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JANUARY, 1909

RELATION OF PLANT GROWTH AND VEGETATION FORMS TO CLIMATIC CONDITIONS.

By J. J. THORNBER.

On several occasions in Experiment Station publications the writer has noted the relation between climatic factors in the Southwest, especially those relating to temperature and rainfall, and the vegetation forms and the seasons of growth of the native flora. Perhaps nowhere in our country are conditions more favorable to extended observation of this kind than in this region where vegetation is still largely in its virgin stage and the controlling factors so pronounced in their effects upon plant growth. On the mesas and mountain slopes and up to altitudes of 4500 feet or thereabouts, the most important consideration so far as growing plants is concerned is that of soil moisture, while at the higher altitudes, namely, 7000 feet and above, the matter of temperature becomes of greater consequence to plants than that of soil water. To state this from an observational standpoint, plant growth of one type or another, i. e., summer or winter growth, obtains at the lower altitudes whenever there is sufficient moisture in the soil, favorable temperatures being for the most part constant factors; while at the higher altitudes growth of any considerable extent begins only when the temperature becomes sufficiently warm, moisture in quantity for germination and growth being usually present. Since rainfall in Arizona takes place during the winter and early spring months and again during the summer months*, there being two well-defined precipitation periods, it is quite apparent that at the lower altitudes there are two seasons of plant growth, viz., a winter and spring season and also a summer season, while at the higher altitudes already noted there is only one growing season which from the nature of the case begins near the first of June and ends with autumn.

* Rainfall in the extreme western and southwestern parts of Arizona is very limited.

While all our native plants respond readily as regards growth to favorable conditions of moisture and temperature those vegetation forms of our flora which are not in any sense xerophytic in habit nor suggestive of desert and semi-desert conditions appear to be most pronounced in this respect, which may be due to their growth being restricted to a definite period or season. These species are for the most part represented by annuals which are confined largely to the lower altitudes already noted, and perennial herbs which constitute a large percentage of the flora of the higher altitudes. The annual species may be divided conveniently into two groups, viz., winter annuals which begin and end their existence within the season of the winter and early spring rains when continuity of moisture in the soil is more certain than at other periods of the year; and, summer annuals which grow only during the summer rainy season, i. e., July to September inclusive. In the vicinity of Tucson there are approximately one hundred and fifty species of winter annuals and about one-third that number of summer annuals. The former are members chiefly of the borage, chicory, evening primrose, grass, mustard, pea, phlox, poppy, plantain, sunflower and waterleaf families, while the latter belong mostly to the amaranth, carpet-weed, caltrop, four-o-clock, grass, morning glory, purslane, spurge and sunflower families.

The seeds of winter annuals germinate at relatively low temperatures, the young plants passing the cold winter months in a seeming inactive rosette stage from which they emerge uninjured by the occasional severe frosts incident to our winter weather, and begin rapid growth with the warm days of late February. It needs hardly be noted that the Southwestern winter and spring season is admirably suited to their requirements of growth. Summer annuals, on the other hand, grow only during the prevailing higher temperatures of our summer months when sufficient moisture obtains. They develop no rosette stage, and from the germination of their seeds to the time of seed maturation, a period of four or five weeks or longer with exceptionally heavy rainfall, their growth is notably rapid. One is led to believe at times that the uncertainty of the summer showers together with the lack of continuity of moisture in the soil at this season has reacted upon the growth of these plants. It must not be overlooked, however, that growth with many other of our species at this season, when moisture is commonly abundant both in the soil and the atmosphere, is extremely rapid.

The distribution or rather limitation of these short-lived plants in our region is exceedingly interesting. Neither group grows in abundance in the extreme western and southwestern parts of the Territory, except, perhaps occasionally, in depressions where storm-water collects from heavy showers, on account of the greatly restricted rainfall in this section, this portion of Arizona, as is well known, being one of extremely low altitudes. On the other hand, neither group becomes a characteristic feature of the flora above altitudes of 4500 to 4800 feet; in the case of winter annuals this is believed to be due to the fact that the lower temperatures of the winter and early spring months at these altitudes retard in no small degree their growth during this period of abundant moisture, after which droughty conditions set in. With summer annuals the case is quite different; the rainfall during the summer and fall months at altitudes of 4500 to 4800 feet is usually sufficient to maintain a good growth of the perennial bunch grasses which are permanently rooted, summer-growing species that tend to hold in check the germination and development of small annual plants. Where these bunch grasses are killed out as a result of overgrazing and tramping, summer annuals or some more resistent perennial form assert themselves and occupy the ground. For reasons given above, winter annuals and summer annuals are at their best, therefore, between altitudes of 1500 and 4500 feet. Even within these limits, especially in shallow soil, summer annual growth is greatly embarrassed by the presence of such species as creosote bush and the various cacti, the well-developed root systems of which appropriate much of the available moisture before the shallow-rooted annuals can take it up; this, in connection with the extremely rapid surface evaporation commonly results in the seedlings of annual plants drying up between showers.

These two groups of annuals, viz., winter annuals and summer annuals, growing at different seasons and under different temperature conditions are for the most part small, rapid-developing, short-lived plants; they are, in brief, mesophytes growing within mesophytic or semi-mesophytic periods amidst desert or semi-desert surroundings. In this connection it will be interesting to observe that thus far no native species belonging to these groups of plants has been found growing during both the winter and the summer periods. From a number of introduced species which grow in this region either as winter annuals or as summer annuals, it might be inferred that any rapidly-maturing, short-lived species having seeds which begin growth either at low temperatures or at high ones and sufficiently tolerant to the temperature during its period of growth might be able to grow successfully in competition with our native winter annual or summer annual species. In the further study of these groups of plants the writer has this suggestion under consideration.

Having in mind the relation already noted between climatic factors and our vegetation forms, it will be interesting to observe the more successful vegetation forms among our cultivated species. The flowering plants which do best at the lower altitudes in southern Arizona during the winter and spring months, so far as the writer has observed, are the common pansy, candytuft, migonette, sweet alyssum, sweet peas, nasturtiums, scarlet flax, lupines, California poppy, Mexican evening primrose, Nemophila, Nigella, opium and Shirley poppies (*Papaver* sps.), annual larkspur (*Delphinium ajacis*), corn flower (*Centaurea cyanus*), pot marigold (*Calendula officinalis*), *Linaria canadensis*, *Gaillardia pulchella*, *Platystemon californicus* and *Linum Lewisii*,* the four latter occurring native over southern Arizona as winter annuals. From custom the above flowers have come to be sown in September and October at which time their seeds begin growth; this growth is continued until the colder winter weather, when, unless protected, they pass through a more or less inactive period, some even developing rosettes. With the return of the more favorable temperatures of late winter active growth sets in again, after which they blossom commonly until the beginning of June, when, even though abundantly watered, they usually die as a result of the hot, dry weather. They are almost without exception annual species with us, and for the most part short-lived; in their manner of growth they behave quite similar to the winter annual species already noted. Among cultivated vegetables

* At our higher altitudes this species grows as a perennial during the summer months.

parsley, celery, lettuce, radishes, smooth peas, spinach, and cabbage with the allied forms of this species grow either wholly during the cooler months of the year, or at least are at their best at this season. So far as growth and resistance to low temperatures is concerned, they, also, resemble the winter annual group of plants.

The summer annual flowering plants which grow successfully at the lower altitudes without protection are less numerous than those already noted for the winter season; their best representatives are globe amaranth (*Gomphrena*), Prince's feather (*Amaranthus* sps.), rose moss (*Portulaca*), marvel of Peru (*Mirabilis*), Cosmos, Petunia and Zinnia, besides numerous species of morning glories. The vegetables that are least affected with the heat during the summer months are beans, corn, Chile pepper, eggplant, tomato, okra, melons, cucumbers and squashes.

On account of temperature conditions it would be as impossible to grow successfully the annual flowering species noted immediately above during our winter months as to grow the list of annual flowering plants referred to as winter growing species during the summer months; and this also holds true, as is well known, for the lists of vegetables. In this connection, the writer's experience gained from a small grass garden on the University grounds at Tucson, may be cited; seeds of such species as timothy, red clover, red top, English blue grass, reed canary grass, perennial rye, also fescue, wheat and brome grasses, together with grasses in general from the Northern states, when sown in the early spring, made a good growth until May or June after which the seedlings were killed out with the intense heat, even with reasonable irrigation; whereas when seeds from the same lots were sown in the fall a good growth obtained for the most part during the winter and spring season, a number of the species maturing seeds before the extreme heat of summer. In concluding this part of the discussion it will be very interesting to observe that the plant families to which our native winter annuals belong are with very few exceptions the same as the introduced winter-growing flowers and vegetables heretofore noted are members of; and the same thing is true for the families of plants representing the native summer-growing species and the introduced summer-growing flowers and vegetables.

At Flagstaff, Arizona, which place has an altitude of approximately 6900 feet, the writer noticed such perennial herbaceous species as bouncing bet (*Saponaria*), bunch and grass pinks (*Dianthus* sps.), bleeding heart (*Dicentra*), day lily (*Hemerocallis*), golden glow (*Rudbeckia*), plantain lily (*Funkia*), rosemary (*Chrysanthemum balsamite* var.), tansy (*Tanacetum vulgare*), Gladiolus, German Iris, tiger lily, columbine, perennial phlox and perennial larkspur growing very luxuriantly in August. The lawn plants, white clover and Kentucky blue grass, which have great difficulty in living through the summer period at the lower altitudes were also making a good healthy growth. Other species which were notably at home in the vicinity of Flagstaff were red top (*Agrostis vulgaris*), timothy (*Phleum pratense*), English blue grass (*Poa compressa*), orchard grass (*Dactylis glomerata*), smooth brome grass (*Bromus inermis*) and common mullein (*Verbascum thapsus*), none of which can be grown to maturity, under ordinary conditions, at Tucson. At an altitude corresponding to that of Flagstaff, in the vicinity of the White Mountains in land which was rather wet during most of the year as a result of seepage, white clover was noted to be spreading considerably, having become naturalized. These observations are especially significant in as much as perennial herbaceous species which make their growth during the summer months, with few exceptions, cannot be grown with any degree of success at our lower altitudes; and also, since herbaceous perennials comprise the predominant vegetation form, so far as numbers are concerned, at the higher altitudes.

In addition to the above list of perennials, such annual species as the California poppy, Canterbury bells, corn flower (*Centaurea cyanus*), pot marigold (*Calendula officinalis*), snap dragon (*Antirrhinum*), Coreopsis, Gaillardia, Zinnia, opium and Shirley poppies (*Papaver* sps.), annual larkspur (*Delphinium ajacis*), sweet peas,* candytuft, sweet alyssum, foxglove, nasturtium and scarlet flax were growing profusely at this same

* The behavior of sweet peas at various altitudes may be noted here; at Yuma, Arizona, which is practically 300 feet above sea level, they begin blossoming in late December or January; at Tucson with an altitude of 2400 feet, the first sweet pea flowers appear in February or March; at Oracle, Arizona, the altitude of which place is 4500 feet, the plants ordinarily begin blossoming in June, the seeds being sown in early spring; while at Flagstaff with an altitude of nearly 7000 feet, the writer noted the first blooms in early August.

season, the temperatures at which time are about the same as those at the lower altitudes, i. e., 2400 feet for the early spring months.

AN ARIZONA MESA.

By J. C. Blumer.

The high Tertiary mesa that lies between Riggs and Bonita Canyons is in its physiography typical of a number of similar areas in the Chiricahua Mountains of southeastern Arizona. Dipping very gently westward its surface is not entirely even, but lies in gently rolling ridges with sharp troughs between, that deepen toward either canyon into very precipitous side canyons often lined with perpendicular pillars of rock hundreds of feet high. Especially along Bonita Canyon these pillars are chiselled by the tooth of time into a multitude of colossal forms that present to the eye a picture at once beautiful in its symmetry and bewildering in its massiveness. The very steep slopes hundreds of feet in height and the precipitous rim that surround this tableland or terrestrial island lend a charm to its exploration perhaps second only to the setting foot upon an unknown island in the sea. Upon scaling the rim of this plateau at an elevation of about 7000 feet, it was a surprise to find conditions very different from the half expected basalt and adobe, with a grama-covered expanse openly dotted with yucca and alligator juniper, which had greeted the eye on similarly formed New Mexican mesas of the same elevation. The rock was a white, disintegrating rhyolite, the soil rather meagre and coarse, and the vegetal covering a more or less open pine forest densely re-enforced by cypress brake and chapparal. In fact, the great difference was only second to that between the floras of the mesa and the adjoining limestone, which cannot be detailed here. In a jaunt of about five miles no less than 13 woody species were encountered.

Of these manzanita (*Arctostaphylos pungens*) is the most typical and abundant shrub, making a dense, low chapparal on south, west, and intermediate aspects and on "hog-backs." On bare rocks it spreads out close to the ground and covers its feet, as it were. This is its characteristic habit on barren soil. Sometimes of the remarkably low stature of three feet, the whiteleaf oak (*Quercus hypoleuca*) is only second in abundance nearly everywhere except upon the most barren sun-lit rocks facing southerly and westerly. It is here that the Toumey oak (*Quercus toumeyi*), common in many places, but rarely taking the form of a tree, attains especial prominence as a constituent of the otherwise purely manzanita chapparal.

A second surprise consisted in the finding of the Arizona Five-leaved pine (*Pinus arizonica*) common quite below its usual limit, even on the most exposed rims of this interesting terrain. In such places it grows singly and scattered, and is of rather singular habit and form. But on north and east aspects, facing the swales and gullies of the interior of the mesa, it becomes the dominant species with as many as 50 to 100 trees per acre, running from 8 to 16 inches in diameter, and producing in places almost a true "forest floor." Usually, however, there is what is known in forestry as an "understory" of whiteleaf oak about 10 feet in height, interspersed with tussocks of coarse mountain grass and occasional *Yucca macrocarpa*.

As usual in similar places, we find *Pinus chihuahuana* the dominant pine on some of the more open, grassy, gentle, westerly slopes of deeper soil, while in steeper and more sheltered situations it is conspicuous by its absence. The Mexican pinyon (*Pinus cembroides*) is a rather prevalent species, which might suggest certain conditions in common with those governing a limestone flora, of which it is frequently the most prominent species. It has a habit of snuggling into thickets of cypress, making tiny groves with a real forest floor on sunny and rocky south and west aspects, and often grows singly or in clusters about the most exposed and barren rocks, a habitat nevertheless entirely at variance with that which it seeks on calcareous soils of like elevation.

The cypress (*Cupressus arizonica*), proved the best surprise. Not seen off this mesa, except in a few isolated groups or single trees, it was stumbled upon all at once growing as a body of young trees in a dense narrow strip running east and west, evidencing its prolific seed-bearing habit. Whether or not the direction of the prevailing winds had anything to do with this peculiar occurrence, this happens to be from west to east, as is shown by many trees storm-warped and leaning eastward on the peaks and passes of the main crest. Absent on more sheltered places, the cypress became more and more abundant westward (a significant direction) especially on the rockiest, most inhospitable situations. Indeed, over large areas here, excepting the secondary pinyon, it produced the only tree growth, in the form of well-nigh impassable brakes and for the first time was seen in what appeared to be its thoroughly native and long-established habitat. Many other facts were gathered which indicate that if any tree species of this region is worth watching from the standpoint of plant movement, it is this one.

The Arizona Longleaf Pine (*Pinus mayriana*) is unexpectedly rare, for only two or three trees were seen. In similar altitudes a few miles away, on andesite, it is a common forest tree. But conditions in this case do not admit of comparison in a way to fix the exclusive responsibility upon the origin of the rock and soil, as can be demonstrated in other places with other species. The alligator juniper (*Juniperus pachyphloea*), though present, is rather infrequent and solitary, its usual habit of occurrence, and on the barren manzanita flats and slopes, altogether absent. *Quercus reticulata* is occasional as another unusually small shrub on high, dry places, but becomes more frequent and larger in some parts of the sheltered draws. *Quercus arizonica* was met only infrequently, though this is often the very altitude of its best development otherwise. *Garrya wrightii* is somewhat rarely present, for only two bushes were seen. The mountain mahogany (*Cercocarpus parvifolius paucidentatus*) was not encountered at all. Both are prominent shrubs on the limestone near by. *Quercus emoryi* is also practically absent, one or two small specimens having been noted. The reason in this case is evidently to be sought in the lower altitude to which this oak belongs. Clumps of Bear grass (*Nolina erumpens*) are present occasionally, the smooth and handsome *Yucca macrocarpa* rather more frequently, and two species of *Agave* were seen two or three times each. The trip being made in November, only the larger perennials were in evidence.

It was evident that several peculiarities marked this plateau from the usual mountain slopes in the neighborhood, though the degree of isolation is not great. It is possible that when such land forms when widely separated are more intensively explored they may yield results in the way of comparative development of organisms, their movements, distribution and endemism, analogous to those already obtained in the study of the insular life of the oceans. Nevertheless, it is beginning to appear that the facts of local distribution can be explained in great part on the ground of immediate present day environment.

INHERITANCE IN TOMATO HYBRIDS.

By H. L. PRICE and A. W. DRINKARD, JR.

Everyone who is familiar with the rapid, sudden and marked changes which have taken place in the family of cultivated tomatoes during the brief period of its domestication will recognize in the history of its improvement strong evidences in favor of the view that the evolution of this plant, which has taken place under domestication, has been wrought through a process of mutation rather than by slow and continuous variation. The stability of the characters which have appeared from time to time gives further support to this view.

In general it has been found that when mutants were crossed with their parent forms the hybrids followed, in the inheritance of particular pairs of characters, Mendel's law for inheritance. The experiments discussed in this paper were undertaken primarily with a view of testing this law for tomato characteristics. In planning the experiments it was our aim to cover all of the character units then recognized in the tomato, thus making the work comprehensive so far as inheritance in this plant is concerned. It was deemed more important to test the many pairs of characters found in the tomato for dominance, particulate inheritance or blending in the F_1 hybrids, and for Mendelian splitting or non-splitting in the F_2 generation, than to establish by a large number of hybrids an exact correspondence to the theoretical expectancy demanded by Mendel's law. The phenomena of dominance and recessiveness, with subsequent segregation, are quite sufficient to establish the fact of alternative inheritance; and the absence of these phenomena is indicative of some other mode of inheritance. Our main problem, therefore, was to determine what form of inheritance existed for each particular pair of tomato characteristics.

The plan outlined at the inception of this work included 21 distinct crosses and many of these differed with respect to more than one pair of character units. In the production of the hybrid races we endeavored to select for mother plants varieties thoroughly established in type. Plats of the mother varieties were grown and observed during the two years the work was in progress, and in every case the offspring from the self-bred plants proved to be constant and uniform in heredity. Four plants each of the F_1 generation of hybrids were grown in the greenhouse and twelve plants each of this generation were grown in the field the following summer as controls. Seeds were selected from the greenhouse plants of the F_1 generation for the F_2 hybrids to be grown in the field the following year. Care was used throughout the work to prevent crossing and the admixture of foreign forms.

RESULTS OF CROSSING.

Inheritance of Particular Characteristics.

In the twenty-one distinct variety crosses made in these experiments thirteen differential pairs of unit characters were involved. When any one of these character unit pairs is considered by itself we find dominance of one character of the pair in the first generation and segregation of the original units in the second generation in approximately Mendelian proportions. Since there is uniformity of behavior in inheritance for all of the characters studied, it will not be necessary to describe each character unit cross in detail. The behavior of the pear and apple fruited hybrids will serve as an illustration for all.

Pyriform × Roundish Fruit.

The pyriform character of tomatoes is correlated with the corolla structure of the flower, the tube being relatively long and narrow. In pear tomatoes the corolla often persists until torn asunder by the lateral pressure of the developing fruit, and thus the constriction at base of neck is accentuated. The round fruited varieties, on the contrary, invariably possess a short, though relatively large, corolla tube. It is evident then that we are here dealing with the conditions of neck and no neck, characteristics which can be coupled definitely with well defined floral structures.

Five distinct crosses were made between pear varieties (with fruit having well developed neck) and round or apple fruited sorts. In some of these crosses the pear character belonged to the maternal parent and in others to the paternal parent. The results of these reciprocal crosses were precisely the same in both the 1st and 2nd hybrid generations of offspring.

Seventy-four plants of the 1st hybrid generation were grown to maturity and bore fruit. The general shape of the fruit was oval, oblong or roundish, depending on the parentage, and was

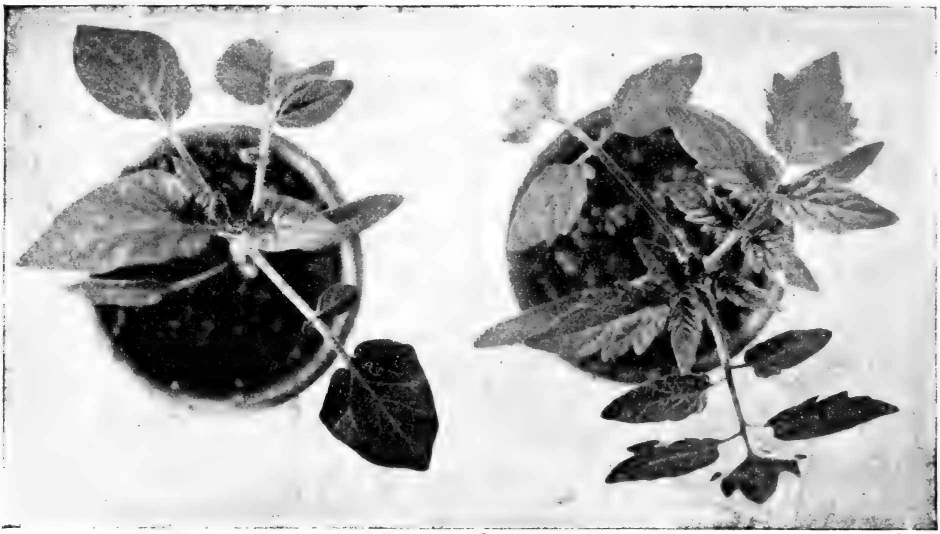

Fig. 1. Types of foliage occuring in F_2 hybrids of the potato leaf (*solanopsis*)—cut leaf (*esculentum*) cross.

in every case intermediate between the two parents. However, not a single plant of the F_1 generation bore fruit with the slightest semblance of a neck, hence there was complete dominance of no neck (roundish fruit) over neck (pear shaped fruit). The intermediateness noted for general shape outlines obviously has nothing to do with the pair of characters under consideration. In crossing many-celled or large fruited varieties with two-celled or small fruited sorts (pear varieties belong to the latter class) the two-celled condition is dominant in the first generation of hybrids but there is a blending or intermediateness in size. Now, in crossing pear varieties with large, round sorts the size of the latter is so reduced, especially in transverse diameter, that regardless of the fact that this hybrid fruit is without neck, it must be classed as oblong or roundish. Three of the crosses under consideration were of this nature and all gave hybrid fruit that was described as oblong or roundish. The other two crosses were Yellow Pear × Yellow Cherry and Yellow Pear × Red Current. The three varieties involved in these two crosses were small and it is interesting to note that the hybrid fruit of the F_1 generation was described as oval. This fruit was slightly larger transversely than that of the round parent and the axial diameter had been considerably increased. The tapering was equal toward each end, therefore the constriction or neck was totally absent.

TABLE OF CHARACTER UNIT CROSSES OF TOMATO.

	Character of Units Crossed	No. of Distinct Crosses Made	Character of Hybrid Plants: F_1 Generation Character Dominant	F_2 Generation: Dominants No.	Dominants %	Recessives No.	Recessives %	Ratio
Fruit Shape	No Neck × Neck (Round × Pear Fruit)	5	No Neck (Roundish or Oval)	115	84+	21	16−	5.47:1
	2-Celled × Many-Celled (Cherry × Large Fruit)	5	2-Celled (Cherry Fruit)	95	79+	25	21−	3.8 :1
	Roundish Conic × Roundish Compressed	2	Conical	35	73−	13	27+	2.8 :1
Fruit Color	Red × Yellow Fruit	4	Red Fruit	88	73+	32	27−	2.75:1
	Red × Pink Fruit	6	Red Fruit	79	76−	25	24+	2.16:1
	Pink × Yellow Fruit	1	Pink Fruit	20	83+	4	17−	5. :1
Foliage Shape, Texture, Color	Yellow × Transparent Skin	9	Yellow Skin					
	Normal × Potato Leaf (Cut × Entire Margins)	2	Normal or Cut Leaf	138	73+	50	27−	2.76:1
	Green × Yellow Leaf	5	Green Leaf	118	76−	38	24+	3.1 :1
	Standard × Dwarf or Smooth × Rugous Leaf	2	Standard Stature Smooth Leaf	36	75	12	25	3. :1
	Pimpinellifolium × Lycopersicum Leaf (Pinnatifid × Normal)	3	Pimpinellifolium or Pinnatifid Leaf					
	Pubescent Foliage × Smooth Foliage (Fruit the Same)	1	Pubescent	16	67−	8	33+	2. :1
			Smooth	20	80+	4	20−	5. :1

Seeds were saved from the F_1 generation of these five crosses and each lot was grown separately. A total of one hundred and thirty-six F_2 hybrid plants were brought to fruiting. Twenty-one of these plants bore typical pear shaped fruit. Thus it is seen that the recessive character had reappeared in 15.4% of the hybrid individuals, the actual ratio of dominants to recessives being 5.5:1. While the proportion of recessives is low, the complete dominance of absence of neck in the F_1 generation and the subsequent segregation of the unit characters in the following generation leads us to conclude that we are dealing with a simple Mendelian monohybrid. Twelve other pairs of unit characters gave similar results in the first generation of hybrids, eleven of which segregate in the following generation in accordance (approximately) with the Mendelian formula. The other two pairs of characters are known to have shown segregation in the F_2 generation but numerical results were not obtained. The results secured for these various crosses are set forth in the accompanying table.

It will be seen that in general the results are uniform and consistent except for the last cross which gave two types in the F_1 generation, each of which again split in the F_2 generation. The numerical results for this cross are too small to warrant conclusions as to its true nature.

INHERITANCE OF CHARACTER UNITS IN POLYHYBRIDS.

In the study of inheritance for other plants it has usually been found that the unit characters which go to make up the individual are independently heritable. This renders Mendelian inheritance for polyhybrids not only of extreme theoretical interest but enables the plant breeder to secure new and stable combinations by crossing old varieties.

Coupling of different unit characters appeared in only one cross in our work. This resulted from the cross between Aristocrat and Burbank's Preserving, in which a complete return to the original parental combinations in the F_2 generation of hybrids was found. The number of plants from this cross was small and the results are not conclusive.

Purple Flesh and Transparent Skin × Yellow Flesh and Yellow Skin.

In the monohybrid table given above, it will be noted that when a pink and a yellow fruited variety were crossed that there was complete dominance of the pink color in the 1st hybrid generation. In this case the varieties differed only with respect to their flesh color, for both are found to have the same skin pigment, viz. yellow. Two other apparently similar crosses were made which gave very different results. This was between the Beauty variety on the one hand and the Yellow Plum and Yellow Cherry varieties on the other. The flesh of Beauty is a deep purplish red or pink, and the skin is practically transparent. The Yellow Plum and the Yellow Cherry varieties have both yellow flesh and yellow skin for fruit. We are, therefore, dealing with dihybrids in fruit color, the parents being different in both flesh and skin color.

The hybrids of the F_1 and F_2 generations, when brought to maturity gave the results embodied in the following table:

Crosses	F1 Generation		F_2 Generation			
	No.	Character	Pink	Red	Yellow	Ratio
Yellow Plum × Beauty	14	Red fruit	6	14	4	
Yellow Cherry × Beauty	16	Red fruit	4	16	4	
Total			10	30	8	1:3:4-5

While apparently exceptional, these results are readily understood when we comprehend the true nature of the crosses.

The complete dominance of the pink flesh factor of the Beauty parent and of the yellow skin factor of the other parents gave plants bearing fruit with pink flesh and yellow skin which produces red. Thus what might appear to be a temporary blending of color is due to the phenomena of dominance and the interaction of two distinct dominant and separably heritable color factors.

In the F_2 generation we find the original parental colors and the F_1 hybrid color or intermediate type. These exist on an average for both crosses in the proportion of 1 pink to 3 red (or intermediate) to 4-5 yellow. The number of reds is too high for a simple and temporary blended monohybrid, but is in harmony with the expected proportion for a dihybrid; which is.75 pink to 2.25 reds; 1 yellow or 3 pink, 9 red and 4 yellow.

Yellow Pear × Honor Bright.

The parents to this cross differ with respect to three attributes—fruit color, fruit shape and foliage color. The Yellow Pear variety is characterized by pyriform shape and yellow color of fruit and green color of foliage; while the Honor Bright parent possesses the three opposite attributes–round or spherical fruit shape, red fruit color and yellow foliage color. In the F_1 hybrids from this cross a complete dominance of green foliage color, red fruit color and round fruit shape occurred. Thirty-two of these plants were observed for foliage color and a smaller number for

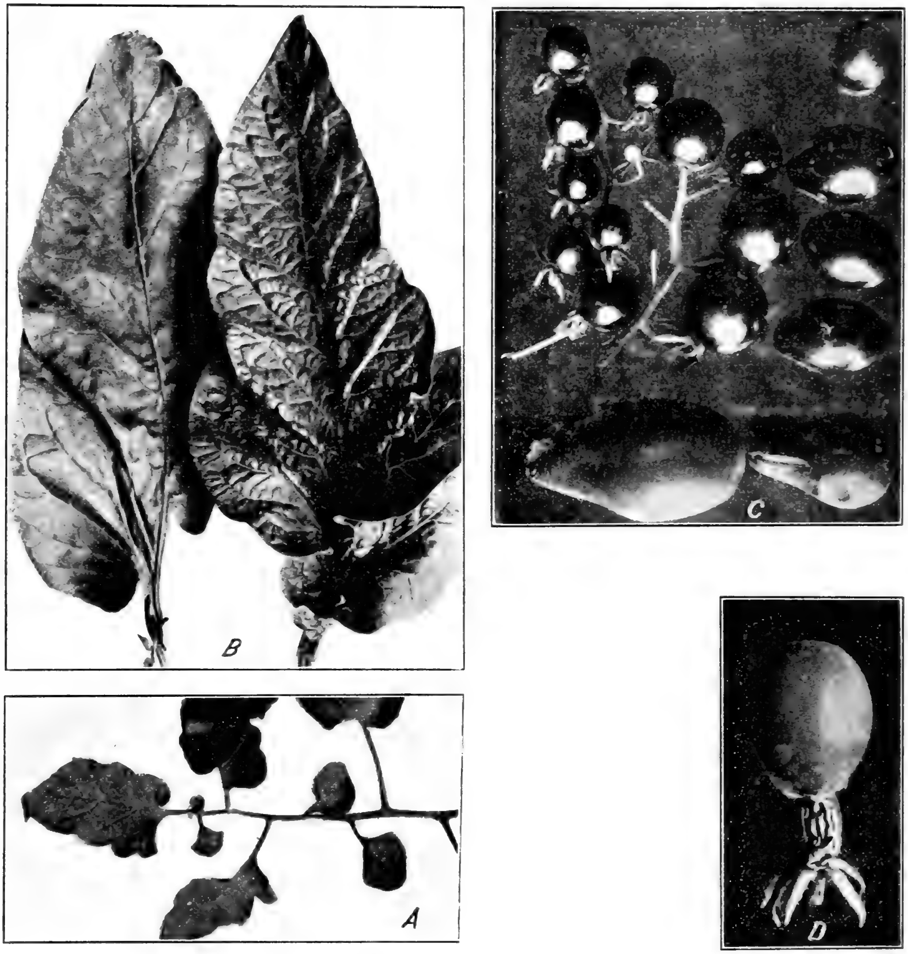

Fig. 2. Smooth Leaf Surface of Currant Tomato (*L. pimpinellifolium*) transferred to Leaf Shape of Dwarf Champion. A. Red Currant Foliage. B (right) Dwarf Champion Foliage. B (left) Combined or Hybrid Type. C. Yellow Pear × Red Currant. Parent forms at left; Middle row F_1 Hybrid Type; Row at right F_2 Hybrid Type. D. Effect of Persisting Corolla in Pear varieties.

the other characteristics. The hybrids were uniform in general appearance. In the F_2 hybrids all the possible types visible or recombinations of characters occurred, despite the fact that we were able to grow to maturity only forty of these plants. The theoretical proportions could not, of course, be secured, since this is not possible with less than 64 plants.

Eight visibly distinct types of plants are to be expected for a trihybrid in the F_2 generation. These types are given in the table below and a comparison is drawn between the theoretical requirements for a Mendelian trihybrid and the actual proportions secured.

Plant Types	Expected for 64		Actual for 40 Plants	
	Numbers	Per cent	Numbers	Per cent
Green foliage, red and round fruit	27	42	15	37.5
Green foliage, red and pear fruit	9	14	3	7.5
Green foliage, yellow and round fruit	9	14	10	25
Yellow foliage, red and round fruit	9	14	7	17.5
Green foliage, yellow and pear fruit	3	5	1	2.5
Yellow foliage, red and pear fruit	3	5	1	2.5
Yellow foliage, yellow and round fruit	3	5	2	5
Yellow foliage, yellow and pear fruit	1	1	1	2.5
	64	100	40	100

It is seen from the above table that the actual results conform in a rough way with the theoretical requirements for a trihybrid. The percentage approximation to the expectancy is remarkably close for the small numbers of plants grown.

GENERAL CONCLUSIONS.

The studies of the tomato hybrids discussed in the preceding pages lead to the following general conclusions:

(1). *A large number of the attributes of the tomato, when crossed with their complementary characteristics of differential character unit pairs, exhibit in the first hybrid generation the phenomena of dominance and recessiveness, and are subject in the second hybrid generation to Mendelian splitting or segregation.*

(2). *These attributes exist as character units which are independent in heredity without respect to parentage.*

(3). *In character unit polyhybrids the different character units are usually independently heritable, and the recombinations of characters occuring in the F_2 generation are in conformity with Mendel's law for polyhybrids.*

(4). *Inter- and intra-specific crosses of tomatoes gave similar results in the hybrids. Such characters as were noted for L. pimpinellifolium behaved in exactly the same manner as those derived from the various varieties of L. esculentum.*

CULTIVATED PLANTS IN THE ARID SOUTHWEST.

By V. M. SPALDING.

To one who is spending a summer in the desert country of the southwestern United States the behavior of introduced and cultivated plants is an instructive study. One finds in the cities of Arizona that a large share of the trees and shrubs that have been long in cultivation are those that are known to do well in warm climates more or less subject to drouth. The commonest shade tree perhaps is the Pride of India (*Melia Azederach*); pepper trees (*Schinus molle*) are frequently planted, and there are palms, oleanders, pomegranates, mulberries,olives, and figs, all of them, when cared for, growing as luxuriantly as the plants of a tropical garden. With them one sees occasional representatives of the desert flora of the region, specimens of cacti, the ocotillo or candlewood, the palo verde and others, that have been brought in from the neighboring hills, responding quickly to the care they receive, but adding a touch of asperity to a landscape already somewhat severe; for these plants, nearly all of them hard leaved, or otherwise adapted to the desert, suggest a struggle with adverse conditions, to which their interesting but not always attractive features correspond. All told, the introduced vegetation is what the early explorers and their followers, who had the first hand in its introduction, would expect to fit such an environment, and which, as a matter of fact, has flourished here down to the present time and is still largely chosen for planting in grounds and along roadsides.

In later years, however, a softening effect has been sought and obtained by introducing plants of widely different characteristics, and it is especially the deportment of these, in a region naturally uncongenial, that affords an opportunity for both interesting and profitable observation. In Tucson five years ago the Virginia creeper was seen only here and there, but it has been passed along in the form of cuttings from house to house until walls, fences, and houses are everywhere covered with its luxuriant growth. It apparently revels in the intense heat and full glare of the sun, as long as its roots are well supplied with water, and the low humidity of the air appears not to affect it in the least adversely. Here is a plant of the deep forests of eastern America, introduced long ago into the damp, cool climate of England and central Europe, where it grows, if possible, even better than in its own home, but which also thrives perfectly in the arid climate of the Southwest. At present its relative, the Japanese Ampelopsis, is only occasionally cultivated here, and that chiefly on the shady side of brick houses, but the success thus far attending its introduction promises well for its more extensive use. The English ivy, which is about the last plant one would expect to thrive in an atmosphere in which at times less than ten per cent of saturation is recorded, is nevertheless doing finely in different parts of the city, and in some places covers the trunks of trees much as it does in its old home in the British Isles. Morning glories and gourds are to be added to the list of climbers that cover fences and lattice with a growth that if equalled, is at least hardly to be surpassed elsewhere. Gardens and flower beds exhibit a very considerable and hopeful variety of both annuals and perennials. Roses bloom freely the greater part of the year; chrysanthemums, and sunflowers and sweet peas produce a perfect wealth of flowers; the lawns are soft with a thick growth of Dutch clover; and a goodly list of other plants are contributing their share to soften the harshness of the desert and make it seem like home. Market gardeners have contributed much to the interesting and important experiments now in progress. They have succeeded in bringing to perfection and offering in any quantity lettuce as fine as has ever been grown, celery, oyster plant, beets, peas, onions, etc. of excellent quality, the finest watermelons and canteloupes, and even strawberries, pears, and peaches.

From what has been stated there seems, at first sight, to be sufficient justification for the constantly repeated assertion that anything will grow here if you only give it water enough, but closer attention to the actual facts of the case makes it evident that this statement is true only in part, and that there are many plants that will grow only indifferently or not at all under the atmospheric conditions which prevail here, especially in the summer time. To give a few examples, geraniums, the universal easily raised plants of moister regions, are very uncertain, some varieties accommodating themselves fairly well to the desert air, while others fail altogether. Sweet peas have to be sown in fall or winter to get the best results, as they succumb to the hot, dry air of summer. *Cobaea scandens* does well in a greenhouse, but seems struck with death when brought into the outdoor air. Madeira vines form small leaves, and make an unsatisfactory growth. Cannas and gladioli, which grow side by side in the East, part company here, the former making a good growth in Arizona gardens, the latter failing altogether. Those who have handled roses for a period of years have learned what varieties may be expected to do well, and what ones may be counted out, and so on through a long list of plants which, by knowledge gained in the costly school of experience, are coming to be depended upon, or are being rejected one after another, as they are found to be unsuited to the environment into which they have been brought. Thus, in a purely empirical way, it has been found that many plants successfully cultivated in regions of greater atmospheric humidity make an entirely normal growth in the dry air of the desert, if their roots are well supplied with water, but that others, however well cared for in this respect, either fail entirely, or come short of making a healthy growth, and this is especially true in the summer months when desert conditions are most pronounced.

The general fact thus broadly stated presents an inviting but intricate problem to the plant physiologist, and from the widely different behavior in the desert on the part of plants which are successfully grown together in regions of greater rainfall, it is evident that each plant has its own peculiar relations to its environment, which must be investigated separately before general conclusions can be safely drawn. It has been suggested that plants which fail to withstand the severe conditions of an Arizona summer are unable, no matter how well supplied with water, to absorb and pass on to the leaves enough to make up for their increased rate of transpiration, but where is the real source of the difficulty? Are the leaves structurally unfit to control transpiration? Are the roots of one variety of geranium, say, less capable of absorption in large quantities than are those of another? Is the conducting system at fault? Or may it be that some of the varieties that fail are directly and injuriously affected by too intense insolation?

A most important work has been accomplished by Prof. J. J. Thornber in bringing together the facts that have been established thus far regarding the behavior of some hundreds of plants whose fitness for cultivation in the desert is of economical or æsthetic interest. Some of these appear in the present number of the PLANT WORLD, but the greater part still await publication. The investigator who addresses himself to the task of ascertaining what actually determines the fitness or unfitness of plants for life in the desert will find no end of promising material ready to his hand.

BOOKS AND CURRENT LITERATURE.

Irrigation Farming by Lucius M. Wilcox is the title of a recent interesting book dealing particularly with western agriculture. It contains 494 pages and includes numerous diagrams and illustrations, being a revised and enlarged edition. The author has endeavored to treat in a general way the entire subject of irrigation, twenty-four chapters being devoted to as many different topics, of which the following are the more prominent: effects of irrigation upon different types of soils; treatment of alkali in land; canal construction; pipes and flumes; reservoirs and ponds in irrigation; methods of applying water to the field, orchard, vineyard and garden; irrigation in humid climates and winter irrigation; all about alfalfa; windmills, engines and pumps for irrigation, etc.

The advantages of irrigation over dependance upon rainfall for crop growth are noted and cannot fail to appeal to the agriculturist at large; one must feel that when irrigation is practiced more in the States where there is ordinarily sufficient precipitation for crop growth, better results will follow, especially in intensive farming. It is to be regretted that the author has sacrificed definiteness and at times accuracy in his often generalized statements; he has repeatedly introduced details in discussions which are intended to be of a general nature, with the resuls that statements are often misleading. Accordingly, if one it not already well versed in the problems of irrigation in his particular locality, the book will prove a disappointment to him and perhaps be misleading.

After condemning the folly of over irrigation in general, which is a very common practice among farmers, the author goes on to say: "A rosebush needs water * * * A garden hose thrust near a bush and allowed to flow freely for an hour or two every day will furnish enough moisture for the roots." But in the extremely arid region of southern Arizona with high summer temperatures and low humidity, the writer of this article maintains a rose garden of thirty bushes representing as many varieties by watering six to nine hours a month according to the season of the year, with a three-fourths inch hose under rather light pressure. This is less than one-fourth the amount of water which the author recommends for a rosebush. Cultivation is made use of as suggested in the book.

In the chapter on windmills the author speaks of a "Merry-go-Round" mill which cost four dollars and seventy-five cents ($4.75) for material, and which pumps an eight inch stream of water irrigating ten acres. He does not, however, state the rapidity of the flow of the stream, the depth from which the water is pumped, the amount of annual rainfall supplementing irrigation nor the kind of crops grown. In Arizona, a well installed modern, twelve-foot windmill and 4000 gallon storage tank costing at least four hundred dollars ($400.00) will supply sufficient water for domestic purposes for two or three houses, irrigate two or three dozen trees and shrubs throughout the year, and occasionally, a garden of a few square rods during the fall, winter and spring months. Winds are not continuous here, as a rule, and the depth of pumping is commonly from forty to one hundred feet. The statement in the book is entirely misleading, therefore, if one has in mind a locality where any considerable amount of irrigation is necessary, or if one has to pump water from even ordinary depths. In conclusion the writer would not be understood as condemning the book; but while there is much of real merit in it, it also has serious faults from the standpoint of practical irrigation.

J. J. THORNBER,

Publication 99 *of the Carnegie Institution* by Dr. D. T. MacDougal, under the title, "Botanical Features of North American Deserts," embodies the results of explorations in the arid southwest in connection with the founding of the Desert Laboratory, together with later explorations there and in Mexico by the author.

The first third of the work is devoted to an account of the topography and botanical features of the leading divisions of the great desert region lying, as to its general east and west boundaries, between western Texas and the Coast Range in southern California, the most northern division being the sage brush desert of Nevada and Utah and the most southern the cactus region of Tehuacan in Mexico. In most cases it is possible to characterize each of these regions by some prominent topographical feature, together with the dominance of certain plants. Thus the sotol region of Texas is particularly marked by the presence of *Dasylirion texanum* and *Agave lechuguila*. The Otero basin in New Mexico includes a great salt and soda flat and the "white sands," on which *Rhus trilobata* and *Yucca radiosa* are among the dominant species. In the region of Tehuacan the cacti are more abundant than in any other part of the world, their massive forms constituting a prominent feature of the landscape. In the sage-brush deserts of Nevada and Utah *Artemisia tridentata* is dominant over wide areas, which are further characterized by the rarity or absence of succulents and plants with storage structures. The great tree yucca, *Yucca arborescens*, forms the most striking feature of the Mojave desert, while *Larrea* and *Gaertneria* constitute the characteristic vegetation of wide mesas in Death Valley. In the Salton basin, with a precipitation of only about 3 inches a year, distinctively arid conditions prevail. Large areas are almost bare of vegetation, but in moister and more alkaline spots there is a considerable growth of *Allenrolfea*, *Sueda* and *Atriplex*, while the leached gravelly slopes exhibit a variety of woody perennials.

Passing from this general survey of the topographical and botanical features of the wide area under consideration, the author presents in more detail a study of aspects of vegetation in the neighborhood of the Desert Laboratory, giving an account in succession of winter annuals and perennials, spinose and succulent forms of the dry fore-summer, plants of the humid midsummer, summer perennials and annuals, and species belonging to the dry after-summer. A section is devoted to temperatures of plants in the desert, and other divisions to the water and soil relations of desert plants, in which are embodied also the results of recent studies of the root systems of various species. Of special interest are the concluding chapters on conditions contributory to deserts, their formation and extent and the influence of the desert on life. A geological sketch of the region of Tucson is contributed by Professor Wm. P. Blake, Territorial Geologist of Arizona.

The numerous plates, some of which had appeared in Publication No. 6 of the Carnegie Institution (the forerunner of the present work) serve fully the purpose of illustration, but it is to be regretted that notwithstanding the good quality of the paper they fail to do justice to the original photographs.

All in all this paper constitutes the most available source of authentic information regarding the topography and plant life of the great desert region of the southwestern United States and Mexico, a region that economically as well as from the scientific standpoint is assuming great importance at the present time.

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Volume 12 Number 2

THE PLANT WORLD

A MAGAZINE OF GENERAL BOTANY

FEBRUARY, 1909

SOME MEXICAN FIBER PLANTS.

By J. E. KIRKWOOD.

The central Mexican plateau abounds in individuals of certain species of Agave, Yucca and allied forms, prominent among which are *Agave Lechuguilla*, *A. falcata*, *A. asperrima*, *Yucca australis*, and *Samuela carnerosana*.

There is some difficulty in designating these plants by their common names as a great lack of unanimity obtains among Mexicans upon this point. Several agaves are called "lechuguilla," particularly *A. Lechuguilla* and *A. univittata*. The name "maguey" is applied to any of the large fleshy agaves cultivated for drink or fiber, as well as the smaller *A. asperrima*, found growing spontaneously in the desert. The former, of which there are several varieties, are referred by Rose* to *A. cochlearis*. In that part of the country to which attention is here called *Yucca australis* and *Samuela carnerosana* are very common. The former with branched stem and pendant inflorescence, closely resembling *Yucca treculeana* which Rose* published in his "Notes on the Useful Plants of Mexico" and called "isote," was known at Cedros as "palma china." The latter, unbranched and with erect infloresc ense, is also called isote by the natives in some parts and in others "palma zamandoca," also "palma pita." But palma pita is also used to designate one of the larger agaves, so the matter is in hopeless confusion, and it is impossible to make oneself clear in the use of these names, unless it is definitely understood what plants are meant. Hereafter in this discussion the plants referred to as lechuguilla, palma china, and palma zamandoca, or simply palma, will be respectively *Agave Lechuguilla*, *Yucca australis*, and *Samuela carnerosana*.

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* Rose, J. N. Notes on useful plants of Mexico. Cont. U. S. Natl. Herb. 5 : 209-259, 1899.

These plants form one of the most conspicuous features of the vegetation, in fact over certain areas one or another of them constitutes a conspicuous element in the landscape. On the long, gentle slopes at the foot of the mountain ranges, palma china is found in great profusion; higher up on the slopes and over broad areas of rolling land palma zamandoca holds undisputed sway. Lechuguilla is mostly confined to low rocky ridges and foothills adjacent to the higher mountains and in such places it thrives in such abundance that it is often difficult to make one's way through it. The leaves, which range in length from twelve to eighteen inches, are beset with strong terminal and lateral spines against which ordinary shoe-leather is scant protection. In many places palma zamandoca may be found enjoying the same habitat with lechuguilla, but its range is somewhat wider, reaching from the lower ridges to far up the mountain slopes between 7,000 and 8,000 feet. The straight unbranched stems of these plants, with their crowns of stiff sword-like leaves, two feet or more in length, raised above the surrounding vegetation, make a picture at once striking and attractive.

The maguey (*A. asperrima*) is less restricted in its range than either of the foregoing forms. While its favorite habitat is the broad foot-slope or the level mesa, it is found frequently on the banks of arroyos or on the high mountain sides. Propagating easily by stolons, like its relative the lechuguilla, it frequently forms dense patches to the exclusion of almost everything else. The maguey, as it grows in the desert here referred to, produces rigid leaves which attain a length of three feet, more or less. The cultivated varieties grow much larger.

Much interest attaches to the plants here under consideration because of their economic importance, especially the palma zamandoca and lechuguilla. Palma china produces fiber but is very little used, presumably owing to the shortness of the leaves and the abundance of the more desirable form. An excellent quality of fiber is obtained from the maguey, but the wild plants do not afford sufficient compensation for the labor of extracting it, and the plants under cultivation are raised chiefly for the sake of pulque and mescal. So the maguey in central and northern Mexico, at least, is of secondary importance as far as fiber is concerned; palma zamandoca and lechuguilla

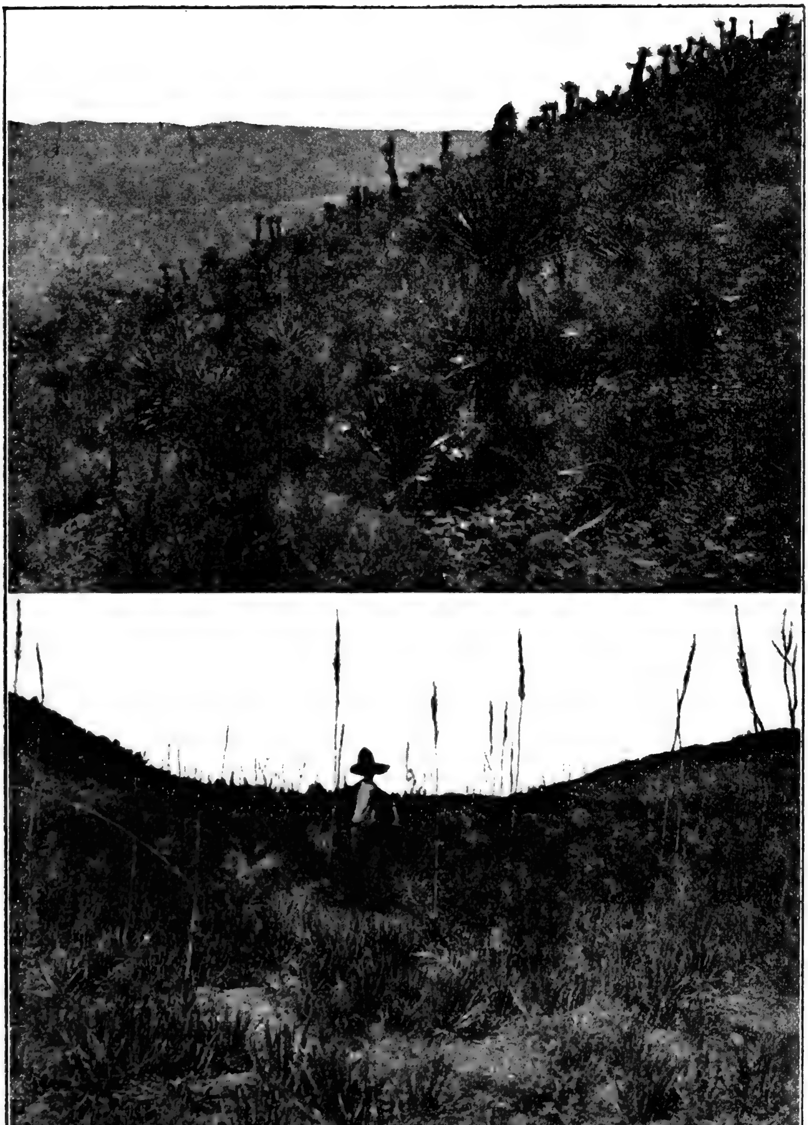

Fig. 1 (above). A mountain side at 7,000 feet covered with a growth of Samuela carnerosana, called palma pita or palma zamandoca; (below) **Agave Lecuguilla**. Scene in June at the height of the flowering season. Cedros.

constitute the source of the principal commercial fibers from the region above named.

From the city of Saltillo come reports* that from that consular district during the fiscal year ended June 30, 1907, were shipped 2,156 tons of lechuguilla fiber, and 5,554 tons of that from the palma. All of the latter went to the United States at 3.7 cents a pound, while the lechuguilla fiber was divided between the United States and European countries at a price slightly lower. And this record of shipment reckons only with the crude fiber and takes no account of the articles manufactured at home from the same material. Maguey fiber brings a higher price but is not nearly so abundant.

The leaves of these plants are narrow elongated organs. Those of lechuguilla are twelve to eighteen inches in length, one to one and one-half inches in breadth, with a thickness of one-third of an inch or less. In transverse section they appear crescentic in outline. Each plant produces a dozen or more of these leaves, diverging at various angles from the base, and surrounding a central bud or "cogollo" of leaves not yet unfolded. In the palma the arrangement of leaves is similar, but the form of the leaf is different. In this case they are straight, about two feet long, at the widest about two inches, and ane-fourth of an inch more or less in thickness. They are somewhat narrowed toward the base, and the distal end terminates in a strong sharp spine.

The fibers of the plants which furnish this commercial product are, so to speak, a part of the skeletal structure of these plants. They are a part of the mechanical tissues which give strength and rigidity to the leaves. In these particular cases they are strands of hardened or sclerified tissue in immediate association with the vascular bundles or conducting tissues. These sclerified strands consist of much elongated cells whose walls are greatly thickened. These cells are closely knit together in long strands of great strength. The thickness of the fiber in the mature leaf differs much with its position in the leaf, those in the central tissues being always thickest and diminishing in diameter toward the surface of the leaf. The thickest of the mature fibers observed in each of the three plants under consideration was about four-tenths mm. in diameter.

* Monthly Consular and Trade Reports, No. 326, page 137, November, 1907.

The number of fibers in the leaf varies greatly in these plants. A section of a mature leaf of lechuguilla showed 150 fibers more or less visible to the unaided eye. In a Yucca leaf 5.5 mm. in diameter and 33 mm. wide, a part of the section 5 mm. square showed 150 fibers, and a like area in a section of a young leaf of the maguey, 7 mm. thick and 60 mm. wide about 50 fibers were visible. Thus it is evident that a lechuguilla leaf may possess about 150 fibers, that of the palma 600 more or less, and of the maguey 300 up. This enumeration includes the finer fibers which are mostly lost in the process of extraction so that probably less than one-third can be counted on as the yield from the leaves of the Agaves, though possibly more than that may be realized from the Yucca.

The fibers extend direct from base to tip of the leaf in each case, and as stated above, in association with the vascular bundles. There are usually two strands with each bundle, one with the xylem the other with the phloem. As a rule the heavier mass of the sclerenchyma is on the side of the bundle nearest the surface of the leaf. These different fibers have characteristic form and structure as they appear in section. Those of lechuguilla near the surface of the leaf are round, semicircular or crescentic in the central part, and associated with the phloem, but a much more slender sclerified strand and one which might easily be overlooked is on the opposite side of the bundle in contact with the xylem. In the maguey, as in lechuguilla the heavier strands are in contact with the phloem and toward the surface of the leaf, but a well developed, though thinner mass, forms an angle in which the xylem is situated. In the palma the sclerenchyma strands are likewise doubled, but in this case the heavier fiber is on the side of the bundle toward the center of the leaf associated with the xylem and on the opposite side of those bundles nearer the surface, and there with the phloem. In all three cases the heavier mechanical strands are, in the bundles near the surface, associated with the phloem, both on the upper and lower sides of the leaf, the orientation of the bundles being reversed, showing xylem uppermost in those bundles near the lower side of the leaf and the phloem uppermost in those nearer the upper side.

In the oldest leaves the fibrous tissue becomes very strongly developed and in some cases too coarse for use. The youngest leaves are united in the center in a long, conical bud. These leaves furnish a finer though shorter fiber, often too soft and weak, however, to be of much use. So these leaves are often rejected. Those most used are of intermediate position and age. We frequently see it stated that only the central leaves or cogollo are used. This I did not observe to be the case. A considerable part of the cogollo is rejected as being too soft, in those places where I have had opportunity to observe the work, though it is not unlikely that in some places only the youngest of the fairly mature leaves are selected.

The manner in which the fibre is extracted varies in the details of the process, depending on the texture of the leaf and the convenience of the operator. The operation is simplest in the case of lechuguilla. For this work the laborer is armed with a heavy knife drawn out at the point into a cylindrical blunt part several inches in length. This knife has no cutting edge but the thick dull blade is used as a scraper. The whole instrument measures fifteen inches or more in length. The point of the tool is thrust into the stem of the plant close to the ground and just below the rosette of leaves and with a quick wrench the stem is parted. A number of plants are then carried to the shade of some bush or tree where the leaves are stripped off and piled close at hand. A block of wood with a smooth surface, four or five inches wide by a foot long, is firmly fixed in position on the ground, and is used as a surface upon which to scrape the leaves. The operator seats himself upon the ground opposite one end of the block, seizes a leaf by its base, places it upon the block and parallel with it, with the other hand he presses the leaf hard against the block under the blunt edge of the heavy knife and then draws the leaf through. This operation is repeated a time or two and in less than ten seconds the fiber of a leaf is stripped of its surrounding pulp. A turn of the stripped fiber is then taken about a short stick in order the better to hold it, and the basal part of the leaf is cleaned in the same way, or sometimes the basal portion is simply cut off at a stroke by drawing the lower part across the blade of a sharp knife set upright and rigid close at hand. In the operation of stripping the fiber a strong pressure is needed upon the leaf and to this end a leverage is often obtained by holding down the point of the knife with the foot, the extended cylindrical part making such an operation simple, or the point is thrust under a convenient root or other rigid object. The fiber thus obtained is laid on a pile to one side, and is soon dried in the sun. From fifteen to twenty-five pounds constitutes a day's labor for one man.

The operation of cleaning the palma leaves is not so simple. These must be steamed before the fiber can be profitably removed. To this end large kettles are constructed of stone or adobe, very frequently built into the side of a bank, thus saving much in the cost or labor of construction; the kettles or cauldrons are usually eight or ten feet in diameter, and over six feet in depth and well lined with cement. In the bottom of the cauldron is a grating, usually of wood, and below this a secondary kettle with a capacity of fifteen or twenty gallons. Below this kettle is the fire box into which are fed trunks of small trees, brush and other rubbish. When the lower kettle has been filled with water, the palma leaves are thrown into the upper receptacle until it is nearly full. Over these leaves is thrown a blanket layer of waste fiber and refuse which retains the steam. The leaves are allowed to cook for several hours and are then removed and stripped in the same manner as described for lechuguilla. The lechuguilla fiber is injured by the steaming process but the fiber of the palma seems not to be the worse for it. The palma leaves, however, are so hard and strong as not to be susceptible of the simple treatment given the leaves of lechuguilla. The fibers of these plants, after drying in the sun, are bound into bundles six or eight inches in diameter, and when sufficient has been gathered it is taken to the headquarters or office of the hacienda, is weighed out and put into the storehouse, and later bound into bales for shipment.

Some of the fiber is utilized in domestic industries and is manufactured into ropes, lariats, bags and matting. The apparatus is very simple and easily manipulated. The fiber is usually put through the following operation. At first as it comes from the bales, or from the bundles as brought in from the field, it is thoroughly separated by tossing a handful at a time into the air and striking it upward with a stick until all clinging and entangled masses are broken up and the heap of separated fibers forms a mass of uniform density and quality. About as much of the separated fiber as would fill an ordinary

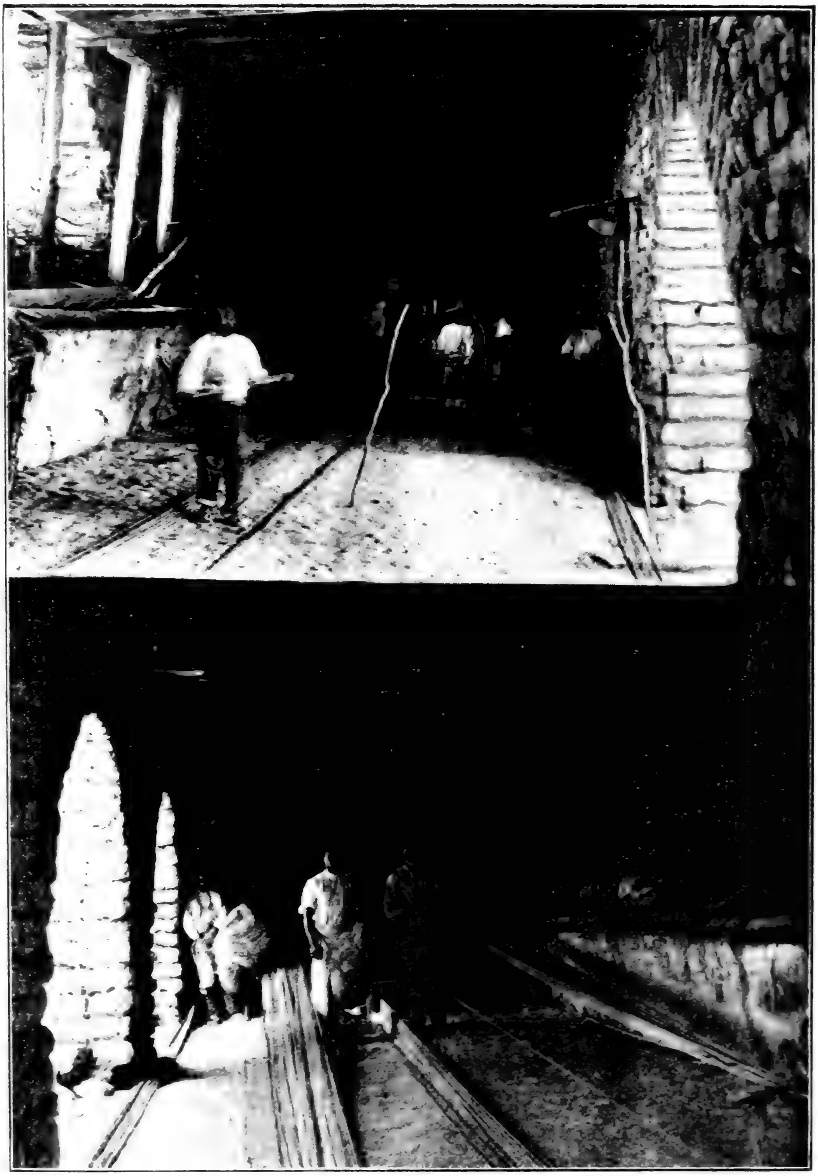

Fig. 2. Opposite ends of the rope walk at Cedros. Spinners and boys operating spinning apparatus and winding the [illegible]

gunnysack is then gathered up by the laborer and carried in a net or bag swung in front and suspended from the waist.

The apparatus for twisting the rope yarn consists simply of a wheel some six inches in diameter set rigid upon an axle which rests in sockets in a p ir of posts. The wheel is kept in revolution by means of a cord passed around the axle and operated by a child. Usually two of these wheels are set up close together with their axles parallel and operated simultaneously. The spinner attaching a wisp of the fiber to the projecting end of the axle which is then set in motion, backs away, feeding out the fiber at an appropriate rate until a coarse thread or yarn is made 100 to 150 feet in length. These strands are given a "lay" by the twisting, and by repeated doubling of the yarns and employing the contrary torsion in the usual manner, a cord of the desired size is obtained. Or the yarns may be threaded into a rude wooden tread-loom for the manufacture of matting or bagging. This machine is provided with two treadles, upon which the operator stands, one under each foot. The hands are then free to operate the bobbin, two feet in length, which boys wind with the yarn spun in the manner above described. This business is one very common in Mexico in those regions where much fiber is produced. It constitutes one of the principal activities of the Campania Ganadera y Textil on the Hacienda de Cedros, from which, according to recent reports, ninety-three tons of palma fiber alone are shipped annually.

The articles made from these fibers are strong, firm and compact, though somewhat coarse and rough. They are such articles as one sees everywhere in use in Mexico, articles very well adapted to the purpose for which they are intended. A kind of heavy matting much used as a floor covering in offices and similar places serves its purpose well. The morrál as the Mexican calls it is used as a nosebag for horses, as a saddle bag, also, and articles of general convenience. Sweat pads under saddles also come from the fibers of these plants. Besides these we find various kinds of cordage, including the lariat, of great strength and durability. For the last purpose, however, the palma and maguey are more highly esteemed, as they yield a more soft and pliable product. Much of the fiber, both of home and of foreign manufacture, finds its way into brushes, of which a great variety may be found. The amount of fiber taken from year to year is said to vary in inverse ratio to the yield of the crops, as the fiber industry is resorted to for a livelihood more often when other means fail. Practically all of the palma and lechuguilla fiber is extracted by hand, a slow and laborious process.

I wish to thank Professor Trelease for his kindness in identifying the plants here under consideration.

Desert Laboratory, Tucson, Arizona.

BOGS, THEIR NATURE AND ORIGIN.*

By JOHN W. HARSHBERGER.

A bog, considered from the view point of the botanist, is an area wet and springy from the nature of the substratum, which consists on top of living sphagnum, or bog mosses saturated with water. Beneath lie the compacted remains of these mosses, and other plants, which form a brown or black mass of vegetal detritus and this, by the weight of the overlying material, is compressed into peat of various degrees of compactness. Bearing in mind this definition of a bog, it appears that true bogs occur only in northern temperate regions, as in Ireland, portions of England, northern Germany, Nova Scotia, Canada and the northern United States. Many thousands of square miles are covered in Europe and North America by peat bogs. About one-seventh of Ireland is bog covered, that of Allen alone comprising 238,500 acres with an average depth of 25 feet.

Transeau† has shown that the largest number of bogs are found north of a line which marks the southern boundary of the great terminal moraine, while the northern boundary of the bog region coincides with the northern limit of the forests. On the southwest, its limits closely coincide with those of the forests. He further emphasizes the distinction between bogs and swamps. Bogs have been referred to as undrained swamps, while swamps proper, in low ground and along stream courses, are drained to a greater or less extent. Transeau, after elim-

* This paper is intended primarily to give to teachers of botany a connected account of what has been done in Amercia and in Europe in the investigation of peat bogs and it incorporates the results of the author's observations of the bogs on the Pocono mountain plateau.

