In this way I had developed races of cactus that though small in size were hardy, and that ultimately, after nine years' work, produced specimens that were absolutely free from spines. After the spines were gone, however, there remained spicules, which grow in little clusters of several hundred here and there over the surface of the leaf, and which are an even greater annoyance than the larger spines to the plant experimenter, although they are sometimes ignored by browsing beasts. At the present day absolutely smooth ones have been produced on my grounds, bearing also smooth, handsome fruit of excellent quality. As these have come from a stock hardier than any oak tree, they can probably be grown in Alaska.

The hardy and partially spineless cactuses first
A Yearling of Different Type

This is another spineless cactus yearling, but one showing a quite different manner of growth from the one in the preceding picture. Here the slabs are put out symmetrically from the edge of the parent slab, and it may be predicted that the plant will grow into a compact tree-like form, and need little attention.
produced were hybridized, when my more extensive experiments were under way, with the best examples of the large Opuntias received from all parts of the world.

In making these crosses I bore in mind always the condition of relative spinelessness, but also the characteristics of the plant as regards size and fruit-production and quality.

The precise parentage of the hybrids of the first generation was recorded, as already stated. But when the seedlings came to be handled by literal millions, and when the specimens that were utilized numbered scores of alleged species, between which it was often difficult to differentiate, it finally became impossible to attempt to follow the exact pedigrees of the selected plants, if my experiments were to be carried out on the expansive scale that was contemplated.

The seeds from different crosses were planted separately, and the character of the seedling would reveal at an early period the quality of the plant as regards the tendency to produce spines, but not at this early stage the quality or quantity of fruit.

When the cactus seedlings first appear above ground, their cotyledons are spineless. This suggests a period when all cactus plants were without spines, for it is a familiar doctrine that the developing embryo reproduces in epitome the stages of
Another Well-Balanced Cactus

This photograph also shows a spineless cactus in its first season. The manner of growth of this specimen is almost ideal. It spreads its slabs in such a way as to get the largest available supply of light and air for each, without mutual interference. Plants that take this form may be grown relatively close together, insuring a large production per acre.
its racial history; and the plant at the cotyledon stage may be regarded as really still an embryo, inasmuch as it is drawing its nourishment from the nutritive matter stored in the seed.

The first leaf that puts out just above the cotyledons may be spiny or hairy, in recognition of the racial period when spines were worn, even in my new spineless varieties. But the quality of these little spicules will enable the experienced experimenter to determine whether they represent future spines or only a racial reminiscence.

So it is possible to make first selection among the seedlings at a very early period, and to weed out from among the hundreds of thousands all but a few.

Unfortunately the cactus requires from three to five years from the seed to come to fruiting time. So the experimenter who is attempting to develop an improved spineless race must wait patiently throughout this long period before he can effect a second hybridization and thus carry his plant one stage farther along the road to the coveted goal.

But by carefully selecting the seedlings that show the most likelihood of a propensity to produce smooth slabs, yet which at the same time are strong of growth and resistant to unfavorable conditions, it is possible to note marked progress even in a single generation. And when the selected
ON THE SPINELESS CACTUS

plants have come to blossoming time and have been hybridized with the best among their fellows, the seedlings of this second generation will show numerous individuals that are markedly superior to their parents or their grandparents in regard to all the desired qualities.

In this second generation (we are not now speaking of the giants and dwarfs referred to earlier in the chapter) is manifested the usual tendency to recombination of the hereditary factors.

In such companies of seedlings as I developed, where hundreds of thousands of plants are grouped together, one is sure to find at least a few specimens that combine the spineless quality of one remote ancestor with the tendency to large growth of another, the fruiting capacity of a third, and so on. By attentive scrutinizing of the seedlings, at an early stage of their development, it was found possible to select thus the few individuals among the thousands that revealed the best combinations of qualities.

These are transplanted by themselves, and given every favorable condition to stimulate their growth and development, and finally placed in long rows for field culture, where they are allowed to stand for three or four years, and in the end, if one out of three hundred or four hundred is found

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A Promising Colony

A corner of Mr. Burbank's experimental cactus bed, revealing what has been accomplished in a single season's growth from slabs set out as shown in an earlier picture. Of course these plants are still under going observation, and it is clear that they are not all of equal merit. There is none here, however, that has not run the gamut of careful selection.
ON THE SPINELESS CACTUS

sufficiently valuable with which to continue the
work, the experiment may be considered success-
ful thus far.

It is tedious to wait another term of years
before going to the next hybridizing experiment
that will give a still better crop of seedlings from
which to make new selections. But of course
numberless experiments with other plants are
being carried out in the interval, and so the time
does not seem so long while it is passing, as it
seems in retrospect.

Let it suffice that after fifteen years of effort,
involving the collection of materials from all over
the globe, the hybridizing in the aggregate of
thousands of individuals, and successive selections
among literal millions of seedlings, I was at last
rewarded by the production not merely of one but
of numerous varieties of hybrid Opuntias that
grow to enormous size, producing an unbelievable
quantity of succulent forage; the slabs of which
are as free from spines or spicules as a water-
melon; and that produce enormous quantities of
delicious fruit.

Some inkling, perhaps, of the difficulties of the
experiments through which this result was
achieved have been revealed in the preceding
pages.

Something of the economic importance of the

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achievement will be suggested in ensuing chapters. Here let it suffice to repeat that the series of experiments in which the giant spineless fruiting Opuntias were developed was in some respects the most painful, arduous, and difficult of all my long series of plant developments; and that there is reason to believe that its results will ultimately vie with the results of any other single experiment in economic importance.

—Here is a new species of spineless giant cactus which towers to almost tree-like proportions, and grows with such rapidity as to produce, on good agricultural land, from one hundred and fifty to three hundred tons of new forage to the acre annually, by the third season after planting, besides nearly one-half as much fruit.