† Transeau, E. N. On the Geographic Distribution and Ecological Relations of the Bog Plant Societies of North America. Bot. Gaz., XXXVI : 401, 1903.

inating plants whose range is local, chose fifteen species as representatives of the bogs across North America as follows: Buckbean (*Menyanthes trifoliata*), tall sedge (*Dulichium arundinaceum*), cow-berry (*Comarum palustre*), *Scheuchzeria palustris*, tall cotton-grass (*Eriophorum polystachyon*), sundew (*Drosera rotundifolia*), pitcher plant (*Sarracenia purpurea*), small cranberry (*Vaccinium Oxycoccus*), creeping snowberry (*Chiogenes hispidula*), wild rosemary (*Andromeda polifolia*), leather-leaf (*Chamaedaphne calyculata*), Labrador tea (*Ledum groenlandicum*), pale laurel (*Kalmia glauca*), low birch (*Betula pumila*), and larch (*Larix laricina*). Of these fifteen species, three, viz., *Dulichium arundinaceum*, *Sarracenia purpurea* and *Kalmia glauca* are endemic. The larch and birch are represented in the Old World by closely related forms, while ten of the remaining are present in similar habitats in Europe and Asia. These facts point to their origin as circumpolar species of a preglacial distribution. Some European bogs, according to incontestable proofs, began to form soon after the surface was freed from the snow and ice of the glacial period. In the lower parts of these bogs, are found traces of the arctic flora which then overspread so much of the northern continental areas. Without going into details, it may be said that the relation of these bogs and swamps is a matter of historic development.

If the wet areas have existed since the time of the glacial tundra, which covered the northern hemisphere, they will show a bog flora today, because the bog flora represents a continuation of the arctic tundra flora which existed in glacial times. If the wet area has originated at a date subsequent to the retreat of the continental ice sheet, it will probably show a true swamp vegetation with such plants as cat-tail (*Typha latifolia*), mat-rush (*Scirpus lacustris*), rush (*Juncus effusus*), sedge (*Carex riparia*), arrow-leaved tear-thumb (*Polygonum sagittatum*), swamp knotweed (*Polygonum emersum*), buttonbush (*Cephalanthus occidentalis*), red-osier dog-wood (*Cornus stolonifera*), panicled cornel (*C. candidissima*), glaucous willow (*Salix discolor*), red maple (*Acer rubrum*), elm (*Ulmus americana*) and white ash (*Fraxinus americana*).

Bogs are formed by the growth of bog mosses (*Sphagnum*) in temperate and arctic regions on hill tops, on mountain slopes, in valley bottoms, in kettle holes and in lake basins. Here the mass of mosses is constantly saturated with moisture, because the cells of the leaves are of two sorts, very large, clear, elliptical cells with the walls spirally thickened and perforated by round pores, and the true chlorophyll-bearing cells which are narrow and elongated and lie between the others. The larger pore-bearing empty cells, store large amounts of water, and the spongy character of a handful of peat mosses is due to the peculiar water-holding capacity of these cells. The upper extremities of the moss stems continue their growth from year to year, while the lower portions die away, and if not completely destroyed are converted into peat. Of the numerous lateral branches arising from each of the shoots, some grow upwards and form the apical tufts, while others turn downwards and envelop the lower portions of the stem. Every year, by the development of a stronger lateral branch, the stem becomes forked; and by the death of the stem behind the fork, two new plants may be formed eventually. The dead remains are gradually compacted and peat is formed. In some cases, peat is formed out of a pure growth of sphagnum, but in the majority of cases, it consists of the remains of bog mosses together with those of other plants which in part have been enumerated above as bog plants. Even tree parts may be incorporated in peat. Although the true peat bogs are confined to the northern hemisphere, yet in the southern hemisphere, according to Darwin and other observers, similar deposits are formed in South America by *Astelia pumila* of the rush family, and among the Chatham Islands, east of New Zealand, by various flowering plants. The formation of peat depends upon the slow and imperfect decay of the bog mosses and other plants associated with the moss remains. This imperfect decomposition in turn is dependent upon the presence of so much moisture, that the access of air is impeded, while the relatively low temperatures in the bog also hinder the process of decay. The compounds at first formed have antiseptic properties and these soon put an end to further bacterial activity, and the process of peat formation becomes a chemical one and extremely slow. The solid decomposition products are brown substances, partly soluble in water and imparting to it the color of strong tea and an acid reaction. The acid reaction is due, says Hilgard,* to

* Hilgard, E. W. Soils, page 122, 1906.

ulmic (as well as apocrenic) acid, readily soluble in caustic and carbonated alkalis, and forming insoluble salts with the earths and metals; while another portion, ulmin, is insoluble in the same, but gradually becomes soluble by oxidation. The gases formed under these conditions are carbon dioxide and marsh gas, the former predominating in the earlier stages, the latter in the later stages. Owing to the antiseptic action of bog water and peat deposits, the remains of plants, of animals and of man, have been recovered from bogs in a fair state of preservation. Through this preservation a succession of layers can be detected in the vegetal remains out of which the peat has been formed. This is especially the case where the peat deposits are formed by the conversion of a lake into a bog. Thus in Europe, according to Geikie,* among the bottom layers, traces of rush (*Juncus*), sedge, Iris and fescue-grass (*Festuca*) have been observed, while in the bottom layers, where lakes have been converted into bogs, shells of *Limnaea, Planorbis* and other lacustrine mollusks occur. The next and chief layer of peat consists mainly of matted fibers of different mosses, particularly sphagnum, mingled with the roots of sedges, grasses and aquatic plants. The upper layers frequently abound in heaths, which appear, when the bog surface begins to show evidences of senility. Trees may invade an old bog to add their quota to the bog deposits. In some cases whole forests have been buried by the invasion of bog mosses and their remains, as the writer has observed in a study of the peat bogs of Ireland, have been preserved in the form of bog oak which, when removed from the peat, have been fashioned into crosses, walking sticks and other ornamental objects.

The study of bog deposits has afforded data as to the forest succession in northern European countries. Upon the character of the forest succession and the order of that succession depends a rational forestry system. In Denmark, for example, it has been discovered by a study of the peat bogs, that the Scotch pine† (*Pinus sylvestris*) and white birch (*Betula alba*) are characteristic of the lower layers. That is, when these particular layers of peat were deposited, the forests in the neighborhood of the developing bog consisted of Scotch pine and white birch.

* Geikie, Sir Archibald. Text Book of Geology, page 478.

† The Scotch pine does not occur in the modern flora of Denmark.

Higher strata of peat contain remains of the oak, while the deposits nearer the surface reveal remains of the European beech. Thus three successive forest growths are represented in Denmark, beginning with the time when the peat began its formation. The character of the forests gives us a means of estimating the secular changes of climate. Norwegian botanists have led in research along these lines. Jens Holmboe,* one of the most recent laborers in this field, has reviewed the work of Axel Blytt, Nathorst, Rekstad, Gunnar Anderson, Sernander, A. Schulz and others, and substantiates their views as to the periodic changes of climate since the end of the glacial period, as revealed by an examination of the plant remains in peat bogs. He recognizes ninety species of plants which have been discovered in the bogs of Norway. After a critical study of the remains as found *in situ* in the peat deposits, Holmboe recognizes the following successive strata: (a) dwarf birch, polar willow (*Salix herbacea*) and water plants; (b) birches (undoubtedly *Betula odorata*) which formed the primeval postglacial forest, similar to the forest which is represented today at the northern limit of trees together with aspen, tall willows, juniper, bilberry, white water-lily (*Nymphaea alba*); (c) pine stratum with alder, hazel, raspberry, twin-flower (*Linnaea borealis*) and twig-rush (*Cladium mariscus*), while in the lowest parts of this stratum with the pine are found remains of dwarf willows and avens (*Dryas octopetala*); (d) the layer of the oak with the ash, Norway maple, hazel and winter linden (*Tilia parvifolia*), these trees being found in a broad belt during the warmest postglacial period, forming in many places extensive forests; (e) the layer of *Pinus silvestris* (Fichtenzone) which occurs only in a few places in Kristiania and Trondjemsfjord and represents the latest fossil layer of peat; (f) then comes last, the heath stratum characterized by the heather (*Calluna vulgaris*), which exists in great abundance on the treeless west coast of Norway, replacing the earlier forests as the most important formation plant. Similarly K. R. Kupffer found just above the clay bottom of a bog in Russia, a layer of sand ten to fifteen cm. thick, filled with the remains of characteristic alpine plants, such as *Dryas octopetala* and willows (*Salix arbuscula, hastata, herbacea, polaris,*

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* Drude, O. Bericht ueber die Forschritte in der Geographie der Pflanzen (1901-04) Geographisches Jahrbuch XXVIII : 214-219. 1905.

myrsinites, *phylicifolia* and *reticulata*), besides other flowering plants, twenty-eight species in all. In Ireland and elsewhere, we find the remains of animals and men where they have been preserved by the antiseptic action of the water. Several perfect skeletons of the extinct Irish elk (*Megaceros hibernicus*) have been dug up during peat excavation.

Little or no attention has been paid to the scientific study of bog deposits in America. A start has been made by Coleman and Penhallow in Canada; Ganong, Transeau and Jeffreys in the United States. Dr. Pehr Olsson-Seffer suggests the word Telmatology for bog study, which is pursued by the use of a spade and a peat auger, which consists of a steel pipe one and one-half m. in length and about four m. in diameter. The lower end of the pipe is closed with a piston which is pointed at the apex and can be lowered or raised in the pipe with a steel rod managed from the upper end. With these tools samples are removed from different bog levels for study and comparison. These samples can then be treated with Gunnar Anderson's nitric acid treatments, or by Lagerheim's oxalic acid method to bleach the peat,after which the fossils can be washed out. In a preliminary paper*, which should be read by all interested in the study of bogs, Pehr Olsson-Seffer gives the latest and best method for studying and preserving materials collected as samples from peat bogs.

Not only can we estimate the character of the flora which preceded our present one, by the study of peat bogs, but we can ascertain much of importance concerning the men who lived contemporaneously with the different types of vegetation. Much that we know of the Viking Age† has been obtained in a study of the Scandinavian bogs. From the bog discoveries it is known how the people were dressed, as well as the character of their riding equipment, agricultural implements, cooking and household utensils, wagons, tools, offensive and defensive weapons, and sea-going vessels. Many of the objects, Du Chaillu says, appear to be of Greek and Roman origin, so that we can approximate closely to the date when the objects were in use, and consequently the taste and manner of living of the period.

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* Olsson-Seffer, Pehr. Examination of Organic Remains in Postglacial Deposits. American Naturalist XXXVII : 785-797. 1903.

† The reader should consult Du Chaillu, Paul. "The Viking Age," I : 193, Chapter XII, for details as to the important ethnologic and archeologic finds.

All of these antiquarian bog finds are within easy access of the sea, varying in depth beneath the surface in the Thorsbjerg bog ten to fourteen feet; in the Nydam five to seven feet; in the Vimose four to five feet.

The Thorsbjerg Bog is situated south of Flensborg in southern Jutland. Among the objects found were fragments of swords (all double-edged), the hilts of all with one exception of wood inlaid with bronze and silver, with scabbards of wood and metal mountings. There were found a number of arrow shafts; remnants of shields; axes whose blades were much decomposed by rust with thirty good handles of ash and beechwood; many broken pieces of gold rings; a mass of beads; discs of amber; a variety of utensils and tools for domestic use, such as bowls of wood and clay, spoons, jugs, knives; trousers of woven woolen cloth; woolen shirts or blouses; horse head-gear of leather; flat, round, wooden shields made of planed boards of different widths; remains of leather shoes; rake of wood with teeth nine inches long; leather sandal in one piece and shield boss with silver top. In the Nydam Bog in 1863, a boat was discovered with Roman coins. The Roman coins enable us to fix the date of the objects as about 250 to 300 A. D. The oak boat found, was seventy-five feet long, ten feet six inches wide, held fourteen benches and was rowed with twenty-eight oars, the average length of which was twelve feet. By its side the rudder was found, ten feet long. The boat was clinch built, that is, the planks were fastened together by large iron bolts with round heads outside and clinch plates on the inside, five and one-half inches from each other. The boat was caulked with woolen stuff and a pitchy substance. The boards were joined to the frame with bast ropes. Another boat of red pine was discovered near by in the same bog.

In studying the flora of the higher mountains in eastern North America, the writer has discovered peat deposits of greater or less extent on Roan Mountain in North Carolina, on Slide Mountain in the Catskills, on Mt. Marcy (Mt. Tahawus) in the Adirondacks, on Mt. Mansfield in Vermont, on Mt. Washington in New Hampshire, on Mt. Katahdin in Maine, on Sierra del Ajusco (11,000 feet) in Mexico. The deposits of peat on most of the mountain summits named are comparatively small and limited in amount. The deposits on Sierra del Ajusco in

Mexico are more of the nature of dark compact layers of humus, rather than of peat. Such high mountain deposits fill shallow depressions between rock masses and are rarely over several inches in thickness. The material is extremely friable, but of a dark brown color, resembling bog peat in all of its essential characters. Such mountain peat is rarely due entirely to Sphagnum, but represents the accumulation of the remains of a considerable number of mountain species. For example, on Roan Mountain, the sand myrtle (*Dendrium buxifolium*) and Carolina rose bay (*Rhododendron catawbiense*) grow out of such peaty soil, which is constituted of their remains and those of mosses. The most extensive and interesting peat deposit was found on Mt. Mansfield along the western side of the saddle that connects the Chin with the higher part of the mountain. There the peaty deposit formed by sphagnum and other plants was about half an acre in extent and at least two feet in thickness. Throughout this peat were found the bleached but perfectly preserved roots of the balsam (*Abies balsamea*), remains of the Labrador tea (*Ledum groenlandicum*), the black crowberry (*Empetrum nigrum*) and other plants found on this mountain peak.

(*Concluded in March number.*)

PRESENT PROBLEMS OF PHYSIOLOGICAL PLANT ECOLOGY.*

By BURTON EDWARD LIVINGSTON.

By physiological ecology is here meant merely the study of the factors which determine the occurrence and behavior of plants growing under uncontrolled conditions. Field physiology would almost be a synonym for the term here used. While pure physiology proceeds, as far as is possible, with controlled conditions, ecology must perforce proceed without known conditions, without the synthetically built up environment of pure physiological research. Here it is necessary to measure and *analyze* natural conditions and to relate these to the behavior of the plants. The problem of measuring the plant phenomena, the determination of the number, size, form, structure, etc., of

* The paper from which this article is abstracted was presented in the Ecological Symposium of The Botanical Society of America at the Baltimore meeting, December 30, 1908.

the plants involved, is essentially the same for both lines of study, but that of measuring environmental conditions is of course much more difficult where the latter are uncontrolled.

There is a principle of scientific research that in an investigation which involves the measurement of a number of causal factors and the relation of these factors to resulting conditions, the various measurements must be of as nearly equal accuracy as possible. Where a number of complex factors are to be dealt with, as in ecology, progress must come from a refinement of methods of measurement on the one hand and from better interpretations of the data which result from the measurements on the other. According to the principle just stated, we must ever seek to improve those of our methods which are the least accurate, not those which are the most easily susceptible of improvement. It is, indeed, often a waste of energy to seek the highest possible accuracy in *all* of a series of measurements where one or more are at best of low accuracy. The accuracy of the resulting summation must be subject roughly to the error of the least accurate of the members.

It is not my purpose to submit any recommendations as to improvement in the general philosophy of ecology, although we must all realize that one of our greatest hindrances at present lies in the careless thinking which fills our literature with wrong or at least misleading imaginings such as are suggested by the Jonah-like words, adaptation, use, purpose, etc. It is to lines along which, it appears to me, improved methods of measurement are desirable, that I wish to call your attention at the present time. Our methods for dealing with the plant responses, with the effects of environment, already possess, in general, an accuracy far surpassing that exhibited by the methods employed in measuring the environmental conditions which act as causes. I am unable to avoid mentioning, however, one phase of plant measurement which has so far received an almost insignificant minimum of attention both from physiologists and ecologists. I refer to the subterranean portions of the plant. Considering the undoubtedly great importance of the underground portions of ordinary plants it would seem that these are well worthy of more attention than has heretofore been accorded them.

The complexity of natural environmental conditions makes it necessary often to break them up into component parts and to measure the parts separately before it is possible to determine the influence of the environment on plant activities. For convenience in handling these factors they have been classified into climatic and edaphic, but I fail to see that such a classification has any relation to the activities of the plant. It may, therefore, be suggested that these terms be dropped and that we classify these factors according to their spatial relations into those which are active above the soil surface and those which are active below it. Each group must, of course, be further analyzed according to the purposes of the investigation, but it must be remembered that the data from separate component factors usually needs to be again summed in order to express the environment as a whole. For the great general problems of plant geography it seems inadvisable to attempt too extended an analysis, rather is it better to seek methods of measurement which will furnish integrated measurements of groups of environmental conditions. With our present lack of knowledge the pressing of the analysis too far often results in such a complex of data that interpretation is impossible. A fairly satisfactory integration of the main air factors seems to be furnished by the atmometer; as to the soil factors we have as yet practically nothing in this direction.

Temperature is very important in plant activities and we have practically perfect instruments for its measurement and for the construction of its curve. Unfortunately, we have as yet no well-tested method by which temperature records can be interpreted in regard to the effect of this factor on plant behavior. A beginning which promises much has been made by MacDougal with his integration of the thermograph record, and Professor Lloyd informs me that he has found a method for interpreting maxima and minima. Here lies one of the best fields for the scientific ecologist with a mathematical turn of mind.

Wind velocity can be measured and recorded by means of the ordinary forms of anemometer, but the instruments are not well suited to field work, largely on account of their expense. Perhaps improvement may be forthcoming along this line.

The conditions of humidity, which appear to be so important to plant life, can best be measured directly by means of the dew-point apparatus, but the instrument is not as satisfactory in the operation as could be desired. The psychrometer or wet and dry bulb thermometer are more easily operated and are quite satisfactory as regards operation, especially where the humidities dealt with are not too low. I would call attention here, however, to the inadequacy of the wet and dry bulb thermometer without a strong current of air. The current should be so strong that any increase in its velocity would produce no further lowering of the temperature of the wet bulb. The hair hygrometer is unreliable unless often standardized by some other instrument. Especially is this so in regions where the humidity is usually low or where the fluctuations are very great. Much improvement is possible in connection with this factor.

The evaporating power of the air, an integration of the temperature, the wind velocity and the relative humidity, is at least not as difficult of measurement as formerly. The porous cup atmometer will give data for a curve as well as a final integration for a long period. I think we may expect much from this or some similar instrument.

Precipitation data are readily obtained, with amply sufficient accuracy, but the factors of superficial and subterranean run-off as well as that of evaporation from the soil surface (all of which are almost hopelessly difficult to measure) make these data very hard to interpret, excepting for particular localities. Their final interpretation will probably go hand in hand with that of evaporation and soil moisture.

For the measurement of light intensity—a factor which has been shown conclusively to be of prime importance in many ecological problems—we have at present no reliable and practical instrument. The delicate bolometer would doubtless give the data needed, but it is not well suited to field work. The so-called photometers (such as those used in photography) are unsatisfactory in the extreme, both theoretically and practically. They are, of course, not photometers at all, but actinometers, and for our purpose it is unfortunate that the shorter light waves are not the most important in plant activity. Here again is a field that should prove wonderfully fertile to him who has the courage and patience to cultivate it.

The determination of the composition of the atmosphere is important in certain lines of investigation and in the solution of general ecological problems in certain regions. For this purpose the methods already at hand are perhaps satisfactory enough, though we are unable to obtain automatic records of fluctuations in these conditions.

If the factors active above the soil surface present great difficulties, those active in the soil present greater ones. What knowledge has been gained by the agriculturists is seldom at the disposal of the ecologist, partly, perhaps, from the nature of the agricultural literature, and partly, perhaps, from a too common feeling that agriculture and ecology are far apart. But the agriculturists have not made very great progress in this field. Their measurements of soil conditions are too often merely determinations of the various amounts of inorganic salts which can be extracted from the soil by one or another cleverly chosen solvent. In some cases determinations are made of the total amount of organic matter in the soil, but it appears that these chemical results lack much in ease of interpretation, so much that they are of little value to the ecologist. Soils have been classified by various workers according to the size of the component particles, but I have not found any adequate method of interpretation by which the data of the physical analysis may be made to explain vegetational conditions. There is no doubt that the data contain much valuable information, if we but knew how to interpret them. A beginning has been made in the important and fundamental inquiry into the attraction of the soil for water and the ability of the soil to conduct water to plant roots, but our ignorance in this regard is almost as dense as that concerning the normal physiology of the roots themselves. Attention may be recalled here to the principle already mentioned, namely, that in the pioneer work in such a field as this it is often not well to analyze the great general factors to too great an extent. Great general vegetational features may be compared with great general soil features, and wonderfully enlightening results have come from such comparisons, as, for example, those obtained by Dr. Cowles and his associates in this field.

The possible importance of small amounts of organic chemical substances in the soil has been strongly emphasized by the work of the Bureau of Soils, and evidence in this regard is rapidly accumulating from all parts of the world. There is now little reason to doubt that bog soils and others which are poorly drained owe the character of their vegetation in great part to the presence in the soil of toxic bodies. There is evidence that many well-drained soils contain similar substances. The ecologist can ill afford to neglect this important line of advance.

The water conditions of the soil have not received the attention which their importance justifies. For determining the amount of soil moisture our methods are confessedly crude and unsatisfactory, but they have not been employed as extensively as their accuracy seems to justify. Graphs of the fluctuations in the water content have yet to be constructed, although their construction is comparatively simple and their value for our purpose must be very great. Such curves should replace the bare and almost useless data of precipitation and run-off. Improved methods of measuring soil moisture will, of course, be of great value, if such can be devised.

As to the rate at which the soil can supply water to the plant—quite a different question from that dealing merely with the amount of soil moisture—we know almost nothing. This rate of possible supply, or the resistance offered by the soil to water absorption by roots, is, I think, perhaps, at present, the most important problem in all ecology, and it has hardly been touched upon. But the problems here suggested seem to be as difficult as they are important.

We know almost nothing in a quantitative way about the relations between the oxygen of the soil and plant development. If this field should be developed we should undoubtedly be placed in condition to explain many dark and complicated points. The capillary power of the soil apparently determines, other things being equal, both the rate of water supply and that of oxygen supply, and perhaps the best that can be done, in the absence of more perfect methods, is to study plant behavior with reference to capillary power and water content. But ecologists have hardly even attempted to relate the easily determined capillary power, which does not fluctuate in any given soil,—to the vegetation, and it is difficult to foresee what important results might be forthcoming from such a simple study.

Finally, for a goodly number of ecological investigations, the bacterial flora of the soil must be investigated. The agriculturists have made good progress here and we may do well to follow them. The possibilities are very great.

NOTES AND COMMENT.

The celebration of the one hundredth anniversary of Darwin's birth by Columbia University bids fair to bring together one of the most noteworthy of the series of contributions now appearing on Charles Darwin and his influence on science. Nine lectures on this subject will be given at different dates from February 12 to April 16, 1909, by Henry Fairfield Osborn, William Berryman Scott, Thomas Hunt Morgan, Franz Boas, Edward Lee Thorndike, Daniel Trembly MacDougal, John Dewey, George Ellery Hale, and Franklin Henry Giddings, whose special fields of research range from botany, zoology and anthropology to modern philosophy and the evolution of human institutions.

An even more extended series of Darwin anniversary addresses to be given before the Biological Club of the University of Chicago, beginning February 1 and closing March 18, includes the following titles: "The World's Debt to Darwin," Prof. E. G. Conklin; "The World of Thought Before and After the Publication of the Origin of Species," Prof. G. H. Mead; "Cosmic Evolution," Prof. F. R. Moulton; "Bridging the Gap Between Living and Lifeless," Prof. A. P. Mathews; "Phylogeny," Prof. S. W. Williston; "Variation and Heredity," Prof. W. L. Tower; "The Interpretation of Environment," Prof. H. C. Cowles; "Darwinism and Political Science," Prof. C. E. Merriam; "Human Evolution—Physical and Social," Dr. Geo. A. Dorsey; "The Influence of Darwinism on Psychology," Prof. J. R. Angell; "The Theory of Individual Development," Prof. F. R. Lillie; "The Evolution of Religion," Prof. Shailer Mathews; "Darwinism and Experimental Methods in Botany," Prof. D. T. MacDougal, Carnegie Institution; "Evolution in Language and in the Study of Language," Prof. C. D. Buck; "Selection, Mutation, and Orthogenesis," Prof. C. O. Whitman.

The commemorative exercises of the New York Academy of Sciences, held February 12, 1909, included a presentation to the American Museum of Natural History of a bronze bust of Darwin by Charles Finney Cox, president of the academy, and addresses on Darwin and Geology, by John James Stevenson, Darwin and Botany, by Nathaniel Lord Britton, and Darwin and Zoology by Hermon Carey Bumpus. In connection with the celebration an exhibition was held, consisting of Darwiniana and selected series of specimens bearing upon the Darwinian theory of natural selection.

Among still other institutions that have embraced the opportunity to celebrate this anniversary of Darwin's birth, coincident with the fiftieth anniversary of the publication of the *Origin of Species*, the Michigan Academy of Science and the Michigan Schoolmasters' Club will hold joint sessions on April 1 and 2, at which papers will be presented dealing with the factors of evolution, the mutation theory, palaeontology from the evolution point of view, heredity and allied subjects. Professor W. B. Scott, of Princeton, and Dr. C. B. Davenport, of the Carnegie Institution, will be among the participants.

It is an interesting fact that the history of botanical science has repeatedly marked a period of approximately fifty years, within which a new thought or principle has been promulgated, that in the course of this period has materially affected, in some cases substantially altered the course of development of the science. Jussieu's presentation of a "natural" system of classification a hundred years before the publication of the "*Origin,*" De Candolle's morphological conceptions set forth some fifty years later, and especially the brilliant contributions of Hofmeister in the middle of the last century are cases in point. All of these, however epoch-making in their day, appear now as merely groping toward the light that came with the "*Origin of Species,*" and there are not wanting indications that much the same history is to be repeated. The year of jubilee may well be kept, but the lack of agreement as to the methods of evolution and its various applications on the part of those who may be assumed to understand it best, shows something of what is left over for the next centennial, or semi-centennial celebration.

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MARCH, 1909

ROLES OF THE SOIL IN LIMITING PLANT ACTIVITIES.

By BURTON EDWARD LIVINGSTON.

According to modern physiological philosophy, the life of a plant is to be considered as a series of reactions on the part of the organism to the ever changing conditions both within and without its body. These reactions, which make up the life activities of the plant, can take place only within certain limits, they can occur only when external conditions are so arranged that they bring forth reactions in the right direction and of the right intensities. Thus a mature seed, in which the internal conditions have not been disarranged since it left the parent plant, will react by germinating when the temperature and moisture conditions lie within certain limits, these limits varying considerably with the kind of seed involved. Another condition limiting germination is the rate of supply of oxygen. Germination fails to occur if the temperature is either too high or too low, and the same lack of response is noted with too low a rate of moisture or of oxygen supply. The plant continues to grow as long as water, salts and oxygen can reach the growing tissues as rapidly as they are fixed by growth or lost by outward diffusion, and as long as the temperature neither falls below nor rises above certain limits. Also, in the case of green plants, growth can continue only with the influx of certain kinds of light energy, at a certain rate, and with the inward diffusion of carbon dioxide at a velocity great enough to supply the green tissues with material for elaboration. If the external conditions change at any time, a more or less marked effect is produced upon the plant, and if such a change carries these conditions beyond the limits mentioned above, growth, and often life itself, ceases. The kind of reaction produced by a change in the environment depends, of course, upon the nature of the organism, upon the internal conditions, as much as upon the outer world. Seeds of one form may develop rapidly when those of another are not affected at all. Also, as a plant develops, its internal conditions,—i. e., its vital nature,—are continually altered, so that one and the same set of environmental conditions may produce quite different effects upon the same plant at different times in its life cycle.

The environment is an exceedingly complex thing, and one very difficult of analysis. As already pointed out, it consists of a number of factors, such as temperature, wave-length and intensity of light, evaporating power of the air, nature of the soil, etc. Each one of these component factors may play an important role in causing the premature death of plants or in producing unusual phenomena of development. Some of the ways in which the soil may affect plant behavior will be briefly considered here.

The presence of some sort of soil is essential to the growth of most higher plants, on account of the mechanical need of an anchorage. This anchorage is effected by the growth of the root system, progressing hand in hand with the growth of the upper parts of the plant. The growth of the roots is determined by several soil factors besides that of mechanical penetrability, which is, of course, an essential feature. The oxygen for root respiration must mainly come from the soil and diffuse directly into the growing roots. Water and the nutrient mineral salts must also diffuse into the roots as they are removed by the plant activities. These are necessary, not only for the formation of the underground parts of the plant, but also for that of the portions above the soil. But it is not primarily the *amount* of oxygen, nutrient salts and water, which determines the behavior of the plant, rather is it the *rate* at which it is possible for these substances to diffuse into the roots. And this rate does not necessarily depend directly upon the amount of these substances existing in the neighborhood of the root system, but is modified greatly by the physics of the soil itself. Soil temperature is also very important. It determines whether or not roots can live and whether they may grow. It also affects the activities of the whole organism profoundly, through its effects upon the possible rates of diffusion through the soil and from the soil into the roots.

The most important of the soil factors is undoubtedly that of the water relation; in higher plants the water used is practically all derived from the soil. This liquid is of most fundamental importance in all life phenomena, being the single solvent in which these phenomena are known to take place, and it is absorbed throughout the whole active history of most plants. Sometimes the presence of water-storage tissues renders it possible for growth to occur for a time in the absence of water absorption, but this is not the usual condition of affairs.

A comparatively very small amount of the water which diffuses into the root system is fixed in metabolism, in the formation of carbohydrates, for example. But the greater portion of the water entering the plant from the soil passes through it and is lost, as transpiration water, from the surfaces of leaves and stems. If the soil fails to supply water to the root system at a rate equal to or surpassing that at which it is fixed by metabolism and lost by transpiration, then growth is checked or partial or total death ensues. Since the amount of water fixed by the plant is so small in comparison with the amount lost, the former may be neglected in this consideration, and we may say here that the main limiting condition for ordinary growth is that it must be possible for water to diffuse from soil to root system somewhat faster than it is lost by the aerial organs.

Since transpiration depends to such a degree upon the evaporating power of the air, it follows that the last named factor must be considered in connection with the rate of soil diffusion; with a low evaporating power plants may thrive in soils possessed of only a low rate of water supply, while if the evaporating power of the air were to be greatly increased the same plants, with the same soil conditions, might cease to grow or succumb entirely. The real determining factor is here the *ratio* of the possible rate of water diffusion from soil to roots to the rate of transpiration. In order that ordinary growth may occur, this ratio must be greater than unity.

The rate of water diffusion through the soil depends upon its capillary power and upon the amount of water present in neighboring regions. Capillary power, in its turn, depends largely upon the size of the soil particles and upon their condition of aggregation. It is probable that soil temperature may be found to play a role in this connection.

The rate of diffusion of oxygen through the soil is dependent largely upon the amount of water present, as well as upon the size and aggregation of the soil particles. With the same soil, the more water present, the lower will be the rate of oxygen movement. Thus, if we increase the water supply beyond a certain limit, we often cause injury to the plants through lack of oxygen to the roots. This consideration can hardly be overemphasized.

The rate of possible supply of inorganic food materials to plant roots is a function of the amount of soluble materials present in the soil and of the concentration of the solution, as the latter is determined by the amount of water at hand. It is to be remembered in this connection that the plant usually absorbs these substances as ions and not as salts. As ions are removed from the soil solution others of like nature take their places, dissolving away from the soil particles themselves. The stream of water entering the roots is probably always far more rapid than is necessary to keep the plant supplied with the non-nitrogenous food constituents. Therefore, since most soils contain the non-nitrogenous salts necessary to plant life, the rate of diffusion of ions or salts is probably seldom, if ever, a limiting condition for plant growth, excepting in the case of nitrogenous compounds. These latter salts are perhaps to be considered the most important of all the inorganic food materials. They are formed and destroyed by bacterial growth in the soil, their amount depends upon the bacterial flora, upon the amount of organic matter present, upon temperature, and probably upon other factors. The rate of supply of nitrates and similar bodies is surely often a limiting condition to the extent or rapidity of plant growth.

In some localities the soil conditions are adverse to plant life, or to the activities of all but certain peculiar forms, through the presence in the soil of poisons. This is notably the case in bogs or moors and, from present indications, also in many upland soils. Such poisons seem usually to be organic bodies resulting from the growth of organisms, such as bacteria, fungi and even the roots of higher plants themselves, but may, of course, be inorganic in certain areas.

Finally, the soils of the arid regions sometimes contain such large quantities of soluble inorganic salts that the concentration of the soil solution is physically very great and thus the entrance of water into the roots is completely or all but prevented. In such areas the successful vegetable forms are those with relatively high osmotic pressures in their tissues. In the case of such plants water will enter the root system from soil solutions so strong that the roots of ordinary plants might even function backward and give up water to the soil.

In view of the exceedingly meagre knowledge which we possess in regard to the details of the general principles above touched upon, it is sincerely to be hoped that botanists will in the future devote more attention to the soil than has been their wont in the past.

BOGS, THEIR NATURE AND ORIGIN.

By JOHN W. HARSHBERGER.

(Continued from February number.)

The conversion of lakes into bogs has been studied by the writer for several successive seasons on the Pocono Plateau, Monroe County, Pennsylvania. The lakes known as Half Moon Pond and Lost Pond, as well as several sphagnum bogs in glacial kettle holes, are all surrounded by the material which constitutes the great terminal moraine. Half Moon Pond is an open body of water about a quarter of a mile long, two hundred yards wide and somewhat crescent-shaped. It is undergoing, however, rapid changes which will convert it into the present form of Lost Pond, while the kettle holes are filled with bogs, partially dry in summer, some with open treeless areas, others completely captured by tree species. The accompanying diagrams will illustrate the stages through which a lake basin passes in its conversion into a bog by the encroachment of various plants. An examination of the diagrams, illustrating Half Moon Pond (Figures 1 and 2), shows that the surface of the lake is covered with patches (A) of the large yellow spatter-dock (*Nymphaea advena*). This plant is slowly, but surely, covering the lake surface with its large floating leaves. The central lagoon is surrounded by a fringe of sphagnum moss, the margin of which extends outward in a floating mass (mo). The inner edge is anchored fast to the bottom, but one sinks knee-deep in the spongy mass. In this circumarea of sphagnum grow the cranberry (*Vaccinium macrocarpon*) (C), cotton sedge (*Eriophorum virginicum*) (V), and the sundew (*Drosera intermedia*) (D). Such a sphagnum fringe is found only on the north, east and west sides of the pond. Sometimes a stiff sedge together

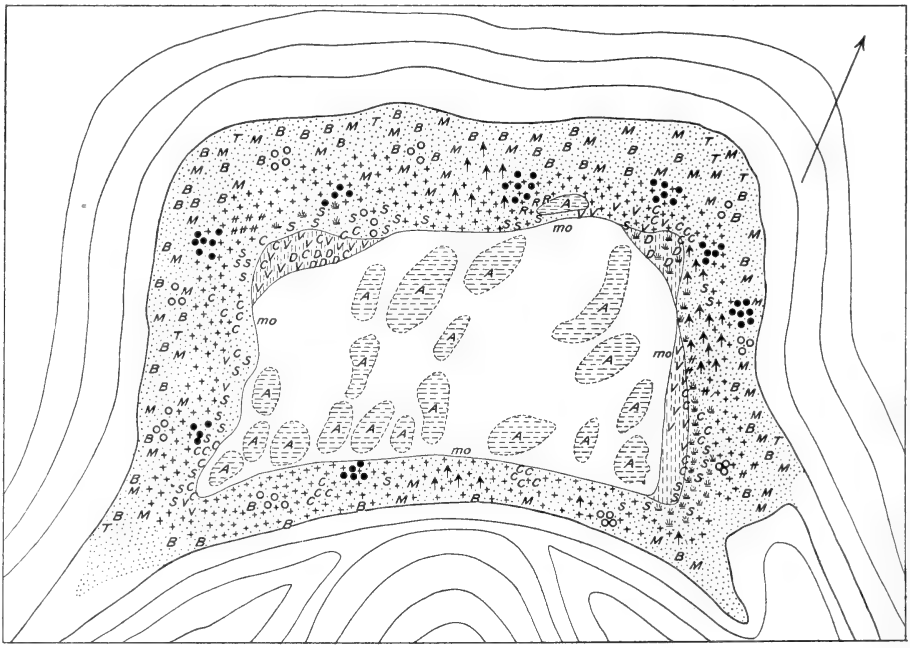

Fig. 1. Diagram showing distribution of plants at Half Moon Lake, Pocono Plateau, Pennsylvania.

with the sundew (*Drosera rotundifolia*) (R), and pitcher plant (S) occur also in this outer circumarea. On the shoreward side of this sphagnum circumarea occurs a well defined fringe of the shrubby leather-leaf (*Chamaedaphne calyculata*) (Figure 1, +)

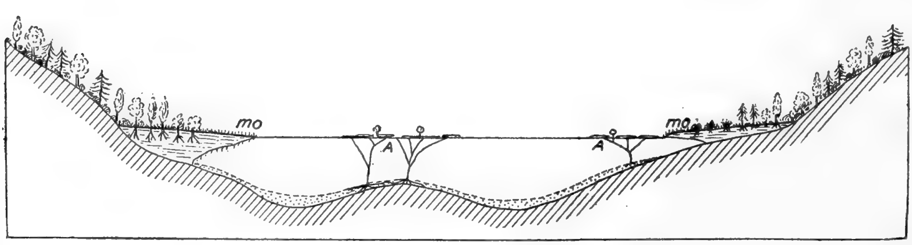

Fig. 2. Vertical section (diagramatic) of Half Moon Lake.

which crowds out most other plants. However, its continuity about the entire pond is broken by clumps of white birch (*Betula populifolia*) (B), mountain holly (*Nemopanthes fascicularis*) (•), larch (*L. laricina*) (↑) and rhodora (*Rhododendron canadense*) (#) together with the high bush blueberry (*Vacinium corymbosum*) (o). On the south side of the lake, this shrubby vegetation comes down to the water's edge. Back of the leather-leaf circumarea is one characterized by a sphagnum foundation, but

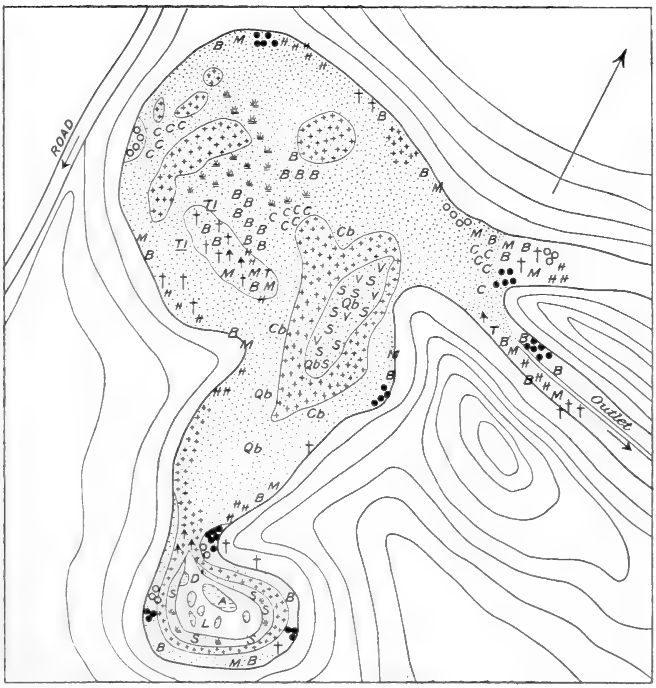

Fig. 3. Distribution of plants in the flat bog known as Lost Pond, Pocono Plateau, Pennsylvania.

which is firm enough to permit the growth of such trees as red maple (*Acer rubrum*), white birch (*Betula populifolia*), black spruce (*Picea mariana*), etc. The fourth, and last zonal arrangement to attract our attention, is the one on the dry soil of the morainic material, which completely surrounds the pond as a series of low ridges curving about the shore. Here is found a forest formation composed of white pine (*Pinus strobus*), black spruce, white birch, red maple, trembling aspen (*Populus tremu-

loides), bird cherry (*Prunus pennsylvanica*), etc. As low shrubs occur the blueberries (*Vaccinium pennsylvanicum, V. nigrum, V. canadense*), chokeberry (*Pyrus arbutifolia*) and such herbs as *Amianthium muscaetoxicum*, bristly sarsaparilla, (*Aralia hispida*), bracken fern (*Pteris aquilina*) together with thickets of red raspberry (*Rubus strigosus*).

Lost Pond is in a later (not the next)stage of bog development. Here the open water has entirely disappeared, except in a small secluded area at the upper end of the pond (Figure 3, L). In the yearly visits the writer has made to this interesting bog from 1903 to 1908 he has noticed the advance of the shrub and tree vegetation out upon its surface, which in some places remains a quaking bog (Qb), into which a stick may be thrust a distance of fifteen to eighteen feet without touching bottom. This bog occupies an irregular depression with its outlet through a narrow valley between two morainic hills. The zonal arrangement of plants noticed at Half Moon Pond is not seen except around the small circular lagoon at one end of the pond (L). The surface of this lagoon is covered with patches of (A) the great yellow spatter-dock (*Nymphaea advena*), tall sedge (*Dulichium arundiaceum*), growing out of small islands of muck fringed with the sundews (*Drosera intermedia* and *D. rotundifolia*) (D), while near the edge are associations of bladderwort (*Utricularia*). This lagoon is bordered by a sphagnum circumarea in which peat mosses, pitcher plant (*Sarracenia purpurea*) (S) and various sedges are associated. Back of these plants occurs the leather-leaf (+), which forms a clearly defined circumarea. Scattered amongst the dense masses of this shrub occur a few pitch pines (*Pinus rigida*) (†). The third circumarea consists of a low fringing thicket of steeple-bush (*Spiraea tomentosa*), high bush blueberry (o), pale laurel (*Kalmia glauca*), rhodora with an occasional pitch pine and clump of mountain holly (•). The outlet of this lagoon is choked by a mass of sphagnum in which the high bush blueberry, white swamp azalea (*Rhododendron viscosum*), larch and white birch occur. Back of this circumarea is the higher, dry ground with a forest formation of exactly the same composition as the one surrounding Half Moon Pond, previously described. The larger open bog portion consists of a subtratum of sphagnum mixed with a coarse sedge (\\|//) rising two feet above the surface. Through such vegetation one must wade knee-deep to reach the quaking bog (Qb), where the peat mosses occur in almost pure growth, but supporting fine pitcher plants (*Sarracenia purpurea*), patches of cranberry, cotton grass (*Eriophorum virginicum*) (V) and *Scheuchzeria palustris*. The uniform surface of the bog is broken by a tree island (Figure 3, TI). The small trees and shrubs found surrounded by the peat mosses are black spruce, red maple (M), cherry birch (*Betula lenta*), white birch, rhodora (#), high bush blueberry (o), sheep laurel (*Kalmia angustifolia*), white swamp azalea, steeple bush and leather-leaf. Green-leaved pitcher plants occur in the sphagnum beds beneath the trees. Between this clump of trees and the elevated, tree-covered, dry ground beyond the bog, occasional larch and pitch pine trees have invaded the bog. The first year's observations (1903) showed relatively few trees on the surface of the bog proper, but in the last season (1908) the writer counted a number of white birch trees which had invaded the bog from the north side of the tree island (Figure 3, TI, B) together with clumps of mountain holly,red maple and cinnamon fern (*Osmunda cinnamomea*). The continuity of the bog surface is also broken by large patches of leather-leaf (+ +) which at first were isolated from each other by considerable intervals of open bog, but during the five years that have elapsed since the first observations were made, these gaps have closed and many smaller associations of leather-leaf have united. This encroachment of the shrubby leather-leaf, so as to surround and enclose large areas of open bog, is especially noticeable in the center of the bog (Cb), where the pitcher plant grows together with the sundew (*Drosera rotundifolia*), sedge (*Carex bullata*) and cranberry. Here and there between the Cassandra bushes one notices patches of a pure cranberry growth (C). The pale laurel swamp loosestrife (*Lysimachia stricta*) and cotton grass (*Eriophorum virginicum*) (V) are scattered amongst the sedges and leather-leaf shrubs over the surface of the bog. At the edge of the bog in the southwest and northwest angles occur clumps of the white swamp azalea.

The stream issuing from Lost Pond is lined by thickets composed of red maple, white birch, mountain holly, choke-berry, white swamp azalea, black alder (*Ilex verticillata*), leather-leaf, service-berry (*Amelanchier canadensis*), witch hazel (*Ha-*

mamelis virginiana), hemlock (*Tsuga canadensis*), black spruce, white pine, sassafras (*Sassafras officinale*), *Viburnum nudum*, high bush blueberry and such undershrubs as sheep laurel, blueberries (*Vaccinium nigrum*, *V. pennsylvanicum*) and the ground plants Indian cucumber-root (*Medeola virginiana*), wake-robin (*Trillium erectum*), bracken fern, bunch-berry (*Cornus canadensis*), white fringed orchis (*Habenaria blephariglottis*), swamp loosestrife (*Lysimachia stricta*), *Dalibarda repens*, trailing arbutus (*Epigaea repens*), and in wet places cinnamon fern and pitcher plant. At the immediate outlet of the bog, pools of water occur in which grow the spatter-dock surrounded by

Fig. 4. View south over Half Moon Lal e.

shrubs of the leather-leaf, pale laurel and sour gum (*Nyssa sylvática*). With the exception of the shrubs and trees mentioned as invading species of the bog surface, and which form a fringe of vegetation around the bog, the transition from the bog vegetation proper to the vegetation of the low morainic hills that form the rim of the bog basin, is rather an abrupt one. On the dry ground of the sloping hills the botanist finds the second growth to consist of pitch pine, white birch, white pine, black spruce, sassafras, scrub-oak (*Quercus ilicifolia*), large-toothed aspen (*Populus grandidentata*), red maple and an occasional chestnut (*Castanea dentata*). The shrubs in this dry soil are laurel (*Kalmia latifolia*), high bush blueberry, blueberries (*Vaccinium nigrum, V. pennsylvanicum, V. canadense*), serviceberry, sweet fern (*Comptonia asplenifolia*), sheep-laurel, chokeberry, bracken fern, wintergreen (*Gaultheria procumbens*), trailing arbutus, cow-wheat (*Melampyrum americanum*), bristly sarsaparilla and lady's slipper (*Cypripealdium acaule*).

The last stages of the morainic bogs on the Pocono Plateau are found in some of the kettle holes that occur in the great terminal moraine. These depressions are filled with a ground

Fig. 5. Details of southeastern shore of Half Moon Lake, showing spatter-dock in water and bog in foreground. Note scattered larches.

soil composed of peat and hair mosses out of which large trees grow, such as black spruce, red maple, pitch pine, sour gum, bird cherry, sassafras, great bay, trembling aspen, white birch, and such shrubs as high bush blueberry, leather-leaf, sheep-laurel, black alder, rhodora, mountain holly, together with such ferns as cinnamon fern (*Osmunda cinnamomea*), hay scented fern (*Dicksonia piloliuscula*), bracken (*Pteris aquilina*) and marsh shield-fern (*Dryopteris thelypteris*). Here grow also such herbs as bunch-berry, bristly sarsaparilla sundew (*Drosera rotundifolia*) and various associated species.

We may classify bogs into several categories: flat bogs, raised bogs and hanging bogs. The flat bog is the usual type of sphagnum bog found in North America. A flat bog usually results when a lake or pond is converted into a bog by the encroachment of vegetation. Those that have been described as occurring on the Pocono Plateau are of the flat type. Ganong* has shown, however, that in New Brunswick there are raised bogs similar to those found in Ireland and other parts of Europe. The raised bogs are formed, as all students of them agree, by the pure sphagnum moss growing upward and carrying the water by capillarity with it, so that in some cases standing pools of water are seen on its surface. Sphagnum is able by capillarity to raise water twelve to thirteen feet above the water level of the basin in which the bog is forming. The weight added to one of these bogs during a rain must be very great. The bursting of bogs is the result of the accumulation of more water than the structure is able to hold, and it gives way suddenly. The great bog-burst of County Kerry, Ireland, occurred on the night of December 27–28, 1896. The scene of this catastrophe is three and a half miles from Rathmore railway station, six miles from Headford, fourteen miles from Killarney and about a half mile from the small village of Gneevgullia. The bog is about 600 acres in extent, 750 feet above the level of the sea and was convex in the center before it burst. It drained off in three directions—toward the Blackwater, the Quarry Lodge and the valley of the Owenacree. The total amount of peaty matter discharged was about 5,900,000 cubic feet, sufficient to cover a large extent of country. The turf cutting had to be made in two directions—toward the Blackwater and toward the Quarry Lodge—and owing to the injudicious way in which the turf had been cut and owing to a heavy rain storm on the night of December 27–28, the bog burst, carrying away the house of Cornelius Donnelly, steward of the quarry, who, with his family, was drowned.

The hanging bogs are found on high mountain slopes, where the angle of inclination is not too steep to permit peat mosses

* Ganong, W. F. Upon Raised Peat Bogs in the Province of New Brunswick. Transactions of the Royal Society of Canada. Second Series, Section 4, page 131.

to grow. Such bogs are always supplied with water from underground sources, or by streams that spread out over a considerable area of mountain slope. One other fact should be mentioned about bogs, and that is, their temperature is known to be low, and the expression "cold bogs" is frequent in our manuals. It has been proved that the low temperature of bogs is not due to evaporation from the surface, but is due rather to a persistence of the winter cold and ice which in such a large non-conducting mass would last through the summer months. It is not surprising, therefore, that arctic and glacial plants are preserved in such bogs, while the surrounding vegetation has undergone marked changes since the close of the glacial period.

A WITCH'S BROOM OF THE DESERT.

By PAUL C. STANDLEY.

One of the most common shrubs in the southern and southwestern parts of New Mexico is *Ephedra trifurca* Torr. It occurs upon the sandy mesas and is especially abundant where they are cut by arroyos. The plant is known among the Mexicans as "popotillo" or "canatillo." With them, as well as among Americans, it is reputed to be a cure for venereal diseases. It is reported that a tea made from one of the species of the genus is used in Mexico as a remedy for kidney diseases, and the tea is even said to be used by some people as a beverage, although it would seem that it could not have an especially pleasant taste since the green stems when chewed have very much the flavor of green persimmons. This bitter taste is probably due to the abundance of tannin in the stems.

The shrub is a rather prominent feature of the landscape in some places and attracts notice because of its lack of leaves. For this same reason the witch's broom, illustrated here, is conspicuous wherever it appears. The cause of this interesting growth is a fungus, *Aecidium minus* (Berk.), according to a determination made by the late Dr. Underwood. It appears in this vicinity in late summer after the beginning of the rainy season. It was very abundant during the summer of 1907, but less so, apparently, during the past season. The bright

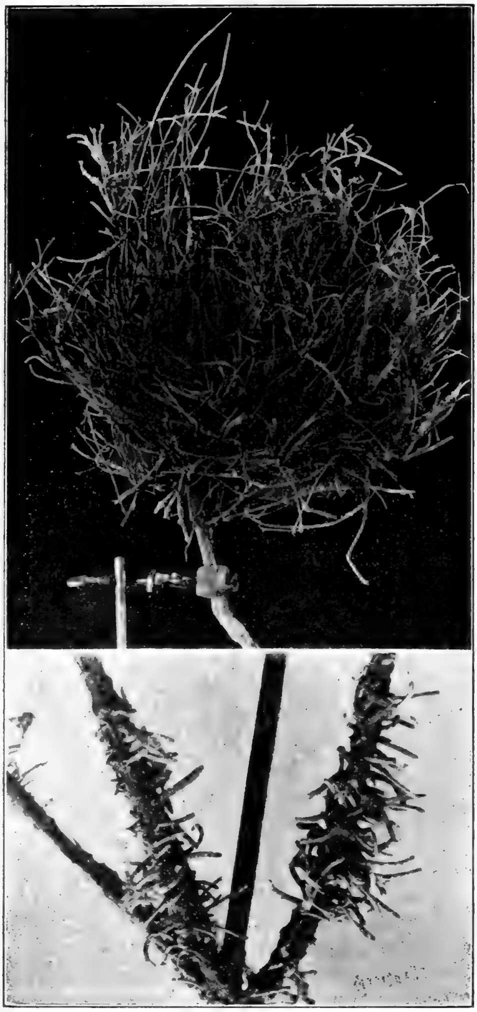

Figure 1. A witch's broom from a bush of Ephedra trifurca × $\frac{1}{8}$. Below is a detail of the broom × $1\frac{1}{2}$.

yellow color of the aecidia and their abundance upon their host gives the dense "brooms" a rather handsome appearance. The whole plant is not affected, but only fascicles of branches here and there. The branches so affected can be noticed as far as the shrub can be seen because the abundance of the fungus gives them a solid appearance quite unlike the ordinary skeleton-like appearance of the plant. One or two other species of

Ephedra are of more or less common occurrence in the vicinity, but the fungus has been observed only upon *E. trifurca*.

New Mexico Agricultural College.

VEGETATION AND ALTITUDE.*

By CHARLES H. SHAW.

It has been widely held that the more intense light of higher altitudes exercises a distinct influence upon the vegetation, and a number of considerations support the view. The stunted forms of alpine plants harmonize well with some of the known effects of light, likewise the greater relative development of their flowers. Bonnier, in his classic experiments in the Alps and Pyrenees, came to the conclusion that light is an important factor in inducing the peculiarities of plants grown at high altitudes. No really discriminating experiments have been made, but the idea has been indorsed by Schimper, Schroeter and most of those who have had occasion to refer to the subject.

Digressing for a time to the general question of light, as an ecological factor, we are impressed by the difficulty of obtaining information in this direction. Looking upon light as a form of radiant energy, several workers have attempted to calculate its intensity from astronomical data. Such efforts do not seem to have been happy in escaping fundamental error. For, in making calculations from the sun's altitude, there is not one varying factor, but three or four which must be taken into consideration, viz.:

Variation according to sine of angle of incidence.

Disproportionate variation of diffuse light (diffuse light being, probably, a very important factor for vegetation).

Diminution with decreasing elevation of sun due to increasing length of path of light through the atmosphere.

Disproportionate absorption in lower layers of atmosphere.

Moreover, there are local conditions quite beyond calculation. Wiesner has given heavy blows to the idea that theoretical calculations are of any real value at all. His readings in

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* Abstract from paper read before the Botanical Society of America at the Baltimore meeting, December, 1908.

various parts of the world show astonishing irregularities. In Buitenzorg the light diminished rapidly between 11 and 12 o'clock on a clear day. Similar data were recorded for Cairo, Egypt. The greatest intensity found anywhere in the world was not in the tropics, but in the Yellowstone. Though some of his results seem hard to credit without further confirmation, it must be owned that his methods seem much more ample and critical than does similar work by other botanists. He attributes much importance to the intenser light of higher altitudes. On the other hand, Clements states that in Colorado the increase of light intensity with increasing altitude is too small to be considered in studies of vegetation.

Further study of the whole question of light as an ecological factor is much to be desired. In so doing, data as to intensity must be obtained by methods which will pass muster with physicists. A certain body of fairly reliable data is now in existence in the work of Cayley, Violle, Langley and others. This goes to show that light is considerably more intense at high altitudes, particularly in the more refrangible end of the spectrum.

In giving attention to this matter it seemed to me desirable to learn something of the responses made by plants to variations in quality of light. Several series of experiments have accordingly been carried out, in which both the plants experimented upon and the controls were exposed to the same amount of daylight (deemed sufficient for normal development), but the subjects of the experiment received in addition a certain amount of blue-violet light. The results so far, while scarcely conclusive, suggest that plants do respond to such a variation in quality of light. Internodes have been shorter and leaves more hairy in the bluer light.

It has also been largely held that evaporation increases with altitude on account of diminished pressure and increasing air movement. Such a fact would be of great importance for vegetation. The more xerophytic forms of alpine plants harmonize well with the belief in its existence. Schimper gives prominence to the idea, Schroeter likewise, and the latter writes vividly of the drying of skin experienced by alpinists, and refers to a kind of dry cured meat prepared in some valleys of the Alps, the process being made possible, it is said, by the increased evaporation occurring at high altitudes. With a view to obtaining further data in the matter, the writer carried on a series of porous cup atmometer readings in the Selkirks during the past summer. These mountains are heavily forested and altogether they much resemble the Alps. The instruments were safeguarded and checked in ways which seem to put part, at least, of the results beyond question; the season was unusually favorable, being dry and warm. One series of instruments was in continuous operation twelve weeks. The results as a whole seem impossible to harmonize with the idea that total evaporation increases with altitude. The maximum in each case was shown by the pair of instruments at the second station, 1,100 meters altitude. Above that a gradual and irregular diminution was shown. Possibly the standard writers may have overlooked the part played by temperature, for this, too, is a factor in the evaporation rate and might overbalance the effects of diminished pressure and movement. It must be kept in mind that the results mentioned refer only to weekly totals and throw no light on what might happen during a certain portion of the day. It will naturally be remembered, too, that the problem of the plant is to maintain a balance between water supply and water loss. If cooler soil or any other circumstances makes the obtaining of water more difficult, then the same or even a diminished evaporation rate might demand increased resistance to evaporation on the part of the plant.

PERENNIAL DODDER: AN ADDITIONAL NOTE.

By FRANCIS E. LLOYD.

A few months ago I reported in the PLANT WORLD that a species of Cuscuta to be found in N. Zacatecas, Mexico, passes the winter in a semi-dormant condition on the host plant. A recent bulletin from the N. Y. Agricultural Experiment Station (No. 305) has just been received, in which it is noted by Stewart, *et al*, that a species of cuscuta which affects the alfalfa in that state "lives over winter in New York alfalfa fields on alfalfa, yellow trefoil, red clover, dandelion and daisy fleabane." Inasmuch as the species in question "does not commonly produce seed in the New York alfalfa fields," the perennating habit is of paramount importance to the dodder. The authors observe that this is contrary to the generally accepted opinion that the plant is an annual, and it was in view of this that the present writer announced his observations made in Mexico. It further appears from the bulletin in question that in 1868 Kühn announced that the dodder lives over winter in the clover fields in Germany. Later Sorauer stated that dodder is perennial, though Kerner and Oliver take the opposite view, excepting with regard to tropical species. Quite recently Hillman has held it to be an unsettled question, and in view of the pertinacity with which the view that the dodder is an annual is held, as observed by Kühn, it is not superfluous to draw attention once again to the observations of Stewart, *et al*, and of myself. Stewart, *et al*, particularly, offer in the bulletin referred to a mass of pertinent evidence, which is of especial importance because of the economic bearing of the question.

Alabama Polytechnic Institute.

A REPEATED CYCLE IN ASSIMILATION.

By B. E. LIVINGSTON.

In the Rothamstead Experiment Station, at Harpenden, near London, my attention was called by Professor Hall to a plant of *Asplenium nigrum* which is of exceptional physiological interest. In the year 1874 a certain soil sample, of something over a liter volume, was placed in a large-mouthed bottle and hermetically sealed with cork stopper, sheet lead capsule and sealing wax. The containing bottle has a capacity of perhaps two and one-half liters, so that there is above the soil a roomy, moist chamber, for samples at that time were preserved without drying, in the condition in which they were obtained from the field.

In this soil sample developed the fern plant here referred to. The room in which the soil samples are shelved is sufficiently light so that the fern has grown to fill the space allotted to it, having now a large mass of mature leaves, below which are withered and decaying ones and above which many young leaves are unfolding. Just how old the plant is it is, of course, impossible to state, but there is no reason to believe that it did not spring from the thallus within a year or two of the time the soil was collected. In any event, Professor Hall informed me that he first noticed the specimen six years ago. At that time it was already a large and thrifty fern. Thinking that there might possibly be some leakage of gases through the old seal, he resealed the bottle with paraffin, applying the new seal without any disturbance to the old. We may be sure, therefore, that during the last six years absolutely no interchange of materials between the interior of the bottle and the outside has taken place. It is indeed probable that the old seal never leaked, and that this condition has obtained throughout the life of the plant.

Moisture, salts, organic matter, and various micro-organisms were undoubtedly present in the soil at the time it was sealed up. A certain amount of free oxygen was, of course, included above the soil. Light entered through the glass, the temperature conditions were favorable and the plant grew normally. The carbon dioxide of the air was replenished from the decay of organic matter in the soil, the original amount of moisture was always present, and by photosynthesis new carbohydrates were formed, the fern thus increasing in size and in number of leaves. The old leaves died and fell upon the moist soil, there to be gradually decomposed through the action of organisms, and thus carbon dioxide was set free which diffused into the air to be again fixed by the photosynthetic process in the living leaves above. This cycle of carbon interchange must have gone on many times, the energy source therefor being, of course, the light that penetrated through the walls of the bottle. Theoretically, at least, there seems to be no limit to the length of life of such an hermetically sealed plant, so long as the light and temperature conditions remain adequate.

BOOKS AND CURRENT LITERATURE.

Studies in Mesa and Foothill Vegetation, University of Colorado Studies, Vol. VI, No. 1, is the first of a series, of which the present number includes Geology and Physiography of the Mesas near Boulder, by Gideon S. Dodds; Climatology of the Mesas near Boulder, by Francis Ramaley; Distribution of Conifers on the Mesas, by W. W. Robbins and Gideon S. Dodds;

Distribution of Deciduous Trees and Shrubs on the Mesas, by W. W. Robbins. Topographic and soil maps, together with maps showing the distribution of several conifers and some eighteen of the more important shrubs and deciduous trees, with a number of photographs, elucidate the text.

The method of carrying out the studies of local distribution is illustrated by the case of the rock pine (*Pinus scopulorum*), which is the dominant conifer of the foothill region, though its extreme limits of range in altitude at this point are approximately from 6,000 to 10,000 feet. Its local distribution depends not upon conditions affecting large and well established trees, but upon those which the germinating seeds and seedlings encounter. There is a greater growth of this pine on the north than on the south slopes, and seedlings are often found growing at the side of a large rock, this choice of habitat corresponding, apparently, to a greater abundance of soil water. On the other hand, its limits below the mesa appear to be largely a matter of competition. The fine-grained soil of the plains is adapted to the growth of grass, which prevents the pine seeds from reaching the soil. The coarser soil of the mesas, being less favorable for a dense growth of grass, allows the pine to get a foothold in the mesa region. This explains in part the good growth of trees on the top, and especially on the rocky crests of the mesas. Extremes of temperature, which are considerably greater on the plains than on the mesas, are very likely of importance in checking the advance of this pine on the former. It is very probable that there the seedlings are killed by late frosts.

By careful comparison of the local distribution of the rock pine with the prevailing atmospheric and soil conditions it seems, therefore, that the factors determining distribution are, first of all, soil moisture, but that temperature is also potent, and that competition, where soil conditions favor other species, is distinctly a limiting influence.

It is a distinct advantage to be able, by the critical study of restricted areas to designate, as is done in the case of the deciduous trees and shrubs, the actually dominant factor by which local distribution is determined. With this satisfactorily established the next step, namely, the determination of the percentages of soil moisture which favor or admit of the growth of a particular species within a given area may be hopefully undertaken. Contributions such as these, in which, by a suitable division of labor, both the facts of local distribution and topographic, climatic, and soil conditions are determined in detail for definite areas, afford valuable and necessary data from which to draw conclusions that at present rest upon altogether too limited knowledge. It is to be hoped that such cooperative work may be greatly extended.

Wicken Fen, described in Yapp's *Sketches of Vegetation at Home and Abroad*, is the largest existing area of the once extensive "Fenland" of England, which occupied about 1,300 square miles around the Wash. The greater part is now under cultivation or much altered by drainage, and even Wicken is drained to some extent and exhibits all the features of a drying-up marsh. The vegetation of Wicken is typical marsh (*Hochmoor*) with grass-like monocotyledons—*Gramineae, Cyperaceae* and *Juncaceae*—mixed with some Dicotyledons; bog plants such as *Sphagnum*, *Eriophorum*, and *Ericaceae* are absent. A narrow reed-swamp with *Phragmites communis* as the dominant plant fringes the artificial drains; where land-formation has progressed, the general vegetation is mixed, *Cladium mariscus*, *Molinia coerulea*, *Phragmites*, being some of the dominant plants. Special attention has been given to the relation of species to soil moisture, and in a list, illustrated by a useful diagram, the author arranges the commoner marsh plants "with respect to degree of soil moisture which would seem to be the optimum;" the groups are: A. Aquatics (*Chara*, *Myriophyllum*, *Nymphaea*, etc.), B. Semi-aquatics (*Sagittaria*, *Butomus*, etc.), C. Wet-marsh plants (*Phragmites*, *Cladium*, *Menyanthes*, etc.), D. Intermediate forms (*Lastraea thelypteris*, *Iris pseudacorus*, *Ophioglossum vulgatum*, etc.), E. Dry-marsh plants (*Molinia*, *Aira caespitosa*, *Spiraea ulmaria*, etc.), F. Aliens from the dry land (*Urtica dioica*, *Ajuga reptans*, etc.). These plants tend to arrange themselves over the slight elevations and hollows of the plain, yet there is mingling, the "wet plants" frequently invading dry places, although the "dry plants" seem less capable of invading wet places. This is traced to the habit of growth of "wet plants." The rhizomes of wet-marsh plants (e. g., *Cladium*) are near the surface where water prevails, but may be found fifteen to twenty centimeters below the surface in drier soil. This and the fact that the roots tend to grow horizontally in wet conditions is shown by figures of *Cladium*, *Peucedanum palustre*, and *Lysimachia vulgaris*.

Five forest beds have been traced in the peat of the "Fenland" in the marginal parts; these indicate transition between the fen-marsh and the forest of the drier uplands. At the present time, bushes such as *Salix*, *Myrica*, *Betula*, *Rhamnus frangula*, and *Viburnum opulus* are increasing and forming thickets; the author regards this as the beginning of another forest period; the factors leading to it are increasing dryness of the fen, due partly to the growth of peat, partly to the effect of drainage. The presence of scattered *Quercus* and *Pyrus aucuparia* indicates the advent of a still drier type of forest.

W. G. SMITH, in Botanisches Centralblatt.

The Plant Geography of the Balkan Peninsula by L. Adamovic, published by the Vienna Academy, recalls the monumental industry exemplified in the massive volumes of Engler and Drude's Vegetation der Erde. According to the author the Balkan Peninsula is divided into two parts which, floristically considered, belong respectively to the Mediterranean region and that of middle Europe. The characteristic plants of middle Europe, such as the larch, heather, crowberry and many others, either disappear altogether or occur only sporadically in the Mediterranean region of the peninsula. The boundary between this and the middle European region marks the southern limit of the spruce, pine, birch, etc., and the northern limit of *Juniperus oxycedrus*, *Buxus*, *Quercus macedonica*, *Platanus orientalis* and others. Both in the Mediterranean and the middle European divisions of the peninsula eight vertical regions are distinguished, including in each case lowland, submontane, montane, subalpine and alpine floras, in addition to those not common to the two, and in each division four horizontal zones are named from adjacent geographical regions, such as the Adriatic, Hellenic, etc.

The marshalling and classifying of facts is accomplished with characteristic thoroughness, but, as in many other papers of this kind, no attempt is made to correlate facts of distribution with climatic and edaphic factors, some of which it would seem must have an obvious relation to the recorded observations. One looks eagerly for any additional thought or original views concerning the general subject, that may serve as a justification for the enormous output of facts, and finally the question arises *cui bono?* Still it is quite certain that the time has not yet been reached when hewers of wood and drawers of water can be dispensed with in such studies, and when the time comes for the realization of Schimper's ideal—impossible in his day—namely, the clear explanation of the great facts of plant distribution over the whole earth, those who come after us will doubtless appraise such collections of data at their full value.

The fourth volume of *Trees*, treating of their fruits, by the late H. Marshall Ward, has just appeared from the press. It is one of the publications of the well known Cambridge Biological Series. It is refreshing for the student of botany to come across a book having its contents stated in so clear and concise a manner as this one has. Nearly all terms that are likely to be confusing are explained as they occur, and frequently accompanied with excellent illustrations, of which the book contains a good number. The relation of the various types of fruits is discussed in the first half of the book, while the second half is given over to a classification of trees and shrubs according to their fruits and seeds. This book, which is interesting to botanists, should prove especially valuable to students of general botany and forestry, and also for the amateur. It should, therefore, find a large sale. Though one more volume of this series is yet to appear, it is very much to be regretted that the author did not live to complete this work as originally outlined. Messrs. G. P. Putnam's Sons, New York, are the authorized American publishers of this interesting volume, which costs one and one-half dollars ($1.50).

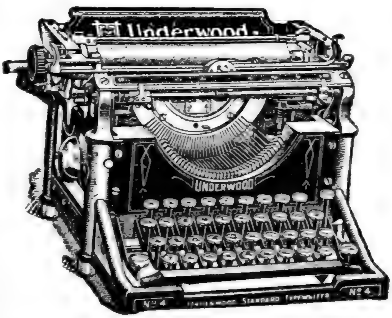
J. J. THORNBER.

NOTES AND COMMENT.

In the February number of *Torreya*, F. C. Stewart and G. T. French give interesting details and what seems ample proof of the perennial habit of *Cuscuta Epithymum*, which, taken in connection with Professor Lloyd's notes in the PLANT WORLD for February, 1908, and in the present number, suggests that this habit may prevail widely throughout the United States, and may be characteristic of more than one species of *Cuscuta*.

With regard to the clover dodder the authors state that in fields infested by it live dodder may be found readily during the winter and spring, at any time when the ground is free from snow. The hibernating threads of the parasite "appear in the form of tufts of short, stout, yellow threads, one-fourth to one-half inch long, attached to the bases of the branches close down to the ground around the crown of the host plant, and especially on the under sides of branches lying close to the ground. Yellow, haustoria-bearing threads tightly coiled around the very lowest parts of the stem are also common," but in no case was the parasite observed on the root. That the dodder thus found is alive and capable of growth was proven by placing portions of the infested hosts in a moist chamber and keeping them for some days at a suitable temperature. Under these conditions the threads of dodder lengthened promptly, and readily became established on young alfalfa plants with which they were brought in contact.

Teachers will be interested to know that James Vick's Sons have arranged to supply teachers and school children with penny packages of flower and vegetable seeds so that they may obtain at the very lowest cost material for school garden work. The arrangement as stated in their circulars is a very convenient one for the children and for teachers as well. Information may be obtained by addressing the firm at Rochester, New York.


UNDERWOOD

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Volume 12 Number 4

THE PLANT WORLD

A MAGAZINE OF GENERAL BOTANY

APRIL, 1909

OVERLAPPING HABITATS.*

BY FRANCIS E. LLOYD.

During the past few years it has become increasingly evident that very closely related species may occupy the same habitat and geographical range. That they do not inhabit exactly the same area is to be expected, and may be explained largely by the element of chance. But both in the case of closely allied species and of widely different ones, the habitats may be widely different, in part, and in part identical. That is, the habitats overlap, and here are the same in their effect upon vegetation, while different conditions prevail in the habitat areas which are not coincident. It is the purpose of this paper to present a case of this kind which came to my attention in N. Zacatecas, Mexico.

The topography of this region may be roughly described as composed of mountain ridges separated by wide valleys. The valleys, in turn, consist of alluvial flats, from which extend gravelly plains of low gradient to the foothills of the ridges. These wide, gentle slopes which are so characteristic of the deserts of this and contiguous regions may well be called foot-slopes. It will be understood that the footslope, as one nears the sierra, becomes broken into low, rounded ridges, between which lie arroyos, water-courses which are dry except during rains. These low ridges merge into the foothills and these into the main ridge of the sierra.

It is quite apparent to the observer that the vegetations of these three topographical features are different, but it is pertinent to say that some elements of the sierra vegetation are to be found through the entire extent of the hills, footslopes and flats. Others are found only in the footslopes and hills,

*Presented at the meeting of the Botanical Society of America at Baltimore, December, 1908.

and only very occasionally, if at all, in the flats. Some species which occupy the footslope are to be found in great abundance also, but in definitely restricted habitats, in the hills, and it is with reference to two plants which show this peculiarity that I wish to refer. These are the alvarda or ocotillo (*Fouquieria splendens*) and palma samandoca (*Samuella carnerosa*).

Both of these plants are practically certain to be found associated on the footslope and on the low ridges which merge into the foothills. Those familiar with the southwestern deserts will recall that the ocotillo is, like the sotol, an "edaphic" species, growing in stony ground, and this is true also of the palma samandoca, although to this general rule there are exceptions. In the higher reaches of the footslope and in the adjacent hills the soil is very stony; and, in the hills, even displaced to various degrees by the underlying rocks, outcrops of which are readily visible.

As one enters the hills by passing up an arroyo, he sees at once that the steep slopes on either hand bear different congeries of plants, and the most obvious contrast is due to the fact that, on the slopes facing toward the northeast, north, and northwest, the palma samandoca is present in numbers large enough to make it the characteristic element, while on the opposite slopes the chief element is the ocotillo. This feature of local distribution is so evident and constant that it is discoverable in photographs with the greatest ease (Figure 1). Similar differences in the vegetation of opposed slopes have been repeatedly observed in various desert regions by Coville, MacDougal, Spalding, Bray, and others, but I do not recall that the species remarked have in any instance been shown to have overlapping habitats, and it is about this point that the interest of this paper centers.

Whatever may be the cause of this condition, it appears quite probable, if not certain, that the factors which bring it about do not operate on the mature plants. This follows from the fact that on both slopes both the species in question do occur, so that the differences are to be seen in the ratios between the numbers of individuals present on the north and south slopes, and not in their entire absence from either. Indeed, we may be observing the gradual colonization of both slopes

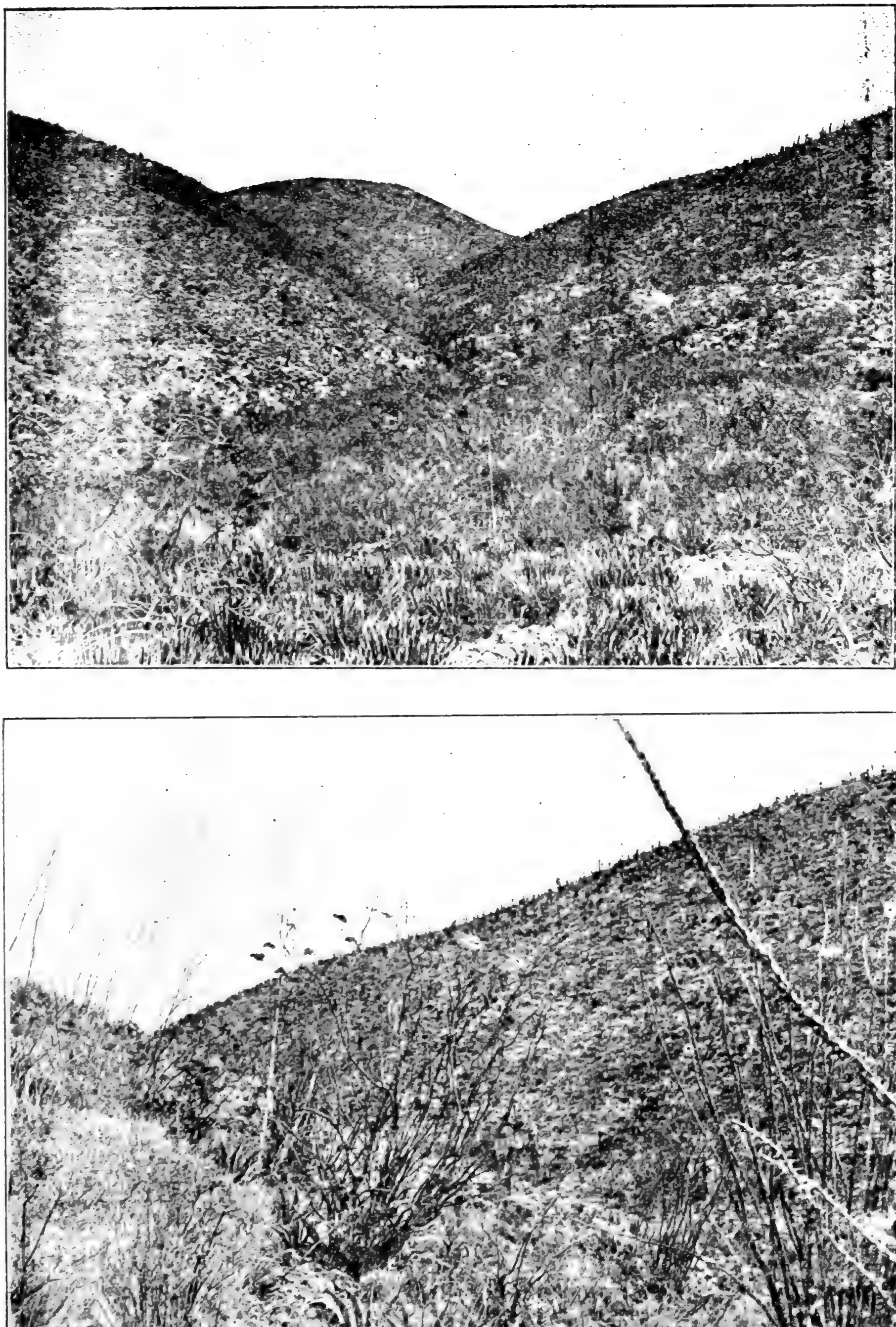

FIG. 1. View looking up an arroyo. The north-facing slope may be distinguished by the up-standing yuccas (*Samuella carnerosa*), while maguay (*Agave sp.*) ocotillo (*Fouguieria splendens*) occupy the south-faling slopes. Cedros, Zac., Mexico.

by both plants in equal numbers, and the question then may be why this colonization does not go on at the same rate on both slopes.

An answer in general terms may be given, that natural selection prevents this colonization at equal rates. Indeed, to use a now well-worn simile, it appears to the observer on the ground, that the sieve-like action of natural selection is at work at the mouth of the arroyo, the sieve meshes being so adjusted that only the one species may enter the one slope, while the other only may gain footing on the opposite slope. The figure, however, is but a figure, and it remains to offer a definite explanation of the condition described.

It is obvious that the two opposing slopes are exposed to widely different degrees of insolation, and this has been called upon in explanation of the different vegetations there found; and it has been stated or inferred that the effect is not direct, but rather indirect, in the effect upon the moisture conditions. But the soil moisture on both slopes is, in the case before us, sufficient for both the species in mature state. It would therefore seem necessary to push the analysis one step farther and suppose that selection is effective only on the seedlings. The same suggestion has been made by Ganong * *a propos* of certain peculiarities of distribution of trees upon the Miscou sandplains. And it is now understood, since the work of Livingston (*Pub. No. 50, Carnegie Institution of Washington*), that the seeds of desert plants do not show any indifference to water supply, and observation has shown that periods of germination in the desert are those during which moisture is abundant. It seems likely, however, that germinating seedlings show considerable differences in the rate at which resistance to drought is acquired, some becoming quickly succulent, or otherwise resistant, while others show little or no capacity in this regard above that of mesophytes. We can easily see, therefore, that the length of the season in the desert during which mesophytic conditions prevail will have a selective effect upon the vegetation, a sporadically short period serving to eliminate the kinds with a long term of non-resistance for the time being, and, in deserts in

*Bot. Gaz. **43**: 341-344, 1907.

which the rainfall is very low, and the mesophytic period constantly brief, altogether.

Now the two slopes, one facing the north and the other the south, are analogous to two deserts, with a long and with a short mesophytic period. We may assume that they receive the same rainfall, as indeed they do. Under the conditions of insolation, however, the same rainfall does not produce mesophytic periods of the same length. The higher temperature and consequent evaporation rate on the south slope reduces more quickly the superficial soil moisture, while at the same time the isobar of vapor tension is nearer to the surface of the soil. The relatively thin blanket of vapor thus produced does not serve to effectually protect the young seedling, which on the the north slope finds far more congenial conditions sustained for a longer period. This view is supported by the character of the other plants which occur on the two slopes. On the north slope are to be found algae, mosses, liverworts, the prothallia of ferns and selaginallas (2 species) and their delicate young sporophytes in abundance, which are absent almost entirely from the south slope. The vegetation of the south slope, on the other hand, is made up very largely of succulents, *Agave lecheguilla*, *Hectia* sp., *Jatropha*, Candelilla (*Euphorbia antisyphilitica*), large cacti (*Biznaga burra* and *colorada*) and the like, plants which may occur, but in much less number, on the opposite slope, where palma samandoca, low shrubs and ferns are dominant.

On the adjacent footslopes the conditions are intermediate between those of the north and south slopes, being somewhat less rigorous than on the south slope and somewhat more so than on the north slope. As a consequence, we find that, while there is here an intermingling of types, among which are ocotillo and palma samandoca, others (some succulents of the south slope and the ferns of the north slope) are absent. Assuming the adequacy of our explanation, the footslope is a desert where the conditions are so balanced as to bring together forms which may be separated by a small departure toward greater or less severity. As a corollary we can see that a slight change in climatic conditions toward greater dryness would result in eliminating the palma samandoca from the footslopes.

There is, however, a certain difficulty involved in the above explanation, which must not be minimized. Why do not the supposedly more resistant plants of the south slope avail themselves, equally with those of the north slope, of the favorable conditions for germination? If the case is as has been stated, we should rather expect that the vegetation of the north slope would be composed of all the plants of the locality, while that of the south slope would consist of the types with quickly resistant seedlings. The answer may very well be that the course of events is bringing this about, and that we are beholding a stage in the process, and this view receives support from the fact that, as above stated, the species are not confined entirely to their apparently appropriate slope, and, further, my notes indicate that more south slope plants are found on the north slope, than north slope plants on the south slope, though this statement needs verification. It is not without significance that, at elevations above the zone in which the ocotillo occurs, the palma samandoca passes to the south slope, where, at the elevation of 8,000 feet the conditions appear to approach those of the north slope at lower levèls. It is not, however, unlikely that some of the plants of the south slope find that the soil moisture of the north slope, meagre as it may be, is above their optimum. Per contra, some succulents (certain cacti) are to be found in habitats where soil moisture is relatively abundant. And it must not be forgotten that competition between individuals is not a negligible factor in the region in question, where the ground is normally quite crowded with perennial vegetation, and this, it appears probable, must enter into a final analysis of the situation. For the present the problem here stated serves to emphasize the necessity of exact observations of the moisture conditions of both the soil and of the atmosphere, and of the further desirability of correlating such observations with the peculiarities of the life histories of each particular plant in question. It is not going too far to say that, in the final analysis, the problem of the desert may be understood only when the physiological peculiarities of each plant have been thoroughly studied.

Alabama Polytechnic Institute.

THE PLANT SOCIETIES OF MONTEREY PENINSULA.

By H. B. HUMPHREY.

Perhaps no locality of equal area within the confines of California holds more of interest to the student of plant distribution than does Monterey Peninsula with its rock-bound and storm-beaten coast, its dunes, its wooded hills, and open level meadows. The coastline of California is, comparatively speaking, quite regular, though to the north and south of Monterey Bay occur a considerable number of peninsulas, all of them interesting from the view-point of the botanist or the zoologist, but none of them seeming to combine so great a variety of conditions affecting growth and distribution as characterizes the region about old Monterey.

In another number of the PLANT WORLD * the writer has, in a general way, dealt with the marine life along the shores of Monterey Bay, and has pointed to the fact that so far as concerns the marine plants and animals of the region, the waters of Monterey Bay seem to supply those conditions necessary to such forms as are peculiar to parts of the coast far to the north as well as south. To a certain extent the same is true concerning the environmental factors that play upon land plants peculiar to the peninsula; though of course one meets here a greater range of variability affecting distribution than is ever true of the bathymetrical zones of the bay.

Monterey Peninsula very naturally falls into six plant zones or formations, which, in the order of their proximity to each other are about as follows: The shore formation, sand-dunes, low-lying meadows, pine and cypress forest, chaparral, and the bald, wind-swept hills.

In each formation one finds a few or many species that appear to be more or less characteristic of this or that particular zone. For example, much of the shore-line from about the eastern limit of Pacific Grove, around the peninsula to the mouth of the Carmel River is characterized by its rugged granitic fringe of sea-worn rock, projecting well out into the sea, and subject to the ceaseless pounding of the waves. The erosive action of heavy winter storms, even upon the most exposed and uninviting of these granite prominences, has laid down sufficient

*The Plant World, X: 245, 1907

detritus to afford an abiding place for a few plants that seem particularly adapted to such an environment, exposed as it is to all the vicissitudes of a near-marine life.

Here, to be more specific, one may observe a fairly luxuriant growth of such plants as *Dudleya* and *Mesembryanthemum*, with their remarkably succulent leaves so well adapted to life under such extreme conditions of moisture supply. Associated with *Dudleya* one commonly finds growing in equal luxuriance the sea-daisy, *Erigeron glaucus*, and *Eriogonum latifolium*, a member of the buckwheat family, and a plant peculiarly fitted to such a habitat owing to its markedly xerophytic leaf characters.

On these same uninviting rocks and associated with the above-named forms are to be found *Astragalus Menziesii*, scattered specimens of *Lupinus arboreus*, and that unwelcome plebeian, *Rhus diversiloba*, which in such an environment appears as a low, rather compact shrub with its leaves noticeably thicker than those belonging to plants of the same species confined to the protecting shelter of the pine forest. Other plants that have adapted themselves to the conditions peculiar to the shore zone are two species of *Tissa*, *T. Clevelandi* and *T. macrotheca scariosa*, *Castilleja parviflora*, *Orthocarpus erianthus*, *Plantago maritima*, *Eriophyllum staechadifolium*, *Distichlis maritima*, or salt grass, known to occur throughout California, but most commonly found near the sea, and usually indicative of the presence of brackish water.

So far as concerns the flora of Monterey Peninsula, the plants that seem to be peculiarly characteristic of the rocks along shore are one species of *Dudleya*, *Erigeron glaucus*, *Mesembryanthemum aequilaterale*, and *Eriogonum latifolium*. While these species are not strictly confined to the exposed rocks, one rarely finds them wandering very far away from shore. They have become so nicely adapted to their trying environment as to develop but poorly or not at all in company with those plants that so characterize the moist, low-lying meadows, even though these border, as they frequently do, along the shore zone.

The typical rock-loving plants must comprise such as are truly xerophytic and capable of thriving in a soil void of nitrogen, and over which there plays almost constantly the salt laden spray of the ocean.

If we consider the various plant zones in their logical order, the one following naturally upon the rock formation is that of the sand-dunes. These dunes of the Monterey Peninsula occur at three different points, marking the position of the beaches of varying extent, and in each case limited on the leeward side by the pine forest that extends over the greater part of the peninsula. The plants that constitute the sand-dune flora, like those peculiar to the rock formation, must be able to thrive in soil poor in nitrogen and in organic detritus. They must also be able to adjust themselves to very material changes resulting from severe winds and torrential rains. Not infrequently, too, during heavy storms at sea, the atmosphere sweeping in over a sand-dune is charged with ocean spray, and such plants as do not take kindly to a suffusion of brine are not likely to find a congenial place in sand-dune society.

Those species that may be regarded as typical dune plants are not numerous; but associated with them are several plants found among the pines, along the ocean shore, or even certain species that commonly occur in the chaparral formation. The species characteristic of the sand-dunes include two species of the sand verbena, *Abronia latifolia* and *A. umbellata*, the sea fig, *Mesembryanthemum aequilaterale*, *Franseria bipinnatifida*, *Œnothera cheiranthifolia*, *Convolvulus soldanella*, *Corethrogyne filaginifolia leucophylla*.

Aside from such plants as typify sand-dune vegetation are many species of mesophytes that after repeated generations have developed along xerophytic lines until they are thoroughly capable of maintaining themselves under conditions quite inimical to the same species in a normal mesophytic environment. This has been made possible in part by the gradual modification of organs, principally the leaves, sometimes by a marked reduction in leaf surface, or by the excessive growth of protective hairs, and in some cases through the adoption of a prostrate or procumbent habit, as in the case of *Œnothera cheiranthifolia* and in *Corethrogyne filaginifolia leucophylla*. Many, if not all, sand-dune plants develop strikingly extensive root systems, this being particularly true of *Abronia*. The roots of such plants must serve not only as absorptive organs, but they must effectively anchor their possessors to an ever-shifting substratum. On examination it will be found that many of the dunes consist largely of a plexus of roots that by continued growth and extensive ramification have become effective sand-binding agents.

In passing over the sand-dune zone one is impressed with the fact that it comprises dunes of differing ages, some being of comparatively recent formation, while others are evidently many years old. On examination the observer will note that the more recent dunes are peopled with but few species, and these consist of such plants as possess ample root systems of great vigor and hardiness. These pioneers prepare the way for new migrants, plants that are quite unable to take possession of the sand without the assistance of shelter and such forms as *Abronia*, *Franseria*, *Œnothera cheiranthifolia*, and other typical sand-dune species.

Not uncommonly one may find the older dunes supporting a flora containing among the hardier types such mesophytes as *Eschscholtzia*, *Diplacus*, and *Mimulus*, plants that in themselves are quite unfitted to such a habitat, and are best able to maintain themselves only after having undergone such modification of structure and organs as to enable them to mature seed in spite of new and trying conditions. Of course, such mesophytes as are least adaptable, and such as do not receive sufficient protection during their incipiency succumb; leaving behind those that have been fortunate in shelter, and those best suited to meet the requirements of such an environment. In this way among others, we may account for the presence of many plants that combine with the typical possessors of the sand hills to produce a sand-dune society.

EFFECT OF ILLUMINATING GAS AND ITS CONSTITUENTS UPON FLOWERING CARNATIONS.

BY W. M. CROCKER AND LEE I. KNIGHT.

It is quite commonly asserted that plants do poorly in houses lighted with gas and that the flowering especially is interfered with. Various inquiries have come to us from carnation growers as to the effect of illuminating gas upon the flowering carnation. These growers claimed to have had heavy losses from gas that seeped from defective pipes through the ground into greenhouses. In some cases it is claimed that the losses occurred during cold weather, when little ventilation was possible and when the ground was frozen, so that upward diffusion from the defective pipes was hindered and thereby lateral diffusion fostered. In all cases it is claimed that the injuries ceased with the repair or removal of pipes.

Various workers have found leaks in gas pipes very injurious to nearby trees. Neljubow found that it produced a peculiar nutation in pea seedlings, especially those grown in darkness. He farther determined that a number of the constituents were rather toxic and that very low concentrations of these constituents (especially ethylene) were effective in producing these nutations.

It is found, however, that no accurate determinations have been made upon the effects of illuminating gas and its constituents upon flowers, and that in no case have the toxic limits and the relative toxicity of the several main constituents been determined. In short, it is not known in any case whether the toxic limit of the gas is determined by the action of one constituent or by the combined action of several. To answer these questions is the purpose of the investigation here reported.

A number of experiments were run to determine the toxic limits of methane, carbon monoxid, acetylene, hydrogen, carbon bisulfid, and benzene to the buds and flowers. As would be expected, hydrogen was perfectly neutral when it completely displaced the nitrogen of the air. In all the other constituents here mentioned, the toxicity was such that in the least amount of illuminating gas necessary to kill the bud no one is concentrated enough to reach one-fiftieth of its toxic limit. It is very probable, therefore, that these constituents play no part in determining the toxic limit of illuminating gas. The absorption of hydrogen sulfid and sulfur dioxid does not modify the toxicity of the gas. This leaves, then, ethylene, the higher homologues of ethylene and acetylene, and certain aromatic sulfur compounds to account for the toxicity of the gas. All these substances except ethylene exist in very small percentages in illuminating gas. All evidence in the following experiments also points to the conclusion that there is enough ethylene in the gas to account for its toxicity. The exposure of potted plants to rather low concentrations of gas in a small greenhouse showed that the vegetation is far more resistant than the buds or flowers, and that the very young buds and those showing color are far more injured than the buds of medium age.

Our experiments in which the individual buds were enclosed and exposed to illuminating gas began with liter flasks in which as much as 25cc. of gas was used. The time of exposure was usually three days, starting when the petals were just beginning to show. A gradual reduction of the concentration by reducing the amount of gas used and by increasing the size of the enclosure finally located the toxic limit. The highest concentration did no apparent injury to the vegetation; but the effect upon the buds was made apparent by a failure to open, by a discoloration and withering of the petals, and by the projection of the stigmas. When using 1cc. of illuminating gas to 20,000 cc., the stigmas still project as shown in Figure *2a*. The use of 0.5 cc. of illuminating gas did not sufficiently retard the growth of the petals to cause projection of the stigmas, yet the buds never opened farther than shown in Fig. 3, although the petals remained fresh for several days. Very young buds were also exposed to the last concentration of the gas (1 part in 40,000 or 0.0025 per cent.) for a period of three days. The injury was not apparent at first, and the buds remained green for several days, but finally turned brown and withered.

A series of exposures was also made upon the open flowers. We selected for this work those that had just opened,in order to be sure that any change produced was due to the toxicity of the gas rather than to the natural death of the flower. Here as well as in all other experiments checks were kept. Fig. 4*a* shows a flower before being corked in a 20-liter carboy; Fig. 4*b*, the same after being corked in a 20-liter carboy (containing air only) for twenty-four hours; Fig. 4*c*, a flower before being corked in a 20-liter carboy and Fig. 4*d*, the

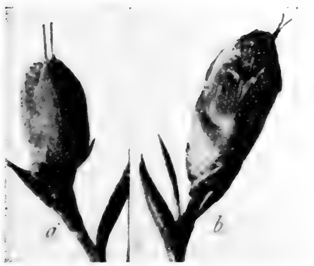

FIG. 2.—*a*, result of treating a bub, just beginning to show the petals, for three days with 1 part of illuminating gas in 20,000; b, result of the treatment of a simllar bud, for the same length of time, with 1 part of ethylene in 500,000.

FIG. 3.—Result of treating a bud, just beginning to show the petals, for three days with 1 part of ethylene in 1,000,000.

FIG. 4.—a, a flower that has just opened; b, the same after being corked in a 20-liter flask of air for 24 hours; c, a flower that has just opened; d, the same after being exposed 12 hours to 1 part of illuminating gas in 40,000; e, result of treating a flower that just opened for 12 hours with 1 part of ethylene in 2,000,000.

same after being corked in twelve hours with 0.5 cc. of illuminating gas. This shows that 0.5 cc. of illuminating gas per 20,000 (1 part in 40,000) causes the complete closing of the flower in twelve hours or less. Higher concentration caused a more rapid closing and a marked inrolling of the petals. Even 0.2 cc. per 20,000 causes considerable closing in twelve hours, though not as marked as 0.5 cc.

The effect of duration of exposure was also tested. No injury was done to a bud just ready to open upon one day's exposure to 2 cc. of gas per 20,000 (four times killing concentration for three days' exposure). On a similar bud 5 cc. for one day was considerably more injurious than 0.5 cc. for three days. The stigmas did not project, but the petals were markedly discolored. During the entire period of experimentation there was no very marked variation in the toxicity of the gas used.

The experiments with ethylene were begun by exposing buds just begining to show the petals to 1, 1-2, 1-4, 1-8, and 1-16 cc. of ethylene in 20 liters. In each of these concentrations the buds were killed on three days' exposure. The usual signs of gas poisoning were noted; petals turned yellow and withered, and the stigmas projected. Since it was evident that these concentrations were far above the toxic limit, we resorted to the use of a 2 per cent. mixture of ethylene with air. Various amounts of this were used, until the toxic limits were definitely located. With 2 cc. of this 2 per cent.mixture in 20,000 (1 part in 500,000), the results were similar to that obtained with 1 cc. of gas per 20,000 (1 part in 20,000). In Fig. *2a* is a bud, just showing the petals, exposed to this concentration of ethylene for three days. Also 1 cc. of 2 per cent. ethylene per 20,000 (1 part in 1,000,000) gives results similar to that shown by 0.5 cc. of illuminating gas per 20,000 (1 part in 40,000). The growth of the petals is not sufficiently retarded to make the stigmas conspicuous; the petals remain fresh for several days but never open farther. Where much less than 1 cc. of 2 per cent. ethylene per 20,000 was used with similar buds, three days' exposure did not prevent their opening.

When open flowers were exposed to the ethylene, it was found that 0.5 cc. of the 2 per cent. mixture in 20,000 (i. e., 1 part in 2,000,000) caused the closing within twelve hours. The result of such an experiment is shown in Fig. 4*e*.

It is seen from the data given above that ethylene must form from 2 to 4 per cent. of illuminating gas to be the constituent that determines the toxicity of the latter. It becomes necessary now to get an estimate of the fraction of the illuminating gas used that is ethylene. This was done by passing large volumes of gas through bromine water, washing and drying the resulting oils, and fractionating for ethylene dibromide. In determinations for volumes of gas ranging from 128 to 208 liters the results showed 2.9 to 3.2 per cent. of ethylene.

It is of great interest to know that the most delicate chemical test for illuminating gas in the atmosphere falls far short of detecting amounts that work havoc with the flowers of the carnation. The tests for carbon monoxid are those used for detecting illuminating gas. The most delicate application of the blood test will detect 1 part of carbon monoxid per 40,000. The iodine pentoxid test is of equal delicacy. If carbon monoxid forms 25 per cent. of illuminating gas, these tests will detect 1 part of illuminating gas in 10,000. Upon three days' exposure 1 part of illuminating gas in 40,000 kills the young buds and the petals of the flowers just beginning to open; while 1 part in 80,000 causes open flowers to close upon an exposure of twelve hours.

The so-called "sleep" or closing of the carnation is a source of considerable loss to growers and dealers, for flowers that once close never open again. This "sleep" is especially likely to occur with cut flowers brought into city markets. Some varieties are so disposed to react in this way that their cultivation has almost entirely ceased. We know several homes lighted with gas where cut carnations can be kept only a few hours without "going to sleep." In one instance the displacement of gas lights with electric lights entirely overcame this difficulty. Our experiments show clearly that one cause of this sleep is traces of illuminating gas (ethylene) in the surrounding atmosphere.

Various investigators have shown that illuminating gas diffuses great distances through the soil, especially if there is a hard-packed or frozen crust over the top. This paper shows the extreme sensitiveness of the carnation to this substance. From these facts it is evident that carnation growers whose greenhouses are in the region of gas pipes must take great precautions against losses from this source. It would be interesting to know whether solid cement walls set into the ground for some depth on the side next the pipes would furnish sufficient protection against leaks of this kind. It is clear that, if (as our results would seem to indicate) the group of illuminants, or, more accurately, if one constituent of this group (ethylene) determines the toxicity of illuminating gas, coal gas is considerably less toxic than water gas, while oil gas is more toxic than either of the others; also the toxicity reported by the German investigators who used coal gas is less than that shown by the gas of the great American cities.

While it seems probable that the limit of toxicity of illuminating gas on the flower of the carnation is determined by the ethylene it contains, it does not follow that such is the case with all parts of the plant or even with the flowers of all plants. It would be interesting to know the effects and toxic limits of illuminating gas and its constituents upon various double as well as single flowers. Similar data for the foliage of various plants such as Coleus, which is supposed to be especially sensitive to illuminating gas, would likewise be of great interest.

During the winter months when the windows are closed we have always been unable to cause plants to flower in our greenhouse over the botany building. Thinking escaping illuminating gas might be the cause, chemical tests were made for it, but never showed its presence. In the face of the results given above, chemical tests are of course entirely worthless. Such data as are given here show the extreme care that must be taken in ordinary laboratories to avoid the vitiating effects of noxious gases. We expect to carry out a series of experiments with all the common gases of the laboratory, determining the nature and degree of effects upon this very sensitive organ. Such a study ought to show the gases to be feared most in connection with a study of plant responses.

Hull Botanical Laboratory, University of Chicago.

BOOKS AND CURRENT LITERATURE.

The *"Spineless" Prickly Pears*, by David Griffiths, * is a timely account of the so-called spineless cacti, some of which are being exploited in a commercial way at the present time. The paper will render a much needed service by giving, as it does, the facts, as far as they have been established up to date, the more important of which are here reproduced.

Since 1904 the Bureau of Plant Industry has made a systematic effort to secure all information available on this subject, and from all sources about twenty-five species or varieties of spineless cacti have been introduced, ten or twelve of which are sufficiently promising to warrant their being sent out to growers who are interested. In all of these the spines are so unimportant that they can be easily handled and stock can eat them without singeing. They have been neither bred nor selected, have been subjected to no horticultural manipulations whatever, and similar plants may be secured by anyone in the same localities where these were obtained. The Department of Agriculture has simply imported the stock and cultivated it, and now, in the spring of 1909, has for distribution about 7,000 to 9,000 cuttings which will be sent in the order of application, to those who wish to try them. None will be distributed, however, outside of the territory indicated on the accompanying map as adapted to the growth of these plants. Beyond the areas thus marked there is reason to believe that winter temperatures will render their cultivation hazardous and success improbable.

The origin of spineless cacti, though they are supposed by many to have been called into being within the last few years, is involved in as much obscurity as that of our common cultivated wheat, barley, apples and other long cultivated grains and fruits. There is good reason to believe that they came originally from America, and were not known to civilized nations previous to its discovery. Precisely how they originated nobody can tell with certainty, but it may be assumed that they are the result of both conscious and unconscious selection carried on through many generations, quite likely since long before the voyage of Columbus. Mexico is the most important prickly

*Bull. No. 140 Pl. Ind., U. S. Dept. Agr. 1909.

pear country of the world and its population has obtained a portion of its sustenance from this crop since the earliest tribal times. The Mexicans appreciate and take pride in the spineless forms, and, though ignorant of the laws of plant breeding, have very likely made slight improvements in these plants, whatever advantage they may have gained from time to time being held by vegetative propagation, which is universally practiced.

It has been assumed by some that the improvements of spineless forms were made in the Mediterranean region of Europe.

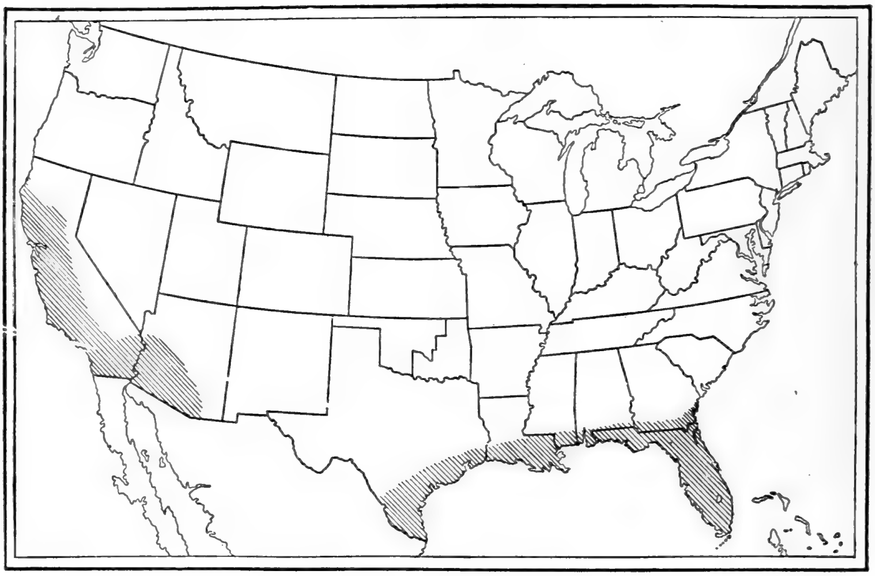

FIG. 5.—Map of the United States, showing the areas (shaded) where "spineless" prickly pears may be grown. The minimum winter temperatures will prevent their growth outside of the shaded areas. Reproduced by courtesy of the Bureau of Plant Industry.

This assumption is probably based on the fact that the plants are more numerous there now than elsewhere in the world. It seems doubtful, however, whether this assumption expresses more than a partial truth, for there is an abundance of forms today, scattered all over Mexico, which are just as spineless as any that grow, and apparently they are identical with the Mediterranean forms. It is quite possible that the spineless forms were taken to Europe from Mexico and South America in much the same condition as they are grown there today, though importations of spineless forms from Mexico and Southern Europe have not been studied thoroughly enough, as yet, to warrant an opinion as to their identity. The varieties commonly found in the United States are few in number compared with those of other warm regions. Those imported by the Bureau of Plant Industry during the past five years have come from Mexico; the Mediterranean region of Europe, Asia, and Africa; the Ha-

FIG. 6.—A "spineless" prickly pear of a kind commonly grown in Arizona and California. One-third to one-half of the fruits have been picked off. Reproduced by courtesy of the Bureau of Plant Industry.

waiian Islands; and from some South American countries. There are forms grown commonly in South Africa and in Australia and some of the Pacific Islands. It is believed that there are not less than thirty species and varieties, belonging to the two genera Opuntia and Nopalea, which have an agricultural value. The small, technically spineless but spiculated forms, of no economic value, are not considered in this list; only those which are rapid in growth and become large plants are here taken into account.

A good prickly pear of any kind must be, first of all, a rapid grower; this is the all-important consideration. The chemical composition of the plant may be left entirely out of account. for the rapid-growing spineless forms do not differ enough in composition to make it worth while to consider that feature. The permanency of the spineless character is of much importance,

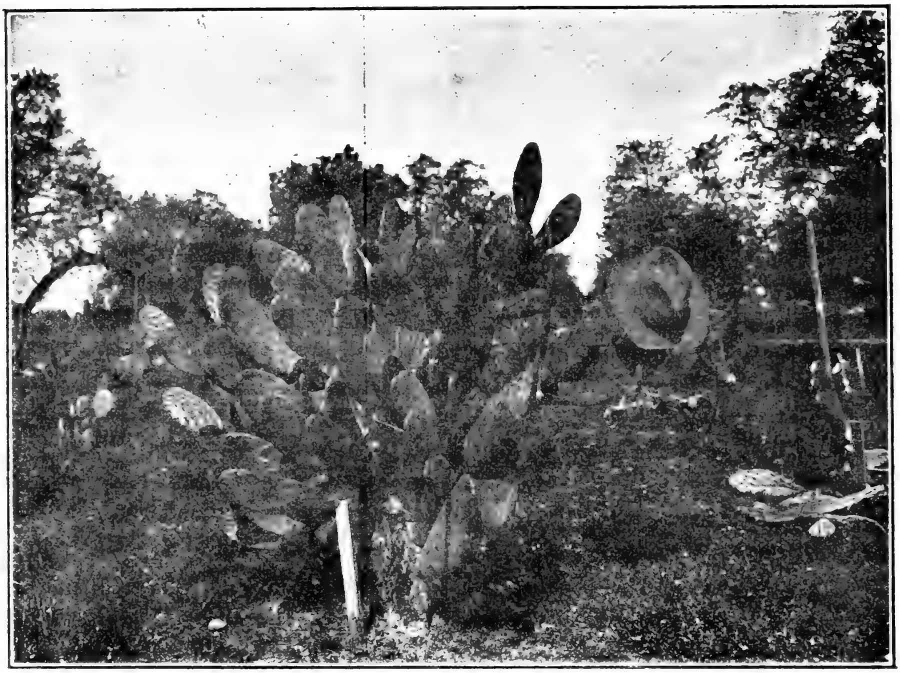

FIG. 7.—A young plant of a yellow-fruited "spineless" and seedless species of prickly pear from the Island of Malta. Reproduced by courtesy of the Bureau of Plant Industry.

and since all "spineless" prickly pears are more or less spiny, it is to be expected that under certain conditions they will become more so. From investigations thus far conducted it seems that hard, unfavorable conditions, such as alkalinity of the soil, extreme heat, drouth, and possibly low temperatures, contribute to increase the spines of the nearly smooth opuntias. But while this is true, observations thus far made do not indicate that there is any probability that the spines or spicules will increase until these prickly pears will require singeing before cattle can eat them, so that this feature can be left out of consideration from an economic point of view, though it involves principles of great scientific interest.

It is essential to remember that these plants cannot be put out to shift for themselves; they must be farmed like any other crop,though, owing to their resistance, they permit more latitude in their treatment than most other plants. The map, Fig. 5, shows in a graphic way where spineless cacti, according to present knowledge, are adapted to grow. There is no doubt, however, that in time they may be bred to withstand a greater degree of cold, thus extending somewhat the area within which they may profitably be grown. The prickly pear plants, as they now exist, are adapted to a region having considerable rainfall, but too irregularly distributed for ordinary crops. They must have water to grow and considerable of it. They are the camels of the vegetable world. They must have water, but they can get along for long periods without it. What is most needed in the spineless prickly pears today is greater hardiness, but this quality cannot be bred into them in two or three years. It might be possible, by careful breeding and selection, in a decade or more to increase the hardiness of the rapid-growing prickly pears so as to withstand a temperature of somewhere about zero, instead of 20° or 25° F., which are the limiting temperatures now, and this would push the limit of their cultivation to the northward very materially. But this will take much patient toil and many years of experimentation.

There are two ways of attacking the problem. One may depend upon selection alone. To gain hardiness by this method one would be obliged to discard the present spineless species entirely and work with the hardy spiny natives, for it cannot be expected that the spineless forms can be so improved within themselves as to withstand 25 degrees more of cold than they do now. The other way is to hybridize the present spineless forms with some hardy plant possessing as many desirable characters as possible. It will usually be necessary to grow this hybrid to maturity, plant its seeds, and then begin a long series of selections from these so-called second generation hybrids. But it will take a season to produce the hybrid, five years more to bring this hybrid to maturity, and two or three years more to bring the seedlings of the second generation to a stage sufficiently advanced to justify selection. One is then ready, provided no accidents have happened and the species which he has selected will hybridize, to begin selection. The slight variation that occurs in vegetative propagation renders this method of improvement practically useless. The method of improvement by seed selection requires several generations of plants; but when it is remembered that cacti can be grown from seed only with difficulty and that several years are required to grow a generation to the stage of seed production, the magnitude of the task of improving cacti is easily seen. It must be remembered that neither of the parents is really spineless, even the so-called "spineless" one having some spines and a strong tendency to revert to a more spiny condition. It takes a long time to breed the spines off entirely, or even practically, but to produce a hardy rapid-growing plant should not be so difficult, provided one's conception of hardiness is not too exacting. The prediction is ventured that if any improvement is made in the hardiness of rapid-growing varieties it will be through the spiny plants and not the spineless ones.

The main work which the Bureau of Plant Industry will undertake with spineless species during the next two or three years is to test varieties which are now being propagated. Vastly more knowledge is necessary regarding these before anyone will be in a position to inaugurate breeding operations.

Spineless Cacti in the newspapers are still much in evidence. With apologies to those who believe in "things as they are," the following bit of applied science "as she is wrote" up for the trade is presented.

SPINELESS CACTUS EXPERIMENTAL CULTURE.

Specimen Plants to be Sent Out.

To secure an immediate widespread test of the value of the THORNLESS CACTUS as a Fodder Plant.

The Demand will Exceed the Supply.

Therefore if you are interested don't waste your own and our time writing us. Send your Order and a Dollar at once. The published "Field Trial Reports" will be mailed free.

Only One Plant to a Person.

And then only to those who agree to report the soil conditions, climate and results in pounds for the first year's growth.

The Western Empire.

Being ever alert to the best interests of its subscribers and readers and realizing the great value of this fodder in supporting a family cow on one-tenth the space required for alfalfa as demonstrated in this year's practical field trials and also the intense and national interest that the Luther Burbank Cactus Experiments have aroused and furthermore appreciating that this is no doubt the coming Fodder plant in many localities has secured the distribution of this season's supply of the hardy standard varieties, propogated and distributed by Mr. Burbank, with his prediction that they will yield 100 tons of cattle and poultry feed per acre.

This means enough fodder for the family cow on the rear end of a town lot.

These Plants Weigh an average of one Pound.

And costs One Dollar each, express paid. Orders will be filed in the rotation received and until the stock is exhausted.

Each Order Will Include

A two years' subscription to the Western Empire for the reason that we intend to collate and publish the actual results attained in all districts where this fodder cactus may be grown and in this way will keep all those fully informed who are assisting us in carrying on these experiments.

No use applying for more than one plant. No attention paid to such letters.

Address Cactus Culture Editor, 207 Times Block

While this kind of literature is being cheerfully circulatep throughout the United States by interested parties, it can hardly cause surprise that a puzzled and sceptical feeling, particularly on the part of people who are constitutionally conservative with regard to things American, should here and there find expression. At a recent meeting of the German Cactus Society reported in the first number of the Monatsschrift fur Kakteenkunde, January, 1909, a paper was presented on *The Plant Wizard and His Satellites*, in which a caution is given against the "charlatanical advertisements of the American Burbank, who is engaged in the breeding of new forms of a great variety of cultivated plants, the small value of whose productions, in comparison with the great sums asked, has been repeatedly pointed out. One of these productions is an *Opuntia*, which, according to Mr. Burbank, ought to be famous for opening to cultivation regions that are now lying fallow on account of sterility. Not only is it expected, being spineless, to yield an excellent fodder for cattle, but also to greatly excel *Opuntia ficus indica* in the quantity and quality of its fruits. A propagating company has acquired possession of specimens of this wonder plant, which are held at one thousand dollars each."

While the purveyors of new cacti are thus achieving fame at home and abroad, the makers of new names for old members of the same group are receiving some attention. In connection with the recent change of name of *Cereus giganteus* to *Carnegiea gigantea* rather severe animadversions are heard, and really it does seem too bad when such a good generic name as Sahuaro was right at hand and in universal use not to take it for the new monotypic genus. The dictum of a special student of any group has to be taken as final—until some other expert in the same group sets it aside—but admitting the technical right of the last systemist to make new genera according to judgment, there is nevertheless a fitness of things in the choice of names which one could wish to have regarded.

In the midst of these trials we note that another of our foreign friends, though a little dazed at the way we do things, nevertheless concludes, after turning it all over, that "cacti are worth to be taken into consideration by all botanists and botanical institutes." Let us sincerely hope that a period of "consideration" is just before us.

Mycologia, the latest journal issued by the New York Botanical Garden, is undertaken in continuation of the work formerly done by the Journal of Mycology. It is issued bi-monthly, the first number bearing date of January, 1909. As stated editorially and indicated by numbers that have thus far appeared, the main features of the new journal will be, first, technical articles of value to investigators in mycology; second, popular articles of value to the fungus-loving public; third, illustrations, many of them in natural colors; fourth, news and notes. The staff, headed by Dr. W. A. Murrill, includes names well known in the annals of American mycology, and it is stated that a number of famous mycologists have been engaged to assist by suggestion or otherwise in the management of the journal.

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The Plant World

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MAY, 1909

DARWINISM AND EXPERIMENTATION IN BOTANY.*

By D. T. MacDougal.

The comprehensive essays upon the work of Charles Darwin which have appeared in connection with the observances of the present centenary make unnecessary any extended historical treatment on the present occasion, since the details of his activities, the development of his theories and explanations, and the influence of his conclusions, considered from the most widely separated view points, have been brought before us so plainly analyzed by a score of skilled writers, and with the principal features made so obvious, that the emphasis of repetition is not needed. The agreement is unanimous as to the tremendous effect of his conclusions upon almost every phase of human thought from astronomy and art to philosophy and zoology.

Numerous as are the contributions that have been made as to the various aspects of Darwin's work, there yet remain certain features which will repay closer examination, and these it is proposed to discuss in connection with the subject of botany.

A survey of the present day activities in any field of natural science would afford but meager data by the aid of which the actual trend of biological thought might be recognized, the most efficient methods of advance be determined, or research effort directed with certainty to the exploitation of the phenomena of living things offering the most immediate promise of widening knowledge. Conceptions of this character may be gained only by the alignment in perspective of past achievements, or by noting landmarks along the devious way followed in the trial and error method by which practically all we know has been acquired.

It will be profitable, therefore, to focus attention upon the particular phase of development of biological science character-

*Lecture delivered at Columbia University, March 19, 1909.

ized by the establishment of the theory of descent and the full presentation of the inclusive generalizations of Darwin, especially with regard to natural selection, since the period in which this occurred was one in which a rapid and notable change in the prevailing attitude of the human mind toward natural phenomena took place. By the most cursory examination of the products of the scientific activities of the nineteenth century, it may be seen that Darwin's great exposition was in itself the foremost movement in such impending change, not only in our attitude toward nature, but also in the means to be employed in scientific inquiry of all kinds.

The establishment of the experimental, analytical method of dealing with natural phenomena by measurement, observation, test and trial may be said to have had its beginning with the work of Becher, the chemist, in 1681, from which time this mode of attack has been used almost continuously in chemistry and physics, a procedure which has placed these sciences on a much more exact basis than those included in biology. The demonstration of the circulation of the blood by Harvey about the time of Becher may be taken to represent the first experimentation in physiology, and other isolated instances might be cited up to the close of the eighteenth century. This and the opening of the last century witnessed the efforts of Senebier, Ingenhousz, DeSaussure, DeCandolle and Lamarck, but their efforts were sporadic and without direct or important consequence. The arrangement and measurement of the action of organisms under controlled conditions in order to ascertain the principles illustrated, or underlying their action, was not recognized in their time, as an efficient means of acquiring knowledge, nor indeed was experimentation acknowledged as a legitimate means of interpreting biological phenomena, a state of mind which still finds representation among naturalists, who, not having caught the full force of the current of modern thought, now and then warn us that inheritance, and evolutionary advance are not amenable to measurement and physical proof, and that the results obtained from study of the domesticated animals and of plants under culture as crops, or in gardens and plantations are of no importance, thereby lending a seventeenth century tinge to discussions of the subject, and giving rise to a situation suggestive of the brilliant retort of Charles Lamb to a critic, to the effect that he was writing for antiquity, not for posterity. Fortunately this reactionary spirit is not strongly represented, and the attitude of attempting to close any door leading to possible realization of research results, or to discredit the use of any method by which new aspects of a subject might be disclosed, has again and again been fitly rebuked by subsequent accomplishment, and never more emphatically than in evolutionary studies.

It is noteworthy that before the awakening in evolutionary studies presaged by the appearance of the "Origin of Species," and before the masterly efforts of Julius von Sachs in the organization of physiological science, Dutrochet was the only physiologist whose efforts are worthy of mention in the half century previous. Scholars were busily engaged in "interpreting the face of nature," the making of minute descriptions and the spinning out of detailed comment thereon, to the entire neglect of attempts to establish the relations between causes and effects in the phenomena of the living world.

Now simple results of observations, not in sequence, no matter whether concerned with the outline or minutiae of leaf structure, flower detail, vascular anatomy, chromatin structure, chromosome involution, seasonal activity, or geographical distribution, do not give, at first hand, results of much appreciable value; whatever importance may accrue to data thus secured, will be due to the manner in which they may be collocated. Properly carried out, this may reveal some forms of relativity and forge the link between cause and effect in certain phases of biology. This may rarely be done effectively, however, and, as long ago recognized by Agassiz, it is peculiarly subject to the danger that comes from the investigator imposing his own ideas upon nature, of making colligations of the most unrelated facts, and of wandering into speculations either unjustifiable or absurd. Inclusive, orderly and corrected results of pure observations in the hands of a master may indeed yield a rich harvest of well grounded generalizations as evinced by "The Origin of Species," and the derived theory of natural selection. The great conceptions involved were based upon twenty years of continuous labor in which every effort was made to keep an open mind as to the larger meanings of the results obtained, and this epoch-beginning work may also be taken to represent the culmination and finale of the observational method in dealing with nature, representing its highest possible realization. When the general state of biological knowledge is taken into consideration, it may be regarded as conclusive that never again will anything of comparable importance, in impulse or achievement be accomplished in this manner.

In addition to the inadequacy of observational methods for detecting causes and effects at first hand, the results obtained have the inherent weakness of being difficult to duplicate, since the would-be observer who seeks to confirm them must wait upon a concurrence of events simulating those of the original observation. In the case of the great range of facts cited by Darwin, anything like corroboration, except in a fragmentary way, was humanly impossible, the energy of a large number of interested workers being absorbed for nearly half a century in poorly rewarded attempts to verify observations cited in support of natural selection. Such duplications which might never be more than partial in their completeness under the most favorable circumstances, yielded but little in support of the main idea, and gave scant aid in the development of its more important corollaries. Neither verification nor refutation being attainable, writings on evolution during this period, in greater part, took on the form of concordances of Darwinism and of critiques upon the probable and possible meanings of passages in his writings, together with much controversial display and attenuated deduction, altogether constituting a situation which goes far to justify the position of Bateson and others, that the immediate effect of Darwinism was to stifle instead of stimulating research, a criticism levelled at Darwin but which in reality is a characterization of the lack of development of biological science. The immediate contributions of value following upon and consequent upon Darwinism consist of alternate interpretations of descent and substitute hypotheses as to orthogenesis, definiteness of variation, environic relations and mechanism of heredity produced by the more vigorous thinkers during the period following the establishment of the theory of descent.

A similar lack of immediate development is to be ascribed to the discoveries of Gregor Mendel (1866), as to alternate inheritance, which now play such an important part in studies in heredity. Mendel's experimental cultures led him to recognize that certain general principles or modes of behavior as to dominance, latency and recessivity, single comparable or antagonistic qualities prevailed when two strains were united in hybrids, and the interpretation of the phenomena involved has yielded conceptions basic to the entire subject of heredity. No benefit accrued from them, however, until they were rediscovered a quarter of a century later, largely by reason of the fact that Mendel's work was not made known to the scientific public, but it is doubtful if the promulgation of his results earlier would have been followed by any immediate advance, since they lay so entirely outside and away from the ordinary course of thought of naturalists.

Darwin's methods were so purely inductive and his conclusions were obtained so directly by interpretation of known facts, that he was averse to anything approaching the method of speculative philosophy as represented by Herbert Spencer. No greater tribute could be paid to him than to recognize that the inexorable logic of his own mental processes quickly carried him into the ways of the experimentalist, and no sooner had his interest been fastened upon certain phenomena than he began to arrange cultures, comparative trials and experiments dealing with many important problems in physiology, and bearing upon almost every phase of heredity and descent, and he assiduously set about their execution while the greater number of his followers were still engaged in a conflict of words and a maze of phrase construction. In "Animals and Plants under Domestication," "Habits and Movements of Climbing Plants," "Power of Movements in Plants," "Insectivorous Plants," "Cross- and Self-Fertilization in the Vegetable Kingdom," "Different Forms of Flowers on Plants of the same Species," and "Formation of Vegetable Mould by the Action of Earthworms" the results of some of this experimentation are given, while in "Life and Letters" it may be seen that his unexecuted plans in research touched upon almost every phase of evolutionary development suggested in the "Origin of Species."

Concluded in June Number.

THE POINT OF VIEW IN VEGETATION PROBLEMS INVOLVING CLIMATE. *

BY EDGAR N. TRANSEAU.

Perhaps the most interesting and important advance that has been made during the last decade in the study of the relation of plants to environment is in regard to the point of view. It is difficult to say just when the movement began, but it is assuredly true that it has only recently gained recognition. To a certain extent the movement has involved the substitution of the ecological for the floristic method in geographic problems involving climate. It has resulted in a general dissatisfaction with the older descriptive methods and has tended toward a better appreciation of the value of exactness both in the delineation of vegetation and the quantitative analysis of environmental complexes. The movement has further brought to our attention the necessity for investigating vegetation processes by experimental methods comparable to those by which plant processes have long been studied. As I see it, however, these are secondary phenomena attending the substitution of dynamic and genetic views of vegetation for the century-old static conception of plant distribution.

Fourteen years ago it was possible for one of the most prominent students of the North American biota to say: † "It appears, therefore, that in its broader aspects the study of the geographic distribution of life in North America is completed. The primary regions and their principal subdivisions have been mapped, the problems involved in the control of distribution have been solved, and the laws themselves have been formulated." Such a claim could have been made only for a static system, since a genetic conception of the problem necessarily involves the indefinite postponement of the approach toward a final solution.

The appearance of the classics of Warming and Schimper served to impress all with the inherent complexity of the problem. We are no longer deeply concerned with the discussion as to whether temperature or moisture is the more important geographic factor. Neither do we hope to erect a stable system

*From a paper read before the Botanical Society of America at the Baltimore meeting, December, 1908.

†Yearbook U. S. Dept. Agri. 1894, p. 214.

of geographic divisions upon either of these bases. When we recall that for North America alone not less than sixty different proposals of geographic zones and regions have been published during the last century, the futility of the point of view which disregards all but one or two climatic factors and emphasizes boundary lines, must be apparent. But we shall be still more impressed with the inadequacy of these proposals if we attempt to relate the actual distribution of plants or plant formations to these "regions."

Recently there has been a rapid increase of local ecological studies in which the successional processes of vegetation have been emphasized. These studies have apprehended to a greater or less extent the dynamics of the habitat and the plant formation. The separation of the local vegetation into stages has assumed the dominance in each of a distinct complex of environmental factors. The occurrence of distinct boundaries has neither been assumed nor insisted upon.

Local studies, however, can not lead to general conceptions of vegetation unless compared and united into larger units. This brings us to the fact that the larger units generally recognized are transcontinental zones and regions. But zones and regions are static entities. They are developed upon assumptions wholly different from those upon which the local studies have been founded. Usually, in zonal classification, temperature is recognized as all-important, and rainfall an unfortunate disturber of symmetry. Not a few are based upon phenological assumptions long since proved untenable or still awaiting experimental evidence. In other words, the succession of local plant formations which has consciously depended upon changes in the concomitant action of many soil, climatic, and historical factors, is made to fit into a larger unit whose fundamental basis is a single, or at most two, climatic factors. It is to be noted further that the problem most debated in connection with zonal arrangements is the boundary; that the term "zone" implies uniformity of structure and homogeneity of composition. But the most striking fact about the geographic distribution of individual species is their dominance in some region and their decline in importance and frequency as we depart thence in any direction. Plant formations in their distribution show the same phenomenon. Further, it appears that the optimum areas of scores and hundreds of species nearly coincide. In brief, actual plant distribution through its lack of uniformity, and homogeneity, its tendency to concentric dispersal, and the coincidence of the optimum areas of many species, seems to demand larger units in harmony with the processes, structure, composition, and origin of its components. Whether we choose to call them "centers of dispersal" is of small moment as compared with the recognition of the fact that zones and their subdivisions are not natural organizations of plants or plant formations. Of course this criticism does not refer to the use of the very convenient expression of certain spatial and temperature concepts, viz., torrid, temperate and polar zones.

The unsatisfactory character of zones as a basis for classification is felt also by students of climatology. Especially is this true of the classification of the climatic types prevailing on continents. The schemes of Hult (1892-3), Koppen (1900), Supan (1903) and Herbertson (1905) are especially interesting in this connection.* Further, the provinces pointed out by Supan for North America show a remarkable coincidence with the natural vegetation centers. If future work both on climate and plant distribution should bring these fundamentally different view points into essential agreement we should have the possibility of a completely dynamic and genetic system of vegetation and climatic units.

*Ward, R. De. C., Classification of Climates. Bull. Am. Geog. Soc. 38: 401-412, 465-477.

A SUMMER LABORATORY FOR MOUNTAIN BOTANY.*

BY FRANCIS RAMALEY AND W. W. ROBBINS.

It is not always possible to study in summer time without feeling the brain fag which comes with exertion in hot weather. The cool breezes of even our most northern cities may be lacking in July and August, and the student who spends six weeks at a summer school may wonder whether he has really gained enough in mind to compensate for the wear and tear of body. For those who would study the outdoor sciences the question is a vital one. Only the most enthusiastic devotee of nature can enjoy long field trips in the hot, moist weather of mid-summer; yet this is the only time when the teacher or the amateur botanist

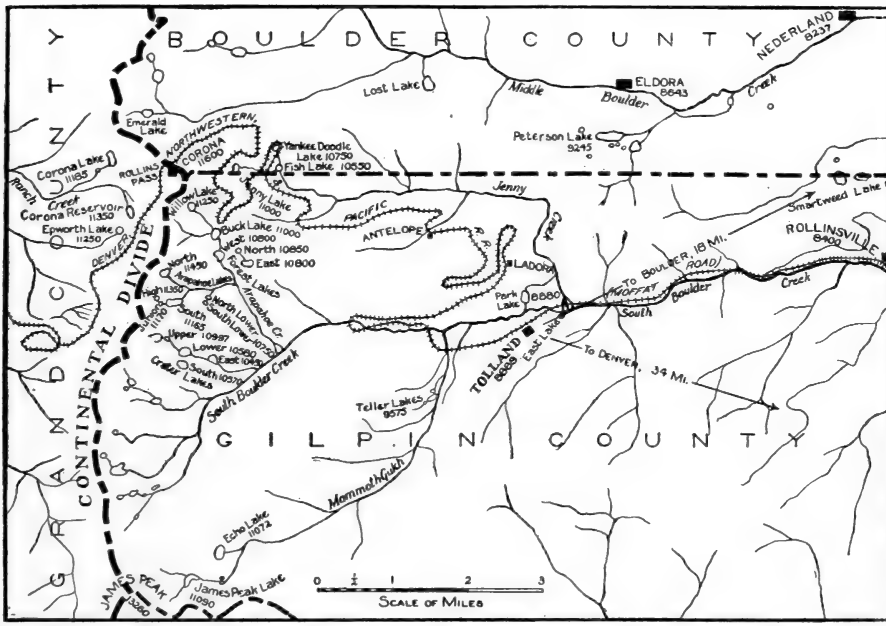

FIG. 1.—General map of the region in which the laboratory is situated. At the eastern extremity of the map is Rollinsville in the foothill region; at the western extremity the alpine regions, the Continental Divide, and the western slope; in the middle of this large botanical field is Tolland. The numerous lakes and streams at all altitudes will be noted. The altitudes in feet of the important points are given.

can get the instruction which may be needed for a better grasp of the subject.

In the Rocky Mountains of Colorado there has been established a summer laboratory for botany and zoology which promises to be useful. The Regents of the State University at

*Prepared for the Baltimore meeting of the American Association for the Advancement of Science.

Boulder, Colo., have made this an integral part of the University, and students who pursue courses in the mountain laboratory receive the same credit for work accomplished as if done in the laboratories on the campus. The six weeks' summer session of 1909 begins June 15, but the laboratory will be open through the months of June and July.

The location which has been selected is an ideal one. The place is called Tolland. It is a mountain hamlet of half a hun-

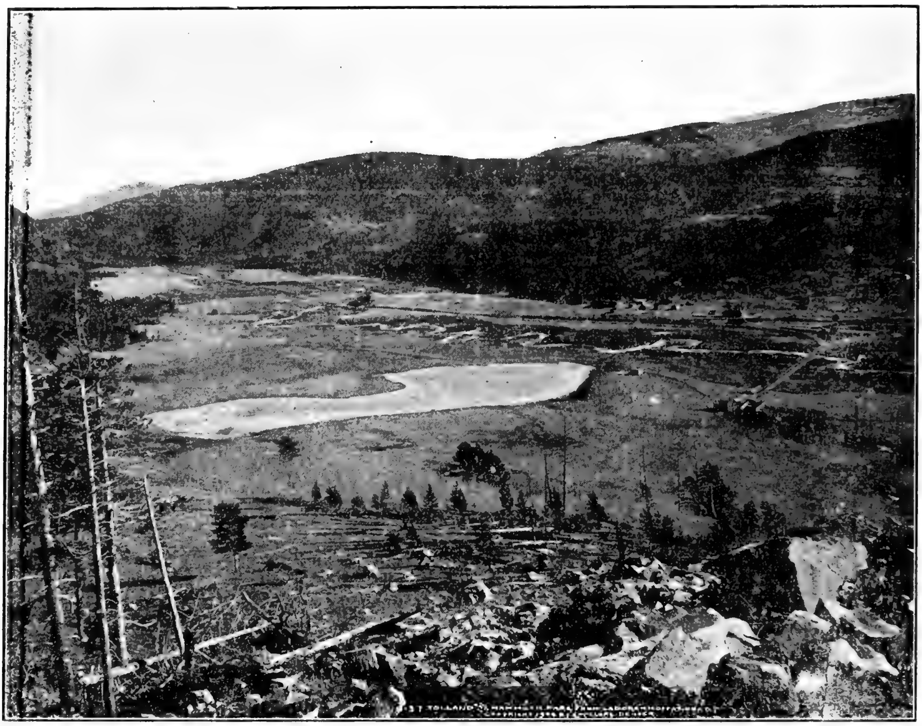

FIG. 2.—South Boulder Park. The Park is a glacial valley converted by stream erosion and in-filling into a flat, plain-like area. Morainal hummocky topography occurs toward the lower end of the valley. South Boulder Creek, which is a rushing stream a few miles west of Tolland, is here seen to be winding its way through the Park; clumps of willows border the stream. A portion of Tolland is seen at the right. The body of water is Park Lake. The hills on both sides of the valley are covered with coniferous forests.

dred houses about forty miles northwest of Denver and eighteen miles in a direct line from Boulder. The town lies nestled at the base of a high mountain in a small valley, through which flows a trout-filled stream named South Boulder Creek.

Tolland is in the center of a most interesting botanical field, the limits of which on the one side are the foothill districts, on the other the Alpine heights, with the intervening montane and sub-alpine regions, all within easy reach. At an altitude of 8,889 feet, with a mean temperature for June and July about

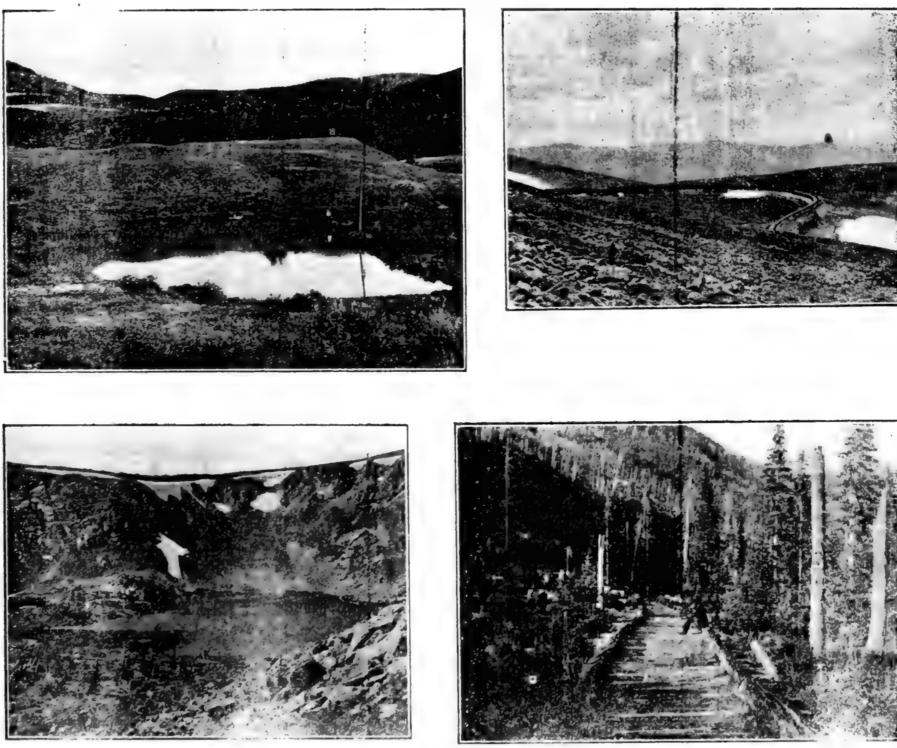

FIG. 3—East Lake (above at left). This pond is a few hundred feet east of Tolland. It is a small body of water of glacial origin; a large morainal ridge is seen back of the lake. Concentric zonation of vegetation is well shown about the margin; (above at right) Corona, a small station of the "Moffat Road" on the Continental Divide at Rollins Pass. A large snow-shed is necessary to protect from drifting snow. Here the visitor may step from the train and find himself above timber-line in an alpine region at an altitude of 11,600 feet. Excursions from the laboratory will be made to this point for the study of alpine vegetation; (below at left) Corona Lake, a deep, rock-bottom, clear-water lake at an altitude of 11,185 feet. The lake receives its water supply from the melting snow banks which are present the year round in the large rock amphitheaters surrounding the lake on three sides. Vegetation studies of this and other mountain lakes are being made by the writers. A formation herbarium has been prepared. Photograph taken in August, 1907; (below at right) South Boulder Canyon above Tolland. An old corduroy road used by lumbermen some years ago. This moist, shaded canyon is rich in herbaceous forms of mountain vegetation.

15 degrees lower than that of New York City for the same months, with plenty of warm, sunshiny days and clear, cool nights, almost ideal conditions are offered for study, both indoors and out.

While teachers in the high schools and in the grades, as well as advanced students and instructors in colleges, have ample opportunity for study at the sea coast, there has been in the past little to draw them to the mountains. The present interest in ecology, which brings so much importance to field work, has not been fully met by the seaside laboratories. The Tolland laboratory should serve those who have not been able to study in mountain districts and to whom plant geography is little more than a name.

The hot, arid plains or the alpine heights are within a few hours ride by train. All of the life zones are so compressed that one may walk from Tolland in the montane zone down the valley for three miles to a typical foothill district, or up the valley for the same distance into the sub-alpine forest. A ride of one hour by train takes the student to the plains, while an hour and a half is sufficient to reach the top of the snowy range, or Continental Divide. Either of these excursions takes the traveler to a region as different from that of Tolland as Maine is different from South Carolina; while in passing the whole distance from cactus plains to alpine tundra, there are as great changes in the plants as would be seen in a journey all the way from Louisiana to Hudson's Bay.

Whether we conceive of ecology as the study of adaptations among plants, or as a part of phytogeography, a mountain region is the place to see and to learn the most in the shortest time. For here, and here alone, are great climatic differences in the environment to be seen and studied within easy traveling distance. It is possible to learn more about plant distribution in a few days than could be learned in weeks of travel north and south in the eastern or central states.

But it is not only for the study of ecology that the Rocky Mountains excel. For plant anatomy and taxonomy they offer most alluring opportunities to the investigator or to the beginner. The plants of Colorado are not so well known that illustrated manuals picturing every species are obtainable. Hitherto undescribed forms are continually being found and the known distributional limits of species are continually being enlarged. Since almost nothing has been done with microscopic anatomy of these mountain forms the student can have the satisfaction of examining plants whose anatomical structure has never been studied before.

. In the neighborhood of Tolland are dozens of small lakes or ponds, some of which are now being used as reservoirs, but others of which furnish most beautiful examples of natural pond-side vegetation. The sub-alpine forests of spruce, fir and pine offer examples of the most important timber trees of the west. These conifers, along with the deciduous trees of stream-banks and canyon-sides can be used in the study of forest botany.

The daily routine planned for students and instructors includes a short collecting trip of half an hour soon after breakfast; work in laboratory or field until the lunch hour; after lunch some little work in pressing plants, or other desired occupation requiring little mental exertion. It is expected that many of the students who come to the laboratory will be there partly for the outing and will not care to work all day.

For those who wish to work through the day, the main business of the afternoon will be field study, except for those who wish to spend the time in microscopic study at the laboratory, or who may be working on flower photography. Each student will be able to choose to a considerable extent the kind of work which he will take up, and those wishing to carry on work by themselves will be encouraged to do so. General lectures, dealing with mountain botany from both the ecological and taxonomic standpoints, will be given in the early evening, and from time to time there will be lectures by specialists on the physiography and geology of the region, on entomology, forestry, ornithology and climatology.

A number of all-day excursions will be taken to points at lower and at higher altitudes. For these the members of the party will carry lunches and enjoy picnic fare while studying the plants of the region visited. An opportunity will be given to those who wish to ascend James' Peak and other mountains of the main range of the Rocky Mountains. If a sufficient number desire it, an excursion can be arranged to the Araphahoe Glacier, 12 miles distant, the most southern glacier in the Rocky Mountain region.

Necessary apparatus for general botany, ecology, taxonomy, nature study and general zoology will be furnished. A limited supply of botanical driers can be loaned to those wishing to make collections. Specimens of typical plants from the various zones may be collected and pressed for demonstration purposes by teachers. An abundance of useful class material for preservation in alcohol is easily obtainable. Those who use a camera can find opportunity to practise their art on general landscapes, ecological formations and on individual plants. For this work a dark room is provided, while the necessary chemicals can be obtained at reasonable prices.

It is intended that the laboratory shall be a center for botanical research* as well as for instruction. The instructors in charge will here continue their ecological studies of lakes and other interesting formations, and will be ready to indicate special lines of work in ecology and other branches likely to prove attractive to students. The botanical opportunity is almost unlimited in this virgin western country, and subjects worth investigating are found on every hand.

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Boulder, Colo.

*The student who is interested in knowing the possibilities of botanical investigation in Colorado may read an article on this subject by one of the present writers in the University of Colorado Studies, Vol. VI, pp. 5-10, Dec., 1908.

BOOKS AND CURRENT LITERATURE.

Forest Trees of the Pacific Slope by George B. Sudworth (U. S. Forest Service, 1908) is a much needed and useful work. It stands as the first volume of four which are to deal with all the native forest trees of North America north of the Mexican boundary. Part II will be devoted to the Rocky Mountain trees, Part III to the trees of the Southern states, and Part IV to the trees of the Northern states. As the work has been prepared largely for the layman, the use of technical terms has been avoided, and essential characters are plainly defined, so that one who is possessed of ordinary discrimination ought, by aid of the figures and clear descriptions, even if he has had little technical training, to be able to identify readily any tree of the Pacific Slope.

Students of distribution are under obligation to the author for detailed information regarding the local range, vertical and horizontal, by states and other geographical subdivisions, in the region occupied by each species. This no doubt was collated very largely with reference to commercial use, but it meets admirably a want that has never before been provided for, except by tedious consultation of herbaria and scattering books inaccessible for the most part except to the favored few. The notes on climatic requirements, tolerance and reproduction, add greatly to the value of the work, not only to those who may use them for practical purposes but also to students of ecological relations. The author deserves the thanks alike of foresters, lumbermen, botanists and all others who want to know about trees in plain and comprehensible language. The remaining volumes will be looked for with interest and with the expectation of similar judicious treatment.

The *Report of the Chief of the Bureau of Plant Industry*, of the U. S. Department of Agriculture for 1908 is worthy of more than passing notice. The undertakings of this branch of the public service are avowedly practical, and it has, without doubt, done more than any other agency to further the interests of agriculture and horticulture in the United States. It is, none the less, a great scientific establishment, in which are employed nearly a thousand persons, including many trained investigators, who are daily bringing to their work the latest methods and the most conscientious effort in the several lines in which they are engaged. The outcome of all this for a single year is very briefly set forth in the present report, from which a few items of special interest are selected for notice.

The investigations in dry-land arboriculture have for their object the discovery of deep-rooted or otherwise drought-resistant trees capable of yielding crops without irrigation. From observations at Casa Grande, Arizona, it appears that olive trees growing without irrigation in a locality of very limited precipitation have developed a finely branched root system, which completely occupies the surface layers of soil over a large area, ready to appropriate moisture from even the lightest rainfall. At Palm Springs, California, where the annual rainfall is only three and one-half inches, an olive plantation of twenty acres has been found which was planted in 1891, and in which the greater number of the original trees are now in vigorous condition, six years after the failure of the irrigation supply. These trees have developed the same minutely divided type of roots noted at Casa Grande, occupying the first foot of soil very completely for an area often eight or nine times that of the spread of the tops. Under these circumstances, if the trees are planted too closely, such competition for soil moisture must result as to interfere with growth that would take place were they planted farther apart. The results of this unintentional experiment, instituted years ago and now interpreted by a scientific observer, furnish important evidence regarding the competition of desert plants, which is plainly a far more prominent factor, as regards their biological relations, than has hitherto been held, and one which is of prime importance in horticultural undertakings in the semi-arid regions of the Southwest.

The investigations conducted in the Physical Laboratory include, among various other undertakings, a comprehensive study of environmental factors at different stations and the relation of these factors to the growth and yield of the principal crop plants. Such determinations are a necessity in the proper interpretation of cultivation and rotation experiments, and the observation of both normal and abnormal conditions now in progress serves to show the actual merits of the different methods employed in conserving the moisture and maintaining the fertility of the soil. The great practical importance of this work, it is needless to say, in no wise detracts from its value as a contribution to pure science, and the same obvious fact is continually impressed on one who proceeds through the report and notes the extended studies which have been made of the relations of both cultivated and native plants to their environment, the power of resistance of certain varieties to drought, cold and other injurious influences, acclimatization and the adaptation of promising plants to special conditions, the transmission of valuable characters, in short, a body of physiological, pathological and other investigations, that would be appalling but for the systematic division of labor on the part of the experienced investigators who have charge of the various laboratories and of the field experiments.

Special mention should be made of the selection and breeding of plants for some special quality, which has been carried on for a period of years. The record of successsful achievement includes the acquisition of blight- and drought-resistant varieties of vegetables and cereals, together with higher producttivity, hardiness and other specially prized qualities of various fruits and flowers, besides the careful testing of a long list of new strains of useful and ornamental plants, from corn and potatoes to chrysanthemums and Easter lilies. Wilt-resistant melons, new and promising citrus fruits, new varieties of figs, millet and alfalfa suited to dry regions, alkali-resistant sugar beets, winter oats and spelt, pure strains of durum wheat adapted to different regions, cotton of high lint index, composite breeds of corn, improved varieties of tobacco, asparagus and other crop plants, represent only a part of what is being accomplished in this remarkable application of science to the affairs of every day life. It is a matter of congratulation that, in spite of occasional ill-founded criticism, this great department of the public service has gone steadily on its way from year to year, until it stands wholly alone in the civilized world in the magnitude, variety and value of its undertakings.

Recent numbers of the Botanisches Centralblatt indicate unabated activity on the part of botanical investigators and writers, and, as usual, over so wide a field as to suggest the inquiry what limits, if any, are to be assigned to the domain of botanical science. The treatment of the subjects included under upwards of twenty different subdivisions is so various, and in some cases the notices and reviews are condensed to such a degree that it is difficult to give an adequate notion of the paper reviewed. There are, however, in nearly every number reviews of important contributions from which it seems desirable to quote, though, owing to limitations of space, this can be done with only a few out of the many that might profitably be noticed.

Heinricher, in a contribution to the Wiesner Festschrift, at Vienna, adds some new facts to his former observations on the influence of light on germination, and offers suggestions as to underlying conditions and causes. He finds that the germination of seeds of *Sarracenia flava* and *Darlingtonia californica* is distinctly favored by the action of light. In general, the seeds of the epiphytic *Rhododendron javanicum* do not germinate in darkness. This was also found to be true of several other species of Rhododendron. Seeds of *Myrmecodia echinata* sprout promptly both in light and darkness. Many species of *Veronica* germinate best in light. Those of *V. peregrina* generally start from three to ten days earlier in light than in darkness; but this interval varies with the age of the seed. Immediately after gathering, it is only three to five days, but seeds freshly gathered, dried immediately and then kept in the dark germinate in light twenty-two to twenty-five days earlier than in darkness, in which they behave as though they were not through with their period of rest.

To light is attributed a favorable influence on changes of the reserve materials, which also take place, but more slowly, in darkness. Some seeds which cannot be brought to germinate in darkness will sprout if exposed to light for some days. By way of summary, the author writes: "on the whole, the experiments indicate that with seeds the germination of which is favored by light this is conditioned by age of seeds, rapidity of drying after gathering, and probably by the method of storing, whether in light or darkness. Moisture of the air where these are stored may also have an influence. The relations are extraordinarily complicated, and consistency of results is to be expected only when all these factors are taken into consideration."

Techet, in the proceedings of the Botanical-zoological Society of Vienna, discusses the *Marine Vegetation of the Gulf of Triest.* The depth of water, character of bottom, temperature, currents and other factors likely to influence local distribution are considered, and maps accompany the text showing the position and bottom and the distribution of various plants, chiefly algae. Admitting the great difficulty of estimating definitely the influence of different factors, the author expresses the opinion that the chemical composition of the substratum is without influence on the vegetation here found, while its physical character is important. The epiphytic vegetation is more abundant in relatively shallow places, and falls off, both in species and individuals, with increased depth. The question of the reciprocal influence of epiphyte and supporting plant is left open. Variations in salinity of the water are thought to have little influence on distribution. Vertical distribution, exhibited in connection with different depths of water, is a conspicuous phenomenon. There is a manifest relation of the vegetation of the gulf to time of year. The "water spring" begins in December and January. In April and May the flora attains its maximum, after which it falls away, and in many places almost disappears.

Hayata publishes in the Journal of the College of Science of the Imperial University at Tokio an *Enumeration of the Mountain Plants of Formosa*, which occur at an altitude of from 3,000 to 13,000 feet. The floristic relationship between Formosa and neighboring countries is shown by a table, from which it appears that botanically the island has the strongest affinity to Central and Southern China and Japan; next to the Himalayas; then to the Malay Peninsula and archipelago, and to North China; and, lastly, to North America. The species the distribution of which is limited to Formosa and Japan are far more numerous than those confined to Formosa and China, and the number of genera found only in these islands is double that of such kinds in Formosa and China. The suggestion is offered that insular conditions are not the only cause of this floristic affinity, and that it may be due to a land mass or mountain chain, which by some geologists is conjectured to have existed between the islands of Formosa and Japan at an earlier geological period.

Recent investigations of Fitting on *Light Perception and Phototropic Sensitiveness* (Jahrb. f. wissenschaftl. Botanik) have modified the views on this subject based on studies of Darwin and Rothert. Having found that the growth of etiolated seedlings of various grasses is greatly retarded by exposure to light, he shows further that the degree of retardation of growth of the hypocotyl is dependent on the intensity of the light, and also on whether the whole or a part of the seedling is exposed to it. Since this retardation takes place following illumination of the cotyledon, the conclusion follows that an influence is transmitted downward to the hypocotyl. It appears, however, that a transmission of such an influence in the reverse direction does not take place, since if the lower part only of the hypocotyl is illuminated, growth of the upper part is not retarded. That the hypocotyl is itself sensitive to light, even if not phototropic, was shown by cutting off the cotyledon, after which growth was resumed in darkness but not in light. From this and other experiments, it is shown that in the several species of grasses employed a localized phototropic sensitiveness does not justify the assumption of a corresponding localization of light perception.

It is of interest to note that, after these many years of extended investigation of the phenomena of irritability in plants, there is still entire lack of agreement concerning some of the most fundamental matters. Fitting, the writer just quoted, in his studies of the transmission of stimulus, reaches the conclusion "that the view that geoperception of the root is located only in the root-tip is not proven"; while Cholodny, in a paper on distribution of geotropic sensitiveness, reaches results that "go to confirm the Darwinian theory of localization of geotropic sensitiveness in the root-tip."

Similarly the good old question of the ascending current in plants, and what causes it, still holds a place in current literature. Janse, in the Jahrb. f. wissenschaftl. Botanik, argues that molecular action, as manifested in capillarity, imbibition, and cohesion, are incapable of setting up movement of water. Transpiration from the leaves and forces at work in the roots play the principal role. These conclusions, based on a course of reasoning, recall some of the earlier discussions of the subject, and lead one to seriously raise the question as to how much real progress has yet been made in the elucidation of this difficult problem.

Wittrock, as the result of several years' investigation, has arrived at the conclusion that *Linnaea borealis* includes a large number of "elementary species," using that term in the sense in which it is employed by de Vries. Four groups, characterized primarily by the color of the corolla, but having other distinguishing marks, include respectively eighteen, thirty-four, fourteen, and seventy-four such forms, or elementary species, besides about a dozen "sub-forms." This study of what has hitherto been considered a single species, familiarly known to both European and American botanists, is well illustrated, and the different types are so clearly represented, that the facts of the case must be accepted, whatever attitude is held towards the interpretation presented by the author.

Bartonia is the appropriate title of a new botanical annual which records the proceedings of the Philadelphia Botanical Club. The first number appeared in February, 1909. The name was chosen in honor of Prof. William P. C. Barton, formerly professor of botany in the University of Pennsylvania, and author of the first local flora of Philadelphia. There is a fresh breath from field and forest in the reports of the out-door work, and an absence of the herbarium odor that sticks so persistently to some publications.

The third edition of the *Botaniker-Adressbuch*, an index to the names and addresses of living botanists of all countries, of the botanic gardens and institutes, of societies concerned in botany and of periodical publications, has appeared bearing date of 1909. It contains about 12,580 addresses, and with the ordinary advertisements makes a volume of 478 pages. This would make a fairly convenient book to handle, and there it ought to end, but to this there are added xviii + 268 pages of "Bibliographia Botanica," W. Junk, Berlin, which might more reasonably have been distributed in the usual manner of book dealers, thereby greatly improving the Adressbuch.

Elements of Physical Geography is the title of an interesting text-book by Prof. T. C. Hopkins of Syracuse University. This book is designed to meet the needs of teachers especially in secondary schools in the state of New York. The treatment is concise—although sometimes too concise where it is attempted to deal with too many subjects in small compass—and the discussion clear, so that the book will be a good one for the beginner. An important part is that dealing with plant geography, which in the main is good, though in our opinion some of the space given to special conditions and exceptional phenomena might better have been spent in a fuller treatment of more general features. A few slight inaccuracies may be noted, but the composition of the book and the number and quality of the illustrations seem to justify the prediction that it will be widely used.

NOTES AND COMMENT

The twenty-second session of the Marine Biological Laboratory at Woods Hole, Massachusetts, will be held from June 1 to October 1, 1909. The department of botany offers opportunity for investigation and also for botanical instruction. The staff in charge of the former includes the names of George T. Moore, B. M. Duggar, Henry Kraemer, Hermann von Schrenk, Erwin F. Smith, and M. B. Thomas. Investigators who undertake work with any member of the staff must make arrangements in advance in order to secure the use of a room and facilities for research. The department of botanical instruction offers two courses, one on the morphology and taxonomy of the algae, and the other on the morphology and taxonomy of the fungi, extending from June 30 to August 10. Application for information may be addressed to the head of the department, Dr. George T. Moore, Water Mill, New York, or to any member of the staff.

The next annual session of the Biological Laboratory of the Brooklyn Institute of Arts and Sciences, at Cold Spring Harbor, will be held during the months of July and August, 1909. The regular class work will begin on Wednesday, July 7th, and continue for six weeks, but investigators may make arrangements for using the laboratory at any time of the year. The work in botany for this session is conducted by Professor D. S. Johnson of Johns Hopkins, Dr. H. S. Conard of Iowa College and Mr. H. S. York of the University of Texas. Botanical investigators may obtain information regarding the facilities offered by corresponding with Dr. Johnson.

It is not practicable here to give detailed information concerning the numerous institutions which, at various points from Bermuda on the east, to Friday Harbor, Washington, on the west, have opened, or are about to open, stations for study or research in botany or zoology, or both. The western universities are coming to make the summer sessions, conducted in part at these stations, a part of their regular work, credit being given the same as at any other time of the year. This is a distinct advantage to students of the biological sciences, which, as regards field work, are pursued most profitably in summer. Experience has shown that these summer sessions, which are largely attended by teachers of secondary schools, have been and are instrumental in disseminating more correct knowledge and in inculcating a more intelligent and reasonable attitude regarding the disciplinary value of the biological sciences than was formerly prevalent in educational centers, and this is due, perhaps chiefly, to the marked improvement in biological instruction in the secondary schools and colleges, which has resulted in no small degree from the opportunities for summer work now so generally provided.

On the other hand it is significant and in the highest degree encouraging that laboratories either primarily or exclusively for research have multiplied in recent years, and are offering almost unlimited facilities for investigation. If only those that have been established in the last decade, or even a shorter period, are taken into account, it is seen that there is hardly any recognized branch of biological investigation calling for work at the seashore, or at a mountain or desert or island station, but is provided with means, and what is more, the presence of one or more recognized leaders of advanced thought and investigation in the departments there represented.

The New York Botanical Garden offers the following prizes for essays not exceeding 5,000 words, from the income of the Caroline and Olivia E. Stokes Fund for the Preservation of Native Plants: (1) $40.00, (2) 25.00, (3) $15.00. Essays must be typewritten in duplicate and must reach the Garden not later than June 20, 1909.

The Henry Shaw School of Botany of Washington University, St. Louis, announces greatly increased provision for graduate instruction and for research. In addition to the Engelmann professorship held by Dr. Trelease, the assistant professorship held by Dr. Coulter and the honorary post of plant pathologist at the Missouri Botanical Garden held by Dr. von Schrenk, a professorship of plant physiology has been created to which Dr. George T. Moore has been called, and provision has been made for two research fellowships in botany, besides a teaching fellowship to which Mr. C. D. Learn has recently been appointed. With the equipment in living plants (upwards of 11,000 forms), herbarium, of over half a million specimens, library with 58,500 books and pamphlets, and a well designed fire-proof building erected a year ago, the greater part of which is being equipped for laboratory use, unusual opportunities are offered for botanical investigation.

A course in plant breeding has been inaugurated at the University of Michigan by Dr. Henri De Leng-Hus, instructor in botany in that institution and formerly assistant to Professor Hugo De Vries of Amsterdam. The Michigan Alumnus shows from the records of its graduate school that there are in the Department of Botany at the present time 25 elections of graduate work as against 19 in Greek, and 68 in Forestry, as compared with 35 in Latin. To one who took the classical course in that institution in earlier days because nothing else really worth while was offered, these changes appear significant.

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JUNE, 1909

DARWINISM AND EXPERIMENTATION IN BOTANY.

BY D. T. MACDOUGAL.

(Continued from May number.)

Although the greater number of Darwin's followers were not able to join him in these exacting methods of scrutinization of natural phenomena, yet he was not alone in the movement toward the adoption of exact methods, as the means by which safe, steady and substantial progress might be made in biological science. A few of the leading investigators had already begun to put to test and trial all organic activities which came within the scope of their researches. In the forefront of these was Julius von Sachs, the very prince of experimentalists, to whom must be ascribed a great impetus and influence in the development of the possibilities of the new mode of inquiring into physiological problems. Sachs and his school directed their efforts to the delimitation of the primitive capacities of living matter, to the calibration of the functionation of organs, and to the physiology and ontogeny of the individual, while attention to evolutionary subjects was principally monopolized by naturalists engaged in studying "undisturbed nature" to very little profit.

It is most suggestive to recall that among the younger workers who came to get the view point of Sachs, was Francis Darwin, and the effects of his experiences are plainly manifest in some of the contributions in which he joined with his father. The movement from the anatomical, and comparative morphological views of Hofmeister, DeBary and Schwendener to modern dynamical, physiological morphology founded by Sachs and exploited by Goebel, has been slowly made, and so recently that it has not yet received full recognition by the pedagogic representation of botany, while the interrupted task of bringing evolution within the scope of experimental science so fairly begun by Darwin has been most forcefully completed by De Vries. Like Darwin, his well considered results obtained by twenty years of experimental cultures have been brought out with a new theory for the interpretation of certain phases of evolutionary development. Without appraisement of the importance of mutation as a factor in evolutionary procedure, it is to be said that the greater service performed by DeVries consisted in his demonstration that the method of trial and test is one by which major phenomena in heredity may be apprehended, their course, frequency and scope measured, and by operations of so simple a nature that it has enormously stimulated research upon the subjects concerned. The power of investigating at first hand many of the activities of organisms upon which rest some of the most essential features of descent, has thus been placed in the possession of a great biological constituency. The resultant specialization of effort made possible with the consensus of thinking upon the general principles involved which may follow, is an ideal condition from which substantial advance may be expected.

It is notable that with the revivification of any branch of biology by the subjection of its materials and conclusions to methods of control and measurement constituting experimentation, a tendency is exhibited by its representatives to illustrate the change by its terminology. Sachs' first book bore the German equivalent of "Handbook of Experimental Plant Physiology"; works on morphology are similarly designated to distinguish them from treatises on comparative anatomy masquerading under the larger title, although physiology has progressed so far as to drop the adjective, in tacit and full acknowledgement that no course of reasoning upon functionation or ontogenetic procedure has any claim to be denoted as physiology which is not grounded upon experimental evidence. My corresspondence files show that DeVries wished to use the term "experimental" to indicate that his work upon mutations as described in "Species and Varieties" was based upon trials and tests in cultures rather than disconnected observations, while a department of the Carnegie Institution still finds it useful to define the aspects and mode of treatment of evolution to which its resources are devoted.

Experimentation consists in acts or operations by which organisms are allowed to carry out their functional performances under controlled conditions, average, extreme, normal, and abnormal, allowing examination at will in order to discover, establish, illustrate or confirm conclusions as to the principles involved, the causal relations presented and the correlations manifested. It is impossible to conceive living matter without its environmental setting and an essential feature of experimentation consists in adjustment and measurement of environic factors, to obtain a basis for the estimation of deviations from the customary or normal throughout the entire range of reaction, thus exhausting the possibilities. Observation, on the other hand, consists in the simple scrutiny, however minutely carried out, of things as they appear in a state of nature, and it is evident that the information obtained in this manner is of great importance when it supplements experimental results, but is, in itself, often disastrously misleading. Some aspects of descent and heredity were recognizable in the multifold observations of Darwin, yet it is notable that of the generalizations proposed by him, those most generally accepted and finally founded are the ones subjected to experimental proof by himself, or others.

The general procedure by which we experiment with functional features of organisms, or their ontogenetic or morphogenetic development is too well known to need explication. It consists essentially in setting the organism in action and calibrating the products, whether these be movements, chemical structures, tissue formations, tropistic reactions, correlations, altered rhythms or reproductive departures. The technique of such work is described in detail in laboratory books on plant physiology, and the limitations of pedagogic work are such that but brief attention may be given to any particular phase of plant activity, consequently it may not be adequately presented. Now if attention be wholly directed to genetics, especially in botany, it may be seen that not only have we perfected new methods of investigation, but that we have used them to some effect in uncovering principles by which inheritance is governed. Allusion to some of the more important features may not be out of place.

A pre-requisite in all work in heredity consists in the operator having an accurate knowledge of the constituency and breeding habits of the strains of plants or animals with which he is dealing. Many species consist of a single individible strain occurring alone in nature, but on the other hand a large number include several elementary species or component strains, which may or may not intercross when grown in contiguity. Furthermore, the liability to hybridization may be extended so that major species not too closely related, may cross-fertilize, while bi-generic hybrids are recognized. The ancestry and breeding habits of the material being known to the experimenter, he may then proceed to study its transmissal of qualities from generation to generation under measureable conditions of soil or climate.

This is the essence of the pedigree-culture, and a few writers af academic habit decry its use, upon the ground that it is dealing with organisms under cultivation or artificial conditions. In fact it makes possible an exact study of the single qualities or characters of a plant or animal, with respect to their composition, purity, reaction in combination, precisely as the chemist deals with substances of known constituency in his exacter work. The physical elements rarely occur in a pure state, yet we are far past the stage in which we would object to the use of pure chemicals in researches, in which also the possibilities of impurity are taken strictly into account. So with the biologist, having tested the reactions of the qualities being studied under isolated conditions, his next step includes the consideration of their behavior when the plant bearing them is thrown into the closest contact with other organisms with which it might react or have breeding relations. Here, as in chemistry, the data obtained by the study of pure elements will afford the safest guide in the interpretation of the hereditary manifestations of the organism, or the final character of its constituents. When these facts are fully understood, it becomes plain at once that the adverse criticisms of the pedigreed culture in researches upon evolution are contentions, not arguments.

It has become plainly evident that it is upon the idea of qualities or single characters that progress in research upon evolution must be based; no longer are we concerned with the origination of species, except as an easy generalization; species themselves are so diverse in their composition and aspect, among plants especially, that it might be said with justification that there are almost as many kinds of species as there are numbers of genera. Evolution concerns variations, accretions, diminutions, appearances or disappearances of qualities, and it is to these manifestations that our attention is now primarily directed, in the hope of advancing what has now become an exact science.

The conception of unit characters, of which ample practical illustrations are known, may be easily misapprehended. While simplicity may be understood for its constitution or organization, yet it is not to be taken for granted that all of the reactions of a unit character are so. On the contrary, its integrations and diverse constructive values may be extremely complicated. This is well illustrated by the results of bringing two streams of heredity together by inter-crossing with resultant alternate, Mendelian, mosaic or fused inheritance, in which the details of dominance, potency, recessivity, mutative, or correlative variations may be traced.

Having the unit character as a workable idea, and with the power to manipulate examples of it in hybrids in which alternate inheritance may occur, it is obvious that widened opportunities are afforded for studies in the mechanism of heredity, especially in the fortunate instances in which the two components of a hybrid are characterized by the number, form, size or behavior of the chromosomes. Some light is also being thrown upon the problem of the physical basis of inheritance.

In the last analyses all organisms are the final result of the reaction or adjustment of living or self-generating matter to environment, mechanical or organic. A full century lies behind us since the first proposal of Lamarck as to the inertia of effects of environment upon the bodies of plants and animals, and his theory of acquired characters confronts us, neither unproven nor impossible. That the germ plasm may be acted upon in various ways to produce alterations in the characters it transmits from generation to generation is established. Such alterations are not fitting or adaptive, and if fitting or adaptive changes of the body itself are transmitted, we do not know it by experience, although the possibilities have not been exhausted.

In a brief paraphrase of the principal ideas presented in this sketch it is to be said that Darwinism, which has so profoundly affected human thought, and is without parallel so far as importance of conclusions and force of suggestion are taken into account, was the climax of the purely observational method of advancing knowledge. It came at a time when biological thought was ripe for a change of attitude and method of dealing with natural phenomena. Its great author, together with other leaders in biology, passed almost wholly to experimentation in the discovery, demonstration and confirmation of the principles underlying the action of the constituency of the organic world. This method was used to the fullest extent, first in physiological inquiry, in the calibration of functional performances and was later applied to ontogenetic development and the interpretation of form, so that even now taxonomic and phyletic generalizations lean upon its results for support. Genetics, descent and heredity escaped more slowly from the domination of illusive speculations and dogmatic philosophy, but now in these, as in practically all branches of human thought, we are no longer content with casual and hazardous arrangements of facts to fit preconceived theories; with unrestrained, metaphysical interpretations of nature, but demand progression by experience and the foundation of generalizations concerning evolution upon known causes, appreciable mechanisms and movements of ascertained direction.

Extensive fields of research lie without the domain of experimentation, yet the data gleaned from them must be put to the test of comparison with results analytically obtained. In a direct study of genetics we have at our command the pedigree culture; the conception of unit characters; some facts and a practicable theory as to the mechanism of heredity, and the physical basis of inheritance; a better knowledge of the nature and causes of variability, due to the use of statistical methods, with a realization of the importance of continuous and discontinuous variations; the power of inducing certain departures by the use of compounds or climatic factors; much evidence, chiefly of a palæontological character, as to the definitness of variations; a comprehension of the relations of environic factors to germ plasm and soma and some important results in selection obtained from breeding operations; together representing reasonable progress in the advancement of knowledge of a subject, established by Darwin, whose own work upon it remains its greatest contribution.

AN ADVANCE IN ROOT PHYSIOLOGY.

BY BURTON EDWARD LIVINGSTON.

Until very recently, the physiology of roots has almost wholly failed to receive the attention of plant physiologists, so much so, that we are at present more densely ignorant of these organs than of any other equivalent portion of the plant. This is somewhat surprising, in view of the important role undoubtedly played by the root system in plant activity, as well as in view of the numerous and thorough investigations which have been directed toward a real knowledge of the physiology of the absorbing surfaces in animals. Happily, however, it appears that the ordinarily invisible underground portion of the plant is at length beginning to attract investigators, so that a fair general knowledge of root physiology and of the relation of these organs to the medium in which they grow may be looked forward to with considerable assurance.

Not the least important of the contributions in this direction are emanating from the workers in a laboratory not primarily concerned with physiology, namely that of the Bureau of Soils of the U. S. Department of Agriculture. During the the past decade these investigators have been led to the view that any real knowledge of the agricultural properties of soils must develop hand in hand with a knowledge of root physiology. Thus there has already resulted a modern investigation of the old theory of DeCandolle, that growing plants excrete poisonous materials from their roots. Bulletins 28, 36, 40, etc. of the Bureau of Soils present data which practically establish the two propositions, that poor agricultural soils often contain harmful substances (probably of organic nature), and that growing roots of wheat actually produce poisons in the medium in which they are grown, these latter possessing a marked similarity in their physiological effect to those demonstrated as occurring in the poor soils. Other investigators in various parts of the world have already taken up this question, and corroborative evidence is rapidly accumulating, so that, although the exact nature of the toxic bodies remains still to be defined, yet the fact of their causation by growing roots, whether directly or indirectly, can not at present be doubted.

Along with the development of these ideas, and supported by other entirely different lines of evidence, has grown up the at first somewhat startling hypothesis, that the good or poor qualities of agricultural soils are not usually dependent upon the salt contents of these soils, and are usually to be related to physical conditions or to the absence or presence of toxic material. A corollary to this hypothesis is, logically, that the almost universally accepted Liebig theory of fertilizer practice is in most cases untenable. According to this theory, if calcium nitrate proves beneficial upon a certain soil, that soil must have been deficient in either calcium or nitrate, or both. It is supposed by the usually accepted theory of crop rotation, that one species of plants removes from the soil more of certain elements than another, and conversely, and that thus a more vigorous growth is produced when the two species are alternated than when the same form is grown continuously for a number of seasons upon the same land.

Now it is incontestable that certain salts *are* beneficial upon certain soils, but it is equally evident to one conversant with the disagreeing literature of the subject, that the effect of fertilizer salts can not be predicted from the chemical analysis of a soil solution obtained with one or another solvent.

The need seems apparent, then, for a new hypothesis, which will explain, or aid in the investigation of, the properties of unproductive soils, on the one hand, and the effects of fertilizer salts, on the other. Vaguely suggested in previous bulletins, such an hypothesis is partially formulated in Bulletin No. 56 of the Bureau of Soils, which has recently appeared.

Various lines of previous research, by the Bureau of Soils and others, have pointed to the conclusion that toxic organic substances are often rendered less toxic to plants by oxidation. Of course any poisonous body will be rendered harmless by complete oxidation into carbon dioxid and water. The natural processes taking place in the soil usually result in the oxidation of organic matter to a greater or less degree, depending upon the conditions. This process of oxidation probably occurs, in the case of some substances at least, without catalytic agent of any kind, merely by contact with atmospheric oxygen. In many cases, oxidation is brought about through the activity of microorganisms such as soil bacteria, probably by means of enzymes secreted by the living cells. To the present time, practically all workers in this field have attributed such oxidation in the soil to the growth of these microorganisms. It has remained for the Washington laboratory to discover a number of very convincing lines of evidence that the roots of growing plants themselves exert an important influence upon oxidation. Furthermore, it is shown in the present bulletin that certain fertilizer salts greatly increase the oxidizing power of wheat roots when grown in solutions; that this oxidizing power varies in a general way, with the growth of the plants; and thus that this power is relatively low in extracts of poor soils and high in good ones. This effect of the living roots, however it may prove to be brought about, must be considered as a very important phenomenon in plant physiology as well as in the study of the soil.

Two sorts of indicators have proved useful in determining the oxidizing power of roots, soluble substances producing upon oxidation insoluble colored compounds (such as alpha naphthylamine, benzidine, etc.), and substances, also soluble, but producing upon oxidation soluble colored bodies, thus giving a colored solution. Examples of the second class are phenolphthalin and aloin.

By the use of the first group of indicators it was possible to locate upon the root the regions where the oxidation takes place. The colored precipitate was formed, and remained upon the surface of the root, in a narrow zone just above the root-cap and in a broad and more intense zone occupying the region of active root-hairs. Higher up, the color fades out, showing that oxidation is progressively retarded as the root-hairs die and fall away. The root-cap and the zone of the greatest elongation failed to exhibit oxidation power. Secondary roots show the same phenomena as primary ones. Where the latter are forming and are about to push through the cortical tissue, oxidation is active, as is shown by the development of colored spots upon the surface of the primary root. Of several lines of evidence that the oxidation here considered is not due to the growth of microorganisms upon the root surface, perhaps the most convincing is the fact that the zone of dead and dying root-hairs (where the growth of microorganisms should be most active) showed little or no reaction.

Phenolphthalin, which gives a colorless solution, is oxidized to the well known phenolphthaleïn by the action of plant roots or other oxidizing catalyte. After the roots have been in contact with the solution for ten to twenty hours they are removed and the solution made distinctly alkaline with sodium hydroxide. Thus the red alkaline color of the oxidized product is developed, and the amount of oxidation is quantitatively determined by the intensity of the color. Aloin solution oxidizes from a pale yellow to a deep wine red, and the color change may likewise be measured colorimetrically.

Many treatments of poor soil extract which are beneficial to growth also accelerate this extra-radical oxidation. Thus, treating the extract with absorbing solids had this effect, as has also distillation of the extract. Nitrates usually accelerate root oxidation. It is suggested that the beneficial effects produced by fertilizers may often depend upon an acceleration of the oxidation process, an entirely new hypothesis in regard to fertilization.

The presence of toxic organic compounds in the culture medium greatly retards oxidation, but the activity of the roots, especially if accelerated by the presence of a nitrate, finally diminishes or removes the toxic property.

From an incomplete study of the nature of the oxidation process, the authors conclude that it is probably mainly dependent upon peroxidase excreted from the roots.

THE FIXATION OF NITROGEN BY MEANS OF BACILLUS RADICICOLA WITHOUT THE PRESENCE OF A LEGUME.

BY EDWIN B. FRED AND W. B. ELLET.

While it is known that *Bacillus radicicola* will live and assimilate nitrogen with the presence of the appropriate host plant, the question naturally arises as to the action of these organisms in the soil without any legume. The fact that *Bacillus radicicola* will live on artificial media and will assimilate very small amounts of nitrogen without the presence of its host plant has been demonstrated several times. *

In order to study the activities of *Bacillus radicicola* without the presence of a legume, a series of laboratory and greenhouse experiments was planned. (1) The nitrogen assimilating power of *Bacillus radicicola* in a nitrogen-free liquid medium using pure and mixed cultures. (2) Its assimilating power in sterilized sand as shown by analysis for total nitrogen and by plant growth. (3) Its assimilating power in a normal clay soil tested in the same way as the sterilized sand.

As the amount of nitrogen fixed is *very* small the reagents used must be absolutely pure and the analyses done in the most accurate manner. As a liquid medium the following formula was used:

Water (dist.)	1000 c. c.
Biphosphate of potash	1 gr.
Magnesium sulphate	0.1 gr.
Dextrose	20 gr.
Sodium chloride	trace.
Iron sulphate	trace.
Manganese sulphate	trace.
Calcium chloride	trace.

Two hundred and fifty c. c. of this medium were placed in large Erlenmeyer flasks so as to expose as much of the surface of the liquid to the air as possible, and the flasks were inoculated with pure and mixed cultures from fifteen of the legumes. The pure cultures were obtained from different sources and, in several cases, the organisms were found not to be true to name. This is especially true in the first two of each series of the sand

*1. A. Stutzer, Mitteil. Landwirtsch. Inst. Breslau, Heft 3 (1900).
2. L. Hiltner, Centr. Bakt. Bd. VI, p. 273 (1900) (II Abt.)
3. E. Laurent, compt. rend., Tome CXI, p. 754 (1890); Ann. Inst. Pasteur. Tome VI p. 722 (1890), Tome VI, p. 105 (1891).
4. Maze, Ann. Inst. Pasteur. Tome XI, p. 44 (1879).

cultures. The mixed cultures were prepared in laboratory by washing nodules repeatedly in sterile water, then in a solution of 1 to 1000 of mercuric chloride, rinsing in sterile water and drying between folds of filter paper. After the nodule has been treated thus, it is cut open with a sterile knife and from the center of the nodule the medium is transferred with an inoculating needle in the ordinary manner. Cultures prepared in this way contain, besides *Bacillus radicicola*, a few yeasts and moulds. After inoculation, the flasks were then placed in an incubator and kept at 25 degrees C. for one month. Table No. I shows the results from inoculation of liquid media.

TABLE I.

Assimilation of Nitrogen by Means of Bacillus radicicola in Liquid Media for Four Weeks.

No.	Culture.	Nitrogen in 1000 c.c. of liquid media.
1	Alfalfa, Pure Culture	7.00 Mg.
2	Alfalfa, Pure Culture	11.20 Mg.
3	Alfalfa, Pure Culture	16.80 Mg
4	Alfalfa, Mixed Culture	12.60 Mg.
5	Red Clover, Pure Culture *	5.60 Mg.
6	Red Clover, Mixed Culture	11.20 Mg
7	Crimson Clover, Pure Culture *	1.80 Mg.
8	Crimson Clover, Mixed Culture	14.00 Mg
9	White Clover, Pure Culture	14.00 Mg.
10	Alsike Clover, Pure Culture *	5.60 Mg
11	Lupine, Pure Culture	11.20 Mg.
12	Vetch, Pure Culture *	7.00 Mg.
13	Vetch, Mixed Culture	14.00 Mg.
14	Cowpea, Pure Culture	8.40 Mg.
15	Cowpea, Mixed Culture	14.00 Mg.
16	Check	00.00 Mg.

The results of this table show very clearly that these bacteria have power to assimilate nitrogen from the atmosphere in artificial media. Recent researches * have shown that this assimilation is greater in flasks with large bottoms than in flasks small at the bottom. This is due, of course, to the fact that, in the large-bottom flasks more surface is exposed to the air. The pure cultures did not assimilate, on the average, as much nitrogen as the mixed cultures. Only one of the series of pure cultures con-

*Organisms grown in these cultures were not true to name.

*A Study of the Legume Organisms, T. B. Hutcheson and E. B. Fred, V. P. I. Agr. Journal June, 1908.

tained very active nitrogen-fixing organisms; these were Nos. 3, 7, and 9.

TABLE II.

Assimilation of Nitrogen by Means of Bacillus radicicola in Sand for Four Weeks.

Pot No.	Culture.	Nitrogen in 100 gr. of Sand.
1	Alfalfa, Pure	4.00 Mg.
2	Alfalfa, Pure	7.00 Mg.
3	Alfalfa, Pure	16.00 Mg.
4	Alfalfa, Mixed	14.00 Mg.
5	Red Clover, Pure	6.00 Mg.
6	Red Clover, Pure	5.00 Mg.
7	Red Clover, Pure	13.00 Mg.
8	Red Clover, Mixed	10.00 Mg.
9	Crimson Clover, Pure	6.00 Mg.
10	Crimson Clover, Pure	7.00 Mg.
11	Crimson Clover, Pure	10.00 Mg.
12	Crimson Clover, Mixen	21.00 Mg.
13	Cowpea, Pure	5.00 Mg.
14	Cowpea, Pure	7.00 Mg.
15	Cowpea, Pure	16.00 Mg.
16	Cowpea, Mixed	22.00 Mg.

In sterilized sand that is kept moist with a glucose solution containing some potassium biphosphate, the legume bacteria will grow and assimilate nitrogen. Somewhat larger amounts of nitrogen were fixed in sand than in the liquid medium, but in both the amounts were small as compared with the assimilation of nitrogen in the presence of the host plant. Here again the mixed cultures assimilated more nitrogen than the pure cultures. After the samples were taken from each of the pots and analyzed, the pots were removed to the greenhouse and planted with buckwheat. For the first week the growth in all pots was about the same. At the end of the third week the plants in the uninoculated pots began to wilt while the plants in the inoculated pots continued to grow. The cut below shows inoculated and uninoculated pots.

Fig. 1.---Buckwheat Planted in Sand Cultures.
No. 1. Uninoculated.
No. 2. Inoculated with a pure culture. Red Clover.
No. 3. Inoculated with a pure culture. Crimson Clover.
No. 4. Inoculated with a pure culture. Alfalfa.
No. 5. Inoculated with a pure culture. Red Clover.
No. 6. Inoculated with a mixed culture. Red Clover.
No. 7. Inoculated with a mixed culture. Alfalfa.

For the investigation of assimilation of nitrogen in soil a clay soil was procured from the Station Plats which had the following analysis:

SOIL SAMPLE FROM PLAT NO. 24.

Total Nitrogen	.106
Humus	1.12
Phosphoric Acid, $N5HNO_3$	22.3 pts. per million
Potash, $N5HNO_3$	193.2 pts. per million
Potash, water soluble	24.2 pts. per million

As in the case of the sand, small wire baskets were filled with this soil and inoculated with cultures from different legumes. These were treated just the same as the sand except the soil was not previously sterilized. The assimilation would hardly be as great in this clay type as in an open and more easily aerated soil, yet, on the average, the amount of nitrogen fixed by means of *Bacillus radicicola* was much more in soil than in sterile sand.

TABLE III.

Assimilation of Nitrogen by Means of Bacillus radicicola in Clay Soil for Four Weeks.

Pot No.	Culture.	Nitrogen originally present in 100 grs. of Soil.	Nitrogen Assimilated in 100 grs. of Soil by Bacillus radicicola.
1	Alfalfa, Pure	107 Mg.	1.0 Mg.
2	Alfalfa, Pure	109 Mg.	3.0 Mg.
3	Alfalfa, Mixed	107 Mg.	1.0 Mg.
4	Red Clover, Pure	110 Mg.	4.0 Mg.
5	Red Clover, Mixed	110 Mg.	4.0 Mg.
6	Crimson Clover, Pure	112 Mg.	6.0 Mg.
7	Crimson Clover, Mixed	109 Mg.	3.0 Mg.
8	Vetch, Pure	116 Mg.	10.0 Mg.
9	Vetch, Mixed	109 Mg.	3.0 Mg.
10	Cowpea, Pure	113 Mg.	7.0 Mg.
11	Check	106 Mg.	0.0 Mg.
12	Check	106 Mg.	0.0 Mg.

While the nitrogen assimilation in the liquid medium in the sand and in the soil was very small, it was so well marked as to give us a reasonable basis to say that *Bacillus radicicola* will live in the soil without the host plant and accomplish a certain amount of nitrogen assimilation.

A PECULIAR SPECIMEN OF ARCTIUM.

BY HARRY B. BROWN.

During the summer of 1907, the writer noticed a peculiar laciniate-leaved burdock (*Arctium sp.*) growing along the railroad near Jessup, Indiana. The plant was then in the rosette stage. The following year, during July, the plant was again noticed. At this time it presented a still more peculiar appearance; it was about six decimeters tall, profusely branched, branches being finer and more numerous than is common for *Arctium*. The whole plant was covered with a tomentum which was particularly abundant on the stem and petioles of the large leaves. The leaves varied greatly both in size and shape, as the accompanying photograph shows. The lower and largest were rather thick, ovate, acute, irregularly laciniate, about two decimeters long and ten to twelve centimeters wide; stem leaves were thin, mostly long, narrow, irregular, and irregularly lacin-

Fig. 2.--Photograph of different forms of leaves on the peculiar Arctium plant. Nos. 1 and 2 are tips of branches showing small heads of flowers and small upper leaves; other figures are different leaf forms found from tip of stem downward.

iate and lobed, divisions tipped with small bristles; lamina almost entirely absent on one side of the mid-rib in some leaves, and ranging from this to an entire absence, merely petiole and mid-rib being present. Some petioles were branched, each division bearing a leaf blade. Normally in *Arctium* there is a petiole at the base of each flower stalk, but in this plant two to four small ones seemed to be present in places. These supernumerary petioles bore no leaf blades. Sections of the stem and petioles showed a microscopical structure very similar to that found in corresponding parts of *Arctium minus*.

The inflorescence was irregular, heads numerous, mostly small, rudimentary, and apparently sterile; two were about fifteen millimeters wide and had purple flowers; heads mostly sessile or nearly so, on or near the ends of the branches; involucre subglobose, its bracts rigid, tipped with spreading or erect hooked bristles. The whole plant had the characteristic odor, texture, and general appearance of *Arctium*.

In trying to account for this peculiar plant form some interesting questions arise. One may think at once that it is an immigrant since it was found along the railroad, but an examination of current manuals and systematic treatises failed to reveal much concerning the occurrence of such a form. In some of the older editions of Gray's Manual, the statement is made that *Arctium Lappa* var. *minus* rarely has laciniate leaves. In the new edition this characterization is omitted. In Small's Flora of the Southeastern United States, the statement is made in the characterization of the genus *Arctium* that the leaves are rarely laciniate or pinnatifid. This form of the plant being so rare there is more likelihood that it originated locally than that it was imported.

It is an interesting question as to how much the environment had to do with the production of such a type. It was growing under rather hard conditions, the soil being the dry, gravelly clay of a railroad grade; it was not shaded. The laciniate nature was not a result of the plant's being mowed often for it appeared in the first year's growth, while in the rosette stage.

Since the plant had leaves that resembled somewhat the leaves of certain species of *Carduus*, being lanceolate, laciniate and more or less pinnatifid and spiny, and since the two are closely related genera it might be suspected that this new form is a hybrid between some species of *Carduus* and *Arctium minus*. But it seems rather improbable that cross pollination could be effected between plants of this type. Then, too, the preponderance of *Arctium* characters is against such a conclusion.

Is the plant a monstrosity or a mutant that has originated among the progeny of *Arctium minus?* This seems to me to be the most probable explanation. *Minus* is the only species of *Arctium* growing in the locality mentioned. Such aberrant forms have been known to appear among the progeny of different species of plants and when they breed true they are known as mutants. The oldest mutant on record is that of *Chelidonium laciniatum*, a laciniate-leaved form which sprang from *Chelidonium majus* at Heidelberg in 1590. Other species and varieties have arisen in a similar way from time to time. The parent species is usually regarded as being unstable or progressive. Can it be that the well-defined genus *Arctium*, with its few species is becoming unstable and is beginning to throw off mutants? Notes on observations made in different places will be gladly received.

Cornell University.

BOOKS AND CURRENT LITERATURE.

Edward C. Jeffrey, in the March, 1909, number of Rhodora, contributes an important article *On the Nature of So-called Algal or Bog-head Coals.* In preparation of material for microscopic examination, hydrochloric acid was replaced by hydrofluoric acid, followed by careful washing of the coals and soaking in hot alcohol containing from three to five per cent of alkali. By this means the coal is softened without disorganization and may be successfully sectioned. In the study of certain bituminous coals known as Bogheads, Dr. Jeffrey has been able to demonstrate that the supposed algae of Renault and Bertrand are, in reality, "large spores or macrospores of vascular cryptograms which flourished during the coal periods, the imagined algae being, in fact, only the pores in the strongly sculptured coats of these spores." As the result of his observation it appears probable that the bituminous matter found in this and similar coals is rather a product of the modification of the natural waxy or cutinoid infiltration of the outer coats of innumerable spores (microspores as well as macrospores), than the product of animal or algal decay, as has been variously suggested.

A book of 750 pages, entitled "*A Manual of Poisonous Plants,*" by Professor L. H. Pammel, has been announced. There are promised numerous illustrations in which most of the plants injurious to live stock of the United States are described and figured, a bringing together of scattered literature, convenient arrangement of subject matter, and adequate discussion of injury from lower forms of plants like the moulds, mildews, blights, and bacteria. In addition there are economic notes of useful plants under each order and genus. The poisonous substances found in plants are given in each case, and the nature of the poisoning and the remedy. The chapters on bacteria and chemistry of poisons have been written by specialists. This book is the outgrowth of many years' work by the author, in classroom and laboratory, with the students of the veterinary department of the Iowa State College. Numerous pertinent notes, interspersed with many quotations, are presented in the author's interesting style, and there is brought together in brief compass a large amount of information that should render the work both useful and attractive to the botanist and intelligent stockman and layman, as well as a convenient text and technical manual for the veterinarian.

J. C. BLUMER.

In a very interesting paper read before the Bohemian Academy of Sciences last year, Dr. Peklo describes two forms of roots found in *Monotropa Hypopitys L.* Specimens growing in soil rich in humus show the well-known hyphal sheath or mykorhiza; while specimens growing in sandy or clay soil relatively free from humus, show all degrees of the reduction of the sheath, some being entirely free from the fungus. These individuals have at the same time more extensive root systems. Instead of the usual dense nests of short, closely set rootlets, there appear long, sparsely branched roots, reaching in all directions into the soil to a distance of 15 to 30 cm. A number of these are pictured in outline.

From a microscopic study of some thirty specimens from a number of widely separated regions in Bohemia, the author concludes that the mykorhiza is in the nature of a gall, or a mycocecidium: the epidermal cells, while still in the dermatogen condition, are stimulated by the entry of haustoria from the hyphae upon the surface. The haustoria draw from the epidermal cells a considerable mass of nutrients, which go to the growth of the fungus. The stimulation of the epidermal cell by the fungus is compared to the formation of gall tissues upon leaves, or the development of the endosperm of the caprifig under the influence of stimulation by the wasp *Blastophaga*.

The epidermis remains intact after infection by the fungus, but now shows in each cell a globule of tannin: this serves as an effective barrier against the further entry of the fungus haustoria, and the cuticularization of certain cell walls confines the intercellular hyphae to regions in which they can do no harm.

The role of the mykorhiza in the life of the Monotropa is not considered one that is essential to the species: Prof. Peklo believes that the individuals living in soil comparatively free from humus are quite autonomous and independent. He does not attempt to explain how they get their nourishment, and those who have been accustomed to look to chlorophyl and sunshine are left wondering and bewildered. On the other hand, the specimens that occur in humus soil he believes to be entirely dependent upon the fungus for their nutrition. The amount of humus is not generally sufficient to support the Monotropa, but the mycelial network covering the roots serves to modify the soil juices that percolate through it, as through the velamen of orchids: and from this modified liquid the root-surface proper absorbs selectively the materials it can use.

If the Monotropa can flourish without chlorophyl and without mykorhiza, especially in soils that contain little organic material, it is time to revise our notions about the fixation of carbon in phanerogams. We are prepared to look upon the mykorhizal fungus of forest trees and of green orchids as "harmless parasites," if necessary; but more time is needed to adjust oneself to the idea of the fungus being parasitic upon Monotropa growing in sand. —BENJ. C. GRUENBERG.

NOTES AND COMMENT.

Since the last issue of the PLANT WORLD so many notices of laboratories for summer work in the biological sciences have been received that it seems desirable to call attention to a few of those which from their recent establishment, or for other reasons, are less widely known than some that have already been noticed.

It is announced that the Marine Laboratory of Johns Hopkins University will be reopened in Jamaica in 1910. The great diversity of climatic conditions in close proximity, the richness of the fauna and flora, the location and topography of the island, and its advantages as regards residence combine to make Jamaica well-nigh ideal for the establishment of a laboratory for the study of marine forms, factors of local distribution, and the numerous problems connected with the fauna and flora of a mountain region in the midst of tropical seas.

The University of Michigan announces the opening of a biological station for instruction and research in the lake region a few miles south of the Straits of Mackinaw, and near the much frequented "Inland Route" from Petosky on Lake Michigan to Cheboygan on Lake Huron. The variety of faunal and floral conditions is hardly as great as in some other locations that might have been selected, but sudents will have the exceptional advantage of personal instruction in "the exact methods of the laboratory, not hitherto commonly used in the field * * * applied to the observation of habits and to the making of field records, both written and pictorial." To specify in part—"a physical examination of Douglas Lake with reference to its contour, depth, inflow and outflow, character of bottom, relation to hydrographic basin, the turbidity, temperature and chemical constitution of its water will be followed by an examination of its plants and animals. After a study of the distribution of the plants of the lake, the distribution of protozoa, sponges, hydras, crustaceans, and other invertebrates in the lake with reference to depth, temperature, and other physical conditions, their relation to the plants and their association with one another to form faunae will be considered."

The work just described, together with the investigation of special problems connected with the plankton and with the embryology of bony fishes, is in charge of Professor Jacob Reighard. Courses in the ecology of plants, a botanical survey of the region, and research in ecology will be under the direction of Professor George P. Burns.

The University of Washington, after conducting its marine station at Friday Harbor for five years, has combined with the Washington State College and other educational Institutions of the northwest in establishing the Puget Sound Marine Station, in the northern part of Puget Sound. It is expected to erect permanent buildings to the sum of about $5,000 for the year 1910. Temporary quarters will be provided for the season 1909, for a six-weeks session, June 21 to July 10, at Friday Harbor, and July 11 to July 30 at Olga.

The instructional staff for 1909 includes the following: Drs. Frye and Howard of the University of Washington, Professors Beattie and Melander of Washington State College, Dr. Bessey of the University of Nebraska, Dr. Kellogg of William College, Prof. Brues of Milwaukee Public Museum, Dr. Brode of Whitman College, Professor Chambers of Pacific University, and Professor Simpson of Puget Sound University.

A motor launch, row boats, dredges, collecting apparatus, microscopes, etc. will be supplied and there will be opportunity for investigation both in zoology and botany. Further information may be obtained by addressing members of the staff as named above.

These announcements, with many more not here referred to, indicate a distinct trend in education and investigation. It is now something over a quarter of a century since the laboratory method of biological investigation and instruction, through the influence of Sachs, Huxley and other pioneers, together with many lesser lights, became firmly established in educational centers and in establishments, then few in number, in which provision was made for research. The result has been an enormous output of data concerning the life history and physiology of a restricted number of plants and animals, and more recently valuable evidence bearing upon questions of heredity and other matters of great theoretical importance has been obtained by means of laboratory investigations. But this work, fruitful though it has been, has been, and is still, conducted with altogether too limited an application of laboratory conceptions and methods to the study of plants and animals in their own homes, with their environmental relations undisturbed. Here and there an investigator has carried into the field the same exactness, the same patience in the accumulation of data, and the same capacity for generalization which has so long been cultivated in the laboratory, and the results, when this has been done, have not been less fruitful than those of the more restricted sphere within which the laboratory student conducts his researches. Although a later development, and consequently with less that at present can formally be set down to its credit, it is a distinctively hopeful indication that at present so many institutions are committed to this broader view and that so many leading educators and investigators are applying themselves to problems which can never be wholly solved in the laboratory.

Out of the mass of material now finding its way into print as part of the outcome of the numerous Darwin memorials of the past season, few utterances, perhaps, are more likely to challenge attention than those expressive of the wide difference of view regarding the problem of variation on the part of some of the leading students of evolution.

In a recent number of *Science* the following quotation from the address of Prof. T. H. Morgan at Columbia University is given: "Whether definite variations are by chance useful, or whether they are purposeful, are the contrasting views of modern speculation. The philosophical zoologist of today has made his choice. He has chosen *undirected* variations as furnishing the material for natural selection. It gives him a working hypothesis that calls in no unknown agencies; it promises the largest rewards."

Referring at some length to this, Prof. H. F. Osborn says: "It is interesting as showing the absolute divorce between the zoological and paleontological observer. * * * If the word "undirected" implies fortuity, as I presume it does, it is an interesting future possibility that the theory of the building up of adaptations out of the natural selection of undirected variations, to use my colleague's language, may prove to be a dogma quite as unsupported by facts as the Lamarckian dogma of the inheritance of acquired characters. I long ago pointed out that a very large number of new characters in the hard parts of mammals are adaptive in direction from the beginning; I am very far from saying that *all* new characters are adaptive in direction; I only make this statement as to those characters I have had the opportunity of repeatedly observing.

"I now challenge the zoologists to produce a single instance of a series of animals in which adaptive characters are being accumulated through the *selection* of undirected variations, *i. e.*, of variations which are thoroughly mixed up, in which *there is no law evident.* Such a series has never been produced by anyone. Of course I bar from this challenge orthogenic changes of character under environmental influences. I refer to the *pure* Darwinian hypothesis. The hypothesis is still as Darwin left it, an ingenious working theory, awaiting either experimental evidence or evidence of any kind.

"While the 'philosophic zoologist' of today has made his choice, the philosophic paleontologist has also made his choice. The latter certainly does not find direction in the old teleologic sense, but quite as certainly he finds no evidence of such fortuity as will justify the use of the word *undirected* as furnishing materials for natural selection. The materials for natural selection are furnished by the *ensemble* of an enormous number of characters, each of which is a unit pursuing its independent history and fluctuating and mutating and moving in direct lines under laws which the philosophic paleontologist has proof of, but totally fails to understand. Consequently he assumes the agnostic position that there is some principle, or principles of direction, or better—to use Prof. Morgan's own words—'unknown agencies' still to be discovered other than the principle of order coming out of fortuity."

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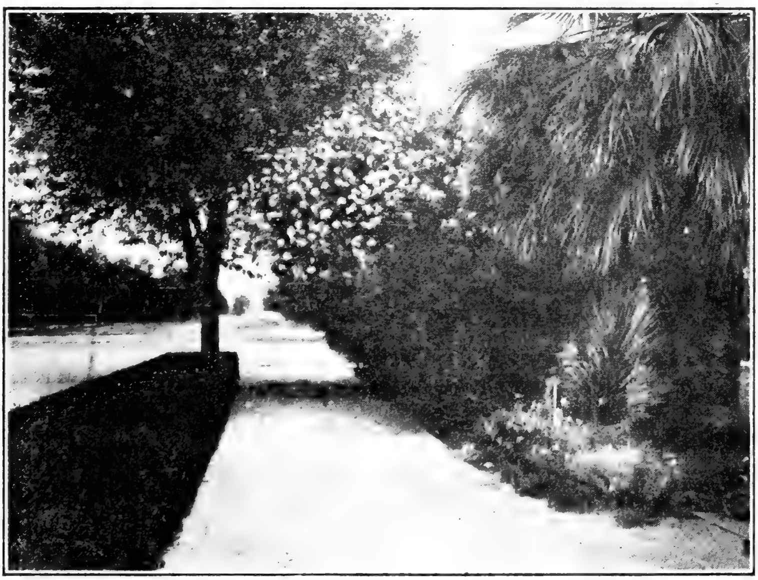

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THE PLANT WORLD

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JULY, 1909

A SIMPLE CHEMICAL DEVICE TO ILLUSTRATE MENDELIAN INHERITANCE.

BY GEORGE HARRISON SHULL.

At the recent meeting of the Botanical Society of America at Baltimore, Dec. 31, 1908, I performed an experiment to illustrate how the absence of a character may be dominant over its presence. The experiment was of such simplicity and appeared to have such pedagogic value that I was asked to describe it in the PLANT WORLD for the benefit of teachers.

In order to make the bearing of the experiment perfectly clear, I will first give a brief statement of just what is involved in Mendelian inheritance, when considered from the standpoint of the "presence and absence" hypothesis, now generally accepted by the foremost experimental students of heredity.

The presence and absence hypothesis assumes that in every case in which two plants or animals which may be crossed together, differ from each other in a simple unit-character, their difference from each other is to be described in the terms of presence and absence of a single character and not as a pair of contrasted characters. For example, when a yellow-seeded pea is mated with a green-seeded one, instead of saying that the contrasted characters are yellow *vs.* green ,we should say "yellow *vs.* absence of yellow." The pure-bred yellow pea is believed to possess all the elements contained by the green pea, with a single pair of units added which makes it yellow instead of green. If the green pea, which I call in such a case the "negative homozygote," is represented by the letters *GG*, intended to indicate that it has inherited its greenness from both its parents, then the pure-bred yellow pea should be represented by *YYGG*, to show that both greenness and the added unit for yellowness was inherited from both parents. This forms what I call the "positive homozygote." Every vegetative cell of the green-seeded pea-plant contains the pair of units or "genes"* *GG*, but when the germ cells are being formed, these two genes separate so that each egg-nucleus and each sperm-nucleus has only one *G*, or green-producing gene.

In the same manner, every vegetative cell of the positive homozygote, or pure-bred yellow-seeded pea-plant contains the two pairs of genes, *YYGG*, since it received a *Y* and a *G* from each of its parents, and all of its male and female germ-cells will contain the two genes *YG*. Now, when a cross is made between these two kinds of peas, we either apply a pollen-grain of the green-seeded pea-plant to the stigma of the yellow-seeded pea-plant and allow a germ containing a single *G* to find its way to an egg-cell which contains *YG*, or we reverse the process, and by applying the pollen of the yellow pea to the stigma of the green pea, allow sperms containing *YG* to reach eggs containing only *G*. The results of these two processes are the same, for $G \times YG = YG \times G$, and every vegetative cell of the plants produced by such a cross will contain the three genes, *YGG*, and as the green seeded character, *G*, can not be seen when *Y* is contained in the same nucleus, all of the hybrid plants of the first generation from such a cross will have yellow seeds, and we say that yellow is dominant over green.**

When these hybrids produce germ-cells the three genes, *YGG*, separate again so that half the egg-nuclei contain *G* and half contain *YG* and similarly half the sperm-cells contain *G*, and half contain *YG*. When sperms that are mixed in this way are applied to egg-cells having the same mixture, some *G* sperms will fuse with *G* eggs, to form *GG* plants (negative homozygotes), some *YG* sperms will fuse with *YG* eggs to form *YYGG* plants (positive homozygotes), some *G* sperms will fuse with *YG* eggs to form *YGG* plants (heterozygotes), and some *YG* sperms will fuse with *G* eggs to produce *YGG* plants (also heterozygotes). Thus, it is seen that three kinds of plants are produced

*This word has been proposed by Dr. W. Johannsen for the internal units or determinants, upon whose presence the production of any simple or unit character depends. It has the advantage of being short and of making no apparent assumption as to the ultimate nature or behavior of such determining factors.

**Professor Bateson suggested that we use "epistatic" and "hypostatic" to represent the relationship between the yellow and green characters, and in other similar cases. Thus, while yellow is dominant over its absence it is "epistatic to green," and green is "hypostatic to yellow."

which may be represented by *GG*, *YGG*, and *YYGG*, and the only difference in these plants is in the number of *Y* genes they contain. Taking the negative homozygote, *GG*, we make the heterozygote by adding one *Y* gene, and the positive homozygote by adding two *Y* genes. If *Y* is dominant over its absence, and this is much the commonest form of Mendelian inheritance, the *YGG* individual looks like the *YYGG*, *i. e.* both will have yellow seeds. If the absence of *Y* were dominant over its presence the *YGG* individual would look like the *GG* individual, both having green seeds, and if dominance were only partial, the *YGG* individual or heterozygote would be intermediate between *GG* and *YYGG*, having greenish-yellow seeds. The important point to emphasize is that the heterozygote and

Fig. 1. Material needed for illustration of Mendelian inheritance.

positive homozygote are the same as the negative homozygote, with one or two portions of something (a *Y* gene in this case) added.

Material needed for the demonstration: Solution of litmus, sodium hydroxide or aqua ammonia, hydrochloric acid; 3 half-liter flasks, glass graduate, 1 dozen 15 cm. test-tubes, and two test-tube stands. Also, if convenient, a blue and a red flower of any species, and if these flowers are at hand, an alcohol lamp, or a bunsen burner if gas is available, ring-stand, wire gauze, and several small beakers. See Fig. 1.

To a moderately dilute solution of litmus add a small quantity of sodium hydroxide or aqua ammonia. In the presence of the class, divide this solution into two of the flasks, calling attention to the fact that the same solution is put into both. Then add to the one flask in the presence of the class a certain quantity * of hydrochloric acid, which changes the solution from blue to red. See that it is perfectly clear to every member of the class that there is now just one difference between the solutions in the two flasks, namely, the one contains a certain portion of acid, the other has none. As it is desired that the solutions in these two flasks should represent respectively the negative and positive homozygotes which are to be crossed together, and as *they are homozygotes because they inherited the same character from both parents*, the acid should be added in two equal portions with the explanation that one acid-producing unit or gene came from the mother and one from the father. The experiment will be rendered more impressive if a red flower and a blue flower of any variety, such as the sweet-pea, is standing in a vase on the teacher's desk, for then it may be explained that while it would take two years to demonstrate Mendelian inheritance by an actual cross between these two flowers, the whole process may be shown in a few minutes by letting the blue solution represent the blue flower and the red solution the red flower. See that the class appreciates the fact now that just as in the case of the solutions, the red and blue flowers differ from each other in only one quality, one-half of which came from one of its parents, the other from the other parent.

Several different experiments may be performed as follows:

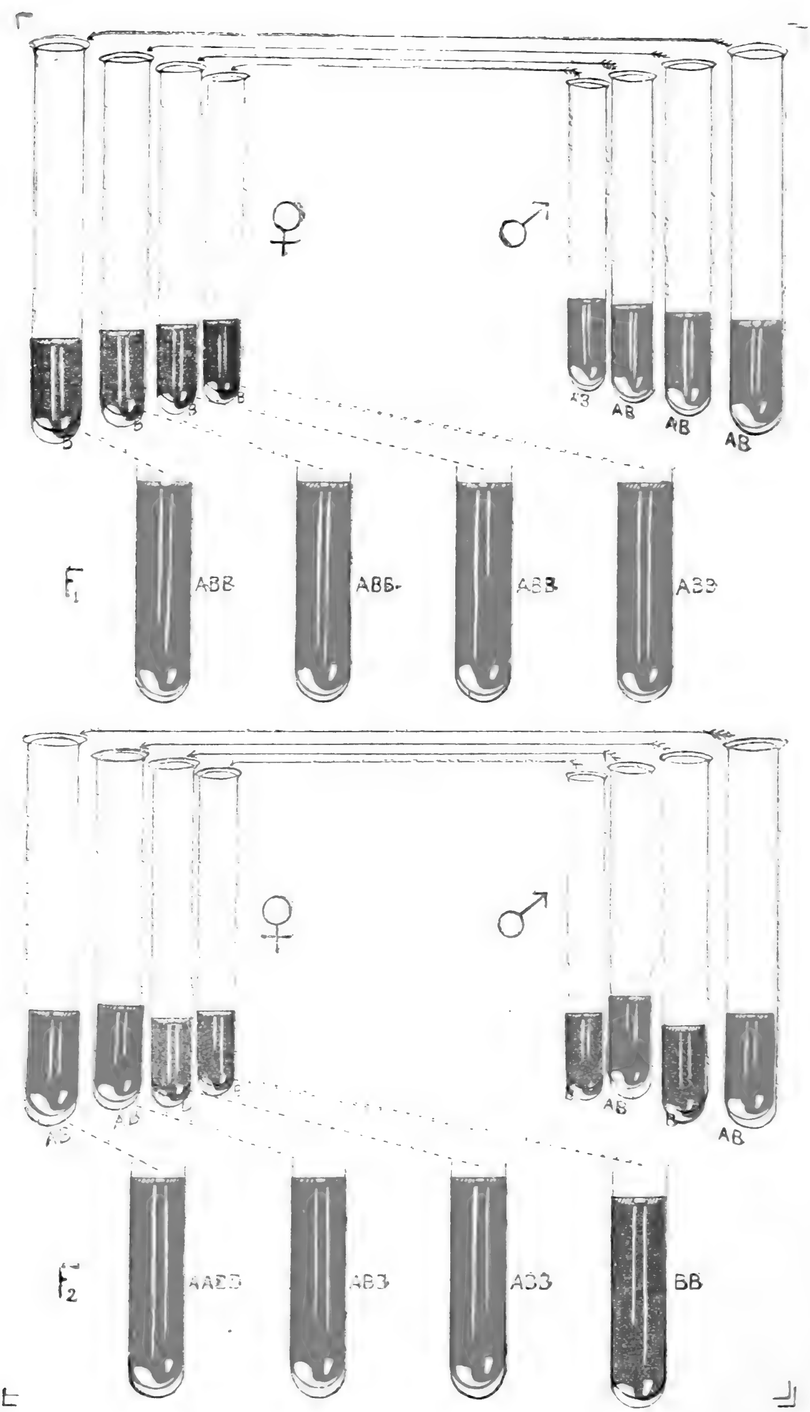
(A) *To demonstrate the more common type of Mendelian inheritance, that in which presence is dominant over absence:* Add sufficient acid to the solution in the one flask to change the color from blue to red, and then add a second equal quantity. These two solutions now represent the two plants to be crossed. Fill four test-tubes one-quarter full from each flask and let these represent the germ cells of the two plants to be crossed. See that is it still kept in mind that the red germ-cells are exactly

*The amount of acid to be added will differ according to the requirements of the particular experiment to be performed, and this must be determined by the teacher in a preliminary experiment.

the same as the blue ones with a single added unit of acid. Have one test-tube rack for the pollen-parent which produces the sperms or male germ-cells (all red for instance), and the other for the pistil-parent which produces the eggs or female germ-cells (all blue). Then take the test tubes with the red solution one by one and empty them into those having the blue solution, explaining that similarly in fertilization a sperm meets and fuses with an egg in the formation of a new plant. The result of this process is the production of four red solutions representing the first generation hybrid between the red and the blue solutions; *i. e.* the dominance of the red or acid over its absence. *

Next explain the production of the second generation hybrids, thus: Each vegetative cell of the first generation hybrid contains side by side the elements received from the two parents, one of these having a unit of acid the other lacking it. When the germ-cells of these hybrids are being formed these elements received from the parents are separated again so that half the eggs have the acid unit and half lack it, and in the same way half the sperms have the acid and half lack it. Illustrate these germ-cells of the hybrids by placing in the "female" test-tube rack two test-tubes one-quarter filled with the original blue solution, and two one-quarter filled with the original red solution. In like manner illustrate the fact that the male germ cells are of two kinds, half having the acid unit and half lacking it, by a similar set of test-tubes in the "male" test-tube rack, two with the blue solution and two with the red. As the test-tubes are taken one by one from the "male" rack and emptied into the test-tubes on the "female" rack, see that the combinations are fully understood. One sperm having the acid unit fertilizes an egg which also has the acid unit, illustrated by pouring the red solution from a test-tube of the "male" rack into one with a red solution on the "female" rack, resulting in a pure-bred red, (positive homozygote). Another red or acid-bearing sperm meets an egg which lacks the acid, as the test-tube con-

*It may seem better, pedagogically to have blue "dominate" over red, as it actually does when blue and red flowers are crossed. This can be easily managed by making the original solution which represents the negative homozygote acid for this particular experiment, adding two equal portions of alkali to produce a blue positive homozygote. As the present experiment was devised to show the dominance of absence over presence it was thought best to make (B) coincide with actual experince in blue × red crossds, giving 3 blue to 1 red. The experiment is equally apt ether way and no misapprehension need result.


♀
♂
B
AB
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F1
ABB
ABB
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♂
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F2
BB

taining the other red solution is taken from the "male" rack and its contents poured into one of the blue solutions on the "female" rack. When all the combinations have been made the four test-tubes on the "female" rack represent the second generation hybrids and show 3 red to 1 blue. That one of the three red individuals of this second generation was a positive homozygote and the other two were heterozygotes, should also have been carefully noted by the class.

(B) *To demonstrate the dominance of absence over presence:* Starting again with the two flasks containing an alkaline solution of litmus, determine how much acid must be added just to make the solutions safely acid; then take half of this quantity to represent the acid-producing unit coming from each of the parents. When this half portion of acid has been added the solution should remain blue, but on adding the second half portion the color will change to red, so that now you are again prepared to make a cross between a blue and a red individual. The rest of the experiment is conducted exactly as in (A), but the first generation will show four blues, and the second generation will show 3 blue to 1 red, that is, the absence of the added acid unit is dominant over its presence.

(C) *To show the equivalence of reciprocal crosses, regardless of the fact that egg and sperm differ much in size:* Take the situation described under (A) after preparation has been made for the demonstration of the second generation. Fill up the test-tubes on the female rack with water until they are half or two-thirds full, leaving those on the male rack one-fourth filled with the more concentrated fluids. As this is done it should be explained that just as the water is neither acid nor alkaline and does not modify the reaction which takes place when the two fluids are brought together, so the food-materials whose accumulation makes the egg larger than the sperm are neutral substances which do not affect the behavior of the hereditary qualities. If desired, this difference between the egg and sperm may be represented throughout all of these experiments, by adding water to the test-tubes on the female rack in all cases, but as the aim should be to keep the demonstration as simple as possible, it would seem best usually to follow the plan suggested here, of making the equivalence of reciprocal crosses a separate experiment.

Finally, to show how appropriately this experiment represents the actual cross between the red and blue flower, dip the red flower into boiling water a moment and then hold it in the fumes of ammonia or dip it into a dilute solution of ammonia or of sodium hydroxide. Similarly take the blue flower and dip it into the boiling water, and then into a dilute solution of hydrochloric acid, in this way demonstrating that the difference between the blue and red flower is due simply to the fact that the cell-sap of the blue flower is alkaline, and the cell-sap of the red flower is acid.

THE PLANT SOCIETIES OF MONTEREY PENINSULA.

(*Continued.*)

By H. B. HUMPHREY.

Although by far the greater part of Monterey Peninsula is covered with forest growth, there is an area varying in width from a few yards to a quarter of a mile or more and extending from Pacific Grove to the northern limits of the cypress forest, a distance of approximately four miles, upon which neither pine nor cypress has succeeded in establishing itself. A probable explanation accounting for the absence of forest growth in this open district may be found in the fact that from Point Pinos to Cypress Point all vegetation is far more directly exposed to the prevailing severe winds that beat in from the open ocean; while at Pacific Grove and Monterey, situated as they are upon the protected shores of Monterey Bay, the pines and other trees may and do encroach very closely upon those plants that characterize the shore formation.

In this open area occur the sand dunes, discussed to some extent in a previous paper, the open meadow land, and the bog areas, each peopled with plants wholly or quite peculiar to it. And yet in all three one may find plants of the same species—plebeian mesophytes—apparently as much at home in a bog as when stationed upon the unstable crest of a dune.

The entire forest floor, in some places to a depth of several inches, is covered with organic detritus in every stage of decomposition. The great bulk of a season's rainfall is absorbed by this cover of vegetable mold, much of it being gradually given up to the under-lying soil, but not a little of it finds its way out of the forest to some small stream that may seek out a course through the sand dunes ultimately reaching the sea. Here and there one comes upon a low, wet meadow in the depths of the forest, or a bit of marsh land in the open; each due to the constant supply of water furnished by the forest cover; and each supporting a flora comprising numerous plants of hydrophytic habit as well as a large number of the more adaptable mesophytes, such for example, as *Sisyrhinchium bellum*, *Iris longipetala*, *Plantago lanceolata*, several grasses, and various leguminous plants, any or all of them thriving quite as well in soil much less copiously supplied with water.

Such typical water-loving plants as *Mimulus langsdorffii*, *Lemna minor*, *Nasturtium officinale*, and *Azolla filiculoides* are apt to be especially abundant in small streams that cut their courses through the sand-dune areas. And one not uncommonly meets with highly specialized xerophytes occupying sand bordering some shallow stream, the home of hydrophytic plants. In other words, here one may find the two extremes of adaptation with reference to water economy without meeting with any intermediate types.

Anything like a complete list of the plants occurring in the bogs and open stretches along shore is impossible here as the writer was in the field but six weeks of three consecutive summers, and was somewhat hindered in the identification of species owing to the want of a suitable manual covering especially the flora of the Monterey district. With the aid of Jepson's Flora of Middle Western California upwards of a hundred species were determined, a number doubtless representing considerably more than half the total of the seed plants one might observe during the course of the year.

With the exception of the typically hydrophytic plants, such as *Nasturtium officinale*, *Ranunculus aquatilis*, species of Lemna, Mimulus and Juncus, and such mesophytes as *Cotula coronopifolia*, *Hookera capitata*, *H. laxa*, *H. terrestris*, *H. ixioides*, *Calochortus luteus*, and a few others, the plants occurring in these open formations are not infrequently found associated with the rock vegetation of the ocean shore, and with those plants that constitute a typical sand dune flora. In order to maintain themselves and produce fertile seed in the midst of such highly modified conditions as obtain in the sand dunes and under the direct influence of salt mist and rock substratum these wandering mesophytic plants are compelled to undergo a variety of structural modifications already alluded to in another paper. It might prove highly instructive to carry out an exhaustive study of the relation of many or all of these plants to their environ-

FIG. 2. The mutual mingling of Monterey pines and live oaks near Pacific Grove.

mental influences. Such a study might incidentally throw some light upon certain hereditary problems.

THE FOREST SOCIETIES.

By far the greater portion of Monterey Peninsula is covered with two well defined formations, *i. e.* pine and cypress. The former is the greater in extent and in the early history of the state must have occupied fully nine-tenths of the total area of the peninsula.

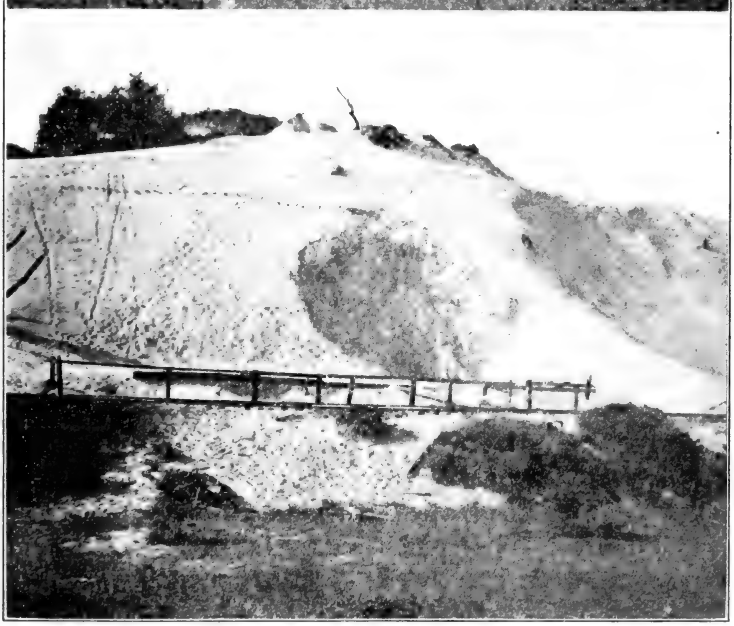


FIG. 3. (above) The march of the dunes into forest territory, near Pacific Grove.
FIG. 4. (below) A fast growing and destructive sand dune.

Pinus radiata, popularly known as the Monterey pine, is a tree of considerable interest to the student of plant distribution. It occurs naturally in a zone measuring at most but a few miles in width and extending from near Pescadero in San Mateo county down the coast to San Simeon Bay. It is not entirely confined to the mainland, for it is also found on the islands of Santa Cruz and Santa Rosa of the Santa Barbaras and on the Island of Guadalupe off the coast of the Peninsula of Lower California. Apparently it meets with the most suitable environment on Monterey Peninsula, where it may be observed in its greatest excellence, a few trees attaining a height of eighty to one hundred feet, and a circumference of sixteen to eighteen feet

It seems to be a tree well adapted to ornamental planting, and handsome specimens are now to be found in such remote parts of the world as southern Europe, Australia, and New Zealand. Probably no species of pine is more popular along the Pacific Coast than is *Pinus radiata;* at any rate it has been more widely planted from Vancouver to Los Angeles than has any other member of the genus.

The distribution of this pine is apparently very intimately related to the influence of precipitation and atmospheric moisture, and its adjustment to these conditions is a delicate one. When the Arboretum at Stanford University was established many of the trees selected were of this species, it being supposed that the conditions of soil, humidity and water supply would not vary so widely from those of its natural home as to seriously influence the growth of the trees in the arboretum. Time has demonstrated this much at least pertaining to the life of the Monterey pine, when grown in the northern part of the Santa Clara valley: when the soil is cultivated and not allowed to run to weeds and grass, the trees do fairly well; and if sufficient water is supplied they may attain to a size and vigor rivaling that of the best specimens in the natural forest. If the trees are allowed to shift for themselves, as they have been largely compelled to do in the arboretum, they manage to make a fair growth for a few years, but do not begin to thrive as they do under natural conditions.

Like the coast redwood, *Pinus radiata* is a tree the distribution of which is more or less governed by atmospheric moisture, though just what factor prohibits its appearance nodrth of an beyond Pescadero is not known. It is very evidently less well adapted to establish itself in localities subject to the action of heavy winds than is its associate the Monterey cypress, which grows upon uninviting granite cliffs and in the very teeth of the wind.

Between the pine forest and the sea the wind has for a long time been piling up a series of sand dunes that serve the forest as a windbreak, and under the protection thus afforded a certain percentage of each year's seedlings escape destruction.

The innermost dunes have encroached upon the outer limits of the forest to such an extent as to bring about the destruction of some large trees; and it is not improbable that as the destruction of forest vegetation continues the inner limits of the dunes may in the course of generations be found much farther inland than at present.

Cowles, in his studies of the Lake Michigan sand dunes, has pointed out the interesting fact that where the growth of a dune is slow, pines and certain other trees are capable of maintaining themselves for many years, though the gradual accumulation of sand renders the life of the afflicted tree much shorter than it might otherwise be under perfectly normal conditions of growth. This fact is likewise true of the Monterey pine, as may be seen by a comparison of figures three and four. Figure three is a good illustration of the advance of dune formation through a part of the forest. Here the accumulation is slow and the trees, though somewhat impaired in vigor and development, are managing to hold their own very much more satisfactorily than are the trees shown in figure four where the growth of the dune is markedly much more rapid. The living pines seen at the left stand in a pocket of some depth, but this, too, is gradually filling up, and the trees occupying it are certainly doomed to an ultimate burial.

It would indeed prove interesting to carry on an extended study of this problem of the relation of the sand dunes to the forest; for without doubt trees existing under such conditions, exposed as they are to the action of severe winds and advancing sand, must undergo some interesting physiological and structural changes.

PARRY AND SOUTHERN CALIFORNIA BOTANY.

By S. B. Parish.

Dr. Charles Christopher Parry's connection with Southern California botany began in 1849, when he became botanist on the Mexican Boundary Survey. Coming west by Panama, he he joined Emory's party in July of that year at San Diego. Here he remained until the eleventh of September, when he accompanied a party to the mouth of the Gila River,which was not reached before December 10th, and then, with greater rapidity, returned to San Diego. The season of the year at which this journey was made was not favorable to desert botanizing, and even the weeks which preceeded it could have afforded no great opportunities of securing many of the plants at San Diego, where Nuttall had spent, in the spring of 1836, twenty-four days of diligent and productive herbarizing. Parry's collections of this year were probably not large, but whatever they may have been, they were lost in transit east, probably in a disastrous fire at Panama.

In view of recent developments at Imperial and other parts of the Colorado Desert, Dr.Parry's impression of its agricultural possibilities is not without interest. "As far as all agricultural purposes are concerned," his report reads, "this is truly a desert. The borders of New River, being subject to frequent if not regular overflow, would seem to present some opportunities for the limited cultivation of maize, beans, pumpkins and melons, such as is practiced by the Indians on the Colorado. Still we must admit that any system of cultivation must be very precarious in a location where its success depends upon such variable causes. The higher adjoining lands being without the reach of these influences, are, from their extreme aridity, and the light porous nature of the soil, quite unfit for any cultivation."

In the ensuing spring, 1850, Dr. Parry collected about San Diego, and along the western end of the boundary line. His collections of Cactaceae were very valuable, including the types of *Cereus Emoryi*, near the terminal monument; *C. Engelmanni*, *Echinocactus cylindraceus* and *Opuntia Parryi* at San Felipe; *O. prolifera* and *O. serpentina* at San Diego; and *O. ramosissima* and *Mamillaria tetrancistra* at indefinite points on the desert. In the same spring he collected on the San Diego plain *Ophio* *glossum Californicum*, which remained known only from his single specimen, until 1882, when it was re-discovered at the type station by its original collector and Daniel Cleveland. In the same neighborhood he found the first specimen of the little *Saxifraga Parryi*, and at San Luis Rey the type of *Microseris platycarpa*. Somewhere in the mountains east of San Diego he gathered *Frasera Parryi, Phacelia Parryi, Pentstemon ternatus* and *Hulsea californica*, and at San Felipe *Condalia Parryi*. Los Angeles also was visited, where *Ceanothus crassifolius* was first secured. Dr. J. L. LeConte was visiting San Diego at this time, and his attention had been attracted by a peculiar pine tree, growing on the coast bluffs at Soledad. At his suggestion Dr. Parry visited Soledad, and found the pine to be an undescribed species, which he named in honor of Dr. Torrey, the honored friend and instructor of the two discoverers.

Early in 1851 Dr. Parry returned overland to El Paso, Texas, and it was not until 1876 that he re-visited California. Then, in company, for a part of the time, with the enthusiastic J. G. Lemmon, and the veteran Edward Palmer, he spent several months in the San Bernardino region. This was almost a virgin field, having been barely touched by Antisell and by Cooper, whose collections were small and unimportant. * To Parry and Lemmon it yielded a rich harvest of new species, as well as of plants then rare and little known. Dr. Parry made his headquarters at Crafton, a ranch a few miles east of the present Redlands, the site of which town and its embosoming orange groves was then an open sheep range. On the borders of the zanja which flowed by the ranch, he found a saxifragaceous plant, which had come down the stream from its mountain source, and which he afterwards named *Boykinia rotundifolia*; and on the nearby stony plains the type of *Chorizanthe Parryi* an abundant plant of this valley.

* Dr. Thomas Antisell was the geologist of Park's Pacific Railroad survey, 1854–5. He collected a large number of plants along the route of the survey, which, in California, extended from San Francisco to Los Angeles, and thence by the Cajon Pass to Soda Lake, in the Mojave desert, and afterwards from San Diego to the mouth of the Gila river. To the report of the survey he contributed a list of the plants collected by him, under the title, "Synoptical Table of BotanicalLocalities." Those relating to Southern California are a list of 104 plants from "Los Angeles, San Gabriel and San Bernardino plains," and of ten from the "Desert of the Colorado." They are of interest as the first published lists of Southern California plants.

Dr. J. G. Cooper was geologist on the Geological Survey of California from December 1860, to April, 1862. He did some work along the coast, at San Diego, San Pedro, Santa Barbara and the Coast Islands, and also examined the Colorado Valley near Fort Mojave. He collected a few plants between Cajon Pass and Camp Cody in 1861.

Several important trips were made to interesting parts of the region. The earliest was through the San Gorgonio Pass to the western borders of the Colorado Desert. The localities visited were the Arroyo Blanco, or Whitewater River, and Agua Caliente, now known as Palm Springs. On this trip Parry and Lemmon collected *Dalea californica* east of the pass, *Nolina Parryi* on the dry, rocky ridges south of the point now marked by the Whitewater section station, and *Phacelia campanularia* and *Cheilanthes viscida* on a rocky hill on the left bank of the Whitewater, and perhaps two miles from its exit. The several canyons also yielded the type of *Astragalus tricarinatus*, and somewhere in the region was collected *Mentzelia involucrata*. At another time our two botanists ascended Cajon Pass, and explored the desert base of the San Bernardino Mountains as far as the Mojave River. At the summit of the pass they found a showy little Gilia, which Dr. Gray named in honor of Mrs. Parry. A small-flowered species, *Gilia Lemmoni*, was collected in the same region, although more abundant on the other side of the range. Another humble herb gathered at this time became the type of *Lemmonia*, a genus still monotypical.

May 29th, Parry, Palmer and Lemmon and eleven friends ascended San Bernardino Peak by way of Mill Creek. It was probably on this trip that *Collinsia Parryi*, and *C. Childsei*, named for one of the party, were discovered; and either then or at some later period *Eriogonum saxatile* was found in Mill Creek Canyon. In July a visit was made to the Bear Valley region, the party going up City Creek and following the crest of the mountains to Holcomb Valley, where two days were spent in botanizing. In this neighborhood were collected the type material of *Allium Parryi*, *Astragalus lectulus*, *Trichostema micranthum*, *Calyptridium Parryi*, *Pentstemon caesius* and *Ivesia argyrocoma*. In the same month Dr. Parry made a visit to the mountain ranch of Ring Brothers, at the head of Edgar Canyon, at an altitude of over 4,000 feet, and not far from the present summer resort of Oak Glen. Here, in the rich soil of a cienega grew a fragrant yellow lily, afterwards named by Watson in honor of its discoverer. This lily was formerly very abundant in the numerous cienegas in the neighborhood of its discovery, but has now disappeared by the reclamation of agriculture. It is, however, still to be found in many places in the San Bernardino and San Jacinto mountains. Late in the summer Parry returned to his eastern home.

He next visited the Pacific coast in 1880, when he accompanied Dr. Sargent and Dr. Engelmann in an exploration of the Pacific coast forests, in connection with the forestry report of the 10th U. S. census. Dr. Parry left the party at San Francisco in September, where he remained until the middle of December, when he came to Colton for the winter. From this place he made numerous excursions by the Southern Pacific Railway to both the Colorado and the Mojave deserts. In the latter desert he discovered *Oxytheca luteola* growing in the moist sand formed by seepage from the railway water tank at Lancaster, and in the neighboring alkaline soil *Kochia californica* and *Atriplex Parryi*. The summer of 1881 was spent in San Francisco, with a June trip to the Yosemite, returning early in December to Colton. In March he went to San Diego, and thence to Ensenada, in Lower California. This trip was made by wagon, and with the party were Pringle, Marcus E. Jones and Orcutt. A number of interesting discoveries were made, among them *Rosa minutiflora*, *Aesculus Parryi* and *Ribes viburnifolium*.

Dr. Parry soon after returned to San Francisco for the summer, but in November once more settled himself in Colton, and in January, 1883, with Mr. W. G. Wright and Orcutt repeated his Lower California trip of the previous year. *Ptelia aptera* was then first collected. The summer of this year was spent in the Bay region, and the middle of September he returned to Davenport, where he remained until the following April (1884), when he sailed for England, passing a year in the land of his birth, studying at Kew, or resting at Ilfracombe, on the Devonshire coast.

November, 1886, found Dr. Parry again in California, where he remained until the winter of 1888-9, and he again returned for the summer of the latter year. He was now devoting himself mostly to monograph work, and traveled much over the state to study the living plants. This led him to make several visits to the southern counties, the last in June, 1889. These studies resulted in valuable papers on such difficult genera as Caeonothus, Arctostaphylus, Oxytheca and Chorizanthe. A revision of the Pacific Eriogonums was projected, and after his return to the east in August he spent some time studying the material in the herbaria at Cambridge, New York and Philadelphia. The next summer he planned to devote to field studies in California. But this was not to be. Seized with a sudden illness, this excellent botanist and genial Christian gentleman died at his home in Davenport, February 20, 1890.

OBSERVATIONS ON CACTI IN CULTIVATION.

BY J. C. BLUMER.

EFFECT OF MOISTURE AND FERTILIZER UPON SAHUARO.

At Sahuarito, twenty-five miles south of Tucson, an individual Sahuaro (*Cereus giganteus*), evidently transplanted, was seen growing in a small sand wash just outside the fence of a corral. It evidently receives large quantities of water overflowing a cattle trough from time to time, and with it a large amount of highly nitrogenous food in the form of cattle manure in solution. The plant is about twelve feet high and sixteen inches in diameter, with thirty-four ribs near the top. It is evidently increasing rapidly in size, and is so insecurely rooted in the sand that it may be easily swayed. The number of spines arising from one areole was found to be the same in this as in an individual of the same species growing on the east slope of Sentinel Hill, near the Desert Laboratory (about twenty-five), but those of the Sahuarito plant were but one-half to one-third as long, and very much more slender and bristle-like. The epidermis and palisade tissue, however, were thicker, and the section cut was richer in starch and chlorophyll. The parenchymatous tissue was somewhat green for several centimeters inward from the sinuses, and at these points the vascular tissue was hardest to sever. The point which first drew attention, however, was the very remarkable profusion of buds, flowers and green fuits in all stages of development, that covered the plant on all sides for three feet from its top. A careful estimate placed the number of these upon the plant on June 9, 1909, at three hundred to four hundred, while many had fallen and other buds were appearing. The walls of the ovaries and the involucral bracts were thicker than the same parts on Sentinel Hill plants.

The Sahuarito plant is quite well protected from wind, and while open to the sun all about, is subjected to strong insolation in the afternoon. Under its influence, coupled with plenty of rich moisture, photosynthesis is probably at its height, while the warm and temporary dry period at the date of observation, perhaps acting especially through the medium of the sandy soil, undoubtedly brought on the unusual wealth of flowers.

A CASE OF STIMULUS AND RESPONSE IN OPUNTIA.

In the enclosure of the Santa Cruz hotel at Tucson, Arizona, there is a planted specimen of Opuntia with flat, spineless joints. On June 3, 1909, and for several days preceding, the numerous stamens of the large light-yellow flowers then in bloom were seen to exhibit interesting movements when touched. As the flowers unfold, the anthers radiate outward until all the stamens stand at a greater of less angle from the vertical. A very slight touch with a pencil will cause them to travel inward, at the same time an occasional strong whiff of wind will shake them without effect. If pushed outward, there was a strong reactive movement inward until the stamens stood nearly erect next the pistil. If pushed inward, little movement took place, and this was apt to occur in any direction. If the stamens were depressed to the right on the near side, there was little or no motion beyond the resumption of their first position; if, however, they were bent to the left, they not only regained their original position, but kept moving varying distances in the opposite direction, the anthers sometimes traveling the distance of a centimeter before coming to a halt. If the bending stress was applied in the same direction all about the flower, the reflex response manifested itself by the rotation about the pistil of the entire body of anthers, coming to a stop only when the filaments had assumed a strongly leaning position opposite to that given by the stimulating object. If the same stress was applied the other way around, the filaments on coming to rest stood nearly erect, as before.

The same flowers were found on succeeding days with their stamens in the original position, and the application of the same stimulus produced in each case the same response as before. The plant grows in a shady place and receives plenty of moisture, which has considerably postponed its flowering period, and elongated its young joints. The same conditions may perhaps bring about more active responses than would be the case if the plant were growing in the open under natural conditions.

BOOKS AND CURRENT LITERATURE.

One of the most noteworthy recent contributions in plant geography is a volume on the Cape * by Dr. R. Marloth, with sections by the late A. F. W. Schimper.

The area embraced is that southward from the southern edge of the Kalahari desert at 27 degrees south latitude, one of the most diversified parts of the African continent. The treatment is such as to convey a vivid picture of the vegetation, to give details as to the gross anatomy of the characteristic species, to throw light upon the relationships of the flora and to correlate the vegetation with climatic and soil conditions as far as this is possible in covering so large an area in which the physical features are so little known.

Scattered bodies of evergreen broad-leaf forest occur along the extreme southern coast of the Cape and on the southward flanks of the mountains at the interior, being limited to localities with 30 to 36 inches of rain. Many of the groups of plants peculiar to the Cape or common to Australia are found in the rain forests, where there is a rich assemblage of trees, notably species of *Olea*, *Gonioma* and *Podocarpus*, together with tree ferns, lianes, epiphytic orchids and ferns.

The greater part of the Cape region proper is covered by two scrub or bush formations, the Rhenoster and the Maquis. The former is chiefly made up of low bushes, prominent among which are the Rhenoster (*Elytropappus*) and species of *Cliffortia* and *Metalasia*, while the Maquis is a mixture of bushes and small trees, species of *Olea*, *Leucodendron* and *Protea*. There are several types of Maquis, but the whole area of these two bush forma-

*Das Kapland, insbesondere das Reich der Kapflora, das Waldgebiet und die Karroo, pflanzengeographisch dargestellt. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition. Bd. II., Th. 3., 436 pp. 146 text figs., 8 maps, 20 heliogravure plates. Jena, Gustav Fischer.

tions has been very much modified by human agency. They are confined to localities with somewhat less than 30 inches of rain, falling chiefly in winter. Several types of swamps and heaths are described for the Cape region proper, in which the Restionaceae occupy the place of prominence held by Cyperaceae and Juncaceae in other countries. The heaths and alpine formations of the highest mountains (6,600 ft.) are also described.

Along the southeastern coast, to the east of New London, there is a littoral belt with warm moist climate, characterized by swamps of *Bruguiera* and *Avicennia*, and by the occurrence of such tropical forms as *Phoenix*, *Hyphaene* and *Strelitzia*. Turning inland from the coastal belt an open savanna is encountered, with islands of forest; still further, 40 to 60 miles from the coast, we encounter the Kaffirland region. This has a highly diversified vegetation, an open stand of trees with abundant shrubs and succulents, and is very rich floristically. It possesses some of the most interesting of the South African succulents, species of *Aloe*, *Euphorbia*, *Haworthia*, *Gasteria* and *Apicra*, many of which resemble in form the Cactaceae and other succulents of the American deserts, while others are unique. The number of species of succulents is greater in the African than in the American deserts, they are of a wider range of natural relationships, and a larger percentage have developed the leaves as storage organs rather than the stems, as witness many bizarre forms of *Crassula* and *Mesembryanthemum*.

The Kaffirland region merges on the north into the Buschveld, a park-like formation, with fewer bushes and more grass, but just as many trees—largely Leguminosae and Combretaceae—and many succulents. By the growing scarcity of the trees and succulents the Buschveld passes over into the Veld of the Orange River Colony, a pure grass-land formation. To the west the Kaffir region merges into the Karroo desert through the growing scarcity of trees. In the Karroo the succulents form nine-tenths of the flora and are preeminent in the vegetation, while the sole trees are those of the *Acacia* type which border the streams. Passing northward from the Karroo the elevation increases, and on this highland the succulents become less predominant and the bushes more so, largely species of Compositae, trees being extremely rare even along the streams.

Marloth does not call the Kaffir and Karroo regions desert, and even apologizes for calling the still more pronouncedly arid Kalahari a desert by saying that it is not such in the same sense as the Sahara. The Karroo has an annual rainfall of about 10 inches, and while by no means devoid of vegetation it possesses markedly xerophilous types only, both of the sclerophyllous and succulent types, and has an open stand of vegetation, so as to fall well within the definition of desert. In the Kalahari the rainfall is sometimes as much as 4 inches a year, often there is no fall for several years. The only vegetation is scattered clumps of *Aristida*, which grows when it may. On the sandy soils in the Kalahari there are often closer stands of grass, and on rock outcrops there are succulents.

The western coastal region from Olifants River northward is almost totally devoid of rainfall, and has sandy or rocky soil. The vegetation is extremely scant and made up only of deep-rooted forms of a most pronouncedly sclerophyllous character, including *Acanthosicyos horrida, Parkinsonia africana, Welwitschia mirabilis* and several Amaranthaceae, Compositae and Gramineae. Succulent desert forms are absent from this region.

Considerable space is given in the opening pages to an account of the climatic elements. Inasmuch as the Cape lies in nearly the same latitude as the United States it is of interest to note that the major plant formations, forest, grass steppe, succulent desert and sclerophyllous desert, are determined in their distribution by the same features of amount and seasonal distribution of rainfall in both countries. Throughout his treatment Marloth gives attention to the influence of soil conditions in causing the occurrence of plant formations different from those of the locality in which they lie, describing islands of Karroo vegetation in the Cape region and the occurrence of the Cape vegetation on particular soils at the interior. The anatomical and other notes touch on a diversity of subjects such as leaf structure, the character of the storage tissues of succulents, the underground storage organs of herbaceous perennials, the absorption of water by aerial parts, and the longevity of desert plants.

Geological evidence shows the Karroo region to have been desert in Cretaceous time. In the late Tertiary, however, there was a glacial epoch in the southern hemisphere which gave a relatively moist climate to the interior, without depriving the desert flora entirely of favorable localities in which it might survive by northward migration. To the duration of the arid conditions, long even in geological terms, Marloth attributes the richness of Karroo and Kaffirland flora as contrasted with the poverty of the more recent Sahara.

FORREST SHREVE.

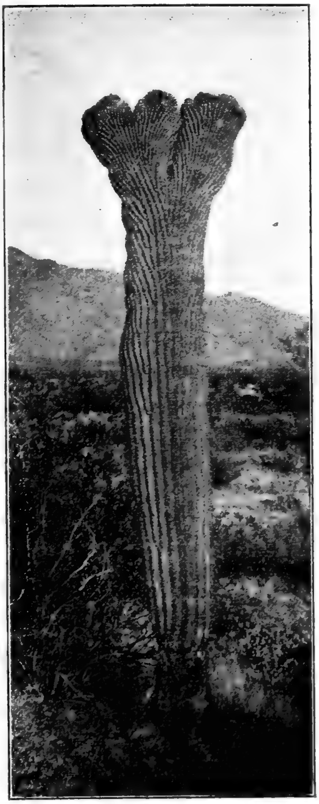
A graft hybrid between the tomato and nightshade has been made by Winckler and is reported in the Berichte der deutschen botanischen Gesellschaft, 1908. After showing in some detail that the new plant must be a hybrid, the author considers its probable structural origin, although the actual process by which it arose is not communicated and probably has not been definitely determined.

It is supposed on theoretical grounds that the cells of the graft hybrid, like the cells of a seed hybrid, must contain chromatin which was derived from both the parents. How this condition could, in the present instance be brought about is then taken up. The adventitious shoots may have arisen from a single hybrid cell, or from a cell which had at least nuclei from both parents, as the shoots in Begonia. But the objection to this lies in the observed fact that, in Solanum, shoots do not take their origin from one only, but usually from a mass of cells.

The interesting possibility is considered that the hybrid may possess nuclei with twice the number of chromosomes found in the parents, which, if found to be a fact, would strengthen, if further proof would seem necessary, the author's contention that the new plant is a true graft hybrid. But it is pointed out that *Cytisus Adami*, which is supposed to be a graft hybrid, has only the number of chromosomes characteristic of its parents, according to the studies of Strasburger. What the nuclear conditions may be in the Solanum hybrid is a matter of great interest and we are promised a report on this phase of the study in due time.

W. A. CANNON.

Aspects of Vegetation in Belgium is the title in English of a beautiful work by Messrs. Bommer and Massart, professors in the University of Brussels. The first volume, by Professor Massart, bearing date of 1908, includes the littoral and alluvial districts, which are represented by eighty-six large plates from photographs. On each plate, as a rule, is given the latitude and longitude, altitude, direction of view, and date of photograph—thus affording a means of noting changes that occur from year to year—conditions determining the association represented, and brief descriptions of vegetation and physical features. For the rest the photographs tell their own story, and so effectually that by studying them in connection with the descriptions one who is accustomed to such work gains a conception of the physiography and plant associations of the dunes and adjacent low parts of Belgium, second in value only to what would be obtained by a somewhat protracted stay in that country. A remarkable degree of success has attended the attempt of the authors to exhibit to the eye the dominant influence of single factors. Some of the most striking cases are brought out in the plates showing the associations of fixed and shifting dunes, the direct action of wind on trees, distribution of water, poverty of mineral constituents of the soil, mildness of winter climate affecting distribution, action of salt water, and changes induced by cultivation. Four more parts of this work are to follow, two by M. Massart, and two by M. Bommer.



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AUGUST, 1909

THE CAUSES OF TIMBER LINE ON MOUNTAINS; THE ROLE OF SNOW.*

BY C. H. SHAW.

In the plant geography of the world there are few features more inviting for study than the alpine vegetation which occurs on many mountains. Sui generis in itself, its characteristics are heightened by contrast with the forest which usually is found immediately below. The limit where the forest ceases, and vegetation of a different and unusual sort begins, constitutes a frontier of unusual interest. Contrary to popular impressions, the cause of timber line is by no means well understood. During the study of certain other problems of mountain vegetation, in the last few years, I have had excellent opportunities for observation of primeval conditions, and the results are embodied in the present paper. Such observational work leaves many questions unanswered; nevertheless it may lead to certain conclusions with sureness. The illustrations are from my photographs obtained at various times.

Most of the work on the subject of timber line has been done in Europe, and there the conditions are peculiarly unfavorable. For in the Alps and Pyrenees, the timber line has been greatly modified by human agencies. When an observer has first to decide whether that which is before him is due to natural causes or not, his conclusions stand a double chance of error. Certain European workers have published elaborate tables showing the precise altitude of timber line and other facts of vegetation

*Read before the Botanical Society of America at the Chicago Meeting, December 31, 1907. By a coincidence, Dr. H. C. Cowles read elsewhere at the same time a paper showing that in many parts of western North America timber line is dependent upon snow.

for parts of the Alps.* When it is remembered that flocks and shepherds have played a considerable and not easily determined part in bringing about present conditions, the value of such tables is less apparent. A study of wooded mountains where conditions are entirely undisturbed would, therefore, seem desirable.

Such, it may safely be assumed, are the Selkirks. So far as is known, even savages have not dwelt there, and the scattered line of settlements now existing along the railroad and the Columbia River constitute too remote a factor to be considered in this connection. The Selkirks possess an additional interest from the fact that in phenomena of timber line and, indeed, of vegetation in general, they bear a strong resemblance to the Alps. In the White Mountains, too, the plant life at high altitudes, so far as it relates to timber line, is quite undisturbed, I believe.

In considering the general question of timber lines, it is to be noted that many errors have been made in regard to their existence. Flahault† has shown that the so-called Alpine pastures of the Cevennes in France are entirely due to the destructive activity of man and domestic animals. In these mountains the natural domain of the beech includes even the highest summits. Acting on his initiative, the government has begun the reforestation of these "alpine pastures," and much progress has already been made.

In the Alps and Pyrenees, the presence of trunks and stumps far above the present timber line, together with other facts of a similar bearing, show clearly for some places that the limits of the forest have not always been what they are today. Demontzey‡ even went so far as to conclude that the present pastures of the Alps owe their existence to, and are evidence of, former forests on the same ground. "Les gazons formant aujourdhui des pelouses continues audessus des forets actuelles ne sont que les temoins de l'existence des forets superieures qui

* Reishauer. Hoehengrenzen der Vegetation in den Stubaier Alpen in der Adamello Gruppe. Wissenschaftliche Veroeffentlichungen des Vereins fur Erdkunde Leipzig. Bd. VI., 1904.

Imhof. Die Waldgrenze in der Schweiz. Gerlands Beitraege zur Geophysik Bd. IV.Heft 3. Leipzig, 1900.

†Flahault, Ch. Les limites superieures de la vegetation forestiere et les prairies pseudo alpines en France. Extrait de la Revue des Eaux et Forets XI. juillet, 1901.

‡Demontzey. Traite Pratique du Reboisement et du Gazonnement des montagnes. 2 ed. Paris, 1882. p. 313.

ont disparu par le fait de l'homme, apres avoir ete la cause dominant de la production de ces gazons."

His view is not shared by others, however. Schroeter,* in his excellent resume of the subject, while recognizing that the Alpine pastures have been much extended, seeks, in climatic causes, the reason for their existence. So far as first-hand knowledge goes, I may say that in a walking trip of several weeks through the Alps, I had much difficulty in finding an illustration of timber line that was beyond suspicion of being artificially caused. I did, however, see the shepherds pulling up little trees near timber line in a manner which left no room for speculation as to its efficiency.

Certain other "timber lines" are still less worthy of the name. One on Mt. Katahdin, in Maine, said to descend as low as 800 meters, was found by Cowles to be merely a case where the steep and rocky character of the mountain side made the development of a forest impossible.

Real timber lines do exist, however, and the question of their cause is one the ecologist is bound to answer. We may accordingly consider some of the various factors which have been assigned as its explanation.

1. *Cold.* The view of the older naturalists was sufficiently simple, namely, that the low temperatures of mountain tops prevent the growth of trees. The rough relation between vegetation zones of altitude and latitude gave support to the idea and it has been widely held. When examined, however, very little can be found in its support. It is without foundation in physiological knowledge for little is known concerning the effects of low temperatures upon hardy plants. That the idea is incorrect is moreover shown by the fact that forests do exist in the coldest districts known on the globe.† Furthermore, so far as cartographic work in the Alps is to be relied on, isotherms and timber lines do not run parallel.

2. *Shortness of Vegetation Season.* If the portion of the year which is sufficiently warm for physiological activity is but short, and relatively cool, the success of the tree might thereby be hindered. This might be true in two respects: (a) The

*Schroeter. Das Pflanzenleben der alpen. Zurich 1908.
†Schimper. Pflanzengeographie.

hindering of reproductive processes; maturing of seed; (b) Of vegetative processes; manufacture of food; growth of new wood.

It is probably true that trees in high altitudes are often unable to mature their seeds. It is not clear, however, that this would limit the development of the forest. Wind-dispersed seeds apparently would have no difficulty in travelling up from below. The idea that insufficient growing time prevents the development of woody shoots must depend wholly upon evidence, and of this little has been brought forward.

3. *Dry Killing in Winter.* Since trees during the resting season are unable to replace the water they may lose, they must be exposed to serious danger from winter drying. Kihlman* reached the conclusion that the arctic limit of the forest is set by the drying action of the winter wind. Schimper† accepted his view and extended it to apply to the timber line of mountains. Diminished pressure and increased insolation would tend to increase this danger for trees at high altitudes, and dessication by wind is probably more emphasized in this connection by present writers than any other cause.

4. Besides the foregoing, many other factors have been suggested. Character of rainfall, summer frosts, soil temperature, possible absence of the necessary mycorhiza, of the necessary soil bacteria—all have been speculated upon more or less and for all it is a question of evidence. Of the latter, very little has been given.

5. *Snow.* That the heavier and longer persisting beds of snow at higher altitudes may have something to do with preventing forest growth has been more or less remotely suggested by several writers, and distinctly by Buehler.‡ However, the factor has not, if the ground taken in the present paper be correct, been given anything like its due importance. The view here presented is that for the Selkirks and neighboring mountains, at least, and probably for the Alps, the late lingering beds of wet snow are altogether the most important factor in inhibiting the development of a forest and bringing about the existence of alpine grassland.

*Cited from Schimper's Pflanzengeographie.
†Pflanzengeographie.
‡A. Buehler. Studien ueber die Baumgrenze im Hochgebirge. Ber. d. schweiz. bot Gesell. Heft VIII. 1898, p. 19–38.

In order to cover the general question as well as possible we may take up in succession some of the phenomena in North America with all of the above factors in view. In the White Mountains of New Hampshire and the Adirondacks of New York, timber lines occur with some regularity at about 1,500 meters. Relatively few of the peaks surpass this altitude, and owing to their isolated position they are much exposed to wind action. The vegetation of their higher altitudes bears every evidence of the severe effects of this factor. As one passes up through the sub-alpine zone the trees become more and more reduced in height, and associate thickly together. At timber line the forest appears as a thicket of stunted trees (*Abies balsamea, Picea* sp.), sometimes, as on Mt. Tahawus, (often called Marcy) so dense with interlocking branches that one is forced to use the axe in order to advance. Farther up the outposts of the dwarf forest are found in little hollows or beside sheltering rocks. At the last we find prostrate dwarfs, strangest monstrosities of arboreal vegetation.

Everywhere in the alpine zone the healthy shoots extend to a certain contour line. Those that pass beyond the intangible limit are moribund or already dead. A sectional view of such a dwarf forest is shown in Fig. 1. The trees grow to a height roughly corresponding to that of the rock which acts as a windbreak. Their form is characteristically that of wind cripples. In both their arrangement and form we see the unmistakable results of this factor. Air currents increase rapidly in velocity with increasing distance from the ground. Doubtless they bring about the results seen largely by dry killing in cold weather. Sand blast action may also play a part. Mechanical pressure of the snow beds leaves its impress on the dwarf trees, especially the prostrate ones, but it is wind which chiefly governs the form and distribution of the trees. It is probably not too much to say that the timber lines of the Adirondacks and White Mountains express a wind relation. Harvey* believes that on Mt. Katahdin, in Maine, the vegetation of which is very similar to that of the mountains just mentioned, the timber line is not a climatic but an edaphic one; that, in

*Harvey. Le Roy Harrier. A study of the physiographic ecology of Mt. Katahdin Maine. The Univ. of Maine Studies, No. 5, Dec. 1903.

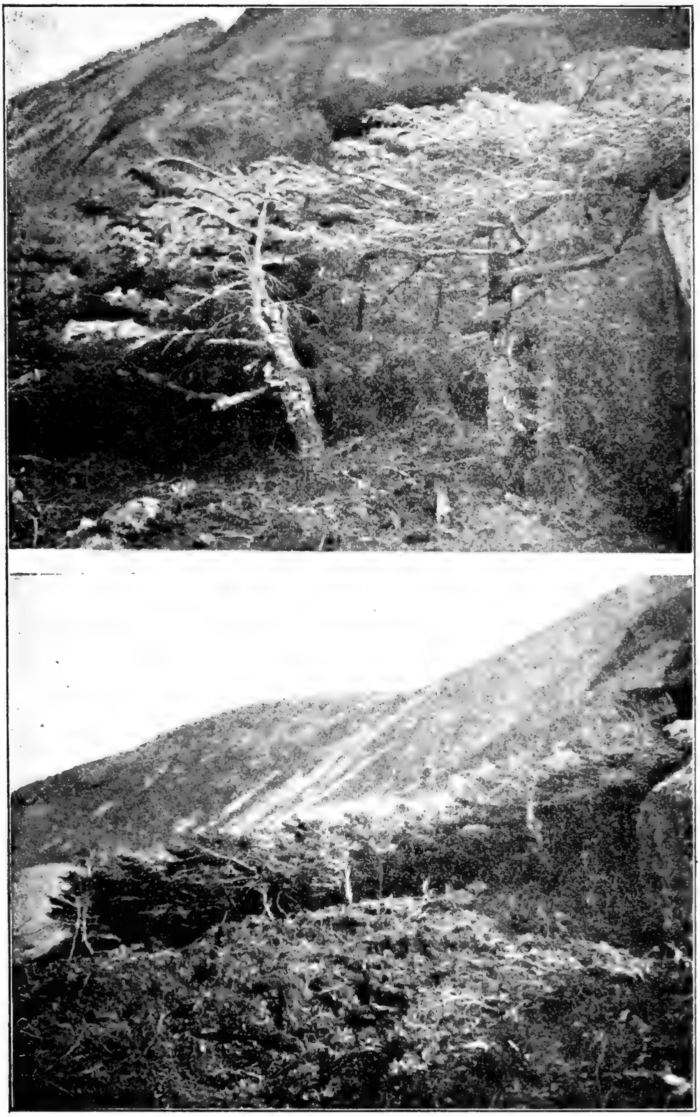

Fig. 1. Dwarf forest near head of Tuckermann's Ravine. Above is a near view of individual trees, while below is given a sectional view of the society, the trees of the foreground having been removed.

fact, as fast as soil conditions permit, the forest is advancing to the summit of the mountain. To the writer this seems scarcely probable. While doubtless a condition of perfect stasis has not been reached, it seems likely that above-ground factors are largely responsible for present conditions.

The mountains of the northwest, especially the Selkirks, present altogether different conditions both as to topography and vegetation. In height, ruggedness and the prevalence of glaciers and perpetual snow fields, they strongly resemble the Alps. They are more or less wind swept, but in the summer, at least, they are far less so than are the mountains of the east just considered. The whole character of the more elevated forests is very different from that described above. In ascending beyond about 1,600 meters, the balsams (*Abies lasiocarpa*) and spruces (*Picea Engelmanni*) which are the dominant species of the sub-alpine forest, begin to appear in little groups separated by shrubs (*Azaleastrum albiflorum, Vaccinium membranaceum*). Higher up this tendency becomes more pronounced; the intervals are occupied by heather plants (*Cassiope, Phyllodoce*) till finally at 2,000 meters, more or less, one emerges into open alpine fields dotted with scattered clumps of spire shaped trees (Fig. 2). On mounds and elevated spots, these clusters of trees wander far upward. A thousand feet above the beginning of the alpine fields, rows and groups of trees still look down from hillock and ridge.

European workers note the distinction between forest line (timber line) and tree line, and some difficulty arises as to definitions, especially where krumholz or large isolated trees are involved. In the Selkirks the outposts of the forest never occur as single trees, but always in groups. In cases so numerous as to be remarkable, the groups at timber line consist of a central spruce or two, of patriarchal size, surrounded by numerous smaller balsams. Possibly this condition might indicate much to him who is able to read it.

The ceasing of the forest at about 2,000 meters to give place to the prevailing open fields can scarcely be explained by any of the accepted causes. Cold can not be the efficient factor, from considerations already mentioned. Neither is it the wind, as is strongly witnessed by the distribution and form of the trees

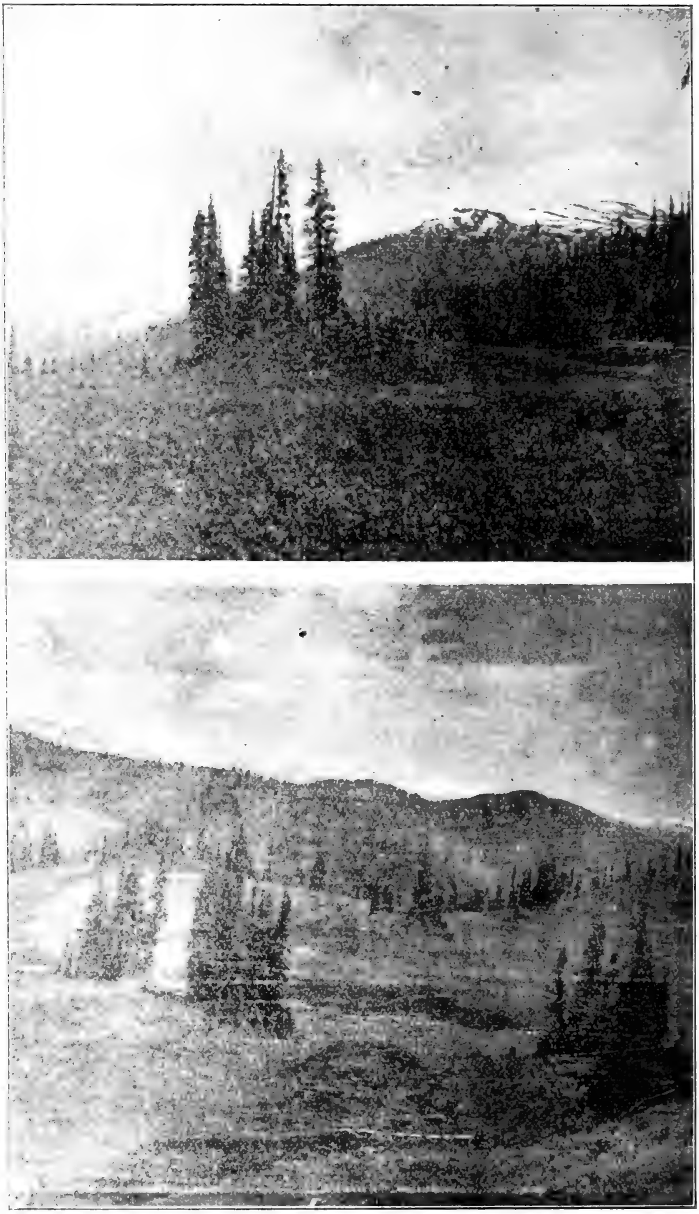

Fig. 2. Landscape at and near timber line in the Selkirks. Above is a group of trees in the upper valley of the Spillimacheen at 1,800 m., and below are clumps of trees and grassland in Ground Hog Basin at 1,900 m.

at timber line. Timber line is lowest in the relatively sheltered valley heads—fine glacial basins as most of them are. To take a specific instance—in ascending the north fork of the Spillimacheen, the first alpine meadows are found in the valley at about 1,800 meters, 400 meters higher, on more exposed shoulders of Mt. Copperstain, clumps of spire-shaped trees still occur.

Where the forest is broken up, the characteristic forms of wind cripples are scarcely seen. Most of the trees are spire-shaped with healthy and flourishing tops. (These statements do not apply to the groups of dwarf trees of higher altitudes.) All considerations point to some other factor which in this case plays a decisive part. What this may be is suggested by the fact that on all sides the trees bear evidence of the mechanical action of snow. They are often branchless and abraded at their bases on the hillward side. Little trees are seen bent over and likewise denuded of branches on one side. Significantly also, innumerable little trees are healthy only in their topmost branches, the rest being dead, matted and infested with mycelia. Further still, the presence of the trees in groups and on local elevations appeared to be a snow relation.

With these ideas in view, I went to the Selkirks in early summer while the snow still lay in the sub-alpine forest and covered deeply the fields above. The conditions seen came little short of a demonstration (Fig. 3). In the forest near timber line, the snow was interrupted only at the spots occupied by the groups of trees into which the forest was becoming resolved. No doubt less snow had accumulated there, and the trees themselves, as dark objects, must have hastened the melting, but the relation was none the less significant. Passing higher up where the snow beds were heavier, the tree groups were more widely separated and more sharply confined to spots where from local contour the snow had not accumulated so deeply. Thus the forest is broken into scattered patches of trees, standing mostly on mounds and hillocks. The vicinity of each group is occupied by numerous small trees. All except the most sheltered show the marks of the struggle with the snow. Only their tops are in healthy condition. The lower branches are dying, covered with fungus mycelia, or have entirely disappeared (Fig. 4.). Such trees present an entirely different picture from that of wind cripples. Just how the snow thus acts so unfavorably can perhaps be partially answered as follows:

(a) During the prolonged melting period, the wet snow may, so to speak, *drown* the buried branches by preventing aeration and at the same time promoting the attacks of fungi. This hypothesis is rather strongly supported by the universal presence of fungus mycelia on the portion of the branch

Fig. 3. Scene in a Selkirk forest. June 20, 1907. Altitude about 1,900 meters.

which has been held under snow. Mention and figure of similar damage due to a species of Herpotrichia are given by Schroeter. Griesch* describes very aptly the relation between Herpotrichia and individual trees at timber line.

(b) Direct mechanical injury. The weight of the snow and its creeping motion on steep slopes at melting time is responsible no doubt for the bent forms of little trees and the bare and abraded hillward sides which so many trunks show

*Griesch. Andr. Beitrage zur Kenntniss der Pflanzengeographische Verhaeltnisse der Berguenerstoecke. Beih. Bd. XXII, Heft 3, Sept., 1907., p. 300.

in their basal portions. Such mechanical action seems, on the whole, however, much less important than the "drowning" by wet snow just referred to.

To digress a moment from the main question, it seems small wonder that places where snow creep occurs to any extent are inhabited only by the toughest and most supple species. In the Cevennes, the higher summits as mentioned above are normally occupied by forests of beech. In attempting to re-forest the areas which have been denuded by man, pines have been planted as nurse trees and now occur together with scattered beeches in the pseudo-alpine meadow. If one chooses a spot where the creep of the snow is pronounced, the pines are seen to be broken and dying while the beech remains unaffected and flourishing. Without going so far as to assign this as a reason why these areas are naturally occupied by the beech, the facts are mentioned as suggestive.

In the Selkirks, as one ascends above the alpine grassland of the valley heads to the elevated outposts of the forests the effects of wind are once more visible. The trees which are permitted by the snow to grow on ridges and hillocks exhibit at an altitude of 2,200 to 2,500 meters the characteristic forms of wind cripples (Fig. 4). These often show the most bizarre forms, due to crippling from both snow and wind and, conjecturally, from the browsing of wild goat and caribou as well.

Finally the farthest outposts dwindle away to prostrate dwarfs or krumholz. Such decumbent trees occur as high as at least 2,600 meters. It is noteworthy that the wind cripples, krumholz, are found only in groups and where the snow does not accumulate deeply. The open grassland due to snow is entirely destitute of them. Possibly herein lies a true distinction of such grassland.

SUMMARY.

The view that timber lines on mountains are brought about by the action of the wind, holds good for the isolated mountains of eastern North America, but can not be applied to those of the northwest, in particular the Selkirks. Two kinds of true timber lines may therefore be distinguished.:

1. Timber lines caused by wind. Such are recognized by a gradual and ultimately great reduction in height of trees,

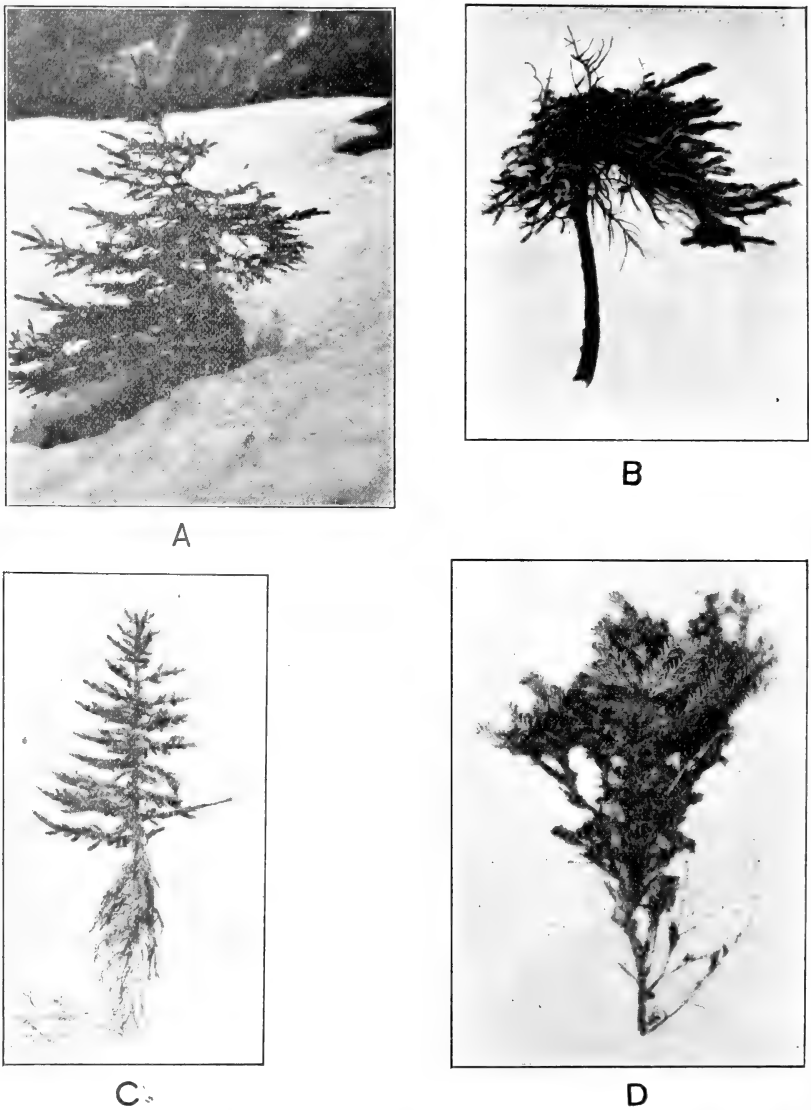

Fig. 4. A.—Small tree and snow. Alps above Murren, May 19, 1906. B.—Wind cripple (Abies lasiocarpa), Selkirks, from interior of a dense clump at about 2,200 meters. C.—A snow cripple (Abies lasiocarpa), the upper branches in good condition, the lower dying, wrapped in mycelia. D.—Branch of Abies lasiocarpa with fungus. The portion of the shoot projecting above the snow is flourishing.

by their massing together in dense level topped societies, thus affording each other mutual protection, and by the occurrence of the upper outposts of the forest as clumps of dwarfs in local depressions and sheltered spots. Wind cripples are characterized by the fact that shoots which project beyond a critical line are dead or dying, often by the entire loss of the conical form; by their much branched and condensed habit, and frequently by one-sided growth. The primary condition which the tree must fulfill in order to exist is to develop sufficient foliage within the limitations set by the wind.

2. Timber lines caused by snow. Such are recognized by the gradual resolution of the forest into clusters of relatively tall trees, and by the occurrence of these groups at timber line and above on local elevations. Snow cripples are distinguished from wind cripples by the presence of healthy upper shoots, by the possession, in their upper portions, of the normal conical form, and by the fact that their lower branches are generally dying or absent. Fungus mycelia abound enwrapping the dead foliage. The primary condition which the tree must fulfill in order to exist is to expand its foliage above the late melting beds of wet snow.

In the Selkirks, wind cripples and a wind *tree line* also occur some distance above the timber line. From the tree line upward, between the snow fields, cold deserts prevail. The alpine grassland of the Selkirks is thus principally due to snow.

In view of the strong general similarity between the Selkirks and the Alps, it is suggested that the ideas here presented in regard to the Selkirks are probably of application in the Alps as well.

NATURAL ALTERNATION OF VEGETATION IN ITS RELATION TO PERMANENT PASTURAGE.

BY L. N. DUNCAN.

On nearly every farm in the south we find more or less land that is too rough to cultivate, or land that probably once made profitable crops, but under ordinary farm practices it has washed and the natural fertility has become exhausted until it no longer makes profitable returns for the labor expended.

We also find land cultivated in the staple crops and making good returns, that would bring larger and more satisfactory returns if it were used for pasture; especially is this true of rolling hill-sides that are liable to wash and soon become very poor if cropped in the ordinary way. On all such lands should be grazing, summer and winter, herds of sheep, cattle, hogs, and other live stock.

We are very fortunate in the south in having two crops that combine nicely and give us a permanent pasture for nearly the entire year. Bermuda grass comes in the early spring and gives us excellent grazing until late fall. Burr clover will then come up and give excellent winter grazing for most of the winter and spring months, until the Bermuda comes back again. This happy and congenial combination of Bermuda grass and burr clover will redeem the poor, unproductive, rolling lands of the south and convert them into dividend earners for the farmer if he will but give these crops a chance to get hold upon the land.

One of the best demonstrations that may be seen, upon visiting the Alabama Experiment Station, is a small plot of poor sandy hill land sodded to Bermuda grass and burr clover and furnishing excellent grazing for about ten months in the year. to several animals If one should visit this plot of land any time from November to April he would find the ground covered with a rich, luxuriant growth of clover. By April the clover is blooming, soon seeds, and passes away, to give place to the Bermuda, which covers the ground from spring to fall.

Re-cleaned burr clover seed should be sown in the fall, from August to November 1st. It is probably best to have the seed in the ground from September 1st to October 1st. If planted in the burrs, which is the best plan, as the burrs carry inoculation, it should be planted in August if possible. After the plant is once well established it re-seeds itself each year. Bermuda may be planted at any time of the year, but there is some danger of its freezing out if planted too near the surface during too cold weather. The best time is probably from February to April.

By thus intelligently taking advantage of the natural alternation in time of two very different forage plants, a succession is maintained by which permanent pasture is insured. The economical importance of this principle, when thus applied, in practice, can hardly be overestimated.

BOOKS AND CURRENT LITERATURE.

The third edition of Fruwirth's monumental work on the *breeding of agricultural plants* is now being brought out by Paul Parey. The first volume, which has just appeared, bearing date of 1909, is devoted chiefly to a discussion of the principles of breeding; the second, third and fourth volumes will include such special subjects as the breeding of grasses, maize, potatoes, tobacco, and a rather comprehensive list of the most important agricultural plants. The matters discussed in the first volume are of special interest to students of the broad subject from the historical and theoretical standpoint; but no one, it would seem, who is engaged in any way in plant breeding can afford to be without the whole work.

Doerfleria is the title of a new international journal "for the furtherance of the practical interests of botanists and botany," published by I. Doerfler at Vienna, which appears to have been undertaken, in part, in response to requests for more frequent publication of the Botanists Directory, or at least of addenda, by which those interested may keep posted as to changes of address of botanists, the appearance of botanical papers and news, including biographical notices, reports of botanical explorations, meetings of academies and societies, convocations, notes on acquisitions of botanical institutes and gardens, "in short everything that may be of interest to botanists generally." Much of this is of course already provided for in existing publications, but the new journal will no doubt serve a highly useful purpose as a medium of communication, especially if the hope of the editor to make its circulation world-wide is realized. The journal is published monthly, and the subscription price is twelve crowns.

The fifth and last volume of *Trees*, by the late H. Marshall Ward, has just appeared from the press of Messrs. G. P. Putnam's Sons, New York, and is listed at one dollar and fifty cents. This number especially will appeal to lovers of trees as they grow in nature and have come to be associated with man, since it contains many fine hand-made cuts showing characteristic forms and habitats of such trees as European larch, Roman cypress, Lombardy poplar, English oak, cedar of Lebanon, Deodar cedar, Norway spruce, silver fir, yew, beech, and hornbeam. Practically all the full-page illustrations, as well as most of the smaller ones, are drawings instead of photographic cuts that so often do not illustrate, of which fact writers of technical and popular publications can well afford to take notice. In the second half of the book trees are classified according to their shapes. The book is written in the same clear, concise style that characterizes the other volumes, and hence will be as useful to the amateur as to the professional botanist. Of this valuable series of books, volume I deals with buds and twigs, volume II with leaves, volume III with inflorescence and flowers, volume IV with fruits, while the present and last one treats of form and habit of trees. These books are already so well known that little comment is necessary, having found their way into the hands of many persons interested in trees and forestry.

J. J. THORNBER.

In experiments of Osterhout, reported in the Jahrb. f. wissensch. Botanik, when seedlings of wheat were grown in a mixture of 400 cc. NaCl and 30 cc. KCl, the roots made nearly three times as great a growth in length as in the pure solution of either of those salts, both of which were shown to be poisonous when employed alone. A like relation was observed between salts of sodium and magnesium. The spores of *Botrytis cinerea* failed to grow in a solution of either sodium or magnesium chloride, but grew well in a mixture of the two, the best results being obtained with a mixture of 100cc. sodium chloride with 10cc. magnesium choride. Calcium also hinders the poisonous action of sodium. The antagonism between the chlorides of sodium and calcium is much greater than between those of sodium and potassium or sodium and magnesium. The experiments were repeated on different plants, with the substitution of nitrates for chlorides and in soil as well as in water cultures, with entirely similar results. Like results have also been obtained by Loeb and Ostwald in their work with various animals. The experiments suggest a combination with some constituent of the living substance; normal life, according to the author, being possible only when the necessary salts combine with the colloids of the plant cell in a definite relation.

R. E. Fries, experimenting on *Spironema fragrans*, a Mexican plant of the Spiderwort family grown in the Botanical Garden of Upsala, has found that this plant, in general like Marica, Cordia and certain orchids, is characterized by simultaneous blooming of different individuals at intervals of from one to ten days. When an individual was kept in very faint light, or exposed to ten degrees lower temperature, the intervals during which blooming was wholly interrupted were lengthened for this particular individual, but when like conditions were restored the typical synchronism of different individuals was again established. This synchronism of blooming on the part of different individuals is believed by the author to be of much importance in connection with pollination.

Burgerstein, in the Ber. d. deutsch. bot. Ges., presents an account of the influence of light of different refrangibility on the development of fern sporangia. Some 25 species of ferns were kept under observation in a greenhouse. Yellow and blue glass was employed with the result that under the influence of the blue rays the prothallia were formed from a few days to some weeks later than under the action of rays of less refrangibility.

From studies of Burck reported in the Revue generale de botanique it appears that in *Stellaria media* dehiscence of the anthers is dependent on the presence of nectaries at the base of the stamens. In this and various other species water is drawn from the stamens by osmotic action on the part of nearby tissues containing much glucose. In addition, then, to the secretion of nectar as an aid to fertilization by insects, and the production of reserve sugar to be used in the development of fruits and seeds, the nectaries of certain species appear to play an important part in determining dehiscence of the anthers independently of the hygrometric condition of the atmosphere.

The views of von Ihering set forth a decade and a half ago, according to which the northern parts of South America were connected with Africa in Mesozoic times by a land bridge, which apparently was not wholly lost until the beginning of the Tertiary, are still maintained by him, and are now brought together with additional material, in a work published by Engelmann on Archelenis (the bridge just referred to) and Archinotis (the ancient Antarctic continent). The need of such a bridge has been keenly felt by students of distribution, but if its aid is invoked to account for the present occurrence of certain closely related species in South Africa and the Southwestern United States, which are not found elsewhere in the world, it appears that in these cases, at all events, there has been a marvelous pertinacity in the maintenance of biological as well as morphological characters since the early Tertiary.

Lidfuss, in a biological study published by the University of Lund, discusses the relation to cold of plants that remain green through the winter. In winter the leaves of such plants—at any rate in Scandinavia and northern Germany—are destitute of starch, its place being taken by sugar. In southern Sweden starch begins to be formed about the beginning and middle of April, and is found in the leaves until fall, being replaced again by sugar in the winter. To prove that the sugar is protective the author fed solutions of various kinds of sugar to different plants and subjected them, with control plants, to low temperatures. It was found after thawing that individuals fed with sugar were much less injured than those not thus fed. From various data the author concludes that sugar protects the protoplasm against death by freezing, in that it hinders the "denaturing" of the albuminoid bodies which takes place when it is not present.

Experiments of Apelt, reported in Beitr. zur Biologie der Pflanzen, go to show that potatoes are capable of being "educated" to endure adverse temperature conditions. Tubers of the Magnum bonum variety, which were kept four weeks in a warm room, at a temperature of 22.5 degrees, were afterward killed by freezing at —2.14, but if tubers of the same variety were kept at zero in an ice chest for four weeks, death did not ensue until a temperature of —3.08 was reached. Kept at intermediate temperatures the critical point was between these extremes. Different varieties of potatoes were found to deport themselves very differently. The promptness of adjustment observed leads the writer to conclude that plants of cold and temperate climes may even be able to keep pace with the advancing cold of autumn months by a gradual lowering of the point at which death by freezing takes place.

Kraus, in a recent publication of the Physical-Medical Society of Wurzburg, discusses certain questions of soil and climate arising in a study of limestone soils. With a different amount of lime goes hand in hand a very different structure of soil, and as a result of this the water content and temperature of the soil are different. Soils containing a high percentage of lime have less capacity for water and a higher temperature, while those with less lime are moister and cooler, so that in these soils highly important physical factors are present which apparently render it quite unnecessary to assume chemical action as a factor determining the nature of the plant covering. But these physical factors are in turn greatly modified by a number of conditions. Soil temperature varies with aspect and altitude, and water content is influenced by the fineness or coarseness of the soil, while, again, the drier the soil the higher does its temperature rise (in sunlight). "All in all, the soils examined present an endless variety physically and chemically, and the origin and continuance of the many plant forms growing on them is to be understood by reference to this variety."

From a review by C. H. Ostenfeld of Wesenberg-Lund's important work under the title *Plankton Investigations of the Danish Lakes* the following abstract is presented of the author's summary of present knowledge of the fresh water plankton of the earth, its conditions of life and forms of adaptation.

The plankton of different geographical areas is analyzed and characterized in part as follows:

1. The arctic fresh water phytoplankton is very poor, and there is a great mixture of littoral and pond forms.

2. The phytoplankton of the north European lakes is richer. Diatoms are abundant; Desmids are also characteristic, and Flagellates are important.

3. The Baltic fresh water phytoplankton is very rich. Myxophyceae are present in enormous quantities; Diatoms occur

in great masses; Protococcoideae are numerous, but Desmids rare.

4. The phytoplankton of the Central European alpine lakes is different according as the lakes are low-lying large lakes or low-alpine, the latter having a poor phytoplankton made up of Diatoms and Flagellates.

5. The phytoplankton of the Mediterranean lakes, of the North American lakes, of the Asiatic lakes, and of the tropical lakes are still insufficiently known.

The life conditions and adaptation forms of the plankton of each geographical area are discussed at length, and the data summarized as follows: The fresh water plankton is characterized by its well-marked cosmopolitanism; the fresh water associations (communities), in contrast to all other associations on land and water, everywhere contain the same types and nearly everywhere the same species. The fresh water plankton is amongst the oldest associations of the earth. This fact may be explained by its very great power of adaptation to outward conditions.

The different plankton associations of the Danish fresh waters are arranged in nine categories; the phytoplankton includes:

1. The true lake plankton, which differs according to depth of the lakes. In deep lakes the Diatoms produce enormous maxima from March to November, although in the warmest period *Ceratium hirundinella* is the main form. Chlorophyceae are very rare; Myxophyceae few (only Oscillatoria and *Anabaena flos aquae* are at times dominant). The shallow lakes are chiefly characterized by the water-bloom, which is due to the dominance of various Myxophyceae; the Diatoms are of minor importance, while the Chlorophyceae may be common.

2. The plankton of coast lakes is little investigated, but it seems to be very poor; it contains much detritus.

3. The plankton of dune lakes contains very few Myxophyceae and Diatoms, but Flagellates in considerable quantities, also many small Chlorophyceae.

4. The plankton of heath lakes is very like number three, but Dinobryon seems to be dominant.

5. The pond plankton is very rich in species and varies greatly from pond to pond. In contrast to the lake plankton

it is rare to find ponds the plankton of which consists mainly of Diatoms. Very characteristic of the ponds are the numerous Protococcoideae, also some Conjugatae are often found. In spring and autumn large maxima are formed by Flagellates, which are perhaps the most dominant forms.

6. Plankton of the artificial marl pits, which are very numerous in Denmark, consists nearly of zooplankton alone, phytoplankton being practically absent, especially in newly dug pits.

7. The plankton of bogs is characterized by the large maxima of Flagellates, while Chlorophyceae are nearly absent and Diatoms play a secondary part.

8. The plankton of very shallow pools of drying up rain-water is very little known in Denmark; the phytoplankton consists of Flagellates and small Protococcoideae.

9. The plankton of pools with manured water is quite peculiar; among organisms with chlorophyll Euglaena is an inhabitant of this association.

NOTES AND COMMENT.

Readers of the PLANT WORLD have noted that the sections devoted to Books and Current Literature and to Notes and Comment have recently been allotted somewhat more space and that a greater variety of topics have received attention. As this has appeared to meet with approval it is proposed to continue the arrangement and, if possible, to enlist the cooperation of working botanists who may be willing to contribute notes of whatever kind that are indicative of actual progress within their sphere of activity and observation. As in preceding numbers, these notes will be as informal as possible. Facts that have become common property will be given brief mention, often without reference to authority. The Botanisches Centralblatt will be drawn upon for items of interest at home and abroad, and work of American botanists now in progress will be given due attention as far as it is possible to obtain reports. Discussion and criticism will be welcomed in so far as they are of a scientific rather than personal nature. Botanists everywhere are invited to contribute notes, suggestions, plans of work, in short anything by which other botanists and teachers of botany are likely to be aided.

Of all departments of botanical literature none perhaps have proven more exasperating, speaking broadly, than that devoted to lichens. Small wonder that very few American botanists have ever specialized in this group. The young student who started with lichens as he did with other plants, by collecting what specimens he could find and then attempting to identify them, was confronted with a mass of Latin description that dampened his ardor, while the anatomically minded were introduced at the outset to a body of controversial literature which, to say the least, was uninspiring. Notwithstanding the contributions of well known specialists, hints on the economic value of reindeer moss and other species, duly brought out in college lectures, and even their part as agents in soil building, somehow the whole lot, like the Assyrian host, were all dead corpses long before they were fairly ticketed and laid away. One might become enthusiastic over anything else in the vegetable kingdom but lichens. Their congenial food was gravestones, and all their connections seemed to reach away "into the abysses of the unbeginning past."

None the less, at least one working botanist of the present day has taken hold of this apparently forbidding group, and has shown it to be one of remarkable interest, one that from the new point of view may be expected to attract and reward serious students. Without attempting here to review, or even summarize, the contributions of Professor Bruce Fink, notice may be taken of two recent papers in which his attention to biological relations, hitherto almost wholly neglected, is shown.

The first of these, entitled "Licheno-ecologic Studies from Beechwood Camp," which appeared in the Bryologist for March 1909, gives a short account of the two hundred acre forest near Oxford, Ohio, which has been maintained for the most part undisturbed for several generations, and now presents well-nigh ideal forest conditions for both taxonomic and ecological studies. A camp was first occupied in the summer of 1908, and although no results of importance are ready to be made public, the account of simple experiments that have been instituted with a view to determining rate of development, growth, and fruit production of various lichens, and to observe accurately the phenomena of invasion and succession is highly suggestive. Further reports will be looked for with expectant interest.

The second paper which appeared in Mycologia, for May 1909, is on "The Composition of a Desert Lichen Flora." Thirty-three species are enumerated which were collected in the vicinity of the Desert Laboratory at Tucson, Arizona, and although the author was hampered by having only material collected by others, his discussion of certain problems suggested by this relatively meager collection is indicative of the new and hopeful methods that are coming into vogue in Lichenology. Instructive comparisons are made between the lichen flora of the Desert Laboratory domain and that of a region previously studied by the writer in Minnesota. The lichen flora of the Arizona area, taken as a whole, is very different from that of the area in Minnesota, with which it is compared, but the rock species, twenty-five in number, show a striking resemblance to those growing on exposed granite in the latter state. Thus, on the one hand, the differences of composition correspond with climatic differences obtaining in the two regions, while the likeness of the rock species may be referred to similarity of edaphic conditions, the studies of the author going to show that lichen formations of horizontally exposed rocks in regions of average rainfall, as well as those of perpendicular or inclined, southward-facing rocks, may show the same structure as the lichens of the desert rocks. The lichens occurring on the rocks in the vicinity of the Desert Laboratory are noticably lacking in species with conspicuously lobed thalli, a fact which may correspond to a demand for decrease of surface in contact with the drying environment, and also, quite possibly, to the advantage offered by a structure not easily torn away from the substratum by desert gales.

Protection is afforded as a rule, by a pseudo-parenchymatous cortex, which protects the living algal cells and the hyphae of the medullary layer against the drying effects of high wind and the direct rays of the sun. What may be protective coloration, manifest in the development of black lines or spots on the upper surface, was observed in every species having a light-colored thallus, but the observations thus far made are not wholly conclusive, notwithstanding the opinion of Zukal that such lines of black occur on the younger or injured portions of thalli to protect the algal cells from the intense rays of sunlight in hot regions.

The lichens of the Desert Laboratory domain were collected at seven stations, and in certain cases, which are discussed at length, are seen to exhibit marked differences referable to substratum on the one hand and aspect on the other. Among other conclusions based on comparative study of habitats here and in Minnesota, the author states that species of Acarospora, with their strong protective cortices and cellular structure throughout, are the most characteristic xerophytes of all our American lichens thus far studied from the ecologic point of view.

In the discussion of lichen distribution as influenced by moisture and air movements the author considers at length the evidence thus far obtained regarding absorption of moisture by lichen thalli from the atmosphere and also from the substratum, and assumes, until otherwise proven, that lichens absorb at least a large proportion of the moisture needed directly from water vapor of the atmosphere and from water falling upon them. He attributes to drying southerly winds an influence accentuating the effect of direct sunlight, thus leaving the northward facing ledges by far the best habitats for lichens.

The value of the paper, as should be the case in contributions of this nature, consists not merely in its presentation of data and conclusions, but also in the pointing out of promising fields of investigation suggested in the course of the work thus far accomplished. In conclusion it may be said that had the author limited his study to a determination and enumeration of the species of desert lichens which were sent to him for examination, he doubtless would have contributed to the advancement of botanical science, but very few persons would have cared, nor does any reason appear why they should.

Tropical Life announces a prize of fifty pounds sterling for an essay embodying research work directed towards ascertaining "exactly what changes (together with their causes and whether these changes occur during the fermentation process only or while being dried) take place in the cacao bean between the time that it leaves the pod until it is shoveled into the bag for export." For further information those interested may address the editor of *Tropical Life*, 112 Fenchurch St., E. C., London.

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WHAT IS THE USE OF RESPIRATION?

BY GEORGE J. PEIRCE.

Business men realize that the degree of economy of time, energy, and material in the conduct of a business is often the factor which determines profit or loss. In almost all cases it determines the degree of either; in many cases it determines the one or the other. Increased economy implies proportionally increased efficiency. Increased efficiency implies increased production and increased success. Waste brings harm or, at best, prevents good.

Turning from these trite generalities to a still general consideration of living organisms, we see that they use material in various ways, building their bodies or liberating energy; that they use energy for doing various kinds of work, manufacturing, digesting, transporting food, moving, growing, reproducing themselves; that the speed with which they do these different kinds of work varies somewhat according to the kind and the individual. A swallow is swifter than a grey-hound, but, in proportion to their sizes, both are slower than a young hay-bacillus. All three absorb their food ready-made; they waste no energy in manufacturing food. But they are not equally active, equally efficient. Why? What are the wastes? One waste is in discarding, as useless, material consisting of complex compounds which it cost much energy to elaborate. The urine and fecal matter of animals, and the by-products of bacteria, contain much valuable material which, as the other organisms living upon these wastes prove, can be used for body-building and for the liberation of energy. In this form of waste bird, beast, and bacillus are alike in quality; whether in quantity or not, I do not pretend to know.

Again, we may ask whether the material retained in the living body and used to furnish energy for the living thing is used economically? To make the question more definite, is the yield of energy high, and is a fair part of the yield available for use? Any answer to this question involves a study of those physiological processes collectively called respiration. It involves at least the quotation of physics and chemistry; and experience causes me sincere regret that not more botanists are at least potentially physicists and chemists.

The calorific values of the ordinary fuels and of the usual foods have been determined with a fair degree of precision. These values are found by experiments involving the complete oxidation (combustion) of the materials in question. A pound of a certain kind of coal will yield, under certain carefully specified conditions of firing, so many units of heat. The products of the combustion will be CO_2, H_2O, small amounts of various other volatile substances, ash, and heat. Similarly the calorific values of starch, sugar, fat, oil, protein (meat), *et cetera*, have been determined outside of the body. These determinations, however, involve the comparatively simple, or at least the comparatively isolated, processes of the laboratory. They can not include the multitude of processes, great and small, going on, in more or less orderly fashion, in the most confusing thing in existence, the living body. These determinations assume that all the energy liberated by combustion is liberated in the form of heat. This assumption is doubtless correct so far as the laboratory determinations are concerned; but it is probably a mistake to apply it to physiological oxidation. Taking this for granted, and seeing a little more plainly that the apparently simple question above, regarding the yield of energy in respiration, is not to be answered offhand, I should like to limit myself to the question whether a fair part of the energy yielded is available for use, or whether much of it is lost.

The study of heat production in respiration, which I have been carrying on for a year, leads me to believe that respiration is a very wasteful process if the liberation of energy in the form of heat is all there is to it. For example, using 80 grams of soaked peas, washed in an antiseptic solution to prevent bacterial action, in each of five silvered Dewar flasks, I found that the temperature rose over 100 p.c. within three days in each flask.* The silvered flasks act only as remarkably efficient insulators, retaining in the peas and within the flasks a very high proportion

*Peirce, G. J. A new respiration calorimeter. Botanical Gazette, 46, 1908.

of the heat liberated. Had these peas been germinating and respiring at the same temperatures in or on the soil, they would doubtless have liberated at least as much energy in the same time, but there would have been no trace of it. The heat would have gone; radiation, convection, and conduction, into air and soil, would have taken place. Such a transfer of heat from germinating seeds tends to warm the surrounding soil. Whether this is necessary or even desirable depends upon circumstances. Seeds germinating in warm weather, in warm soil, respire more rapidly and produce more heat, than seeds of the same sort germinating at less favorable temperatures, *i. e.* in cooler weather and cold soil. Seeds germinating in cold soil in early spring may help themselves by warming their immediate surroundings with the heat which they liberate and lose; but it is hard to see that they benefit themselves by giving still more heat to soil already warm when germinating with the temperature high and with their rate of respiration correspondingly increased.

One may determine the amount of heat required to raise the temperature of the apparatus used, namely, a silvered Dewar flask of 250cc. capacity, the lower quarter of the large thermometer inserted in the flask, the 80 grams of peas and the 60 p. c. of water which they absorbed while soaking for 24 hours. This is, however, a tiresome task, unnecessary to describe here, and we may content ourselves, at least for the time, with the knowledge that the amount of heat required to raise the temperature of this apparatus and contained peas 100 p. c. within three days is large. Furthermore, this heat can not be used by the germinating peas which liberated it in the experiments to which I have referred.

The human body is said to have a "normal temperature," 98.6 degrees F., 37 degrees C. This temperature is maintained with slight fluctuations, so long as the body is in ordinary health. But from the smooth surfaces of the body, heat, liberated by respiration, radiates at rates which vary greatly with the circumstances. Clothing of various sorts tends to reduce radiation, but although it more or less successfully does so, it does not save the heat for use by the living being. The heat radiated from the exposed skin of the face and hands is no more completely lost to the living man than that which is held in his clothes.

He can not use either. Feathered and fur-bearing animals lose less heat by radiation, etc. than naked-skinned animals. They maintain a body temperature independent of that of their environment with less cost of material, with less rapid respiration, than if they were bare. The body-temperature of many animals, however, is not independent of the temperature of their environment. In this respect they are like plants. Instances are known in which the body temperature of plants and plant parts rises for a time considerably above that of their environment; but this is only temporary. The smoothness and great area of the surface of most plants in proportion to their mass makes rapid radiation inevitable at low temperatures of the air, and the maintenance of a body-temperature independent of the environment is impossible. The "normal temperature" of the higher animals is probably that at which the bodily functions taken collectively, go on best. It is probably the optimum temperature. Although there is doubtless an optimum temperature for all the bodily functions, taken collectively, of each kind of plant, it is not a temperature which the plant itself can maintain. It inevitably loses too much heat. Are we then to regard respiration in plants as a very wasteful process, or are there in it, both in animals and plants, other uses than the liberation of energy in the form of heat? What possible uses are there?

When we realize that our knowledge of *chemical* energy is entirely inadequate, that the only means most of us have of forming any conception of it is furnished by the forms of *mechanical* energy which sometimes constitutes the measurable end-product of reactions or processes, then we see at once that the heat liberated in respiration and mostly lost by the organism may perhaps be the end rather than the main product. A simple illustration will at once suggest what I mean. When a rapidly revolving saw is driven through a piece of wood too large to be used without cutting, there will be certain products, material and energetic, useful and useless, desired and undesired. A piece of wood of the proper proportions is the product desired, neither the saw-dust (another material product) nor the heat (mechanical energy) set free by the saw rapidly moving in the resisting medium wood. We can measure the heat and all the other products of sawing. We can also measure the material products and the heat, CO_2, H_2O, etc. liberated in respiration. But we can not measure *all* the products and we can only inadequately apprehend what they are. Physiologists have come to see that CO_2 is not the essential or invariable product of respiration, but we have not yet realized that heat may not be the essential, although it appears to be the invariable, product of respiration in plants and in animals. The calorimetric experiments above referred to show that only a small part of the heat liberated can possibly be used by the living organism. May we not, therefore, regard it as the end-product of a series of reactions liberating or transforming energies? Some of the energy may be converted into work; some may escape measurement, whether converted into work or not, because we know neither the energy nor the work; the unused (chemical?) energy may escape, after transformation, as heat.

Whether respiration is to be regarded as wasteful or not, who can say? If the work to be done is essential, if the processes are fundamental, and if, for their accomplishment, a certain form or forms of energy are necessary, other forms being by-products, then we can not regard respiration, any more than wood-sawing, as wasteful. The heat liberated is, under certain conditions, very useful; it may warm the chilly soil immediately surrounding the sprouting seed; it may melt the snow about and above the growing stalks of spring flowers and of those wild plants which, the summer through, make their way through the edges of snow banks high up on mountain sides. But, for the most part, the heat liberated in respiration must be regarded as useless, the end-product in a chain of unknown links. The use of respiration would appear ,therefore, to consist not in the liberation of energy escaping and measurable as heat, but in supplying living organisms with necessary substances or with energy in those needed forms which are accompanied by heat as a by-product or end-product.

Stanford University, California.

QUERCUS LEANA; A HYBRID OAK.

BY LOUIS W. SAUER.

It is now quite universally accepted that the Lea oak (*Quercus Leana,* Nutt.) is a hybrid between the shingle oak

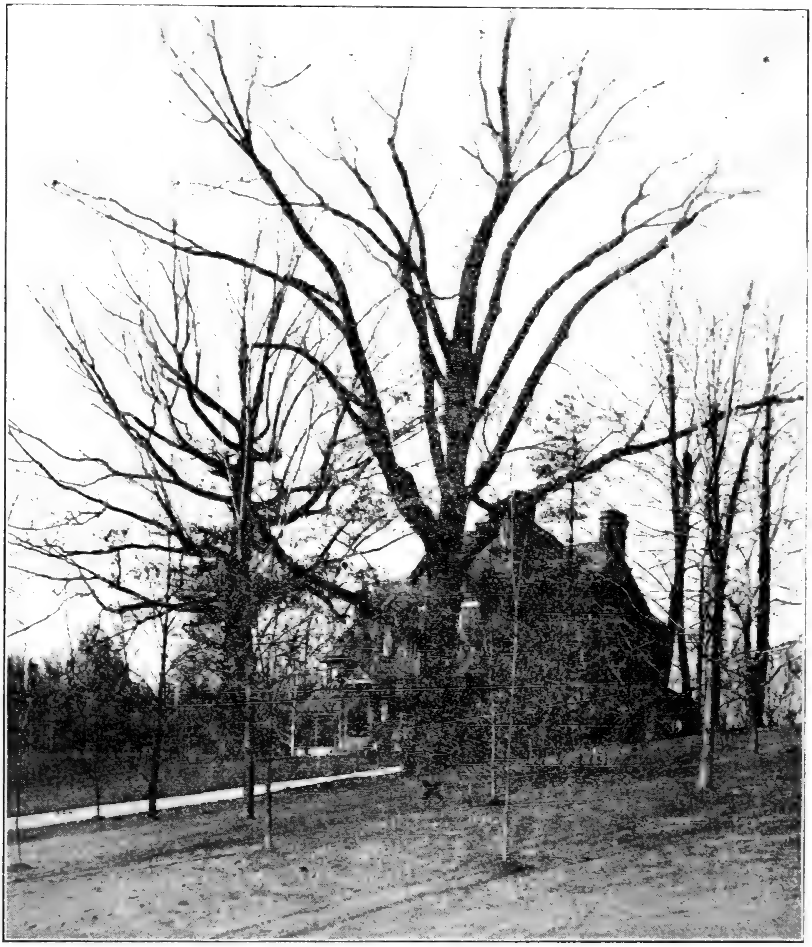


Fig. 1. Quercus Leana on grounds of Captain Holden, Cincinnati, Ohio.

(*Q. imbricaria,* Michx.), and the black oak (*Q. velutina,* Lam.). Before the characters and description of the hybrid are taken up, we shall briefly consider the two parents.

Quercus imbricaria, Michx., Shingle Oak.—A forest tree usually 60 to 75 feet high, with a trunk of less than three feet in diameter. The leaves are oblong or lanceolate, entire, quite acute at both ends, dark green above, and gray and tomentulose ventrally. The flowers open when the leaves are about one-third grown (mid-April); the staminate being borne in the axils of linear-lanceolate bracts on hoary aments 5 to 7cm. long. The calyx is divided into four yellow, pubescent segments. The stamens are usually four, the anthers being emarginate and yellow and quite glabrous. The pistillate flowers are borne on slender tomentose peduncles, the involucrate scales of which are pubescent and about half as long as the acute calyx lobes. The short, yellow stigmas are reflexed. The fruit is usually broad, full and rounded at apex, but narrowing at the base. It is chestnut-brown, 1 1-2 to 3 cm. long, enclosed for 1-3 to 1-2 its length in a thin cup-shaped cup. The acute cup-scales are pubescent on their surface.

Quercus velutina, Lam. (*Q. tinctoria*, Michx.), Black Oak, Yellow Bark Oak. - A forest tree from 60 to 80 feet (occasionally 150 feet) high, with a trunk three to four feet in diameter. The leaves are obovate or oblong, rounded, mostly 7-lobed and occasionally divided nearly to the middle by wide sinuses into narrow, obovate lobes, or into nearly entire lobes. The young leaves are bright crimson, the mature leaves are dark green and lustrous above, thick and firm, with a yellow-green, brown or dull copper below. The fruit is solitary or in pairs; the nut being ovate-oblong, obovate, or hemispherical, broad and rounded at the base, full and rounded at apex, and is red-brown in color. The shell is often striated, and the cup encloses a half of the length. The cup is thin and deeply turbinate.

Quercus Leana, Nutt. (1842), (*Q. imbricaria*, Michx. × *Q. velutina*, Lam.) (*Q. imbricaria*, Michx. × *Q. coccinea*, Englemann, 1877).—Lea Oak.—This hybrid oak was discovered by Thomas G. Lea, in Clifton, a suburb of Cincinnati, in the late thirties. The specimen is today in a very healthy condition, measuring 75 or 80 feet in height, and having a diameter of more than three feet. From a distance it resembles the white oak in general contour. This hybrid has been found in solitary specimens in widely separated localities, ranging from the District of Columbia to Tennessee, Missouri, and to Michigan.

The winter buds are acute, puberulous, and about 1 cm. long (Fig. 2). The leaves are convolute in the bud, oblong-obovate to lanceolate, entire, sinuate-dentate, or dentate lobed, with acute or rounded bristle-tipped lobes. The apex is usually slightly 3-lobed, the base gradually narrowed and wedge-shaped or rounded. The unfolding leaves are scurfy-pubescent and not reddish. At maturity the leaves are from 10 cm. to 15 cm.

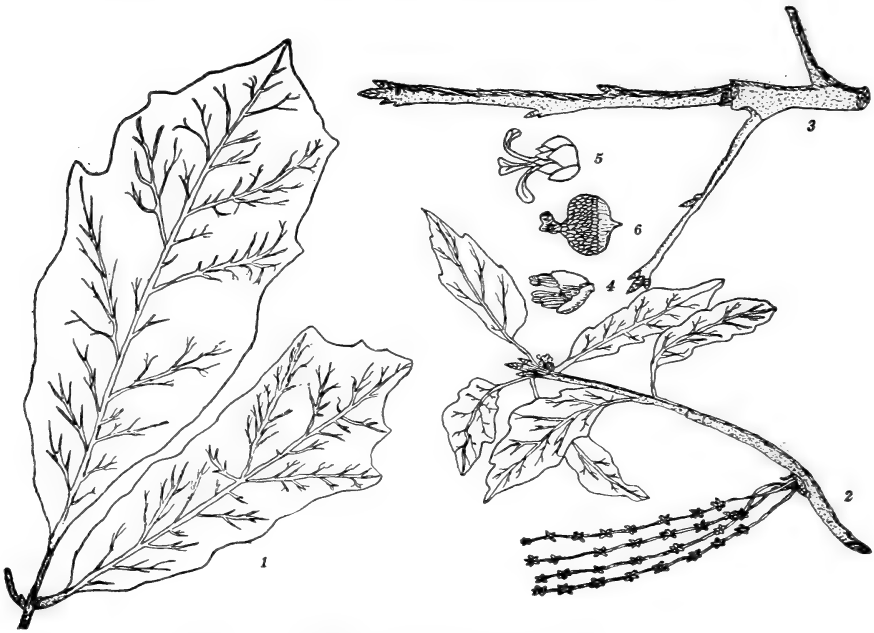


Fig. 2. Leaves and flowers of Quercus leana.
1. Leaves (natural size).
2. A flowering twig with staminate and pistillate flowers and immature leaves.
3. Twig showing winter-buds.
4. A staminate flower (enlarged).
5. A pistillate flower (enlarged).
6. An acorn (natural size).

long, and from 5 cm. to 7 cm. wide. It is of thick and firm texture, lustrous and dark green above, rusty-brown and puberulous below, with slender petiole, mid-rib, and primary veins. The petiole is from 2 1-2 cm. to 4 cm. long. The fruit is sub-sessile or pedunculate, and usually solitary. The nut is short, full and rounded at both ends, and is covered nearly to the middle by the turbinate, hemispherical cup. The scales are ovate, loosely imbricated, pubescent, light red-brown. The shell of the fruit is often striated as in the black oak.

There are four excellent reasons for considering this oak a hybrid, and these are:

(1) Hundreds of acorns have been planted, but there is no record of one having sprouted.

(2) The few specimens discovered are isolated from each other.

(3) The leaves closely resemble those of the shingle oak.

(4) The cup and fruit bear marked resemblance to those of the black oak.

The author thanks Captain Holden of the Lloyd Library for aid in locating the Cincinnati specimen of *Q. Leana*, Nutt.

University of Cincinnati.

THE LIGHT REQUIREMENT OF PLANTS.

BY JOSEPH Y. BERGEN.

There is probably no higher authority on the relations of plants to light than Professor Julius Wiesner of the University of Vienna. He has, during many years, published important papers on this general subject, and in 1907 he set forth the principal results of his researches in his *Lichtgenuss der Pflanzen*, W. Englemann, Leipzig. As there are few important topics in plant physiology of which most of us know as little as we do about the amount of light needed by plants for successful life and growth, it may be worth while to sum up for the readers of THE PLANT WORLD a few of Wiesner's statements and to comment on some of them.

The author defines the term *Lichtgenuss* as meaning substantially the light-requirement of any given species of plant. The relative light-requirement signifies the fraction of the total amount of light in any particular region which will enable the plant in question to thrive there. For example,if a plant will flourish in the evergreen woods of the Adirondack regionwith one-third of the total light which falls on unshaded areas there, its light requirement is 1-3. It is noteworthy that as a rule the light-requirement increases in the higher latitudes. *Acer platanoides*, which in Vienna, lat. 48.12 deg. N., has a light-requirement ranging from 1 to 1-55, in Tromso, Norway, lat. 69.50 deg. N., has a requirement of from 1 to 1-5.

Evidently, as the author remarks, the introduction of light-measurements, even if at first they may be somewhat crude, initiates a decided advance over the plan of describing the habitat of a species as sunny, partially sunny, shaded, or deeply shaded. Every such extension of our knowledge of plants makes one long for an ecological flora of his own locality. Impracticable for extensive regions, such a flora could be worked out for a limited area in such a way as to include most of the things best worth knowing about the commoner seed plants treated. It might cover their light, heat, and moisture requirements, their relation to soil composition, to animal and plant parasites, and to pollinating insects. Much attention should be paid to the influence of these factors of the environment in causing variations. Who now knows all of these details that might be learned about any single species?

One of the chief difficulties in the way of getting an accurate knowledge of the light-relations of plants is that it is very difficult to determine with reasonable accuracy the amount and kind of light which they daily and yearly receive. Notwithstanding the existence of good photometers for the physicist and so many kinds of sensitive paper which will give some kind of measurement of relative light intensity, there is no instrument which measures illuminations as promptly and accurately as the thermometer measures relative temperatures. As is well known the light from different portions of the spectrum affects the plant very differently. Apparently, transpiration is most favored by blue light, heliotropic movement by light from the portion of the spectrum between violet and ultra violet, photosynthesis by light from the red to the yellow portion. Blue and ultra violet light are necessary to the healthy growth of green plants, serving to prevent excessive growth and etiolation. It is evident then, that sensitized paper which is acted on by only a few kinds of rays is not a satisfactory measure of the value of any given illumination for plants. If, however, we know that the light which they receive in any particular case is merely weakened sunlight, with the several regions of the spectrum all proportionally represented, we may fairly make use of ordinary photographic paper for our measurements. It will then be necessary to standardize the paper in some way in order to know what fractional part of the full sunlight the area, plant, or part of a plant under consideration is at the time of observation receiving. These questions of photometric methods and of the nature and intensity of daylight are fully discussed in the first two sections of Wiesner's work. *

One of our author's important contributions to the general subject of light-relations of plants, discussed in detail in earlier works and briefly outlined in his *Lichtgenuss*, is the classification of leaves with reference to their utilization of light. Those which show no fixed relation to the incidence of light, such as pine needles, are classed as aphotometric. Those which show some relation, either fixed or adjustable, are photometric. Of the latter class there are two divisions, *euphotometric* leaves, and *panphotometric* leaves. Good examples of the euphotometric class are those in the interior of the crown of most deciduous trees. These exercise the greatest economy of light and are so placed as to receive as much diffused light as possible. If they are borne by plants which grow in the shade of forest trees (not on the margins of woods) they extend almost horizontally to get the maximum amount of the light which filters through the leaves above them. Panphotometric leaves show the most complex adaptations of any, since they can ward off some direct sunlight by exposing their edges to it, but offer a much greater surface for the absorption of diffused light. Such leaves as those of *Robinia Pseudo-Acacia* and *Phaseolus*, which meet the varying illumination of different periods of the day with rather prompt changes of position are in the highest degree panphotometric.

For botanists in general the most suggestive part of Wiesner's book and the one to which reference will oftenest be made, is the fourth section, which deals with the light-requirement of the plants of some of the principal physiographical regions, as steppes, deserts, tundra and tropical forests. It also takes up the light-relations of a few of the great groups of plants and gives in a good deal of detail the author's values for the light-requirement of many species, mostly of seed plants.

The lowest light-requirement of any kind of plant reported on (which needs light at all) is that of some lichens. These grow, but do not fruit, in lower Austria, with a light-require

*The reader who is desirous of looking up the literature of this subject will find sufficient references for the purpose in Pfeffer's Physiology of Plants, Clarendon Press, Oxford, 1900–1906, and in Burgerstein's Die Transpiration der Pflanzen, Jena, 1904.

ment of 1-156. Most lichens of that general region find their optimum in an illumination of 1-10 to 1-20.

Most grasses are sun-loving plants and many species have a light requirement closely approaching unity. Some shade-tolerating species, however, were found in Austria to vegetate, but not to fruit, in an illumination of 1-60 to 1-70 and tropical species in Java grew in an illumination of 1-100.

Many plants which form the herbaceous carpet of the forest floor under deciduous trees have a light-requirement which varies greatly at different seasons. Such species push forward their flowering and fruiting either before the trees are in leaf, or, at any rate, while the leaves are still very small. The foliage often grows and does photometric work the summer through, under a greatly lessened illumination. *Hepatica triloba* is given by Wiesner as a typical example of this change of requirement, generally blooming, near Vienna, in an illumination of 1-2 to 1-3 but continuing its later growth normally with 1-15. It is a fact familiar to botanical observers in regions where the European ivy, *Hedera Helix*, grows freely as a wild plant that it blossoms and fruits only in well lighted places and there takes on a very different habit from that which it manifests in the shade. Near Vienna and about Trieste it blooms with a light-requirement of 1 to 1-4.5, but grows well with as little illumination as 1-48. It should be noted that plants growing under trees almost never get the total illumination of the region throughout the whole day, even when the trees are bare. The value of the illumination in leafless beech forests in April was found to be 1-1.5 to 1-2, and in the shadows of the tree trunks as low as 1-6 of the total outside of the forest cover.

As might be expected, epiphytes, whether vascular cryptogams or seed plants, often have a very low light-requirement. The well-known epiphytic fern, *Asplenium Nidus*, grows at Buitenzorg, Java, in illuminations as low as 1-38. An orchidaceous epiphyte, *Taeniophyllum*, common in the same locality, grows in illuminations as low as 1-32 and blossoms in those of 1-5 to 1-8.

Practical foresters have long known that there is much difference in the power of various kinds of timber trees to endure shade. Beech, maple, and red spruce, among American trees, are tolerant of shade, while most oaks, hickories, chestnut, locust, and larch are intolerant. Wiesner gives many valuable data in regard to the relative light-requirement of temperate European and American and of arctic and tropical trees. A remarkable instance of gradual adaptation of a leaf during its development to increasing light intensity is displayed by *Amherstia nobilis*, a beautiful Caesalpiniaceous tree which flourishes in the garden at Buitenzorg. The young leaves are flacid and almost colorless, evidently containing little chlorophyll. They hang vertically downward and are greatly sheltered by the older leaves. Little by little they become firmer and assume a green color, until at length they can withstand the full glare of the tropical sun. Apparently the fully developed ones in some instances receive about five hundred times as much light as the youngest and most protected ones.

Summing up a few of the good and bad points of Professor Wiesner's book, it may be said to contain more detailed and authoritative information upon the light relations of plants than any other single work. It is extremely interesting and suggestive of many lines of investigation for the plant physiologists of all countries. On the other hand it does not seem to be well arranged for reference, the topics discussed are not treated with regard to their relative scientific importance, and the index is most inadequate. A brief glossary would have aided the reader who is not familiar with the author's other writings on this general topic, but none is given. It would seem to many botanists that Wiesner, in trying to fix the light minimum for the species studied, has too readily assumed that when a plant does not grow well or grow at all on the forest floor or in the shade of other shrubs or herbs it fails to flourish wholly because of the shade. Lack of water or of nutritive salts or even deleterious substances given off by the roots of the trees may at times figure as factors in the problem.

THE PRESENT STATUS OF PLANT PATHOLOGY. *

BY VENUS W. POOL.

For the purpose of ascertaining the opinions of pathologists at the various Experiment Stations in regard to the different

*A paper presented before the Botanical Seminary of the University of Nebraska' May 1909.

problems connected with plant pathology at the present time, a circular letter was sent to the pathologist or botanist of each Station. A few university men who were more or less interested in the subject were also included. I here wish to express my thanks to the following men whose interesting, thoughtful letters furnished so much material for this paper: Schaffner, Ohio; Buckhout, Pennsylvania; Edgerton, Louisiana; Brookes, New Hampshire; Heald, Texas (University); Swingle, Montana; Barre, South Carolina; Bolley, North Dakota; Norton, Maryland; Freeman, Minnesota; Reed, Virginia; Jones, Vermont; Ball, Texas; Rolfs, Florida; Beattie, Washington; Selby, Ohio; Ganong, Massachusetts; Garman, Kentucky; Barnes, Chicago (University); Beal, Michigan.

In the discussion of the various problems of plant pathology I have endeavored to present the general concensus of opinion as given in these different letters. The phases of the subject which will be taken up are the recognized breadth of plant pathology, the permanency of the results of present investigations, the effect of general cooperation, the real motives back of investigation work, repetition and superficial nature of many publications, non-development of pathology in our universities and the probable future centers of activity.

In the broadest sense plant pathology is one of the most far reaching of botanical subjects. Although it has been one of the last evolutionary processes, it has opened up new fields or rather brought into greater prominence the weak points in Physiology, Plant Chemistry and Physics, and consequently there must now develop a revolutionary process. It is necessary, for example, in the study of many so-called physiological diseases that our knowledge of plant nutrition be worked out much more completely. The normal functions must be exactly understood before variations in conditions become evident. Consequently in the development of plant pathology there is great need for a closer application of chemistry and physics. "Plant pathology combines pure botanical science with the practical application of scientific principles. The standing of plant pathology as compared with other phases of botany has perhaps been lowered on account of the tendency to over-emphasize the practical side of the work." "Pathological investigations as they are often carried on do not yield the results that they should. There are several reasons for this. There is usually a lack of thorough fundamental training. The best training would be acquired by the pursuit of a broad fundamental course of study, in which the ability to think was inculcated rather than the ability to heap up facts and store them away in the memory. Following this should come more special work along the line of pathology and its related problems." "The study of chemistry and physics, especially the former, should form a large part of the fundamental training. No other introductory subject can play so large a part in the success of any biological science as chemistry properly studied."

"The majority of workers are sufficiently endowed with the the necessary personal characteristics as perseverance, definite system, etc., but the most serious lack comes in rega d to fundamental rather than superficial ideas, clear thinking, critical judgment and philosophical habits of mind." "Some of these qualities are hereditary, while others can in a measure be acquired." "A great many persons who come nominally to pathological work for results, have received no effective training for this work and the general standing of plant pathology suffers as a consequence of this incomplete training." "Much good work has been done and for lack of perseverance and patience has been lost." "Some pathologists believe that the subject is in a rut. Investigators have gone forward on certain fixed lines and have departed very little from these." This can be easily remedied for the reason that every problem that comes up has its individual peculiarities and these must be studied as they are rather than as something else has been. The fact is sometimes lost sight of that nature is limitless and the human mind is limited. However, if the pathologist has the proper training and the necessary capacity for pathological research most of the obvious defects of pathological work as hitherto developed, will disappear.

In attempting to discuss general cooperation we face a peculiar state of affairs. This is the "seamy" side. "General cooperation might be of value but from experience not practicable." "General cooperation might bring about results were it not for the regrettable matter of personal jealousy which enters into cooperative work. If this could be eliminated, results would follow." "There is too great lack of confidence between workers to encourage cooperation." "General cooperation is a misconception. It results in working somebody else. No cooperation should be expected other than answers to questions which require no cooperation. Published work which can be understood by all is the sort of cooperation the world wants."

On the other side there are these opinions: "Honest cooperation is the thing." "Everyone engaged in research work should know the problems engaged in by others. If a new idea is discovered it should be given publication before the work is completed so that it may be a benefit to others." "If a plant pathologist is big enough, no personal or institutional competition will be undertaken; organized, cooperative investigation will be instituted instead."

Here, I wish to express the idea of cooperation that has long suggested itself to me. The essential thing in cooperation is that a definite interest be shown by the various parties concerned in the specific problem which requires cooperation. If the same problem comes up at two different places, the investigators should each work it in their own way. The results should then be compared, ideas exchanged, mistakes discovered. If the imperfections are not brought to light in this way it leaves the farmer or the student to wonder which apparent facts he had better believe, when a very little honorable cooperation on the part of the technical workers would remove the difficulty. There can be no fixed methods of cooperation, rather our interpretation of the problem which comes up should outline all methods of work.

The permanency of the work carried on by one person and in one locality is questionable at times, although excellent results have been obtained by persons working alone. "Investigation consists of both breadth and depth. Breadth is secured by interchange of ideas, visits, etc. Depth by persistent work by one's self."

Various opinions exist as to the real motives back of much of our station work. "There is the feeling that personal competition takes a more prominent position than scientific inquiry among our investigators along all lines. Most investigators would not admit to themselves that such a condition of affairs existed." "Scientific inquiry is so largely stimulated by the pride of personal achievement that it is almost impossible to displace this egoistic factor by the love of science without losing in energy thereby." "Competition in the right spirit is desirable, but when it is carried on in a petty or selfish way it is not." "Research work should be based solely upon the desire to further human knowledge."

Some are optimistic enough to believe that the whole-souled scientists, if not in the majority as far as numbers are concerned are yet more influential in the policies of our stations.

It is generally conceded that there is too much repetition of superficial observation in all lines of investigation. However, there are two ways in which we may look at this. For the purely technical worker who receives bulletins by various writers, the duplication and superficial character of many publications is a source of vexation when it is necessary that the mass of subject matter be scanned thoroughly for any new ideas which may have crept in with the old. For the farmer who receives bulletins issued from his own station, this repetition does not occur. In fact it would do no harm if his attention were repeatedly called to the different new methods which science is obtaining for him.

Although the idea is an old one that there should be a classification of station literature, yet it would be well if starting with the year 1910 all bulletins issued by the various Experiment Stations be put into two classes, and given a uniform class name, as *e.g.* an extension series, a repetition of old but important facts; and a station series, one in which nothing will appear except results of new work. Such a scheme is now in force at a few stations, and the relief experienced from these should be an incentive for other stations to fall in line. Since the Adams fund, together with others, have furnished a sound foundation for research, workers in these lines should receive due consideration.

Pathology has not been developed in the various colleges and universities on account of a lack "of properly trained teachers, a lack of sufficient preliminary training among students, incompleteness of pathology subjects, scattering of the subject around in other departments as Mycology, Bacteriology, Physiology, etc., and lack of any considerable amount of available literature for American students. Contrast our condition in the United States with that of Germany as far as publications of an elementary character are concerned." One pathologist writes "I have upon my shelves at the present time fifteen small volumes in the German language treating of plant pathology."

"There are not the positions open to pathology students that there are in other lines of teaching, since pathology is not taught in high schools, secondary schools, etc. Plant pathology has been taught in a very uninteresting manner. It is peculiarly difficult to teach, one side being pure science, the investigation of the cause of the disease, and the applied side or the application of preventive methods."

The future centers of training for plant pathology and allied agricultural subjects are bound to be in our great universities. The future centers of activity must be at the experiment stations and kindred places, where it is only a step from the laboratory to the field.

In summing up these various opinions it seems that if the results of investigations are to be permanent there must be some means of enlarging and correcting the different view-points. If we would have this, a broad, healthful, inspiring cooperation must be instituted, a something to which we give of what we have, and from which we receive stimulating assistance. Back of all his it is to be remembered that there is no fixed course. Each one must blast his own way. The easy things have all been done. The hard problems are left.

Nebraska Experiment Station, Lincoln.

BOOKS AND CURRENT LITERATURE.

The Proceedings of the Society of American Foresters, of which a separate volume is now issued each year, contain much material that is quite as interesting to botanists as to professional foresters. Among the papers to which special reference may be made is one by Herbert A. Smith (Vol. III, No. 1) on *Tolerance and Intolerance of Trees.* The author holds that tolerance has been badly overworked as an explanation of the silvical conditions observed in our American forests, and comes at once to the important question: To what extent have the effects of a deficient supply of soil moisture been ascribed to a deficient supply of light?

Discussing the well-known habits of growth and the structural peculiarities of trees grown in the open, the author holds that these are plainly referable to light conditions, but says, "We shall come nearer the heart of the matter if, instead of trying to draw a final conclusion from the presence or absence of this or that structural feature of the leaf, we think rather of the physiological activity which is going on within it."

Narrowing the question to the supply of light and the supply of nutrient soil-water, it is evident that there must be for both of these requirements of the plant a certain optimum, any falling off from which must be accompanied by a proportionate abatement of activity. With a falling off in the supply of either water or light, the work begins to grow languid. Under these circumstances it may well be that either an access of water or a moderate access of light would stimulate leaf activity and, in consequence, growth of the tree; for either would stimulate transpiration, while more light, would in addition, furnish more utilizable power.

Such an assumption appears most consistent with the facts as we know them. A moderate thinning benefits a crowded stand, but too heavy a thinning endangers it. The thinning relieves the competition of the roots for soil-moisture, and at the same time brings the stimulus of more light and results in conditions which make evaporation more easy. A half-starved, feebly active organism, which has let down its guards against giving off water too fast—has let its safety-valves, so to speak, get out of order—all at once receives the call to leap into full functioning. In spite of the fact that there is probably more water available for it than before, the chances that it will die for lack of water are decidedly increased. And it is worth asking, too, whether the roots have not shared in the general let-down of activity during partial suppression so that they can not at once get to work at full speed.

Admitting that this and other considerations advanced by the writer are, as yet, largely theoretical, they are, nevertheless, highly suggestive and well worthy of being put to the test of extended investigation. This is especially true of the closing paragraphs, which are avowedly speculative, but which none the less can not be ignored. It seems, so the author puts it, that there is ground for maintaining that intolerant trees are on the whole those best fitted to endure deprivation of moisture. Is not a thin foliaged tree one which has adapted itself to meagre conditions? Given an abundance of light, moisture, heat and plant food, and full-foliaged trees ought to develop, just as heavy feeding and generally favorable conditions tend to breed heavy stock. Reduce the supply of any one of these necessities of plant life to a point below the needs of the organism at the summit of activity, and the plant will no longer need the same leaf area. Cold climates, poor soils, and desert regions are the homes of the narrow-leaved and sparsely-foliaged broad-leaf trees. Drouth-enduring vegetation is characterized by an excessively small green surface. The plant has perforce adjusted itself to starvation conditions. A similar adjustment naturally follows subjection to low summer temperatures or poor soils. In other words, pioneer, high-latitude, and xerophytic vegetation does not need and does not develop a great expanse of leaf surface. Survival is not a question of being able to keep a place in a crowded forest under deficient light conditions—of light they have more than they can use. Hence xerophytic and pioneer trees naturally become relatively intolerant. They can not succeed in association with the tolerant trees developed on rich, moist soils and in a warm climate—climax species—because, though they can endure deprivation along these lines better than the climax trees, they are not fitted to endure deprivation of light. Thus is explained the fact that intolerant trees are commonly found on poor and dry soils, a fact extremely inconvenient for the theory that what we have been taught to regard as intolerance is really inability to compete with other species for soil moisture.

In Vol. IV, No. 1, of the same publication, Frederic E. Clements presents a paper on *Plant Formations and Forest Types*, which, although it embodies principles already set forth in previous writings of the author, brings out so clearly and directly certain fundamental conceptions that it must be reckoned, in spite of its brevity, as an altogether useful contribution to the formative subject of which it treats.

Regarding the forest as an organism showing both development and structure, the logical course of procedure in ecology and in forestry, is fundamentally the same. In one as in the other, the habitat, or sum of physical and biological factors, is taken as the cause, the development of forest as of individual tree the response, and the structure of forest as well as of tree the final formal expression. Between the tree and the forest there is, however, the important difference that the latter requires so long a period to reach maturity that first-hand investigation of the forest development can only be fragmentary. It must be studied in motion, as it were, but this movement can not be easily traced to its conclusion. In consequence it is necessary to use the method of reconstruction in which the various stages of structure are shown in their proper sequence, and give a picture of the life movement of a forest much as the individual films give motion in a living picture. Thus recognizing that the development of a forest gives its structure, we must depend upon the latter to re-establish for us as much as possible of the development that has already disappeared.

Carrying out this thought, the structure of vegetation may be viewed from three different standpoints, all equally an outgrowth of its development. These are (1) its composition as to species, (2) the fundamental response as to the action of physical factors, (3) the subdivisions or plant associations within the vegetation itself. Physical factors act upon plants individually and in groups, hence the species which are acted upon, as well as the habitat or sum of causes, must be reckoned with in any analysis.

The strict correspondence between vegetative and physical factors gives rise to a vegetative unit or plant formation for each habitat. Though difficult of exact demarcation at present, the general kinds of formation are distinguished by the terms forest formation, chaparral formation, prairie formation, etc. Societies, communities, and other more or less definite elements of the formation are recognized, and a knowledge of their structure and development becomes necessary to its correct understanding.

The development of a formation is the result of certain processes which might well be called functions of this complex organism. These have been fully set forth by the author in previous publications. Without further reference to these except to the matter of succession it may be said that the latter is of primary importance from the view-point both of the ecologist and the forester. It is accordingly considered at some length with reference to the works of Steenstrup, Berg, and other European foresters and the more recent works of Graves and Zon in relation to forest types. As pointed out by Dr. Clements the application of the methods of forest types to forestry brings it into harmony with the fundamental principles of ecology. It places forester and ecologist upon the same basis in so far as the study of forest vegetation is concerned, and means that each will inevitably share more and more the view of the other. Both must bear in mind constantly that reproduction, development and succession are at bottom the same great process directly connected with the habitat factors which are its causes, just as the formational factors are its results. The paper amply justifies the contention of the forest ecologist that the time for thorough-going investigation to lay securely and permanently the foundations of practical forestry is fully come.

NOTES AND COMMENT.

The steps recently taken by Harvard and Johns Hopkins Universities in providing for the development of plant physiology is of such interest and importance as to call for more than passing notice. The former has long been recognized as one of the oldest centers of botanical teaching and research in the United States, while the latter has only in recent years had a botanical department, yet both institutions have indicated in a way that should command the attention of the younger botanists of the country what sort of men and what sort of preparation is now called for in universities that attempt the difficult task of making adequate provision for this branch of the science. Accordingly, it seems worth while, though involving matters of personal detail, to call attention to the preparation of the men who have been called to direct the work in plant physiology at the institutions named.

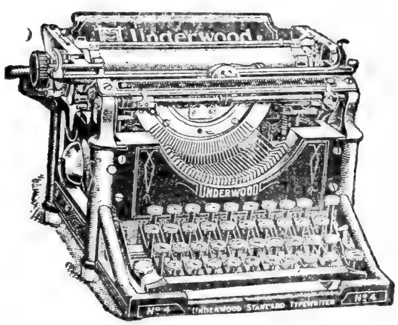
Dr. B. E. Livingston was graduated with the degree of B. S. from the University of Michigan in 1898. From 1896 to 1898 he was assistant in Plant Physiology in the University of Michigan and held the same position in the University of Chicago from 1899 to 1905, during which period he was for a time field assistant on the Mich. Geological Survey and collaborator in the U. S. Bureau of Forestry. From 1904 to 1906 he was soil expert in the U. S. Bureau of Soils, and during the latter portion of the period was in charge of the division of Soil Fertility. He received the degree of Ph. D. from the University of Chicago in 1902, and was research fellow at the New York Botanical Garden in 1903. From 1906 to 1909 he has been a member of the staff of the Desert Laboratory of the Carnegie Institution of Washington, and in 1908 carried on research work at the Pflanzenphysiologisches Institut at Munich. His published papers form a list too long for notice at the present time. Dr. Livingston assumes his duties as Professor of Plant Physiology at Johns Hopkins Oct. 1, 1909.

Quite as full, perhaps, have been the years of preparation of Dr. W. J. V. Osterhaut for the work which awaits him at Harvard. Graduating from Brown University as A. B. in 1893, he remained one year in that institution as instructor in botany, taking the degree of A. M. in 1894. In the meantime he had spent three summers at Woods Hole with Prof. Setchell, the first summer as student and the second and third as instructor. He next worked with Strasburger in the Botanisches Institut at Bonn, where he engaged in research and came in contact with such men as Schimper, Schenck, Noll, and Pflueger. His first botanical work was on the fertilization of Florideae, and this was continued at Bonn as an investigation of the cytology of fertilization in Batrachospermum. This led to an investigation of Equisetum and other plants with reference to the existence of a centrosome. His papers on the role of osmosis in marine plants and on the importance of balanced solutions, as well as on plasmolysis and the penetration of salts into the cell indicate the scope and something of the results of his later studies. He was appointed instructor in botany in the University of California in 1896 and later became associate professor in the same institution.

The equipment for the work which Dr. Osterhaut will take up at Harvard is well known to botanists in this country. At Johns Hopkins a greenhouse and laboratory for plant physiology were built last year and a good ecological and taxonomic garden has recently been planted. With such standards and with such facilities for work the prospects for plant physiology in two of the great universities of the eastern United States seem particularly bright.

The call of Professor L. R. Jones from the University of Vermont to the newly created chair of Plant Pathology in the University of Wisconsin is similarly indicative of enlarged ideals and higher standards. The subject of vegetable pathology has been of slow development, owing to a number of causes, not the least of which has been insufficient preparation and too narrow specialization on the part of many who have engaged in it. It is now recognized that no specialty in the whole range of botanical science more imperatively demands a thorough knowledge of the normal processes and habits of plants, together with a working use of all the other indispensable tools of modern research.

The record of Professor Jones in the general botanical work of theUniversity of Vermont for the past twenty years is too well known to call for detailed comment. His special studies in the field of pathology have been conducted both at home and abroad, in part in collaboration with the Bureau of Plant Industry, and are also well known. The action of the University of Wisconsin, which by common consent is representative of the most progressive state universities, in establishing an independent chair of plant pathology and calling to it a specialist who is also a botanist of wide and thorough preparation augurs well for the scientific development of this subject.



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OCTOBER, 1909

INFLUENCE OF ARIDITY UPON THE EVOLUTIONARY DEVELOPMENT OF PLANTS.

BY D. T. MACDOUGAL.

From every excursion which the biologist has made hitherto into speculation as to the origination of living or self-generating matter and its development into organisms, in which he has called to his support extreme or unusual intensities of terrestrial and atmospheric conditions, he has been ruthlessly recalled by the geological historian with the reminder that the general composition of the atmosphere, its pressure, the temperatures and other conditions prevalent on the earth's surface were uniform and continuous with those now encountered and not widely different in their total departure in any stage of the earth's development in which life might have originated.

Knowing full well that life did not always exist, that self-generating matter, so far as our observations go, is not now originating, we persistently return to the idea that the beginning of life must have occurred at some stage of the earth's history more favorable to such action than the present.

THE ORIGIN OF LIFE.

In the search for supporting ideas upon which to base speculation, two conceptions serve as encouragement for a renewed attack upon this fascinating problem. One is embraced by Chamberlin's planetesimal theory of the growth of the earth and the attendant modification of surface conditions, which necessarily showed a complex widely different from the present, and the other is one growing in favor with physiologists to the effect that the essential activities of living matter rest upon catalysis and enzymatic processes, with the characteristic reaction velocities directly affected by internal and external limiting factors.

The protamic mucleus may be taken to represent the first form in which self-generating matter might be said to have the characters of protoplasm, but previously to its synthesis, there must have occurred an increasingly complex series of carbon compounds with hydrogen, oxygen, nitrogen, sulphur and phosphorus, while iron, calcium, magnesium and potasium, are also involved in its activities at the present time. That these main constituents were present in the atmosphere at partial pressures of varying intensity, and that unstable carbides, nitrides, phosphides and sulphides brought by infalling planetesimals were passing into more stable unions, with the formation of hydrocarbons, ammonia, hydrogen phosphide, etc., is suggested by Chamberlin, and the possible interactions and combinations might result in the synthesis of very complex substances, well up toward the simpler forms of living matter. The hypothesis formulated by him also assumes that the surface of the earth was unworn piled talus, but little of which had gone into solution. The development of the hydrosphere moistening this layer, and forming pools and small bodies of water all exposed to the light of the sun, together with the variations in temperature, partly due to the heat of impact or infalling bodies, the influence of magnetic fields induced by bodies circulating about the earth would determine the paths of ions and electrons traversing them, and in addition, other states of ionization due to radial activity, would all be possible contributory factors in making a synthesis that might form a beginning of the physical basis of life. Any resulting thermo-catalyzer would be a possible agent for self-organization, and in the development of an organic type, its characteristic activities would consist in the degradation, or reduction of the potential energy of the medium or substratum and the oxidation of the acquired substances. Living matter is, in fact, a thermal engine in which the oxidation is, comparatively, exceedingly slow.

EXPERIMENTAL PRODUCTION OF SELF-GENERATING MATTER.

It seems quite probable that combinations similar, analogous or even identical with the earliest forms of living matter might now be produced in the laboratory, in enclosed spaces or under special conditions. Doubtless compounds of much greater intricacy have been built up, but while we might make such substances, yet it would be extremely difficult for us to furnish the supply of material and the continuance of conditions which would permit this matter to exercise its initial functions to any appreciable extent. The tests and criticisms which have been applied to the results of the few essays that have been made for the production of bodies which would be self-maintenant in a suitable medium, have been for the most part misdirected. Thus in the consideration of the hitheito unsuccessful efforts to produce bodies simulating some of the properties of self-generating matter,tests for the physical and chemical properties of protoplasm as well as for phenomena of the cell, have been applied, regardless of the fact that the cell probably stands removed by a million years of evolution from the simple living material which first took shape, and represents, in fact, simply a successful form of organism and by no means the only possible morphological organization.

PROPERTIES OF LIVING SUBSTANCE.

After growth and decay, the next most important property of living matter is that of irritability, of impressibli ty and adjustment to environment. The primitive substance of protoplasm endures because of a capacity for withstanding the current range of temperature and insolation, and this endurance was made possible by fairly automatic adjustments, one of the simplest of which is encountered in recognizable form in living plants today in the decrease of water content, which follows lower temperatures acting upon protoplasm. Few adjustments are so simple, and of course more complicated ones become possible as atomic group after atomic group was added to the constituency of living matter.

So far the properties suggested are those common to all living forms, but there must have ensued many differentiations of living matter, of which we have two survivals in those developing into plants and into animals. It seems probable that the first specialization resulted from the formation of substances in some of the living masses which converted radiations of certain wave-lengths into heat and other forms of energy active in promoting the reduction processes. The highest development of this power of absorption of light rays is to be assigned to chlorophyll, but preceding the formation of this very intricate and unstable substance there may have occurred a series of other compounds acting as screens capable of absorbing rays from the lower part of the spectrum, of which the reddish and bluish pigments of the lower algae are surviving examples. Many disintegration products constituting the reds and blues of plant tissues sustain physical relations of a similar character to sunlight.

ENVIRONMENTAL RELATIONS.

It is not possible to form any rational conception of living matter without including its environmental relations. These become of the utmost importance at the moment of formation of self-generating matter, and it may be assumed with perfect safety that of all the possible synthetic processes, only those which ensued in the presence of a medium which furnished substances suitable for building material could survive. Furthermore, when the accumulation of this material and its specialization is considered, it is apparent that successful origination occurred only on solid or semi-solid substrata rather than in undifferentiated solutions in open waters. Still, an abundance of this liquid would be of great importance to the colloidal masses which we may think of as the earliest living things; and, as will be shown presently, water has continued to be the most important of all the constituents of environment, especially with regard to the vegetal organism. The first method of multiplication of individuals or colloidal masses undoubtedly consisted of simple fragmentation resulting from the accumulation of a mass too great to be held together by surface tension, and the separation of these masses must have been accomplished, or made possible by flotation which continues to be one of the most efficient agencies in the dissemination of plants, a fact especially emphasized by the results of our studies upon the re-vegetation of the Salton basin.

Wherever portions of the colloidal mass came into contact with solid substances, gelation or aggregation ensued, and the layers of material thus differentiated would give form and stability in place, representing the earliest form of anchorage organ, which must have been the first member of the vegetative axis to take on definite functions and structure. In this, as well as in other features of the plant, evolutionary development was slow so long as the monotonous condition of an aquatic habitat were to be met.

The present occasion does not permit a discussion of the probable evolutionary development of the vegetal organism from the stage of simple colloidal masses to the gametophyte, and the evidence at our disposal is so lacking that such discussion would be entirely speculative. It will be quite pertinent to call attention to the fact, however, that these earlier rhizoidal anchorage organs stand in no direct or genetic relationship to the roots of modern seed-plants.

THE ORIGIN OF A LAND FLORA.

As has been so succinctly described by Bower, types of vegetation with gametophytic reproduction must necessarily remain aquatic, or at least hygrophilous, since free water was necessary for the movements of gametes in effecting fertilization. Furthermore, the stimulus of desiccation, when such forms were stranded or left above the water level, does not appear to have any direct consequence in the way of development of incidental structures which might facilitate such sexual reproduction, a fact probably due to the morpho genetic limitations of gametophyte, not easily understood.

The problem of aridity was in reality solved in quite another way by the prolongation of the vegetative existence of the germinating zygospores, formed by the union of the gametes, finally resulting in the independent sporophyte. The sporophyte was not dependent upon free water for any part of its existence and its individual occupation of drier areas was accompanied by a development of the anchorage organ anew, this time from a highly developed shoot-like axis, and the differentiating effects of dessication upon the root have been scarcely less marked than those affecting the shoot.

The necessity for anchorage was even greater than before, but now the nutritive salts no longer bathed the entire body but were present only in hygroscopic layers on the soil particles with a vertical distribution not uniform and with much horizontal irregularity. The formation of absorbing mechanisms and conducting tissues has been followed by a refinement of form and habit reaction in the modern plant, as shown by the researches of Cannon, so that, in the language of the systematist, the appreciable features of the root-system doubtless present diagnostic characters quite as marked and as easily recognizable as those of the shoot.

So long as the gametophyte retained its separate existence, however, and depended upon free water for its reproduction, there could be no real land flora, since the plant must stand, as it were, with one foot in the water. The sporophyte waxed in importance unceasingly, however, by the development of the shoot and root-systems, until its vegetative activity overshadowed those of the gametophyte, its protective tissues finally enclosing the sexual generation, and with the formation of the pollen tube the seed-plant became wholly able to get away from the stream margin, the low flat moisture-saturated land and to occupy great continental areas and mountain slopes.

SCARCITY OF FOSSIL REMAINS IN ANCIENT DESERTS.

The total area of deserts at the present time is equal to about one-sixth of the total land exposure, and undisputed evidence is at hand that extended arid areas existed in all of the great geological periods. Since aridity or humidity depends upon topography, and the prevailing winds, it follows quite naturally that these ancient deserts did not necessarily occupy positions coincident with the deserts of the present. Thus the facts seem to indicate extensive desiccation in what is now eastern America and parts of Europe in the Lower Carboniferous and Permian, while some coincidence of locality is found in arid areas in Wyoming and Texas. While evidence is accumulating to show that great swings or variations in climate are in progress in various regions, yet it would be difficult to demonstrate the proportion of arid area to the total land area in any previous period and thus give a quantitative basis for the conclusion that the earth's surface is undergoing progressive desiccation.

It is noteworthy that formations which give evidence of desert conditions are notably free from fossil plants and contain but little in the way of animal remains, At the time of these earlier periods of aridity, vegetation had not developed forms capable of occupying dry land. During the Carboniferous, however, great areas of low-lying land existed in which conditions for gametophytic reproduction were very favorable, and a luxuriant development of ferns and related forms became possible.

ARIDITY, THE MOST IMPORTANT FACTOR AFFECTING THE DEVELOPMENT OF THE PLANT.

The seed-plant with its pollen tube and vascular system may be considered as the major vegetational response to limitations of the supply of moisture, and desiccation has been and continues to be the most important condition affecting the evolutionary development of plants. Temperatures alone have been unduly drawn upon in the interpretation of distributional features of ancient and existing floras, a fact made more plainly apparent by recent observations at the Desert Laboratory, in which it has been found that several species range over a vertical mile. Such species endure cold of –35° C., and have a growing season of less than a hundred days in the more boreal or alpine portion of their ranges, while in the southern or lower localities inhabited by them, temperatures of 48° C. may be encountered, the growing season extending over 300 days; the thermometer oing below the freezing point not more than 12 hours during the entire year.

It is no surprise, therefore, that it is learned that there is no single feature in the structure and functionation of plants that with perfect assurance may be connected with the influence of temperature alone, although alpine and polar floras bear a distinct aspect by reason of a combination of conditions of moisture, insolation, duration of the seasons and course of the humidity.

While temperature is not in itself a direct factor in shaping the general trend of evolutionary development in plants, yet it is indirectly concerned by the influence exerted upon precipitation, and the relation of the amount of rainfall to the possible evaporation. The great periodic changes in climate, produced by whatever cause, may be taken to have affected vegetation chiefly through the desiccation effects, which not only determined the ranges and habitats of forms but also played a predominant part in evolution.

GENERAL EFFECTS OF DESICCATION.

The consequences of a decrease of the supply of moisture in any region are very complex. If, for instance, the rainfall in

Oregon, Indiana, Illinois, New York or Florida were decreased gradually to one-third or one-fourth the average amount now received, the total production of organic matter would be greatly lessened and consequently the amount of hnmus would decrease; wind erosion would remove much of this from its place of formation and by this means alone the distribution of many species would be totally altered. The soil moisture would ultimately be so depleted that the surface layers would show as great a proportion as the underlying layers, and carry an excess during seasons of precipitation, a fact that would have the profoundest influence upon the vegetation native to the region affected, determining not only the habit of the root-system, the form of the shoot, but also becoming a factor in distribution, and giving a new form to the competitive struggle among the organisms in a locality. The change in precipitation would result in the formation of long outwash, detrital slopes or bajadas, piedmont to the mountains, giving new habitat conditions, and a further differentiation would consist in the surface deposition of soil salts, giving alkaline and saline areas upon which halophytic forms might flourish. The lessened relative humidity would result in modification of foliar surfaces, make necessary special structures in seeds and spores, and would be followed by a more intense insolation by reason of the non-absorption of some portions of the spectrum, and lastly, the course of the temperature of the soil would change with the depletion of the humus and the altered moisture relations.

If desiccation ensued as a result of simple horizontal reduction of the precipitation, in a region with an unbroken surface lying at nearly the same height above the sea, the effect would be sweeping, monotonous, and with almost total absence of selective effect that would mean extermination, or change in a flora *en bloc*. The majority of interpretations of the paleantological record assume such results. It is to be seen, however, that desiccation in a region with divirsified topography and great differences in level would result in great differentiation, and if this reduction took the form of limiting the rainfall to one or two brief seasons, or limited periods, a maximum of effect might be expected.

The development of desert conditions in the manner described over a region of any extent would entail the least disturbance on mountain summits, where by reason of the lowered temperature and the facilities for condensation, the evaporating power of the air would remain lowest. The original or pre-desert forms would be able to maintain themselves on such elevated slopes with but little adjustment. Similar survivals might ensue along the lower drainage lines, where the underflow in streamways and washes might support a moisture-loving vegetation as it does in southwestern Africa and southwestern America.

So much for survival by localization. A second manifestation would consist in a restriction of seasonal activities. The rate of evaporation on the lower levels might be lessened by lower temperatures during the winter season and at this time rapidly acting annual plants with broad leaves and mesophytic habit might develop from sprouting seeds and carry through their cycle of activity, remaining dormant in the form of heavily coated seeds during the warmer, dryer period of the year. Perennials with deciduous leaves might display a coincident activity. This survival of moisture-loving plants in a region of pronounced desert character is most marked, however, in places where the precipitation occurs within definite moist or rainy seasons, such as the great Sonoran desert, in which two maxima of precipitation occur separated by periods of extreme drought. Both the winter and summer rainy seasons are characterized by the luxuriant growth of broad-leaved annuals of a mesophytic habit, which might not be distinguished from those of any moist region. Some species are active during the summer season, and others during the winter, while a smaller number perfect seeds during both seasons. A number of perennials parallel this activity of the annuals, with the result that in the most arid parts of Arizona half of the native species are in no sense desert plants, requiring as much moisture for their development as do those of Maryland, Michigan or Florida. The desiccation of a region is seen, therefore, not to result in the extermination of moisture-loving types, but rather in the reduction of their relative importance and a limitation of their activities to brief periods or moist seasons.

TWO TYPES OF VEGETATION RESULTING FROM DESERT CONDITIONS.

Two types of vegetation may be definitely connected with arid conditions, representing fairly distinct stages of development due to the influence of aridity. In one form the chief operation has been one of reduction and protection of surfaces. Leaves have been reduced to linear vestiges representing various parts of the foliar organ, branches to spines or short rudiments, stomata have special constructions and all parts of the shoot are heavily coated and hardened; root-systems have been extended horizontally and the individuals thus isolated, becoming more or less accommodated to soils containing a large proportion of salts. The spinose, stubby and switch-like perennials which result from such action, are characteristic of low enclosed desert basins, like that of the Salton and those of southern Africa and central Asia, where the scanty rainfall does not occur within such regular limits as to make distinct moist seasons.

The second type of desert vegetation includes forms which have not only been modified in the manner described, but in addition have developed the storage function as a further step in the same direction. An increased capacity for rapid and effective absorption, together with an enormous development of storage mechanisms, in xerophytically modified stems, branches, leaves or roots, has resulted in such groups as the cacti, the mesembryanthemums, the euphorbias, agaves, yuccas, sotols, crinums, crassulas, and others in which the individuals often accumulate sufficient surplus water to meet its vegetative needs for a decade, while species are not unknown in which the supply on hand is sufficient to carry on the annual seasonal activity of shoot extension and reproduction for a quarter of a century. These forms are desert plants *par excellence,* showing two distinct stages of modification, the latter consequent upon the first. Marloth's view, therefore, that the regions characterized by succulents, of which he names the Karroo of South Africa as an example, and which by implication would also apply to most of Arizona, Sonora, Chihuahua, and southern Mexico, are not true deserts, is directly controverted by the evidence obtained from a consideration of the evolutionary history of the constituents of the floras.

As a total result of the slow desiccation of any region, a very important proportion of the flora would consist of moisture-loving species, or mesophytes, and the remainder would be included in two classes, the spinose forms with reduced shoots and leaves, and the succulents with shoots reduced but with the additional development of storage structure in some organ of the shoot or root. The total number of species within an arid region is not less than that of the most densely closed tropical area, but the number of individuals is less, the inter-relations of the individuals and species are widely different, and the competitive struggle for existence is of a nature much unlike that of a tropical forest. Increase in aridity tends to localization in distribution, and humidity to diffuseness.

XEROPHYTES ARE OF RECENT ORIGIN.

Evidence of the existence of xerophytes in previous periods of desiccation is extremely scanty. Calamites and Lycopods, with a slender central cylinder and a heavy enclosing cylinder of thin walled tissue, have been alluded to in this connection, but their great sporophytes probably stood in swamps, or at least were hygrophytic in habit, and by the requirements of their separated gametophytic reproduction could not exist on land areas independently. It is also to be noted that many forms peculiar to swampy areas at the present time display reduced shoots and leaves of a specialized structure due to the action of certain constituents in the substratum, being known as "swamp xerophytes" and if brought to light as fossils might give the impression of having lived in an arid climate. It is true, of course that desert conditions are not favorable for fossilization, yet many opportunities for such action undoubtedly occur in the carrying and burying action of the torrential floods of desert streamways, while wind blown deposits might preserve the more indurated forms. Many of these and the skeletons of the Cactaceae would seem well adapted for preservation in this manner. The view that such forms are of recent origin, that is since the Cretaceous period, within the present period of advancing desiccation, would predicate a very great phylogenetic activity, unprecedented, perhaps, but by no means impossible. Among earlier types of plants capable of withstanding aridity, most successfully, the cycads, Bennetitales, and conifers may be included. Some of the forms of these groups now inhabit desert areas, although others of similar structure with regard to foliage demand the greatest possible supply of moisture, so that the ascription of any causal relation between the leaf of a pine or cycad and desiccation must be made with many reservations.

The recession of large expanses of water included in a desiccating region, such as has occurred in the great basins in Nevada, and in the bolsons to the southward and eastward in New Mexico, Chihuahua and Arizona would present special conditions. The rate at which the waters of such inland seas might recede, however, would be such that the advance of vegetation to cover the emersed areas would be quite as rapid as that necessary to follow a receding ice-sheet or a change of climate due to any cause. Thus our observations on the Salton show that beaches a mile in width may be bared within a year, while the agencies most concerned in their revegetation are combined wind action and flotation by the waters of the lake, together with the action of the small but torrential streams which occasionally rush down the shallow washes carrying the heavier seeds and rocks with equal ease.

PROBABLE EFFECTS OF INCREASED HUMIDITY.

Many regions, inclusive of the great central basin of Asia, the deserts of north and south Africa, southern Australia, and of the Americas, with a total area equal to one-sixth of the land surface of the world, offer the most diversified evidence as to the physiographic and vegetational effects of dessication, which have been described, but when the attempt is made to consider the probable happenings consequent upon a reversal of the climatic swing, in which an arid region receives an increasing precipitation, conclusions must be drawn chiefly from experimental evidence derived from the laboratory.

Here, as in the decrease of the supply of water, no mass movement or extermination of a flora is to be taken for granted. Many highly specialized succulents, extremely local in their distribution would undoubtedly quickly perish with the progression of a climate bringing an excess of moisture; alterations in temperature would not exercise such violent action upon plants of wider range, however. That both together might not totally exterminate a type of succulent, is shown by the existence of cacti in tropical rain-forests and on the high northern plains of Nevada, Idaho and Montana. If plants of wider latitudinal distribution are taken into consideration it may be seen that with an extension of polar climate, the extermination of a species in the higher part of its range would be coincident with additions to the eligible area on the southward. If the land area was limited, or if mountain barriers intervened, such dissemination would of course be impracticable and the forms involved would soon perish.

The unfavorable influence of increasing moisture upon the xerophytic forms of a region would also include effects of an indirect character. Soil temperature and moisture relations would undergo great alterations, humus would increase and other changes would ensue, entailing conditions which the specialized structures would be unfitted to meet. Furthermore, succulents and spinose forms being advanced types, their retrogressive evolution to conform to moist conditions would be a process resulting in enormous loss of species. Some spinose types representing the lesser specialization would seem to offer the best morphological possibilities for such a change.

Perhaps the most important of all the altered conditions brought about by increasing moisture, however, would be the total transformation of the competitive struggle for existence. Animals would no longer play the predominating role as in arid areas. The number of individuals representing the constituent species of a flora would be multiplied a hundred fold, perhaps a thousand fold, and once more the amount of food material offered to animals would decrease their total importance in selection, while the intensest crowding between roots and between shoots would once more be resumed and horizontal differentiations of associations such as that in forests, would ensue.

The element of the flora which would respond most readily to ameliorated aridity would, of course, be the hygrophytic annuals and perennials, which had survived the period of desiccation in their refuge of the rainy seasons, and in the moist areas along streamways and on elevated peaks. These would quickly occupy the greater part of the surfaces available for plants to the great intensification of the inter-vegetal struggle for existence. As these hygrophytes survived in the moist situations and the moist seasons of an arid period, so the surviving zerophytes in a moist period would find refuge in restricted habitats on talus slopes, rocks and sand, in which the soil-structure relations would be best suited to their specialized structure and might display their seasonal activity during a period of the year in which the precipitation was least.

GENERAL CONCLUSIONS.

In a brief summarization of the main features of the subject, it is to be recalled that free water was a very important agent in origination of self-generating matter, and that the development of the vegetal organism up through the gametophytic stage was accomplished in its presence.

It was in the stress of aridity encountered in extended and elevated land areas, however, that the development of the sporophyte, with its highly differentiated vascular system, complicated physiological organization and seed-forming habit, occurred.

Certain geological formations laid down at a time when the prevailing types of vegetation were characterized by separate gametophytes are devoid of fossils. Fossil xerophytes are unknown, although fair evidence of aridity in the Cretaceous and earlier is at hand. Certain groups of plants, however, including the cycads, Bennetitales, and conifers show structures which would be suitable for existence under arid conditions, although not all of the forms so equipped inhabit arid areas.

Rock formations indicate the prevalence of arid conditions over extensive areas as far back as the records may be interpreted. The desiccated regions coincide only in part with deserts of the present time. Desert conditions appear to have prevailed in central Asia, north and south Africa, western and eastern South America, parts of Australia, and southwestern America since Cretaceous times. In the Lop basin of Asia, the central valley of Arabia, portions of the Sahara, the Kalahari in southern Africa, the Lake Eyre basin in southern Australia, the Salton basin in California, and the elevated basins of Nevada and Utah, the characteristic vegetation is composed largely of spinose and switch-like forms, in which the chief development has been toward restriction and induration of surfaces; a result attributable to the degree of aridity, the seasonal distribution of the rainfall and also to the intervention of great climatic oscillations.

The Karroo in south Africa, the Brazilian and Chilian deserts in South America, the Sonoran and Chihuahua deserts, and preeminently the arid areas of southern Mexico, offer a wide variety of types of vegetation in which the evolutionary development has been carried much farther, with the acquisition of exaggerated storage functions, representing the extremest and latest stage of differentiation of the sporophyten its long encounter with arid conditions on land areas.

THE HEATH OF LUENEBURG.

BY BURTON EDWARD LIVINGSTON.

Between the channels of the Weser and the Elbe, as they lead northwestward with many windings, through the low country that borders the German Ocean, lies a region as full of interest to the lover of the out-of-doors as any that he may anywhere come upon. Here is one of the great heath areas of Europe, characterized among the Germans as the Heath of Lueneburg, the *Lueneburger Heide.* Partly, no doubt, because of its sparse population and the large amount of uncultivated, if not absolutely natural land—a condition that favors the long, free rambles so dear to the German soul—partly because of the innate love of all Germanic peoples for great, open country, with broad outlooks and a faroff horizon, and partly because of its fame as a region of wonderfully beautiful landscapes and picturesque details, this country has become in the last decade or two a veritable Mecca to summer travellers from all Germany. If improved methods of cultivation do not bring it to an untimely end, the heath seems to bid fair to maintain in German literature a place second only to that of the mountains. Students of plant ecology will remember Graebner's excellent studies, presented in his *Heide Norddeutschlands,* wherein the problems of heath vegetation are so ably considered. Numerous other botanical studies have been made in these regions and there is also a rather long list of more general and popular publications upon the heath country, among which a number of excellent guide-books with accurate maps form a not unimportant part. Perhaps the most attractive of all these books is Richard Linde's beautifully illustrated production entitled *Die Lueneburger Heide*.

Geologically, the region is not unlike northern Michigan and Wisconsin, a series of low, indefinite moraines, with broad plains lying between them, the latter diversified by numerous streams and small ponds and stretches of bog or moor. The dry land is predominantly sandy, so much so that dune complexes have developed in many localities, and the heavy rainfall apparently finds its way readily to the stream channels and the marshes, thus leaving the surface sands in a comparatively dry state during the greater portion of the summer season. The winters here are long and the ground is snow-covered for a great part of the time, although the temperatures are by no means extreme.

Fig. 1. The edge of the forest—near Bergen

The comparatively short growing season, together with the rapid drainage of the soil, and its lack of soluble salts, are probaly the main reasons for the heath character of the vegetation. The Heide is physiologically arid, albeit it has a large rainfall and a high humidity. The vegetation of the sandy areas is characterized by an almost exclusive growth of the northern heath-plant, *Calluna vulgaris*, found also in America from Massachusetts to Newfoundland. This and the juniper (*J. communis*) are the conspicuous plants of the open heath. The swamps and the stream margins bear quite different vegetation. The moors are also characteristically xerophilous in the nature of their plants; Calluna is found here as well as on the drained sand. These moors are also physiologically dry,perhaps mainly because of toxic organic matter which is present in the soil; their actual water supply is ample. The heavier soils, and in places the sands as well, support fine forests of mixed needle and broad-leaved trees.

Fig. 2. Among the Junipers—near Manhorn.

In late summer the Calluna areas, sometimes stretching for miles, form great masses of color, pink and lilac purple, for the densely flowered tips obscure the green of the minute foliage below. The stems stand a foot or more high and form an exceedingly dense covering for the soil. In mid-autumn, when the bloom has gone, the foliage and the general aspect of the plant becomes a rich brown color. The glorious sunny days of October present a more sombre Heide, which is, however, no whit less attractive than the brighter one of the mid-summer bloom-time.

A short ride from Hannover brings one to Lehrte, a junction point whence the railroad leads northward across the heaths to Hamburg. To avoid the railroad we left the main line at Celle, and proceeded to Bergen, the end of a branch line. Here is heath country on every hand. A pleasant walk of a day from Bergen brings the wanderer again to the railroad, at Soltau or Fallingbostel. We chose the latter goal for our wanderings.

Fig. 3. Sandy way across the Heath.

The road leads out from the little, scattered hamlet of Bergen, sandy, and uncertain of direction, like a road from some village in the New Jersey barrens. Beyond the village a number of farms were passed. The roadsides were largely heather-covered, and patches of the European cranberry were common, bearing green, but already edible fruit. This plant, the German "Preiselbeere," or kronbeere, *Vaccinium Vitis Idaea,* (occurring also in northeastern and northwestern America), plays much the same role here as does the wintergreen, *Gaultheria,* in Michigan. It seems to take the ground much more rapidly than Calluna, thus quickly occupying cleared spots at the roadside or other openings in the heather. The bright green shoots and rather large leaves rise several inches in height and the plants bear an abundance of fruit.

Presently we approached and entered a beautiful mixed forest with pines and spruces predominating. Here the kronbeere flourishes also, like wintergreen or arbutus under our northern pines. Not long since a high wind had over-turned a number of trees, many of the trunks of which were still lying or leaning where they had fallen. Doubtless with the coming winter

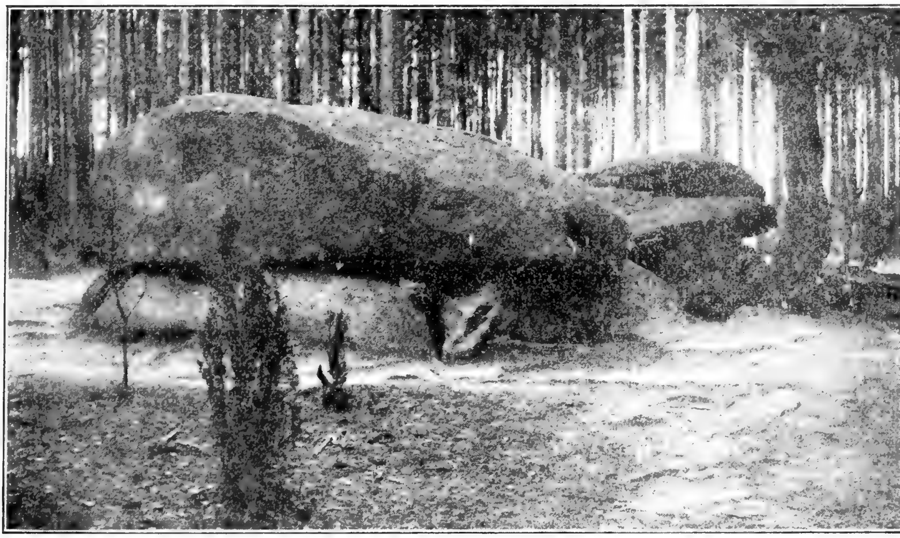

Fig. 4. Prehistoric grave—Siebensteinhaueser, near Fallingbostel.

these dead trunks would all be removed and used for fuel or other purposes. The value of the forest—probably originally planted but now having all the appearance of a natural one—was evidenced by the progress that had already been made in clearing away the debris from this storm, also by the placarded notices near the forest margin, calling attention to the danger from fire and to the laws which make it criminal to light a fire, or even to burn tobacco or carry a lighted cigar, within the limits of the forest. This forest is communal, owned jointly by the farm-holders of the neighborhood.

From the forest margin the road proceeds among somewhat scattered farms, where cattle and bees seem very important—

he who has not eaten heather honey has yet a joy in store for him!—and at length passes Manhorn, a tiny hamlet with but a half-dozen red-roofed houses, seen across bright meadow among darker trees. Beyond the farms of Manhorn was little to see but far-stretching heather. Imagine a rolling plain, stretching through blue haze to a still bluer horizon, the latter partly demarked by dim, dark forests; all under a blue sky with a few scattered cloud-puffs; the ground densely covered with waving brown heather; here and there, sometimes singly, sometimes in groups, dark, mysterious junipers rising from the brown carpet, with forms low and rounded, or tall and columnar, or again fantastically deformed by the wind; and through this plain a winding strip of golden sand which marks the road we are to travel. Somewhat in this way does the open heath leave its impression on our mind. The tall, dark, sentinel-like junipers (the German name for them is Wacholder) should never be forgotten. Now and then a belated Calluna plant was still in bloom, everywhere the withered capsules told of the past glory of the bygone summer.

The map showed "Hun's Graves" not over-far to the southwest, and a detour was made to visit these. The country falls off to a lower level—some ancient glacial basin, no doubt—and the yellow sand of the wheel tracks becomes deep upon the slope. At length a dark forest-mass rose in the plain, and within it, several miles from the nearest habitation, were found the prehistoric graves. These had, of course, been long since opened and were now quite free to the curious prowler. They are somewhat irregularly oblong inclosures, wider than a man's height and some twice or thrice as long, formed by upright, closely placed boulders, and covered with one or more enormous flattish stones. It must have been truly a giant's work to build them! In truth, they are not Hun's graves at all, on the contrary were probably already standing in the open heath, gray and weathered and their story long since forgotten, at the time when the first Huns came ravaging and burning hither. All that may be surely said is that they are the relics of a prehistoric people. Now they are much prized and wondered at, talked of by the inhabitants, and often visited for a day's outing. The area about them is kept as a natural forest park, protected by the usual explanatory and threatening placards.

The only human beings seen in this detour of several miles were a woman and a boy gathering Preiselbeeren among the six or seven tombs, and a mapless wheelman who inquired the direction of the "Seven Stone Houses," as the graves are called.

Presently we found ourselves on a fine smooth road, stretching away between lines of white birches, toward Fallingbostel. Passing more and more cultivated land and several villages, we at last reached the interesting little town, with its red roofs reflected, together with the green of meadows and of waving trees, in the tiny river upon which it stands. Inquiry from the station mistress brought out the information that a train for Hamburg was due in a short time—also that this same woman had a son living in far-away Chicago and that she knew much of American conditions.

West of Hamburg another visit was made to the Heide. At Cuxhaven, where the southern margin of the Elbe joins the shore of the German Ocean, are bathing resorts and much fortification. Heavily constructed concrete bomb-proofs shelter great guns which command the seaward approach to Germany's greatest port. South of the point the seashore has a broad, sandy beach, flanked to landward by low and broken dunes. Here the heath extends quite to the beach, Calluna being the main plant upon the dunes, torn and deformed by the wind and often brought to its death by the removal of sand in the wind cuts.

On the inland road back to Cuxhaven, the walker notices several powder magazines or the like, surrounded by numerous and repeated barb-wire fences and other ingenious stockades, and further protected by word of print in the form of placards which point out the danger of loitering here and forbid the use of camera or pencil in the neighborhood.

Ecologically, this shore has much in common with the south shore of Long Island, the plant species, of course, being different but the general aspect much the same. It is a moist, wind-swept, yet almost desert area, probably mainly made arid by a too-well drained soil and a short growing season.

Desert Laboratory, June 25, 1909.

BOOKS AND CURRENT LITERATURE.

Flora of the Islands of Margarita and Coche, Venezuela, by John Robert Johnston, stands as Contribution No. XXXVII from the Gray Herbarium of Harvard University, bearing date of June, 1909. Some of the more important data and conclusions, for the most part in the words of the author, are as follows:

The island of Margarita is the largest of the Venezuelan islands that extend along the coast from Curacoa to Trinidad, being 67 kilometers long and 32 wide. The mountains of the eastern end rise to an altitude of 795 meters and the peak at the western end a little higher. As a whole it is a very dry island, having, as compared with other tropical districts, almost no rainfall. None the less, there are dense woods covering the mountains above 400 meters that collect and retain the moisture of the clouds which envelop them, thus furnishing a source for small streams below.

The flora of Margarita, as thus far collected, consists of 644 species, of which 40 are cultivated and 66 are cosmopolitan. There are 419 common to tropical America. Of these 37 are limited to the West Indies and 82 to South America. Thus it is evident that the flora is of a general character in that the majority of the species are common with the West Indies and to South America. Members of the Leguminorsae are the most common plants, while the Compositae are represented chiefly by inconspicuous weeds, and there is, as would be expected, a marked lack of grasses and sedges. The Cactaceal, which cover the plains for miles, include 12 species. The Bromeliaceae are characteristic and conspicuous. Among other groups characteristic of tropical regions occurring on this island, are Melastomaceae, Aroideae, Piperaceae, Loranthaceae, and various Filices such as Trichomanes, Hymenophyllum, and Cyathea.

In considering the local distribution of the plants of the island the author first discusses their occurrence in regions of different vegetative conditions. The lagoons are bordered by mangroves—*Rhizophora Mangle, Laguncularia racemosa*, and *Avicennia nitida*—and on the sandy stretches adjacent are such low succulents as Batis, Salicornia, and Trianthema. On the plains stretching inland are great numbers of the melon cactus, flat-stemmed Opuntia, tree-like Pereskia, and the tall, candelabra-shaped *Cereus eburneus*, together with arborescent acacias, various species of Croton, and other Euphorbiaceae. On the hills beyond there are great stretches of Agave and Aloe, in places trees with leathery leaves, and among these an undergrowth including various bromeliads. A few epiphytes, including Rhipsalis, certain Polypodiaceae, etc., also occur. In the valleys, under cultivation, are groves of coconut, mango, sapodilla, and orange trees, which afford a good place for the growth of annual plants. The trees of the forests which clothe the mountain sides from 300 meters upward include Bombax, Clusia, Cecropia, the palms Acrocomia, Oreodoxa, and Bactris, and a variety of other woody plants which become dwarfed as the summit is approached. At lower levels there is a thin undergrowth of ferns and orchids, which becomes thicker at higher altitudes, including besides these Dioscorea, Smilax, Piper, Philodendron, Anthurium, and other characteristic genera, with a few grasses, and in wet places Cyperus, Scirpus, Eleocharis, and a few other Cyperaceae. Thus, the distribution of plants upon the island is seen to be definitely correlated with the great variety of vegetative conditions determined by its geographical position and physical features.

The distribution of individual species, whether in groups or singly, in one place or scattered in many, and whether on one slope and not on another, presents an interesting field for study. As to the question why certain plants are found on one slope and not on another, the palms are taken as an example. At an altitude of 500 meters or more, palms of various kinds are scattered about among the other forest vegetation. This occurs, however, only on slopes to the northeast, that is, exposed to the northeast trades. The opposite sides at this high altitude present an ordinary forest-front undotted by a single palm. Moisture, then, either by its immediate presence, or in its relation to the winds, very probably is here a controlling factor.

The distribution of plants on the island according to season is quite as impressive a phenomenon as their distribution in the various topographical regions. In the rainy periods the fields are carpeted with green and the bushes and trees are heavy with foliage and bright with flowers. In the dry season the fields are almost devoid of stick or leaf and many bushes and trees are to every appearance dead. When the rains come on in July or August, *Tribulus terrestris* and *Kalstroemia maxima* cover the roadsides and plains, numerous weeds form a rank growth in the coaconut groves and cane fields, and on the hillsides various shrubs, among them Capparis, Cassia, and Bauhinia, are in leaf and flower.

A highly interesting comparison is made at some length between the flora of Margarita and that of other regions, which, however, can not be reproduced here. It may be said in brief that from such comparison it is evident that the flora of Margarita is largely composed of plants common to many parts of the American tropics, but that it contains twice as many plants characteristic of South America as are characteristic of the West Indies, and finally that while Margarita has some plants common to all the islands about the Caribbean Sea, yet as a whole it has a flora quite distinct from the northern islands and at the same time closely approaching that of the Venezuelan islands and the north coast of the mainland.

The Reproductive Characteristics of the Lodgepole Pine by Gordon E. Tower, in the Proceedings of the Society of American Foresters (Vol. IV, No. 1), brings out the interesting fact that there is a well-defined and very distinct variation in this species associated with a particular quality in one of the physical factors of its environment. The presence or absence of lime in the soil not only affects the general appearance of the forest but has an important bearing upon the opening of cones and the production of seed. Trees growing on a sandy soil poor in lime produce cones which open at maturity, or very soon after ripening, and do not persist long on the trees. On the lime soil the cones are very persistent, rarely opening on the trees at maturity, and often remaining closed for thirty or more years. Furthermore, the time and very often the manner of seed dissemination becomes greatly altered in the two forms. In the lime-form, too, the cones are closed very effectively, the scales being pressed tightly upon one another, making an hermetically sealed chamber, impervious to water, in which the vitality of the seeds is preserved for a very long time.

Just why the cones of the silica-form open early, while those of the lime-form remain closed, can not be readily explained. A thorough drying of the cones of both forms causes them to open, and we would quite naturally presume that the difference is more or less closely related to the soil moisture conditions. On the siliceous soil with its poor water content, there is less moisture available to be supplied to the cones, and they open therefore, as soon as mature. The fine, compact, lime soil, on the other hand, has a better water content so that more water may be supplied to the cones, and these remain closed in consequence. This explanation, however, does not prove satisfactory. In the lime-form, as long as the stem of the cone remains united to the parent wood, moisture can be supplied to them, but when, as often happens, the stem of the cone becomes separated from the parent wood as a result of the growth in diameter, no moisture can be supplied directly to the cones. The latter condition is of very common occurrence, and yet cones do not open which have had no direct connection with the woody tissues for twenty-five or thirty years.

In the dissemination of the seed, the factors of chief importance are wind and fire. With the silica-form, where the cones open shortly after maturity, the first named factor is primarily important because of the relation it bears to seed dispersal, fire being a secondary consideration. In the lime-form the conditions are reversed, fire being of primary importance, and the wind a factor which may have only a secondary influence or even none at all.

An interesting article appears in a German annual report (Jahr. d. Verein. f. ang. Bot., p. 182, 1907.) which is very important if substantiated by further observation. Count von Armin-Schlagenthin, who is connected with a German-Swedish seed establishment, and which acts as an increase agent of certain German pedigreed seeds, reports that the climatic conditions of two winters produced remarkable results upon the pedigreed wheats. These results were nothing else than very radical mutants which appeared in the harvest following the freeze. One of the most remarkable things is that the mutants were formed after the germination of the seed, a kind of mutant hitherto scarcely thought of as possible. The new forms are reported to be fully constant from seed, as much so or more than the parent forms, which were very constant. The possibilities of accidental seed mixing, the effect of vicinism and cross pollination are considered as nil, as every possible precaution had been taken with the different varieties that mutated. It is suggested that the change is not due to the direct action of the cold but to the effect of warmth upon the green portions of the plant while the roots remained frozen. If any mutations of the above sort are possible, there are plenty of opportunities in this country to observe them.

L. R. WALDRON.

Some Unsolved Problems of the Prairies, with special reference to the prairies of Illinois, are formulated by Henry A. Gleason in a recent issue of the Bulletin of the Torrey Botanical Club. Their successful study, the author points out, involves reconstruction by means of books of travel and description, lists prepared by botanists of a past generation, areas of limited extent on which prairies are still preserved, and comparisons of prairies farther west as described by present-day ecologists.

Some of the questions proposed are:

1. What were the conditions, climatic or of other nature, at the close of the glacial epoch, which led to the invasion of prairie plants from the west rather than forest plants from the southeast? Emphasis is laid upon the accumulated effect of centuries of arid climate in the southwest, from which the plants of the prairies immigrated, as efficient in causing the treelessness of our prairies.

2. The flora of the prairies of the Wisconsin glaciation in the northern part of Illinois is very different from that of the Illinoisian glaciation at the south, estimated to be eight times as old. Does this flora at the south indicate the survival of a pre-Wisconsin interglacial flora, which persisted during the Wisconsin period, or an invasion of prairie species from a different direction or at a different time, or merely an adaptation to different conditions of soil, temperature, or other factors?

3. The aquatic plants surrounding the sloughs and ponds of the prairie were generally of broad distribution, or at least

in no wise typical of the prairie province. The latter class of plants was usually semi-xerophytic, and occurred in the uplands. What is the significance of this? Does it throw any light upon the order of entrance of plants, and of western plants in particular, into this area?

4. The occurrence of prairie species beyond the eastern limits of the province suggests a search for such relict colonies to determine the former maximum extension of the prairie.

5. Is it possible that there was a post-glacial period with so little rainfall that the distribution of certain plants now occurring at widely distant stations along the Illinois River and in Nebraska and Dakota was formerly continuous over the whole desert-like intervening territory?

6. What was the structure of the original prairie associations? Probably the time has passed when this question could have been satisfactorily answered.

7. The normal succession for prairie associations has not yet been fully investigated * * * In this region the forest is everywhere pushing out upon the prairie. We are ignorant of the factors which tend to retard or accelerate the advance of the forest, or of the nature of the tension zone between the two associations, or of those particular species which may be called pioneers in the forest advance.

Wild Flowers and Trees of Colorado, by Professor Frances Ramaley, is a very convenient and beautifully illustrated little book of 78 pages. The first part is a short essay on the plants of Colorado—their habits, distribution, and relation to altitude. Examples of the most interesting species of flowering plants from different altitudes are described and figured. The second half of the book is devoted to forest formations and forest trees. Keys are given for the determination of all the native trees of the state, together with notes regarding their distribution and grouping into formations.

Rocky Mountain Wildflower Studies, by Professor B. O. Longyear, of the Colorado Agricultural College, has recently appeared. A copy has not yet been received by the PLANT WORLD, but it is described as "a charmingly written series of Colorado nature sketches."

NOTES AND COMMENT

Contribution No. XXXVII from the Gray Herbarium, an abstract of which appears in this number of the PLANT WORLD, suggests some reflections which may be opportune at the present time. The character and make-up of this paper, fairly representative of the series, to which it belongs may be taken as also representative of a body of botanical work of permanent value which under the general designation of "contributions" has been published by American botanists. Under the same title, however, have not infrequently appeared various papers of all sorts, lists of plants, studies of anatomical details, photographs and descriptions of plant habitats, and other matters which by all means ought to be printed and thus made accessible to those likely to be interested, but which after all hardly deserve to be dignified by the title "Contribution No. — from the University of ———." Dr. Asa Gray used to modestly contribute "notulae exiguae" to the journals, and there is no doubt that these "notelets" have had quite as much value and been quite as much respected as if he had bestowed upon them some pompous title. The times of amateur production and over-haste in some of our botanical centers (in which the writer regretfully acknowledges his full share) may perhaps be winked at, but why not now, by common consent, adopt a better practice, already followed by some of the best institutions, and make it general. One set of papers, the best worked out, representing extended study or research, such for example as would be required in the production of a doctor's thesis, might properly retain the name and place of contributions, while observations on a collecting trip, preliminary reports of laboratory experiments, and the many things that fall into the same category might simply appear with the name of the writer and that of the institution from which it is sent. True, contributions, so-called, would not multiply quite so fast, but meantime there would be great satisfaction in knowing that whatever appears under this dignified title represents the better and more permanent work of the institutions concerned.

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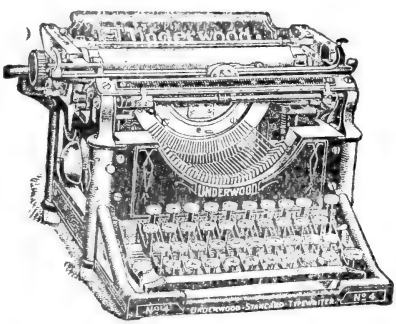

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THE PLANT WORLD

A MAGAZINE OF GENERAL BOTANY

NOVEMBER, 1909

THE BOTANICAL ASPECTS OF STANFORD UNIVERSITY.

BY GEORGE J. PEIRCE.

Stanford University has appealed to a great variety of people. Founded as an expression of parental affection, and for the perpetual benefit of the children of others, it attracts the sympathy of all who are capable of high and tender sentiment. Its rich endowment, exaggerated by irresponsible report, astonishes those who hear of it. Its buildings charm the visitor. The chief events of its brief history have continued it in public attention. Although more written about already than is good for it, I am asked to add to the descriptions of Stanford University one more, namely of the botanical aspects of its situation.

A glance at the map of California shows that Stanford University is situated about thirty miles south of San Francisco, at the western edge of a great flat valley bounded on the east and west by mountain ranges, some of the peaks in which are considerably over 3,000 feet above sea level. In this valley is the Bay of San Francisco, which receives from the east the waters of central California and from the west the tides of the Pacific Ocean. The latitude of Stanford University is approximately that of Richmond, Virginia, its elevation about 100 feet above sea. Between the quadrangles, into which most of the University buildings are grouped, and the Bay of San Francisco, a little more than four miles away, the land is flat, slowly sloping through the Arboretum and the town of Palo Alto to the marshy shore. In the opposite direction the elevation, at less than twice the distance, is over 2,700 feet. Between this range and the ocean is another of nearly 2,000 feet elevation, and the intervening country is much broken.

The differences in topography within short distances produce and are equalled by the differences in precipitation and humidity. In fact, one of the most striking features of this part of California is the differences in rainfall in adjacent localities. The average rainfall on the University Campus may be stated as approximately 16 inches. Within a distance of five miles it increases to between two and three times as great, and at an air-line distance of about twenty miles the average annual rainfall is between 80 and 90 inches. Upon the valley floor snow has fallen, so far as I know, only once in my twelve years' residence here, but on the peaks and sides of the mountains snow falls almost every winter. In some winters the snowfall is very light, a mere sprinkling, scarcely visible at a distance; but in seasons of abundant rain, the snow may come far down the mountain sides. In one year the snow remained for several days on the ground as far down as within 1,000 feet above sea level.

In addition to the usual seasons of the temperate zone, the Pacific coast of the United States has two others, with their corresponding effects on vegetation. The rainy season begins in mid-autumn—the first rain usually falls in October—and ends in April. Very rarely does rain fall in June, July, August, and September in the vicinity of this University. It is useless, and frequently injurious, to all forms of agriculture and even to the native plants, when rain does fall out of season. The first rains start the many annuals of the valley floor and of the unforested slopes, substituting verdure for brownness. Thus we have in autumn what is sometimes called our first spring. Many plants continue to grow throughout the winter, since the frosts do little more than depress the growth-rate. The second spring coincides with the spring of the same latitude elsewhere, only it is richer in bloom than other regions with which I am acquainted. This may be due to the quality and the amount of sunshine. I shall speak of this later.

The range of temperature in this region is considerable. The mean annual temperature on the Campus is approximately 58 degrees Fahrenheit, but the minima and maxima within a period of twenty-five years reached the extremes of 20 degrees and 106 degrees. Between the means of the coldest and the warmest months there may be a difference of 20 degrees, but between the maximum and minimum of a single day there is commonly as great a difference. "Reliable frost data are not available," * but during the winter of 1899–1900 the common garden nasturtium (*Tropaeolum*) vegetated all winter in my garden, quite unprotected. In every other year, however, this plant has been killed by frost. On the other hand, a few hundred feet above the floor of the valley, what is commonly called a "frostless belt" runs along the foothills. Within this, edible oranges are grown on a commercial, though small, scale.

Another condition greatly affecting vegetation also deserves mention, namely, the invisible water-vapor in the air, and the fog. Humidity tables, if taken by themselves, would mislead a visiting botanist. In fact, I think their value to any student of the vegetation of this region is slight because of the great differences in the humidity of the air over the open country and in the wooded canyons. Among the wooded canyons themselves there are considerable differences according to their direction, whether they are or are not the channels in which the fog-streams flow through the mountains from the ocean into the valley. In these fog-channels the air is damp and cool even in mid-summer, while elsewhere it is dry and may be hot. The rainfall is greater in these fog-channels than on the valley floor; but naturally I can not substantiate this statement by figures, for the country is still too sparsely populated to yield the data. The loss of water from the soil by evaporation is least where the rainfall is heaviest and *vice versa*. This results from the topography previously described.

The main source of water for plants, cultivated and wild, on the floor of the valley is the gravel beds underlying the surface alluvium.** But this source is supplemented, to an extent wholly unknown, or even capable of estimate at the present time, by the fogs. In the vicinity of this University fogs may come through the mountain passes from the ocean, or they may be so-called land or Bay fogs. The latter exercise less influence on the vegetation than the former, owing to their duration and the times of their occurrence. In summer they are brief and come about sunrise, if at all, in the winter they may last much

*McAdie, A. G. Climatology of California. U. S. Dep't of Agric.: Weather Bureau, Bull. L. Washington, 1903.

** Branner, J. C., Newsom, J. F., Arnold, R. Geologic Atlas of the United States: Santa Cruz Folio, California. U. S. Geologic Survey, Washington, 1909.

longer, but their moisture is then less needed owing to the rains which they commonly follow. The fogs of ocean origin come as streams from the great bank of fog, fifty miles wide and over one thousand miles long, which lies along the Pacific coast most noticeably in summer. * These fog streams, coming generally in the afternoon, flowing over the passes and through the canyons, spread out on the valley floor to varying distances, and becoming confluent may there attain a depth which at times equals the height of the passes. The check which fog offers to evaporation, from soil and vegetation, is obvious; but beyond this conservation of moisture, very valuable in itself, there is an actual contribution of moisture which we may someday be able to reckon in inches of precipitation. There are many plants in this region which absorb moisture from fog and become wet, for example lichens, ** mosses, etc. Other plants seem actually to comb out moisture, which falls in drops from the leaves and branches. I have heard of two instances where men have made use of this phenomenon. One settler in the mountains between here and the sea-coast, having an otherwise inadequate supply, collects the fog product of a certain group of trees and thus secures enough water for his stock. This case is extreme, but it fairly indicates the value of fog to plants which thrive where no rain falls during four or more months of each year.

At the same time that I thus emphasize the value of fog to the perennial plants of this region, I must also speak of the amount of light and sunshine. It is greatly to be regretted that there are no adequate instruments for measuring and recording the amounts and qualities of light reaching the earth's surface. The various "sunshine recorders" leave very much to be desired. The verbal communications of experiences of photographers confirm my own impression regarding the amounts and qualities of sunlight in different regions. The far-famed clearness of the summer air in the Sierra Nevada Mountains results in "over-exposures" when the photographer in that region does not adjust his camera accordingly. The impression, as one travels eastward from coast to coast, is not of increasing cloudiness so much as of decreasing brightness; the sunlight of the Mississippi

*Mc Adie, A. G. *loc. cit.*, p. 239 *et seq.*

**Peirce, G. J. Nature of the association of alga and fungus in lichens. Pro. Calif. Acad. Science, 3rd Ser., Bot., Vol. I, 1899.

valley is less bright than that of this part of California. The differences in the composition of the air as regards moisture, dust, and smoke entail qualitative and quantitative differences in the absorption of light by the air of different regions. Ten hours of sunshine will not necessarily give New York, Ohio, Nebraska, and California the same amounts or the same qualities of light. There will be differences in the proportions of the so-called luminous, thermal, and actinic rays as well as in the total amounts of sunlight. These differences I can not state; I can only suggest them for consideration. Valuable as are the tables published by the Weather Bureau, the physiological botanist wishes that he could know more about the sunlight of any given region than is indicated by records of "clear, partly cloudy, and cloudy" days and the "percentage of possible sunshine." So slight a difference in the brightness of daylight that neither the trained eye nor the available instruments can determine it will be responded to on a spring morning here by the flowers of Eschscholzia, Calandrinia, etc.; they will remain closed or they will open accordingly. Taking into account the work of Delpino, Klebs, Voechting, and their followers regarding flowering and the other forms and stages of reproduction, one must admit the probable importance of the influence of sunlight on the reproductive function in plants. * The prodigality of bloom described by John Muir, the yields of grains and fruits, the quantities of seeds of forest trees, the productivity of the smaller plants of this region, must be attributed in part to illumination, superior in quality and in quantity, as well as to the more readily determined factors of temperature, soil-fertility, water supply, etc.

I think I have thus laid the foundation in this discussion of the topographical and climatic conditions, for a description of the vegetation of the environs of Stanford University. Let me summarize, however, what I have so far said, before I proceed to more. We have here, within a day's walk of the University buildings, a range in elevation from sea-level to 3,000 feet; a range in average annual rainfall from 15 to 80 or 90 inches; a range in temperature from 20 degrees to 106 degrees Fahrenheit, with a mean near 58; a range in humidity from 20% or 30%

*See Peirce, G. J. Text-book of Plant Physiology, p. 274+.

to saturation; a range in water from the point of saturation through salt, brackish, and fresh, to the rain and fog which bathe the leaves and the lower plants; a range in light from the gloom of heavy clouds to the day-long sunshine, the brilliancy of which can not be expressed in definite terms.

Turning now to the plants living under these conditions, let me begin at and near sea-level. So far as the proportion of salt is concerned, the water of this part of the Bay of San Francisco is the same as sea-water. The differences between Bay and sea-water here are mainly in stillness, aeration, and organic content suspended and dissolved. The shore is heavy clay and beyond the marsh extend flats for greater or less distances, daily covered by the tide. Into the marsh are cut tidal channels, here called sloughs and pronounced slews! Larger or smaller fresh water streams empty into the heads of these. Most of the streams are dry in summer. The algae growing under these conditions are correspondingly different in kind and habit from those of the sea coast.

On the Bay shore many shallow ponds have been made by building sod-dykes and pumping the Bay water into them. These ponds are filled in winter or spring (less frequently at other times) by windmill or electric pumps and the water evaporates during the summer. In a good season salt is crystalizing out by late August. The water in the ponds changes, then, in about six months from, say, a 3% solution of common salt to a saturated solution. If there are late spring rains, the concentration of the solutions in the ponds is less than 3%. The algal vegetation of these salt ponds is very interesting. Beginning with the spring the vegetation of the ponds is similar to that on the marsh and in the Bay. As evaporation progresses there is an increase in the unicellular motile forms, Carterias become abundant, and the Ulvas, Enteromorphas, and Cladophoras decrease. Later these and the Carterias disappear and their places are taken by bicilliate Dunaliellas, green and red-brown, which serve as food for the very peculiar crustaceans living in the increasingly saline solution. Finally the color of the water in the ponds changes to a red, in shade between blood and rust. This color, attributed by various authors to iron salts or to the algae, is due, I believe, to chromogenic bacteria. These, cultivated on brine to which

0.5% agar-agar has been added, form red colonies. By this time the water in some of the ponds has become so concentrated that common salt crystalizes out. Despite the concentration, which is sufficient to preserve meat or other putrescible substances from decay, there are animals, algae, and bacteria living and even swimming in the almost syrupy liquid. Organisms living under such extraordinary conditions are themselves extraordinary; but only the beginnings of studies of saline organisms and their environment have been made by zoologists, botanists, and physiologists.

On the heavy soil of the marsh Salicornia and other herbaceous plants grow, Salicornia predominating near the water, the vegetation becoming more mixed as the soil lightens and becomes dryer. A mile, more or less, from the water's edge are willows along the streams. The valley-floor, quite park-like in places from the live oaks, richly repays cultivation and in the absence of cultivation carries a rich and varied flora, mainly herbaceous. Climate and soil are so favorable that the gardens, orchards, and fields are planted with an enormous variety of plants, trees, shrubs, and herbs, among which wild plants of many kinds also thrive. The Arboretum of Stanford University contains some interesting foreign trees, as do also some of the older and larger "places" of wealthy San Franciscans.

The foothills are grassy, with scattered oaks, or covered with "chaparral," a scrubby growth consisting of a considerable number of species. This is so close in places as to be almost impenetrable. The influence of the close-growing shrubs upon the herbaceous plants is often very interesting. Castilleias which may reach a height of eighteen inches in the open are four feet or more tall in the chaparral. Eschscholzia Californica, the "California Poppy," which ordinarily has stems one or two feet long, is much taller in the chaparral. A specimen brought from the chaparral near Monterey is eighty (80) inches long! The effect is similar to what one sees here and elsewhere on a small scale in hedges.

The mountains were originally timbered and there are still fine virgin forests within half a day's or day's drive. The steep slopes and the canyons are growing up again, after lumbering or firing, to a mixed forest in which redwoods, madrones, and laurels are the most abundant forms. Torreya or Tumion, or California Nutmeg, is not a common tree, but there are many specimens of it, some of a height of fifty feet or more, on the mountain sides or in the narrow valleys in the mountains.

About five miles westward is the great fault, the Portola or Andreas Fault, along which repeated movements have taken place resulting in earthquakes. In many places along this fault-line there are ponds, some very small, others large enough to be used as a part of the water supply of San Francisco. The vegetation of some of these ponds and their immediate surroundings is extremely rich, and forms occur there not known elsewhere in the region. The water in the higher of the ponds is less hard than elsewhere on the peninsula. This may account in part for the unusual abundance of Desmids and other strictly fresh-water forms.

The streams from the mountains into the Bay are peculiar in that their beds, in the lower part of their course, are raised above the valley-floor. Along the shaded banks of these streams and in the streams themselves, plants of all sizes from trees to algae may be found which otherwise are very limited in their distribution. Thus, within a half mile of the botanical laboratory I have found in the San Francisquito Creek, or on its banks, a Batrachospermum, liverworts, and trees which do not otherwise occur in the valley but are abundant in the coast ranges.

I might go into details regarding the plants living in the extremely diversified country lying within a radius of twenty miles of Stanford University, but such detail would be more valuable if given by systematists. The specialists on algae, fungi and lichens, archegoniates, herbaceous plants, and trees, have here abundant material under their hands, and no one's energy is sapped by excessive heat or cold.

A DOUBLE-FLOWERED SARRACENIA.

BY W. C. COKER.

While collecting in Hartsville, Darlington County, South Carolina, in August, 1908, I was fortunate enough to find a clump of *Sarracenia rubra* Walt. that bore only double flowers. The flowers were completely double, all signs of gynoecium and andraecium having disappeared in a profusion of persistent petal-like segments. In figure 1, A, B, two of these flowers are shown slightly enlarged with a normal one of the same species, D, for comparison. Two of the plants of the clump were collected and are now in the herbarium of the University of North Carolina, one was left growing in position, one was sent alive to the New York Botanical Garden where it was placed under favorable conditions in the propagating house. This cultivated plant has flowered again this spring, and the flower, which is still fresh (June 19th), is shown in fig. 1, C (enlarged about 1-3). It will be noticed that the doubling, while decided, is not quite so great as in the flowers of the preceding year. In reference to this matter Professor Jno. M. Macfarlane, of the University of Pennsylvania, who is our chief authority on the Sarracenias, writes me as follows: "I am very pleased to get notice of *S. rubra* showing double flowers in nature as in all my wanderings throughout the southern states I have never seen a case of this. I had excellent opportunities last year for watching thousands of flowers for a couple of weeks in April, from South Carolina along the Gulf states, and although I saw all in flower, none showed a tendency to double." So far as I have been able to ascertain doubling of this complete sort has not before been reported in the genus *Sarracenia*. In the hybrid *S. Atkinsoniana* a second row of petals between the normal ones and the stamens is recorded (Gardener's Chronicle, vol. 58, page 210, 1885). A similar record of two rows of petals has also been made for *S. flava*, with the stamens partly petaloid and connate in several groups, and the stigmas also petaloid and separate; the ovary and ovules scarcely changed (Gardener's Chronicle, vol. 38, p. 914, 1873). For minor abnormalities in *S. purpurea* see Bulletin Torrey Bot. Club, vol. 1, page 83, 1880; and American Journal of Science, vol. 16, page 488, 1878. See also Journal of Botany, vol. 13, page 56, 1875. *

University of North Carolina.

*I am under obligations to Prof. William Trelease for references to the literature.

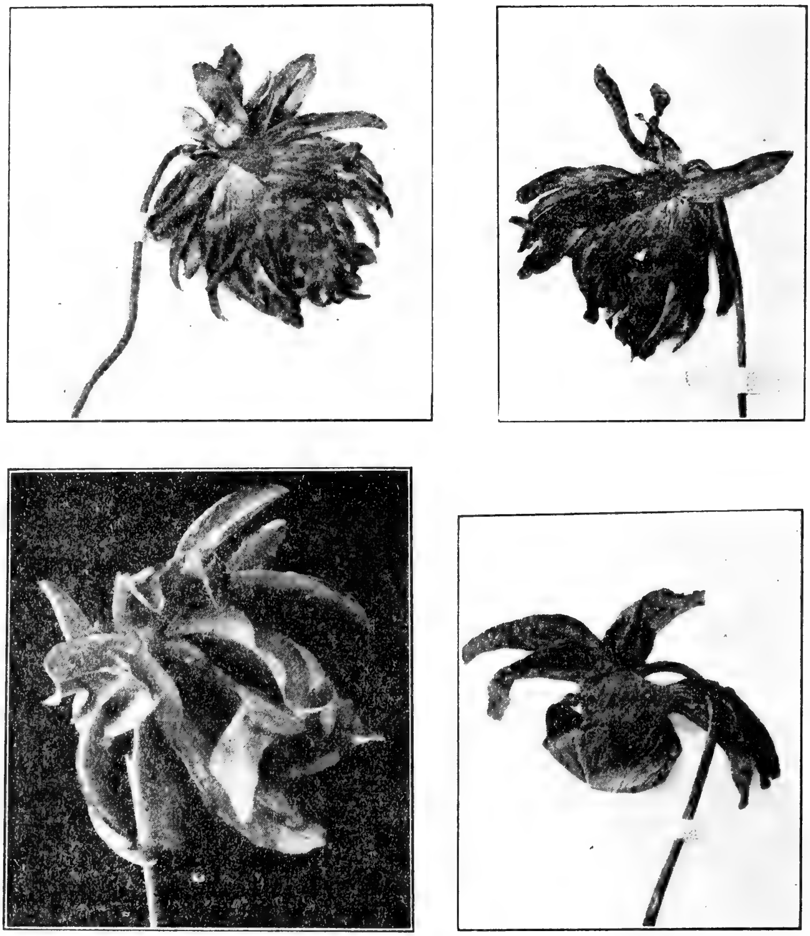

Fig. 1. Saracenia rubra Walt. A. B. Double flowers from Hartsville, S. C., August, 1908. D. Single flower for comparison. Slightly enlarged. C. Saracenia rubra Walt. Double flower from New York Botanical Garden, from Hartsville, S. C., June, 1909

SUGGESTIONS FOR LICHEN STUDIES.

BY ALBERT W. C. T. HERRE.

To say one is studying lichens is a rather ambiguous statement, as indeed such a remark would be regarding any large group of plants. But, generally speaking, the study of lichens has meant in America investigation from the taxonomic side only, though there have been a few brilliant examples to the contrary. As a matter of fact, this remarkable assemblage of plants (which, so far as the United States is concerned, we may place under the Ascomycetous fungi) offers the widest possible field to the young botanist, whether he wishes to study physiological, morphological, taxonomic, or ecological problems.

Owing to the inaccessibility and scattered nature of much of the literature, it is exceedingly difficult for the beginner to make a start in lichenology, especially if he wishes to name and classify his material. And this is necessary, for along with the study of physiological problems should go an exact knowledge of the forms handled, while it is even more important in ecological and morphological studies. Too often the results of experiments or observations can not be duplicated or verified because of the original author's uncertain identification of material. Sometimes, of course, this is of no consequence, but very often it makes an enormous difference as to the species used.

In the case of lichens, the only North American lichen flora is Tuckerman's incomplete Synopsis, which is helped out very much by his Genera Lichenum. But Tuckerman's books are among the rarest of all botanical literature, the Synopsis now selling at $25, on the few occasions that a copy is in the market. This makes it very difficult for the beginner to identify his plants. For the lichens of the eastern United States the forthcoming work by Fink, on Minnesota lichens, will be a great help, while the writer's works now ready for publication will cover most of the western lichens. But the best thing for a beginner to do is to have at least a part of his collection identified by a competent person, and then obtain, either by purchase or exchange, a set of correctly determined lichens to use for a standard of comparison.

The author believes that one very valuable field for the earnest worker, and one as yet but little cultivated, is the publication of local lichen floras, such as have been prepared for many parts of Europe, taking for a basis a county, a state, or better, some natural biological region. Such floras, with carefully prepared keys, will arouse the interest of both amateur and professional botanists and induce them to become acquainted with lichens. The publications of mere lists of species, however valuable to the specialist, is only a bug-a-boo to the beginner or the general botanist.

In the realm of experimental physiology lichens offer one of the most attractive fields. The spores may be germinated, grown in nutrient cultures, with or without algae, treated with various toxic salts, and their responses to all sorts of stimuli noted. Then there is a vast deal to be learned about their behaviour under various atmospheric and climatic conditions, their power of growth and continued viability under extremes of heat and cold, their power of retaining moisture during prolonged drouth, and of absorbing it from various substrata or from humid air. Unfinished experiments by the author show that certain lichens of xerophytic structure maintain a moisture content of 50% during our rainless California summer, while on a rainy spring day some absorb so much water as to increase their dried weight more than 300 per cent.

Many lichens readily lend themselves to measurements of their annual growth, and while the statements of the texts about the slow growth of lichens are in a measure true, several experimenters have shown that many lichens are very rapid growers. Such lichens as the *Stictas*, *Peltigeras*, *Collemas*, *Lecanora sordida*, *Lecanora frustulosa*, *Lecidea fumosa*, and many of the *Parmelias* and *Physcias*, to name no more, would be admirable for such investigations. To be most valuable, the experiments should extend over several years.

The influence of ocean water upon lichens would be a good thing for some one living at the sea shore to investigate. A number of lichens, such as *Caloplaca coralloides*, *Catillaria franciscana*, and *Arthopyrenia halodytes*, grow only where they are frequently bathed by the waves, while many others, e. g. *Dendrographa minor*, grow only where they are constantly moistened by the salt spray. What would be the effect of fresh water on these species, and of ocean water on other lichens from a more inland habitat? Does any one know?

The influence of moisture on a given lichen is abundantly illustrated in a number of cases, but by none better than *Ramalina reticulata*. Where this plant grows on foggy coasts the thallus is excessively subdivided, with perforated expansions but a fraction of a milimeter in breadth; while in the dry, interior lowlands the unperforated expansions may reach a breadth of more than 40 mm., the whole plant being markedly coarse in habit. In fact the variation in habit of this plant is a pretty good indication of the fog channels and rain-laden wind currents of the Coast Range mountains.

But what would be the result of the acclimatization of a lichen? So far as the writer knows, this has never been attempted. Yet it would seem that a form like *Ramalina reticulata* might readily be "planted" on the limbs of trees on the coast of Florida or Louisiana. It might live and in time vie with *Tillandsia usneoides*, or—it might not. But it would be interesting to transplant a number of lichens and see what changes, if any, the new environment would effect. For example, it might throw some light on why a given species should be so much more luxuriant in one region than another. R. H. Howe states (Bull. Torr. Bot. Club, XXXVI, 315; 1909) that the "great luxuriance of Pacific Coast specimens (is) due evidently to abundant moisture." This is not so evident to those of us who live at present on the Pacific Coast and who are familiar with the flora of all parts of the United States; it may be true of some species perhaps, but it is certainly not true of the *Usneas* of which he is speaking. One could hardly be so sure of abundant moisture when six or seven months often pass without rain, the annual precipitation of 15 to 40 inches coming during the winter months. It is true that there are some summer fogs, but they lack much of supplying adequate moisture, though of course they have an appreciable effect upon vegetation. The aridity of California in general is shown by her xerophytic forests and impenetrable gnarled chaparral, and by the great number of endemic xerophytic lichens, such as *Heppias and Acarosporas*.

The excessive length of species of *Usnea* in some regions is directly due to their having never been disturbed; for example, *Usnea longissima* reaches a length of six or seven meters in the forests of Baron Rothschild's estate in Hungary, where an axe has not been allowed for more than one hundred and fifty years; here in California it is ten or twelve feet long only in the redwood forest not yet visited by the lumberman, where it grows upon trees which are from 500 to 1,500 years old. The author also believes that the greater size of many California lichens may be due to the prolonged growing season, though of course this can only be settled by careful measurements and extended series of observations.

A number of European investigators and a few Americans have made valuable contributions to the physiology of lichens, but the field is still almost a virgin one. Relatively few exact morphological studies have been completed, and the researches of Stahl and Sturgis stand almost alone in the investigation of the sexual reproduction of lichens. The tissues of most lichens do not readily lend themselves to the niceties of killing, fixing, staining, and sectioning, and some of the published papers have been ridiculous from the slip-shod methods used. But ways may be found of overcoming most of the difficulties, and here again the field is clear for the pioneer. Of course in the above has not been included the masterly investigations into the thalline structure conducted by DeBary, Schwendener, Bornet, and others. Enough has been said, however, to show that there is a very extensive field for physiological and morphological investigators.

The ecological study of lichens is a most fascinating department of plant ecology and they illustrate very well the influences of varying conditions of temperature, light, and moisture. Professor Bruce Fink has done most valuable pioneer work in this line. Too many students of phytogeography have altogether neglected lichens, taking for granted that they had no ecological significance, but this is a great mistake. But the writer wishes to say that it is also a mistake to rush into ecological work until there has first been acquired a thorough and exact knowledge of the organisms studied. By all means take up ecology. But do it only after you know your plants in the field and in the laboratory, know them macroscopically and microscopically. Study them from the standpoint of the systematist and the physiologist; then you will be more nearly prepared to attempt the problems of variation and distribution, problems which tax every bit of knowledge and every power of thought.

A great deal of desultory work has been done on the lichens of North America in general, but so far as the writer is aware the only regions in the United States of which we have exact, definite knowledge (relatively speaking) of the lichen flora are New England, Minnesota, Iowa, Northern Illinois, Southern California, and the Santa Cruz peninsula, California. This means that an immense lot of investigation awaits local students almost everywhere; one might safely count on ten years' work almost anywhere west of the Missouri. No matter where you live there is not a winding canyon, not a group of old forest trees, not a precipitous crag by the waterside, not an insignificant ledge of rock outcropping in the hill pastures, but which has an interesting story to tell of its lichen flora, a story that will amply repay the careful perusal of any keen-eyed, thoughtful lover of nature.

THE PARASITISM OF ORTHOCARPUS PURPURASCENS BENTH.

BY W. A. CANNON.

When in March, 1908, the root systems of some of the desert annuals were being studied an examination of the roots of Orthocarpus revealed the presence of numerous small enlargements of the finer roots of the plant which proved to be haustoria. Further examination showed that the plant was united by these haustoria to the roots of several of the neighboring annuals, and, hence, that Orthocarpus was a parasite, probably of the same nature as Castilleja, its near relative.

Orthocarpus is a low annual, mostly less than 15 cm. in height, which comes after the winter rains, and is dependant on the rains for its appearance, and if they are abundant it may be found in favorite places, as on the lower slopes of Tumamoc hill, where the Desert Laboratory is situated, in large numbers. The plant is gray-green in color and gives no hint either by its aspect or its local distribution, of its parasitic nature.

In the habitat of Orthocarpus, and growing at the same time, may be found a large number of other plants, chiefly annuals. Of these the following were seen to be the host plants: *Astragalus nuttallianus, Bigelovia hartwegii, Bowlesia lobata, Daucus pusillus Delphinium scaposum, Eritrichium pterocaryium, Eschscholtzia mexicana, Festuca octaflora, Gilia bigelovii, Lesquerella gordoni, Lupinus sp, Mentzelia sp,* Pectocarya *linearis, Phacelia tanaeceti-folium, Plantago fastigiata, Silene antirrhinum, Streptanthus californicus,* and *Sysimbrium canescens.*

The typical root system of Orthocarpus may be described as having a well developed tap root and few laterals. Three leading modifications of the root system were seen. These were roots with short and coarse laterals, or those in which the laterals were filamentous and either long or short, or, finally, root systems in which the tap root is broken up into three or more branches. While the immediate causes which bring about these variations were not studied, they are thought to reside in part in the nature of the root system of the host plant, which will be apparent from the following brief account of some of the parasitic relationships.

In association with *Astragalus nuttallianus,* Orthocarpus has a prominent tap root with both long and short laterals. The long branches of the tap-root are independent of neighboring plants, but the short ones bear the haustoria. Both long and short roots are rather coarse. In this case the length of the haustoria-bearing roots is presumably dependent on the distance by which the roots of parasite and host are separated, which, however, would not adequately account for the coarseness of the roots of Orthocarpus.

While growing in association with *Festuca octaflora* as host, the roots of Orthocarpus are filamentous, and the root system is poorly developed, On Eritrichium as host the roots of the parasite are also filamentous, but they are very numerous. In

Fig. 2. Orthocarpus purpurascens on Astragalus nuttallianus, March 15 1908.

connection with the Silene the main root of Orthocarpus was broken up into four relatively large roots, and the laterals were few.

Whatever may be the cause of the modifications of the root system of the parasite it is of interest to note that the soil conditions were as uniform as one would find in a single habitat, and that the root systems of the host plants had specific differences which the root system of Orthocarpus in some instances at least and to a certain degree reflected. Thus, the root of Astragalus are coarse, and those of Festuca and Eritrichium are filamentous, or relatively fine, and when the roots of the parasite are attached to the roots of those plants they are coarse or fine, as the case may be.

The parasitic habit is more prevalent among the flowering plants than a person not especially interested in the subject may at first suppose. Among the families richest in parasites is the Scrophulariaceae in which there are said to be 450 species which are at least partly dependent on other plants for their food supply. To these must be added *Orthocarpus purpurascens*, and presumably others of the genus, which is a hemiparasite, and, as is shown in this note, is attached to a rather large number of hosts, both perennials and annuals.

BOOKS AND CURRENT LITERATURE.

Sernander, in a recent number of a Swedish botanical publication, discusses the time of arrival in western Goetland of *Stipa pinnata*, which was noticed by Linnaeus as a new element in the Swedish flora in 1761, and had already been discovered by Falck in western Goetland. In the plant associations of this district in which the species in question occurs xerophytes and semi-xerophil mesophytes predominate. Their species as regards distribution in Europe are southern and especially south-eastern. They are designated by the author as xerotherms, a self-explanatory term corresponding to their habit and history. Most of them as they occur in western Goetland are widely separated from other stations in Scandinavia, and Stipa and some others are also separated from their continuous area of continental distribution.

The Stipa associations appear to have entered western Goetland by way of southern Sweden during a dry and warm period preceding the present time. Kerner, Engler and Drude hold that there have been two dry periods in Central Europe in post-glacial time; the first of these is designated by the author as a sub-arctic steppe period and the second the xerothermic period during which it is assumed that Stipa and certain of its associates became established where they now are.

Two principal lines of evidence are adduced in support of this, the first based upon the formation of peat bogs in Scandinavia, the uppermost layers of which appear plainly to correspond to different climatic periods. One of these was distinguished by its dry climate, which was also relatively warm, during which pine forests existed in central Scandinavia at least 100 meters higher on mountain slopes than at present, and the hazel occurred farther north than now. At the same time the area of peat bogs and swamps became less and forests encroached upon them.

The second line of evidence is derived from observations of the effects of unusually dry and hot summers on the movements of plants at the present time. In the dry summers of 1901 and 1904, for example, many plants on exposed rocks dried up and perished, and a succession of such summers would necessarily result in the replacement of mesophytic by xerophytic associations of plants. What is thus seen to be now taking place has evidently been carried out on a far grander scale in earlier post-glacial time.

From a report of the British Vegetation Committee's excursion to the west of Ireland (1908) it appears that in Connemara the conspicuous plant formations are (1) the submerged and reed-swamp vegetation of the numerous lakes, together with wetter and drier "Flachmoor," (2) heath pasture or heath moor on drier hillsides of metamorphic rock, and (3) woodlands on rocky islands or in sheltered ravines. "These woods are regarded as a higher stage in the succession from the heaths. In comparing the vegetation of Connemara with that of northwestern Scotland, it is noted that while peat is being rapidly formed in west Ireland, denudation exceeds growth in northern Scotland."

Burck, in the *Biologisches Centralblatt* (XXVIII, 1908) takes up anew Darwin's law of cross-fertilization in the light of recent views concerning what is fundamental in fertilization, and especially from what is known of plants with cleistogamic flowers, which for periods wholly beyond reckoning have been reproduced by self-fertilization without losing their constitutional vigor and fertility. He concludes that floral biology has departed farther and farther from the views held by Darwin.

Vaccari (Malpighia, XXII, 1908) presents the results of his ecological observations on the flora of the Archipelago of Maddalena, a group of small islands near the northern coast of Sardinia, and concludes that judging from its flora this archipelago may be regarded as the remnants of an isthmus which formerly united Corsica and Sardinia and constituted, till relatively recent times, with the adjacent islands, a continental area continuous with northern Africa.

Fischer in a recent study of the colors of flowers as influenced by action of light (Flora, XCVIII, 1908) ascertained that various plants with red or blue colored flowers, *e. g.* species of Cydonia, Campanula, Digitalis, Aconitum, Fuchsia, produce only small quantities of coloring matter in darkness, while plants with yellow flowers, *e. g.* species of Geum, Ranunculus, Chelidoninm, Glaucium, exhibit but seldom such a diminution of floral coloring under like canditions.

The investigations of Blaauw on the relation between the intensity of light and the length of illumination in certain phototropic curvatures indicate that a definite quantity of light is required to produce a reaction. The essential condition foi the production of a phototropic curvature is the supply of a definite quantity of radiant energy, and whether this quantity is supplied in a short or a long time is a matter of indifference.

From a review by Lind of a work by Galloce on the ecology of Danish lichens (1908) the following abstract will serve to indicate the essential features of this noteworthy contribution. The author first discusses the general effect of water and light on lichens, maintaining that their vegetative activity is but slightly affected by difference of seasons. In following chapters he takes up the various habitats of lichens in Denmark, namely, downs, heaths, moors, woods and stones. Taking these habitats in order:

1. The sands of the seashore are destitute of lichens, most likely on account of excess of salt; dunes in process of formation support a very few species, and grass-covered downs a larger number. As protection against intensive light lichens growing on unsheltered soil either develop a brown pigment in the cortex,

by means of which the light is caught and the interior is protected, or in other species the individuals become as white as chalk, so that the sun's rays are reflected.

2. The species of the heaths occur on the inland sands, in the Calluneta and in the Ericeta. The first are a sort of small desert where the vegetation is very scarce and the lichens found on them are almost the same species as those found on the dunes. In the Callunetum the growth of lichens depends largely on the removal of Calluna, following which a rich vegetation of lichens especially of *Cladonia rangifera* appears. In the more dry Ericeta this species thrives even better than in the Callunetum, but in the moister Ericeta all lichens disappear.

3. The moors have no lichens as long as they are thoroughly soaked, but as soon as they are dry enough for Calluna to grow upon them the lichens invade the ground at the same time. If the heather is cut off they become dominant, but disappear as soon as it grows up again.

4. The lichens of the woods affect different kinds of trees, apparently according to the mass of light which they suffer to pass through their crowns and whether they are isolated or growing together. Thus if a single spruce is left in the middle of a wood, while all the trees around it are cut, its trunk will be quickly covered with Lecanora. On young beech trees, which keep their leaves during winter, no lichens thrive, nor do they grow on the beech to any extent if it is planted in rich mould, but if it is growing in acid and moor-like soil the trees will grow more scattered and the trunks will be covered by a rich vegetation of bushy lichens. The oak has the greatest number of lichens of all the trees of the forest on its trunk, 63 species being enumerated.

5. In all, 138 species of lichens are enumerated as living on rocks. None are found in Denmark on common chalk, but on other sorts of limestone 36 species have been distinguished. Other facts which can not here be referred to, which are based on thorough study of the lichens of Denmark in their habitat relations, add to the value of this important pioneer work in a field that has been but little cultivated.

Bouget, in a paper on the geographical botany of the Pyrenees, points out the interesting fact that plants which at lower levels grow only on siliceous soils are found on limestone in the upper alpine zone. The limestone soil absorbs and holds heat better than siliceous soil, and this, according to the writer named, is the probable cause of the observed change of habitat.

A Danish writer who has given special attention to the disease of crucifers caused by *Plasmodiophora Brassicae*, finds that its geographical distribution in Denmark is determined more by conditions of soil than by means of dissemination. West of a certain boundary formed by a glacial moraine the soil is sandy and the disease is common, while east of the same boundary the soil is more fertile and is free from the Plasmodiophora. Chalk in the soil and soil moisture are both important factors, and it is recommended to supply chalk and drain the land on which cabbage, turnips, etc., are grown.

Potter, in recent experiments on checking parasitic diseases of plants, found that a concentrated solution obtained from orange juice charged with the waste products of metabolism of *Penicillium italicum* was capable of preventing the extension of decay in oranges attacked by this fungus. These, and other results reported by him, indicate that the waste products of metabolism of parasitic organisms may be successfully employed in checking the progress of plant diseases due to the action of these organisms.

Lind, who has studied the distribution of the gooseberry mildew, *Sphaerotheca mors uvae*, since its appearance in Sweden, finds that man is the worst conductor of infection, and next are the birds. The wind was wholly inefficient, even at a distance of 40 meters.

NOTES AND COMMENT.

Nothing seems to disturb the mental equilibrium of the average botanist and horticulturist so quickly and surely as a question concerning the products of Luther Burbank's breeding operations. The preposterous statements of the daily press, and the equally unsound indiscriminating praise of friends of Mr. Burbank, including some scientists known as botanists and zoologists, have combined to raise a very real prejudice against anything purporting to come from Santa Rosa.

The influence of such antagonism is to be seen in the recent agitation concerning the nature of the Wonderberry, which has been sold to a nursery by Burbank. It is to be noted regretfully that a number of botanists have exhibited methods of treatment no more judicial or fair-minded than that of the average newspaper reporter.

The Wonderberry is described as a hybrid between *Solanum Guinense* and *Solanum villosum* by Mr. Burbank. A number of skilled systematists give as their mature opinions that it is simply *Solanum villosum* or *Solanum nigrum*. This conclusion was reached upon simple taxonomic data, although it has long been well recognized among breeders and students of heredity that a simple examination of the external appearance of an individual could not yield an accurate diagnosis of its ancestry, both structural examination and pedigree cultures being necessary.

Now comes the announcement of the results of studies by Dr. W. A. Cannon on the origin, variation and inheritance of hairs in hybrids, in which it is noted that one type of these organs in the Wonderberry is exactly like one of *S. Guinense*, and is not found in *S. villosum*. Many other features being like *S. villosum*, the hybridity of the Wonderberry is, therefore, well established, and a rude shock given to the specialists who consider taxonomy as a court of last resort in dealing with the results of purely physiological operations in breeding and heredity. If this lesson results in a more judicial attitude on the part of the botanist toward results in breeding and experimental evolution, the misjudged attack on the Wonderberry will have been not without good results.

A recent trip in southern California brought to view more than one proof, if any were needed, of the progressiveness of the up-to-date people who inhabit that favored land. One of these is the eucalyptus industry. It appears that there are already about 25 companies incorporated under the laws of California, and two or three times as many companies not incorporated, that are pointing out the certain road to wealth, by embarking in the enterprise of planting eucalyptus trees. In their office in Los Angeles, very beautiful specimens of woodwork are to be seen made from "Blue Gum," "Australian mahogany," and other species. Illustrated lectures are given and literature is liberally distributed. One of the most conservative of the concerns heads its first page "$12,000 profit every 10 years for every man who plants 5 acres of commercial eucalyptus."

The impossibility of over-production is pointed out as one of the strongest features of the growth of the industry. Comparisons are made of the rapidity of growth of eucalyptus and other woods. Methods of planting and care are described, and the possible investor is told that this is "better than grain or cotton or fruit, because weather conditions do not affect eucalyptus. After the roots reach the sub-irrigated strata, the tree grows, rain or shine," and finally "plant a eucalyptus grove".

Without attempting to even guess on the probability of realization of what is so confidently offered as an unparalled opportunity, it is of interest to reflect that a great experiment is being inaugurated, the observation of which from year to year can hardly fail to yield valuable scientific results. Here are a number of different species planted side by side, each with its own requirements as to temperature and other environmental factors, its own habits as to rate of growth, its own histological characters, and capacity of adjustment. The accumulation and interpretation of data thus easily accessible affords unlimited scope for the exercise of the best qualities of a well-trained scientific mind.

Teachers in the schools and colleges of the country might advantageously read and ponder the following words of Rufus W. Weeks in the *Arena:* It is well known that a scientific man in looking abroad upon the world sees it from the point of view of his own science, whichever of the sciences that may be. For example, if he is a mathematician, the whole complicated scheme of things presents itself to him as an affair of numbers, dimensions, quantities; if he is a minister, steeped in the lore of sin and holiness, all the facts of the universe group themselves around notions of right and wrong; if he is a physicist all resolves itself into atoms and the groupings and movements of atoms. None of these views appears to me at all comprehensive; and those scholars appear to me to be nearer right who say that the point of view of *biology* is really central; that *life* lies at the middle point of things. For the biologist, after learning all he can learn about living things, can feel his way back into the sciences of physics, learning of the atoms and of how their groupings and their laws made the necessary preparation for life; and, on the other hand, his science of biology leads him up to man, the highest of living creatures, and so to all the phenomena of mind and soul, and to all the thoughts of justice and of goodness and of their opposites. And so I propose that, for the moment, at least, we take Life as the central fact of the Universe.

An article by Steinbrinck in a late number of the *Berichte der Deutschen Botanischen Gesellschaft* merits notice, not so much as a contribution to science as because it represents a form of controversial literature which happily is less in vogue than formerly in centers of botanical activity. The paper is entitled "Ueber den ersten Oefnungsvorgang bei Antheren," but the real subject is the mistakes of a gentleman named Schneider, who had ventured into the preserves of the author and had even dared to call some of his previous work in question. If it is admitted that such offenders deserve to be drawn and quartered, or at least flayed in public, it may nevertheless be permissible to suggest that the process be shortened out of consideration for lookers-on. A slight change of proportion would be a relief. In an article of twelve pages, say, ten perhaps might go to the statement of scientific facts and two to castigation, instead of the reverse.

An article by Dr. John Gifford on the Everglades of Florida in a recent number of *Conservation* makes one wish that the homely work of preserving vanishing data appealed more strongly both to the scientific and popular imagination. The whole world, from the man in the street to members of learned societies, has been astir over the finding of the north pole, although as far as botanical science is concerned the results might almost be summed up in Lieutenant Danenhauer's report after a disastrous expedition that "there is a great deal of ice up there, and it will probably keep." The draining of the Everglades is well under way and when accomplished it will open for cultivation an area estimated at three times the extent of the land now cultivated in the whole state of Florida. Economically speaking, its reclamation is a highly important and desirable undertaklng, but once completed a most interesting set of relations will be changed forever. Yet probably it would be quite impossible to get an appropriation of ten thousand dollars for work on the botanical history of the Everglades and that of the West Indies, to which it is related, where ten times that sum is readily forthcoming to pay for polar expeditions.

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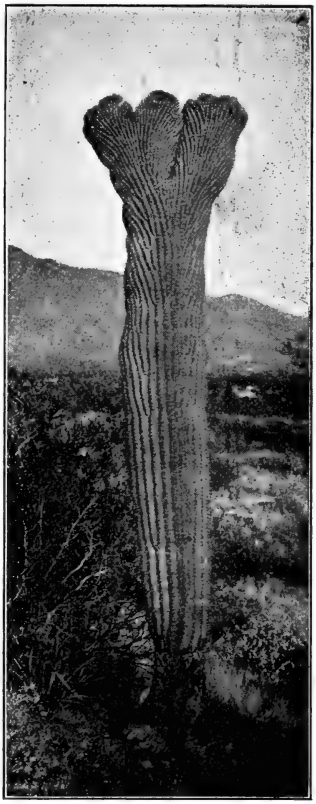

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DECEMBER, 1909

SUCCESSIONAL RELATIONS OF THE VEGETATION ABOUT YARMOUTH, NOVA SCOTIA.

BY EDGAR N. TRANSEAU.

The following observations on the plant formations of the southwestern coast of Nova Scotia were made in the vicinity of Yarmouth during the months of August and September, 1907. Most of the time was spent on the islands and peninsula which separate Yarmouth Harbor from the Bay of Fundy. The coast was visited as far north as Port Maitland and as far east as Tusket.

The coast is characterized by high, rocky seacliffs with numerous indentations. Some of the promontories were originally islands which have now become connected with each other and with the mainland by bars. Inside the bars tidal flats and salt-marshes are in process of extension. In a reentrant just north of Yarmouth Light aggradation has raised the soil sufficiently to afford a foothold for bog vegetation. The higher levels about Cape Fourchu also present depressions in which the bog associations are dominant. At Tusket extensive areas of bog occur.

Without going into the details of climatic conditions, the region is characterized by cool summers, abundant rains and frequent fogs. The rate of evaporation is very low as shown by the very moist condition of the soil in the most exposed situations. These facts together with the prevalence of strong winds are largely responsible for the limited flora and the vegetation types. It should also be mentioned that these conditions are characteristic only of the coast, becoming notably drier a few miles inland.

The forest is composed almost exclusively of black spruce. Three or four miles inland these are mixed with other conifers and broad-leafed hardwoods. The successions here outlined are therefore typical only of the region directly influenced by the coastal conditions.

The Submerged Beach, both on the Bay of Fundy and the ocean side, is rocky and affords a suitable foothold for the growth of laminarias and rockweeds. The *Laminaria Formation* is characteristic of this topographic situation, extending from the lowest tide line to considerable depths. Two species of laminaria were found washed ashore by storm waves (L. longicruris and L. digitata) and small specimens were observed in situ in shallow water at low tide. Associated with the laminaias are Desmarestia aculeata, Chorda filum, Cladophora sp.,

Fig. 1.—Cliff west side of Cape Fourchu at low tide, Fucus-Ascophyllum Formation.

Cystoclonium purpurascens, Ahnfeldtia plicata, Euthora cristata, Deleseria sinuosa, Chondrus crispus, and Polydes rotundus. Close to the surface of the rocks to which the laminarias are attached occur Leathesia difformis and Corralina officinalis. The latter is said to be the commonest plant in the zone below twenty meters.

Within the rockbound harbors where wave action is reduced to a minimum, where tidal inflow and outflow are the principal aqueous movements, and the bottom is muddy the *Zostera Formation* occurs. At low tide this has the appearance of a submerged meadow. Zostera marina is the dominant plant. Melosira and Ceramium rubrum are the principal algal associates. These are not nearly so abundant as in the harbors farther south. Consequently the eel-grass washed ashore is clean and when dried forms a valuable packing material.

The Lower Beach (Fig. 1) is the zone between low tide and the upper limit of the summer waves. As elsewhere along the coast, from the standpoint of vegetation it is sharply divided into two sub-zones. These are most distinct on the rocky exposures. Here the lower sub-zone extends about two meters vertically on the cliffs and is occupied by a dense growth of rockweeds—the *Fucus-Ascophyllum Formation.* The principal species noted were Fucus vesiculosus, F. furcatus and Ascophyllum nodosum. Associated with them, but quantitatively insignificant, are Polysiphonia fastigiata, Ulva lactuca lanceolata, Chordaria flagelliformis, Cystoclonium purpurascens, Cladophora sp., Chondrus crispus and Rhodymenia palmata.

Above, the rocks are bare. Thus, on the exposed headlands the marine succession terminates abruptly in the Fucus-Ascophyllum Formation. Since the principal physiographic process here is erosion the battering down of the cliffs results in the destruction of the rockweeds and succession of the Laminaria Formation.

Within the harbors where rocks afford a foothold the laminarias and rockweeds maintain their usual positions. As a rule, however, such situations are areas of deposition and consequently muddy shoals prevail. These are, for the most part, bare of vegetation except for scattered specimens of Ulva lactuca latissima and mud-inhabiting bluegreen algae—the *Ulva Formation.* The upper portion of the lower beach in such situations favors the development of the *Saltmarsh Formation.* This is inaugurated by the Spartina glabra association, in which Spartina glabra alterniflora * is the dominant plant. Fucus, Ascophyllum, Cladophora, and various bluegreen algae are scattered throughout. The Spartina is usually less than a half meter in height.

The Middle Beach is reached only by the storm waves of the winter months. On the headlands it is free of vegetation and

*Nomenclature of higher plants follows Gray's New Manual of Botany, 7th edition, 1908.

increases the gap between the marine and terrestrial formations (Fig. 1). The height of this barren zone varies from six to ten meters.

Inside the harbors as the development of the saltmarsh proceeds, the Spartina glabra association of the lower beach is followed by the Spartina-Juncus association. Spartina patens and Juncus Gerardi are the character plants. With them in varying abundance occur Salicornia mucronata, Juncus balticus littoralis, Glaux maritima, Sueda maritima, Atriplex patula, Plantago decipiens, Triglochin maritima, Spergularia marina, Potentilla Anserina, and Limonium carolinianum.

At the upper limit of the middle beach, just east of the Markland hotel, the saltmarsh passes into the Agrostis-Juncus association of the *Freshwater Marsh Formation.* Part of this area is occasionally invaded by storm waves, but the seepage of fresh water from the adjoining hills is sufficient to overcome the effect of the sea water. Agrostis alba, Juncus balticus and J. effusus compactus are the commonest species. Festuca ovina, Carex stipata, Rumex Brittanica and Aster novi-belgii are of secondary importance. Here and there shrubs and herbs belonging to the Alnus-Myrica association occur, showing clearly the coming in of this association, to be described later.

It should be noted that by way of the saltmarsh there is a continuous and definite succession of plant associations from the deeper waters of the bay to the upland.

The Upper Beach. Between the inner and outer False Bay the conflicting currents have built a beach well above the upper wave limit. The materials are mostly large cobbles and pebbles with sand in the interstices. Plant food is at a minimum and extremes of temperature at a maximum. The *Ammophila-Atriplex Formation* occupies practically all of this area in the usual open manner. The formation is difficult to characterize, owing to the large number of both weeds and typical beach plants present. The latter class includes Ammophila arenaria, Atriplex patula littoralis, Mertensia maritima, Spergularia marina, Plantago decipiens, Arenaria peploides, Ambrosia artemisiæfolia, and Ligusticum scoticum. To the former belong Spergula arvensis, Ranunculus acris, Leontodon autumnalis, Senecio vulgaris, Chenopodium album, Galeopsis Tetrahit, Aster tardiflorus, Aster novi-belgii, Matricaria inodora, Festuca ovina, Achillea Millefolium, Agrostis alba and Rumex acetosella. The presence of several alders points to the succession of the alder thicket.

Near the northern end of the island upon which the lighthouse is situated, is a small pond—the last stage of a larger water area now occupied by bog. Here all the stages from freshwater pond through bog to forest are well represented.

The Potamogeton association occupies the deeper water. It consists of a single species, P. epihydrus. The marginal shallow water supports a dense growth of Hippuris vulgaris (Hippuris association). The water level fluctuates markedly and the zone of Hippuris terminates abruptly at the low water level.

The area immediately surrounding the pond is occupied by the Carex-Juncus association, in which the dominant species are Carex hormathodes and Juncus articulatus, the sedge being very much more abundant than the rush. North of the pond the area has been pastured and the secondary species show a tendency toward the development of the *Pasture Formation*, described later. They are Juncus effusus, Carex lanuginosa, Lysimachia terrestris, Mentha arvensis canadensis, Rhinanthus Crista-galli, Equisetum pratense, Melampyrum lineare, Rumex Brittanica, Epilobium densum, Agrostis hyemalis, Hypericum virginicum, Iris versicolor and Ranunculus acris.

On the south side where undisturbed conditions prevail, the substratum is of the quaking bog type. The Carex-Juncus association consists of an almost pure growth of Carex hormathodes.

The Calamagrostis-Sphagnum association of the *Bog Formation* follows. The principal species are Calamagrostis canadensis, Sphagnum, Vaccinium macrocarpon, and Drosera rotundifolia. The secondary species are Viola blanda, Juncus effusus, Hypericum virginicum, Osmunda cinnamomea, Smilacina trifolia, Galium trifidum, Carex Oederi pumila, Microstylis unifolia, Eriophorum gracile, Solidago uniligulata, and Impatiens biflora. Between this and the next association there is a very gradual change, the substratum rising as development proceeds.

The Alnus-Myrica association which is so important in the development of the forest in this region, is here found in a practically undisturbed condition (Fig. 2). Although described in the bog series, it is found in a great variety of topographic situations. The dominant plants are Alnus incana and Myrica Gale. Rosa nitida is very abundant. Of less importance are Rhus toxicodendron, Pyrus melanocarpa, Viburnum cassinoides, Vaccinium pennsylvanicum, Picea mariana, Aster umbellatus, Iris versicolor, Calamagrostis canadensis, Cornus canadensis, Eriophorum virginicum, Lysimachia terrestris, Carex paupercula

Fig. 2. Cranberry bog near Markland, showing invasion of black spruce.

irrigua, Aster junceus, Linnaea borealis, Rubus hispidus, Melampyrum lineare, and Deschampsia caespitosa.

In the numerous open places throughout this rather extensive association, in addition to the ground cover of Sphagnum, are Smilacina trifolia, Carex Oederi pumila, Eriphorum gracile, Carex maritima, Drosera rotundifolia, Vaccinium Oxycoccus, V. macrocarpon, and Empetrum nigrum. It will be seen that this is merely another phase of the Calamagrostis-Sphagnum association, and that the open places are to be looked upon as remnants of the former vegetation covering. Near the border where springs occur Typha latifolia and Symplocarpus foetidus are abundant.

The occurrence of the black spruce in this association and its dominance in the older part of the bog, point to coming in of the climax forest.

In order to present the bog series in somewhat more detail two other bogs will be described. On the rocky hill west of the Markland, in the midst of a second growth of spruce is a bog area which presents a noteworthy variation in its constituents (Fig. 3). It is shallow and has developed on a solid rock surface. The youngest part is represented by the Juncus-Sphagnum association. The substratum cover is made up of Sphagnum and

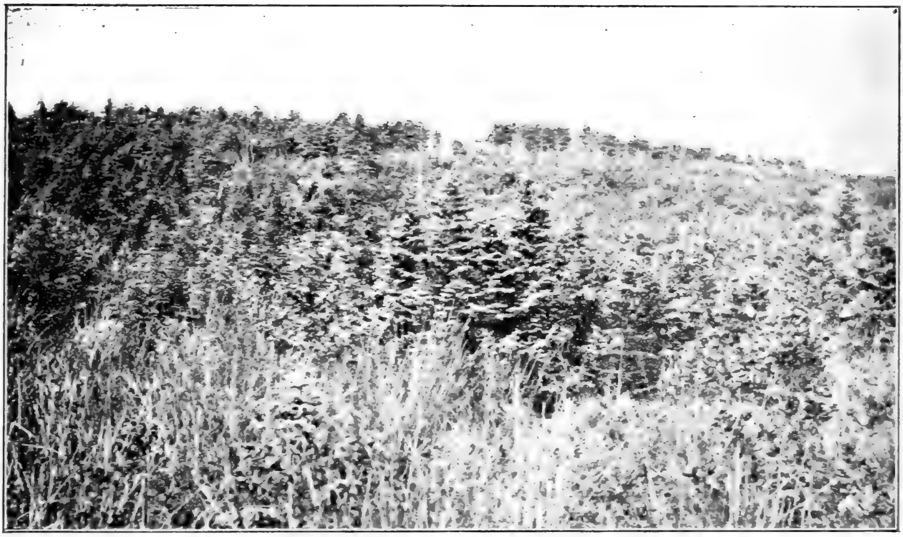

Fig. 3. Area on top of cliff just east of Fig. 1. Showing spruce forest, alder thicket, and in the foreground the Jancus-Sphagnum association.

Polytrichum. Juncus effusus is scattered throughout. Vaccinium Vitis-Idaea, Cornus canadensis, Vaccinium pennsylvanicum, and Chiogenes hispidula with their various colored berries are the most conspicuous forms in late summer. Of less importance, but scattered throughout, are Deschampsia caespitosa, Rubus hispidus, Drosera rotundifolia, Calamagrostis canadensis, Empetrum nigrum, Carex trisperma, Solidago uliginosa, Aspidium cristatum, Aster junceus, A. acuminatus, Gnaphalium polycephalum, Vaccinium oxycoccus, and Agrostis hyemalis. The close relationship between this and the Calamagrostis-Sphagnum association is evident.

The Alnus-Myrica association, which follows, is here dominated by Myrica carolinensis and Kalmia augustifolia. But Alnus incana is abundant. Viburnum cassinoides, Ledum groenlandicum, Ilex verticillata, Pyrus arbutifolia, and P. sitchensis are frequent. The undergrowth is mainly Aspidium thelypteris, Osmunda cinnamomea, Equisetum pratense, Dicksonia punctillobula, Symplocarpus foetidus, and Lonicera canadensis. On drier sphagnum hummocks Chiogenes hispidula and Cornus canadensis are prominent, with Oxalis Acetosella, Rubus hispidus, Aspidium spinulosum intermedium, and Smilacina trifolia as frequent associates.

Near the railroad station at Tusket is an extensive bog which presents a shrub stage not found in the two bogs mentioned above, although seen elsewhere; the Chamaedaphne-Rhodora association. The ground cover is of sphagnum overgrown with Rubus hispidus. Chamaedaphne calyculata, Rhodora canadensis, Ledum groenlandicum, Kalmia augustifolia, Andromeda glaucophylla, Spiraea salicifolia, and Chiogenes hispidula form the bulk of the vegetation. Small tamaracks and black spruce are scattered throughout. The accessory species indicate a tendency toward the development of the Alnus-Myrica association, but in this bog the Chamaedaphne-Rhodora association passes directly into the forest formation. The list includes Gaylussacia baccata, Vaccinium oxycoccus, V. macrocarpon, Scirpus cyperinus, Eriophorum gracile, E. virginiana, Sarracenia purpurea, Drosera rotundifolia, Amelanchier canadensis, Alnus incana, Myrica Gale, M. carolinensis, Ilex verticillata, and Nemopanthes mucronata.

Farther to the east the bog has passed over to the tree stage, exhibiting a dense growth of Picea mariana and Larix laricina (the *Picea-Larix Formation*). There are occasional trees of Abies balsamea and Picea canadensis. The undergrowth is principally the yew (Taxus canadensis), Hypnum Schreberi, and Sphagnum. In the interior this undergrowth is sparse, but toward the better lighted margins occur many plants already listed under the preceding association.

The transition to the Picea Formation is very gradual as shown at several nearby points. The tamarack occurs as a straggler in the spruce forest even on the higher elevations.

The relation of this series of bog associations to those first described is probably the same as the relation of the pure spruce forest of the coastal strip to the interior of Nova Scotia. These bogs are farther from the coast, occupy more matured and extensive areas, hence are richer in species.

The *Picea Formation.* Throughout the rather narrow coastal strip along the Bay of Fundy in southwestern Nova Scotia, the black spruce forms a continuous and nearly pure growth. In addition to Picea mariana one occasionally observes Abies balsamea and Picea canadensis. The forest varies greatly in density from an almost impenetrable thicket to an open forest with abundant undergrowth This latter condition is not unlikely to be attributed to man's interference. The striking feature of the habitat is the shallow and moist soil. Sphagnum and Hypnum Schreberi occur about the bases of trees everywhere. In height the trees are usually less than ten meters, and along the cliffs less than half that height. The open places support relicts of the Alnus-Myrica association and some characteristic forms like Phegopteris polypodiodes, Arctostaphylos uva-ursi, Dalibarda repens, Aster junceus, and Linnaea borealis.

The succession from the marine formations through the salt-marsh and bog have been outlined. Another succession beginning with the bare rocks on the headlands would lead us through a lichen formation; a crevice-plant formation, made up largely of the bog herbs and low shurbs already mentioned; to the alder thicket and the spruce forest.

Where the forest has been cut and burned, a secondary succession is started by the coming in of Pteris aquilina, Solidago juncea, S. caesia, Hieracium scabrum, Danthonia spicata, Holcus lanatus, Prenanthes trifoliata, in addition to the many relict species (the Pteris-Solidago association of the *Clearing Formation*). This may revert directly to the forest or be further modified by cattle into the *Pasture Formation.*

Pastures are common along the coast and are occupied by the Agrostis-Festuca association. Agrostis alba and Festuca ovina are the common grasses. Juncus balticus and J. tenuis dominate the wet places. The more frequent associates are Aster tardiflorus, Euphrasia americana, Mentha arvensis canadensis, Viola pallens, and Fragaria virginiana.

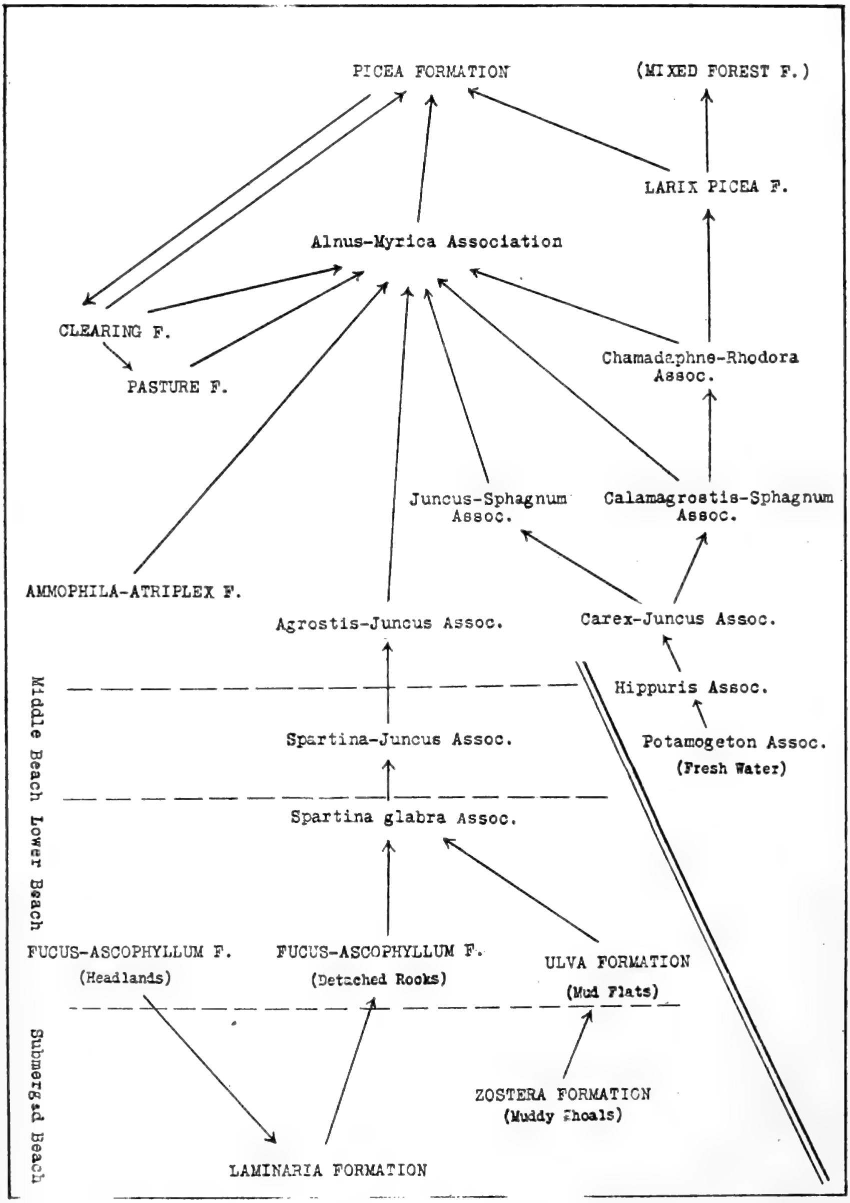

Fig. 4. Diagram showing genetic relations of the vegetation units near Yarmouth, Nova Scotia.

Figure 4 presents in a diagrammatic way the natural relationships of the several associations, the arrows indicating the physiographic successions. Geographically, all of the associations and formations belong to the Northeastern Conifer Forest center, and taken as a whole exhibit a rather typical composition.

THE RECIPROCAL INFLUENCE OF SCION AND STOCK.

BY W. B. MCCALLUM.

In spite of the voluminous literature upon the question of the reciprocal influence of scion and stock the problem still seems to be one of controversy. Recent physiological literature, however, contains a number of contributions which add very materially to our information on the subject and may enable us to get a somewhat clearer idea of the phenomena involved. The problem is of more than horticultural interest, for it offers to the physiologist instructive material in the study of correlating influences between members of the plant body. When a part of the plant, for example a shoot or bud, is taken from its normal position and placed in a new, and perhaps quite different, relation to the rest of the plant, both morphologically and physiologically, its behavior gives us some clue as to the formative and other influences exerted upon it by the adjoining parts.

A certain confusion of interpretation exists on account of the criteria often taken to denote change in the scion or stock. Naturally the changes most looked for are such as appear in differences in size, form, color, etc. of foliage, or fruit, or other parts, changes in the rate of growth, and like phenomena. It is, of course, apparent that profound physiological changes may have occurred without having been manifested in any of these ways. Indeed, as shall be mentioned later, some of the most important results of grafting are of this order. Some investigations showing a purely physiological reaction between scion and stock may be mentioned.

In the leaves of *Epiphyllum* are found certain albumen bodies not found in the leaves of the related plant *Peireskia.* Mitosch grafted Epiphyllum upon Peireskia stocks and in the leaves of the latter which subsequently developed these bodies were formed. That such phenomena are not necessarily of general application is shown by the results of Meyer and Smith who grafted *Datura stramonium* upon *Solanum tuberosum* and determined that the alkaloids of the former were not to be found in the latter. Also L. Guignard selected plants which contain cyanogenetia glucosides and made grafts between these and related forms which do not produce these compounds. His results show no transfer of the glucoside or glucoside forming capacity from stock to scion or scion to stock.

On the other hand that pronounced physiological influences do pass between stock and scion is demonstrated by many investigators. L. Daniel studied the photosynthesis and respiration of species of *Artemisia* and *Plagius* when grafted upon Artemisia stock as compared with similar ungrafted plants. With *Artemisia* these functions were much less active in the grafts than in the checks, while in the case of *Plagius* the grafted plants decomposed more carbon dioxide and liberated more than twice as much of this gas as did the checks. C. Laurent found grafted forms of cabbage to contain an increased amount of crude fiber and saccharine matter and a decrease in total ash content, though certain of the ash constituents were increased. Grapes grafted upon different stocks Laurent found to show differences in composition, as well as resistance to fungus diseases. Later the same author gives results of analyses of stems and leaves of grafted and ungrafted cabbage, and seeds of grafted and ungrafted beans which show that the grafting affects certain functional capacities of the stock as indicated by changes in the chemical composition.

S. Riviere and G. Bailkache have shown that variations of color, size, content of sugar and acid, and also dry matter in apples and pears occur when grafted on different stocks. More recently the same authors have made careful analyses of grapes grown upon their own roots and upon the roots of ten other varieties and find that the stocks exert a well marked influence on certain functions of the scion as indicated by constant differences in the sugar and acid content of the juice.

Influences of a more conspicuous nature and showing a mutual influence of stock and scion is seen in the grafting of many variegated plants. Timpe in an extensive series of experiments has obtained some very interesting results with these plants. He grafted the variegated on the green form, and *vice versa.* The gross observations were supplemented by micro-chemical determinations of the sugar, starch,and tannin contents, in addition to anatomical examination. With *Ulmus campestris* a decided influence was observed not only in the size and coloring of the leaves but also in the anatomical structure of the leaves. The variegated leaves became reduced in size almost to that of the normal leaf, accompanied at the same time by the disappearance of the variegations. With *Acer plantanus* scions with green leaves grafted to stocks of the variegated form become yellowish in appearance and show a poorly nourished condition, while with the variegated scion grafted to the normal green forms the variegations are much later in appearing, the leaves retaining for a much longer time their normal appearance. Similar results were obtained with *Acer Negundo.* With *Aesculus* when variegated and green forms are grafted together, there appears on the leaves of the green form (whether this is either stock or scion) yellowish spots and stripes, and the leaves are much thinner. These peculiarities persist when the green shoot is used as a scion, but when it is used as stock they, after a time, disappear. *Weigelia* and *Cornus* graft with difficulty, but when successful, with *Weigelia* variegated scions on green stocks grow well, but green scions on variegated stocks are scarcely able to live, while the reverse is true of *Cornus.* A number of herbaceous forms tried by Timpe all showed an inability of the variegated condition to traverse the area of the graft union.

The most interesting results on variegated plants are those obtained by Baur. In *Abutilon Thompsoni,* Baur found that not only is the chlorosis transferable from a chlorotic stock to a green scion, but when a chlorotic scion is used it may spread to and render chlorotic the leaves of the green stock. Baur ascertained that this chlorosis is due to a virus which inhibited the formation of chlorophyll. Occasionally shoots appear that are immune to this virus and when grafted on chlorotic shoots remain green. If another shoot of a susceptible variety is grafted on this one this second shoot will become chlorotic showing that the virus passes unchanged through the immune form.

That distinct morphological changes in the scion may occur as a result of the specific influence of the stock is recognized by almost everyone experienced in grafting, especially fruits, yet conclusive results are not so easy to obtain. Records, however, of observations and accurate measurements just published by Waugh, give us some very definite information in this respect. Waugh's observations were on various leaf and twig characters and rate of growth, of scions of Milton plum grafted upon a number of other stocks. His careful measurements show a decided difference in size and shape of leaves, and in the nature of the growth of the shoot of scions upon each of the different stocks. These differences are constant for each variety used as a stock. Of course in this and similar cases interpretation of the results is always complicated by the difficulty of distinguishing between variations due to some specific influence of the stock, or to mere differences of nutrition supplied by the different stocks, for even with a perfect graft union this latter could easily occur. However, were this the cause, similar modifications would occur on any stock if subject to the proper conditions of nutrition, and this has not been found to happen. One of the most conspicuous cases usually attributed to changed conditions of nutrition is that of dwarfing, for example the dwarfing of pears when grafted to the quince, or the apple when grafted on Paradise apple stock. But even here we may entertain doubts as to whether these results are not due to more fundamental causes than decreased nutrition. A fact often lost sight of is that by no variation of nutrition of a shoot on its own stock are we able to obtain those modifications that often follow when it is grafted to certain other stocks. While the maintenance of specific correlation of the members of the plant body calls into activity various nutritive processes, yet these can not be considered primary causes, and in the unfolding and maintaining of specific form and structure, and even function, specific influences more fundamental than and precedent to the nutritive processes are operative. We may assume that the initial protoplasm of all the individuals of a species is identical. We may also consider that while the origin of a variety involves a certain change in the nature of the protoplasm, this change may be limited to a very restricted region, involving often only the protoplasm controlling certain local structures or functions, as for example, the color or flavor of the fruit, shape of the leaf, etc., while the rest of the protoplasm making up the plant remains unchanged. When by means of a graft the protoplasm of two such varieties becomes continuous it is only to be expected that formative substances and influences should pass freely from one to the other. Many seeming illustrations of this occur. Some fruit trees, *e. g.*, Canada Red apple, which have a naturally straggling habit become compact when grafted to more compact stocks. Many late varieties are known to mature their fruit earlier when grown on certain other stocks. Twenty Ounce apple, for example, ripens much earlier on the Early Harvest stock than on its own. Often the influence of the stock is to increase the actual reproductive tendency, as is seen in some citrus fruits which become more productive when grafted to *Citrus trifoliata* than on their own roots. The increased acidity of apples grown upon wild crab stock is an illustration of the same thing, all seeming to indicate that substances or influences of some sort, that concern certain functions in the stock pass into the scion and produce similar results there.

One of the most striking of all influences of this sort and one used extensively in practical operations is the remarkable influence of the stock upon the fruiting condition of the scion. Seedlings of the tree fruits are often many years in coming into fruit. Certain apples, for example, if grown as seedlings, or from grafts on seedling roots, do not bear until they are ten or fifteen years old, or even older, but when a scion from one of these seedlings is grafted to an old bearing tree it comes into fruitfulness at once. The breeder does not wait the long time necessary for his seedlings to come to fruit but he grafts them at the end of the first year to bearing trees and they come into fruit immediately. On the other hand if a twig from a bearing tree is grafted back to a seedling its bearing will be delayed many years.

Such phenomena are analagous to Voechting's classic experiment in which a bud from a second year beet which normally would develop into a flowering shoot was grafted to a first year beet and produced only the leafy cluster characteristic of the first year growth. Results even more striking have but recently been obtained by Edler who grafted white sugar beets upon the common red table beet. No direct effect of the action of the stock could be seen on the scion, but seeds from the scion were obtained andthese the next year gave 71.3 percent white beets,28.1 reddish,and .6 per cent red. As there was no sexual mixing, Edler could only interpret this as a result of the grafting. In the second geneiation these split up farther. The seed from the white beets gave 53.3 per cent white, 25.5 reddish, and .1 per cent red. The seed from the reddish gave 52.7 per cent white, 46 per cent red or reddish, and 1 per cent white, and in a similar manner the seed from the red beets broke up into red ,white, reddish and reddish orange. Grafting the red beets on the sugar beets gave similar but less striking results.

Finally, Winkler's recent remarkable experiment may be mentioned. Winkler made a graft between tomato and nightshade and fiom the cells formed by the fusion of the two callus areas he caused a bud to regenerate. This bud then comes from cells derived from both plants. As it developed into a leafy shoot it showed both in leaf and stem structure the perfect characters of each parent. Here, seemingly, is stock and scion actually fused into one.

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VEGETATION GROUPS OF THE DESERT LABORATORY DOMAIN.

BY J. J. THORNBER.

A list of plants found growing by the writer on the domain of the Desert Laboratory near Tucson, Arizona, has recently been published (Publication No. 113) by the Carnegie Institution of Washington. The list includes 449 species distributed over four well-marked areas, viz.: (I) Tumamoc Hill, the mass of volcanic rock on which the Desert Laboratory is situated; (II) The long slope lying at the foot of the hill and beyond; (III) The flood plain of the Santa Cruz river; (IV) Santa Cruz river and irrigation ditches. The species of each of the above areas have been grouped under the following vegetation forms: (1) trees; (2) shrubs; (3) woody climbers; (4) dwarf shrubs; (5) half shrubs; (6)perennial herbs; (7) biennial herbs; (8) annual herbs including (*a*) long-lived annuals; (*b*) winter annuals; (*c*) summer annuals.

The accompanying table presents the various species from the standpoints of habitat and vegetation form.

Vegetation forms	I. Tumamoc Hill.	II. Mesa-like mountain slopes.	III. Santa Cruz flood-plain.	IV. Santa Cruz River and irrigation ditches.	Introduced species.	Total.
Trees	2	2	11	....	....	15
Shrubs	16	10	10	....	3	39
Woody-twiners	2	....	3	....	....	5
Dwarf-shrubs	13	4	....	....	....	17
Half-shrubs	21	7	3	....	1	32
Perennial herbs	38	24	33	7	6	108
Biennial herbs	1	1	1	....	....	3
Annual herbs:						
(a) Long-lived	....	9	28	....	20	57
(b) Winter an'ls	38	47	13	....	24	124
(c) Summer an'ls	7	25	12	....	....	44
Algæ	....	....	....	7	....	7
Total	138	129	116	14	52	449

The data in the table suggest some interesting observations. It may be taken as almost axiomatic that biennial species are not a success in our region. The intense conditions prevailing regularly over a considerable portion of the year, together with occasional prolonged droughts, render their existence almost impossible. Either our plants develop root-systems extensive and permanent enough to endure for some years, as in the case of many perennial herbs and all the suffrutescent and woody forms; or else their growth is completed within the course of a few weeks, or at most a few months, during those portions of the year when mesophytic conditions prevail to some extent over the country. There appears to be little middle ground in this matter. In areas I and II ,where the most pronounced xerophytic conditions obtain, the woody species, including trees, shrubs, dwarf shrubs, half shrubs, and woody twiners, constitute 30 per cent of the plants. It needs hardly be said that to these plant types belong our characteristic desert forms.

The short-lived winter annual and summer annual species, on the other hand, make up 43 per cent of the plants of these same two areas. That these plants are unable to withstand arid conditions may be inferred from the fact that with their first approach they cease further growth and begin dying. Such species as *Phacelia distans*, *Ellisia torreyi*, *Pectocarya linearis*, and *Harpagonella Palmeri* die off in early spring, except in the shade of bushes, even with the presence of considerable moisture in the soil. As opposed to these, plants like *Phacelia crenulata*, *Plagiobothrys pringlei*, *Amsinckia intermedia*, and *Gilia floccosa* are able to endure considerable drought by virtue of a better developed root-system. They are, nevertheless, species of short duration. As heretofore noted, growth obtains in these plant-groups during the moister portions of the year, after which they disappear entirely from the foothills and mesa country. Those of the winter annual type, which are by far the more numerous, begin to grow in the fall with the advent of winter rains and prevailing lower temperatures, such temperature conditions being essential to their germination, * and continue until well in April, after which time they cease to be a factor in the floral covering.

*The writer germinated successfully seeds of winter annual species last summer with proper conditions of moisture in a refrigerator; while seeds from the same lots with the prevailing summer temperatures remained unchanged.

In contrast with these, the summer annuals begin growth during the summer rainy season, when maximum temperatures prevail, and come to maturity in the course of six weeks to two months.

The perennial herbs of these same two areas constitute 22.6 per cent of their flora. Since this vegetation form includes 28 per cent of the plants of the flood-plain, their presence can not be taken as indicative of xerophytic conditions. Many of them are, however, extremely drought-resistant. Of the perennial herbs indigenous to areas I, II, and III, 20 per cent are bulbous, tuberous or fleshy-rooted species. Among these such plants as *Apodanthera undulata, Martynia althæfolia, Tetraclea coulteri, Talinum lineare, Rumex hymenosepalus,* and *Brodiæa capitata* begin growth earlier and continue later in the season than perennial herbs in general without storage organs. Their growth, also, is unchecked with dry spells which characterize even our more favorable growing periods.

The data relating to species growing in the Santa Cruz flood-plain are of less value than those of the former areas, in consequence of agricultural operations that have been carried on there for many years. The distribution, frequence, and abundance of numerous plants have been changed; exotic species have found their way in, and not unlikely, indigenous plants have suffered eradication. The vegetation forms best represented are trees, shrubs, long-lived annuals, and, as already noted, perennial herbs. For the four areas 11 of the 15 trees occur here and 52 per cent of the long-lived annual plants for the four areas are indigenous to the flood-plain, and 32 per cent more are introduced species growing in the same area, making a total of 84 per cent of this type of annual plant occurring here. There can be no doubt that these plants which continue their growth during our long season find the deep alluvial soils of the flood-plain with their greater water-retaining capacity more conducive to their existence than the scant, parched soils of the mesa-like mountain slopes and foothills. On the other hand, area III contains 24 per cent of the indigenous shrubs, and 6 per cent of the dwarf shrubs, and half-shrubs for the four areas, as against 68 per cent of the shrubs and 91 per cent of the dwarf shrubs and half-shrubs for areas I and II.

The plants which are characteristic of alkaline situations are 10 in number, all inhabitants of area III. The most important are members of the Chenopodiaceæ, 3 being shrubs, 2 half-shrubs, and 1 an annual herb. Four other families of plants are represented with one species each.

The exotic plants that have become established in a new country are always an interesting group. Especially is this true in a region like our own, where the various factors are so sharply defined as to leave little doubt concerning the particular character or characters of a plant which makes for its success. Of the introduced species taken as a whole, 47 per cent deport themselves as winter annuals. It is a fact worthy of note that with few exceptions these exotic winter annuals are natives of the Mediterranean region of the Old World. Our climatic conditions, which are quite similar to those of southern Europe and especially northern Africa, appear to be so entirely adapted to their manner of growth that many of them have little difficulty in securing a foothold here. Several of these species, among which are *Erodium cicutarium* and *Hordeum murinum*, are becoming common plants upon the mesas; especially the former, which in many localities in Arizona at this time is more abundant than any other species during its period of growth. * Another species worthy of mention here is *Matthiola bicornis*. Seven years ago this plant, apparently an escape from nearby flower-beds, was represented by a few scattered individuals on the mesas near the University. At the present time it occurs in considerable abundance in this vicinity; besides, it has been observed growing on the flood-plain, and even across the river on the mesa-like mountain slopes.

The composition of the flora of the Desert Laboratory domain and adjacent areas as concerns the more important plant families represented, together with the number of species for each, in addition to which there are 38 other families with 1 to 3 species each, is as follows:

Gramineæ	70	Polygonaceæ	12	Plantaginaceæ	5
Compositæ	65	Cichoriaceæ	11	Polypodiaceæ	5
Solanaceæ	16	Nyctaginaceæ	9	Portulacaceæ	5
Cruciferæ	16	Cæsalpinaceæ	8	Acanthaceæ	4
Euphorbiaceæ	16	Polemoniaceæ	7	Asclepidaceæ	4
Boraginaceæ	15	Hydrophyllaceæ	6	Convolvulaceæ	4
Malvaceæ	15	Labiataæ	6	Liliaceæ	4

*Thornber, J. J. Alfilaria (Erodium cicutarium) as a Forage Plant in Arizona. Bull 52, Ariz. Exp. Sta., May, 1905.

Chenopodiaceæ	14	Mimosaceæ	6	Ranunculaceæ	4
Cactaceæ	13	Onagraceæ	6	Scrophulariaceæ	4
Papilionaceæ	12	Amaranthaceæ	5	Zygophyllaceæ	4

The following brief summary will be interesting to the botanist from the standpoints of taxonomy and phytogeography.:

Number of plant families	68
Number of genera	269
Number of genera common to both hemispheres	126
Number of genera common to North and South America	58
Number of southwestern genera	39
Number of introduced genera	22
Number of species	449
Number of southwestern species	264

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BOOKS AND CURRENT LITERATURE.

Vinson, in a recent number of *Science*, describes the method by which the fruit of a seedling date may be ripened into a perfect commercial product in less than three days, by simply subjecting the sprays of fruit to the vapor of acetic acid. By this process it is expected that dates may be shipped green and afterwards ripened at their place of destination, thus preventing the deterioration on the way which is due to the inversion of the cane sugar in the ripe date. The author finds that the ripening processes are initiated not only by acetic acid but also by a number of other chemicals. Detailed results of his work will soon be published.

Molisch, in the Sitsungsberichte of the Vienna Academy, describes experiments in which the buds of Forsythia, Syringa, and various other plants produced new shoots in response to immersion in warm water. As a rule, the same result was not attained by prolonged exposure to an atmosphere saturated with water vapor at the same temperature. The author points out that during immersion in warm water there is not only a raising of temperature, but that a whole complex of other factors is involved, such as interference with respiration, absorption of water, the swelling of cell membranes and of certain cell contents, as a result of which a highly efficient stimulus is brought to bear. The exact processes involved in the action of this stimulus are not yet investigated.

Nadson, in the Jahrb. f. Pflanzenkrankheiten, records the wholesale destruction of oak seedlings in one of the districts of Russia, which is attributed to disturbed symbiosis, the mycorrhiza growing on the roots of the seedlings having become parasitic through the influence of unfavorable conditions. A similar condition of affairs has been observed in the chestnut. In general it appears, according to the author, that a mycorrhiza fungus is in its essential nature a parasite, but that its parasitism is commonly restricted to the outer cell layers of the root, and that it brings some advantages to its host by supplying water and food substances; there are cases, however, such as those cited, in which it becomes an aggressive parasite and is highly destructive.

In *Science* for Nov., 1909, Professor George J. Peirce writes of the possible effect of cement dust on plants and records his observations in the vicinity of Concord, Cal., where a manufactory of Portland cement is operated. It appears probable that the injury to vegetation is much greater where, as in southern California, there is no rain for the entire summer, after the leaves of deciduous plants have developed, than it would be in regions of abundant rainfall through the growing season.

In the same number of *Science*, H. A. Anderson gives an account of investigations of algae of the Upper Cayuga Lake Basin and offers some interesting suggestions regarding the possibility of the cultivation of Spirogyra, Chaetophora, and some other green algae on a sufficiently extensive scale to provide food for certain aquatic animals that, in their turn, serve as food for fishes.

In Muhlenbergia for September, 1909, S. B. Parish contributes notes on some introduced plants of southern California. These notes have the value of personal observations carried on continuously for more than two decades, and give a reliable history of the appearance and movements of a number of species which are now widely spread in the San Bernardino valley and beyond.

Zinger, in a paper recently published by the Imperial Society of St. Petersburg, gives an account of the four species of Camelina found in Russia, viz.:

(1) *C. microcarpa*, a wild plant of the steppes;

(2) *C. pilosa*, which occurs as a weed in winter crops, and is frequently found in southern Russia.;

(3) *C. glabrata*, a cultivated plant occurring infrequently in summer crops as a weed;

(4) *C. linicola*, which occurs exclusively in crops of flax and is especially characteristic in northern Russia.

From biometrical studies and continued series of pure cultures the author comes to the conclusion that changes taking place in the order *C. microcarpa, pilosa, glabrata, linicola* consist chiefly in a gradual transition from xerophytic to hydrophytic types and increased size of the seed. The loss of xerophytic characters consists in the gradual reduction of pubescence and certain other changes in the external and internal structure of the vegetative organs.

The author believes that *C. linicola* (the species which grows with flax) has arisen by a peculiar process of selection from the cultivated *C. glabrata*, and that this latter had its origin in the wild *C. microcarpa*. Cultures of *C. glabrata* with flax, or under similar conditions, exhibit all the morphological and anatomical characters of *C. linicola*. Nevertheless it is believed that the latter species is not the direct product of environmental forces, but rather the result of a process of selection which takes place in sorting and cleaning flax seed. Slight individual variations, rather than mutations, according to this view, have afforded the material for selection to act upon.

Various American pines, particularly a number of western species, have the habit of holding their cones unopened for several or many years, and to this habit John Muir and others have attributed the capacity of some of these species to hold their own on fire-swept ground. The fire causes the opening of the cones, and a new generation of trees arises from the seeds thus released.

Actual tests of the viability of the older seeds, however, have been almost wholly wanting, but in the *American Naturalist* for November, 1909, Prof. W. C. Coker gives an account of recent germination experiments with seeds of *Pinus serotina*. In the neighborhood of Hartsville, S. C., the cones of this pine were often found to remain unopened for ten or more years. In the tests made last summer at the New York Botanical Garden it was found that although the percentage fell off with increasing age, a fair number of seeds as much as fourteen years old germinated.

Louise Hoyt Gregory (Bull. Torr. Bot. Club; 36; 1909) reports as the result of her investigations of the effect of mechanical pressure on the roots of *Vicia faba* that pressure up to as much as 1400 to 2000 grams has no effect on the mitotic figure or division wall of the root cells. With the same pressure, however, certain morphological changes, such as breaking up of the plerome cells, splits in the periblem layer, and displacement in both plerome and periblem, were noted.

Fitting's recently published monograph on the conduction of stimuli in plants, while adding little new to the subject, is a valuable contribution, in that it brings into one volume, and ably organizes, the extensive, but uncorrelated data on this subject. Fitting's thorough acquaintance with the subject, coupled with his evident broad perspective results not only in a comprehensive treatment of the problem of stimuli and their conductions, but remarks and suggestions regarding the relation between these and other phenomena, as of growth and development, makes the book a very suggestive one.

The volume is divided into two parts. The first deals with stimulation from external and internal sources. Among the former are discussed stimulation due to touch as in Mimosa, or Bryophytum; contact, and chemical stimulation, as in Drosera; wound stimuli; and the various tropisms which he distinguishes from the others mentioned. The second division presents an interesting discussion of stimulation from sources internal to the plant as a whole. Here the main topics are treated: 1. The various correlative phenomena of growth or depression following fertilization. 2. The transference, through changes in internal condition, of a tropic state from one organ to another, for example, the relation maintained between the segments of jointed plants, such correlations as between a flower or fruit and its stalk, where the tropic conditions of the latter varies with the morphological stage of the former, or the regulatory influence of the main axis on the nature of the lateral organs. 3. The liberation of formative stimuli. Here are discussed polarity, certain types of regeneration, etc. 4. Correlation of growth. 5. Correlation between parts of the cell. In the closing chapter the author argues for a much more extensive action of the phenomena of irritability than is generally held. He considers, for example, many of the internal correlations of growth and organization to be fundamentally phenomena of irritability rather than of nutrition.

The second part of the book deals with the process of irritation through the plant and this is treated under the following heads: 1. The paths along which stimuli are transmitted. 2. Distance and rate of transmission. 3. Dependence upon external conditions. 4. Difference in electrical potential accompanying the transmission of some stimuli. 5. The nature of the process of the transmission of stimuli. 6. The relation of the actual conduction of the stimulus to the other parts of the process, *i. e.* to the perception and reaction phenomena. The book includes a very complete literature, and, unfortunately, lacks an index.

NOTES AND COMMENT.

The guide to the newly established garden of Johns Hopkins University, recently reprinted from a University calendar, indicates on the part of those in charge a clear conception of what a garden planned primarily as an aid to botanical research and instruction should be. As stated in the introductory pages of the guide, the four sections into which it is divided illustrate respectively (I) The chief types of vegetative organs of plants; (II) The structure and biology of the reproductive organs of plants, *i. e.* of sporangia, flowers, seeds, fruits; (III) The genealogy of plants as indicated by their classification. It includes illustrations of the various kinds and degrees of kinship, of historically important systems of classification, of the modern system of Engler, and finally, it also illustrates in some detail the variety in structure and in geographical distribution found among the members of a few selected families of seed-plants; (IV) Useful and ornamental plants. In the further development of the garden, it is planned to illustrate various types of plant associations, some of the important facts of geographical distribution, and the habitat-relations of various plant forms.

The address of Lieut.-colonel David Prain, C. I. E., LL. D., F. R. S., president of the section of botany of the British Association, at the Winnipeg meeting, contains some things hard to be understood, but many of epigrammatic clearness and force. Although impossible to report, except by reproduction as a whole, it brings encouraging evidence of much needed searching of heart on the part of at least some who take it upon themselves to speak for botany at such gatherings. It is perhaps putting the case mildly to say in the words of the author, "Re-orientation in botanical study has led to seismic disturbances in the taxonomic field"; nevertheless few will doubt that the statement in the next paragraph still holds true, viz. that "the exemption from radical change in method, which marks systematic work, is due to those characteristics that expose it to the charges of discouraging originality and of calling only for technical skill."

Having thus frankly admitted all that the narrowest specialist in any of the more modern departments of Botany would think of charging, the constructive part of the address is to be commended for its breadth of view and sympathetic treatment of related branches of the subject. The studies of the paleobotanist, the morphologist, the physiologist, and the ecologist are discriminatingly discussed in their relation to systematic botany. The psycological attitude of the systematist is taken into account in the following interesting fashion. The existence of two distinct attitudes on the part of authors towards their "species" is common knowledge. In the absence of more suitable terms we may speak of them as the "parental" and the "judicial". To the parental worker his species are children, whose appeals, even when *ad misericordiam*, are sympathetically received. To the judicial worker his species are claimants, whose pretensions must be dispassionately weighed. The former treats the recognition of the species as a privilege, the exercise of which reflects honor. The latter views this task as a duty, the performance of which involves responsibility. With amply characterized forms the mental attitude is inconsequent, but when critical forms are reviewed it is all-important. Here the benefit of a doubt is the practical basis of a final decision. This benefit in the case of the parentally disposed worker may lead to the recognition of a slenderly endowed species; in the case of the judicially inclined, to the incorporation of an admittedly critical form in some already described species, the conception of which may thereby be unduly modified.

The author's closing words somehow turn the memory to the olden time when generous exchanges of plants, with expressions of friendship and often with a touch of poetry and latin, and delightful collecting trips, with utter freedom form all notions of evolution, mutation, association and competition, characterized the "*scientia amabilis.*"

WANTED.—One copy Mutants and Hybrids of the Oenothera, by MacDougal, Vail, Shull and Small, Publication 24, Carnegie Institution of Washington. Will pay original price and postage. Address: Prof. A. W. Gilbert, Cornell University, Ithaca, N. Y.

Title pages of volumes 11 and 12 of the PLANT WORLD, and the index to volume 12 will be sent to subscribers with the January, 1910, issue.

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