

The Adaptations of Plants to Resist
Dry Weather.

Jennie Maude Currie.

Outline.

I Prevention of over transpiration.

1. Methods of mature plants.

a. Surface reduction.

(a) Fleshy plants.

(b) Slender plants.

b. Movements to avoid light.

c. Closing of stomata.

d. Covering hairs, etc.

(a) Unicellular.

(b) Multicellular.

e. Changes of epidermis.

2. Methods of young leaves.

a. Diminution of surface.

b. Vertical inclination.

c. Protection by plant.

II Storing of water by plant.

1. Fleshy leaves.

2. Epidermis.

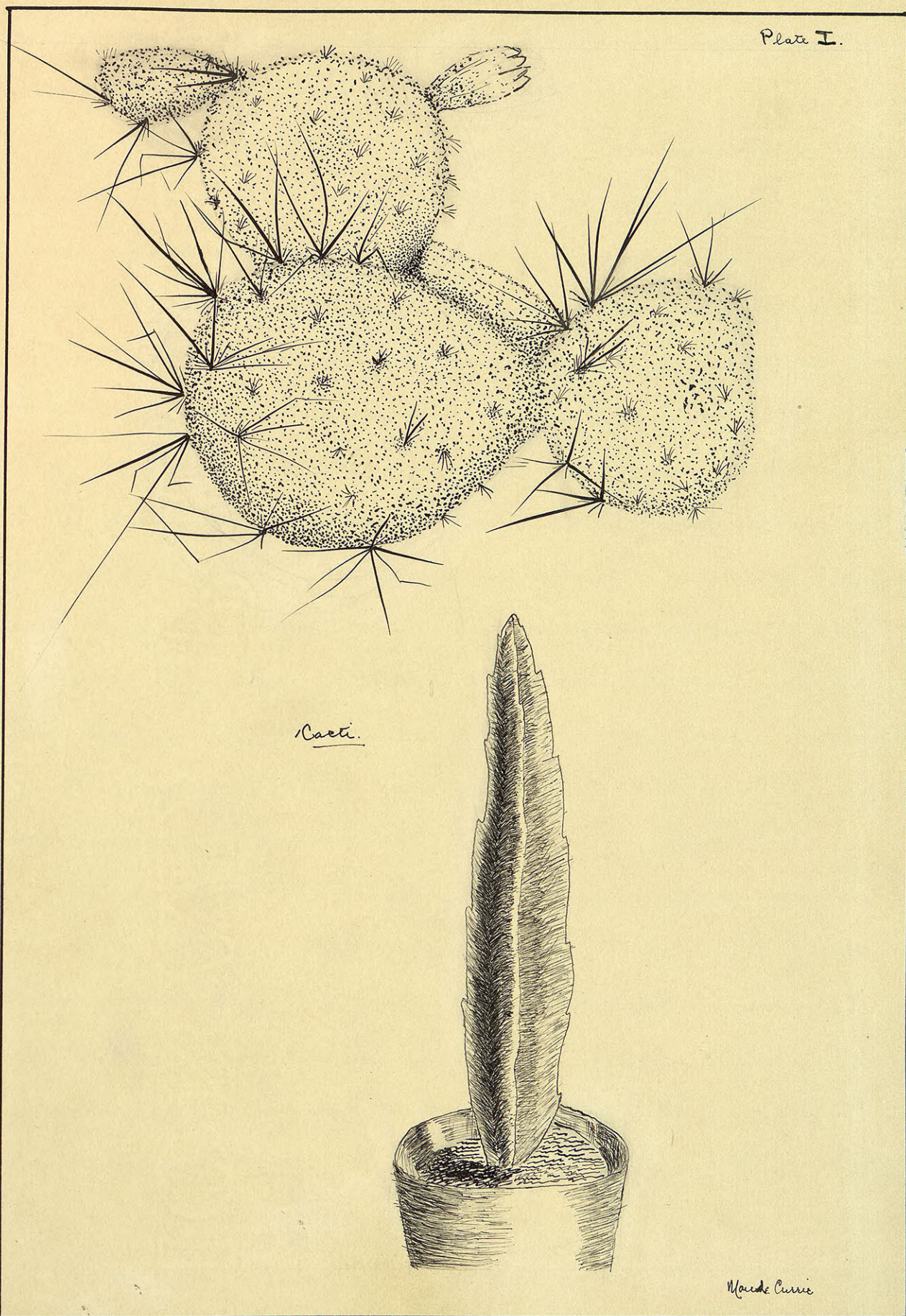
3. Roots.

The two great methods which the plant uses to resist drouth are, 1st, the prevention of over-transpiration and, 2nd, the storing of water. The first head may be divided into the methods used by mature plants, and those used by young plants. These are each sub-divided, and each sub-division will be taken up in its turn.

Mature plants resist over-evaporation, first, by surface reduction. This is accomplished in two ways, - by fleshy plants and by slender plants. In thick, succulent plants, - the cactiform, the stems are fleshy and take the place of leaves. Thus the transpiring surface is reduced in proportion to the volume of the plant. The *Euphorbia Canariensis* has a very large, long stem and branches, and no leaves, but large prickles. These fleshy plants are found in deserts, and other tracts where the climate is especially arid.

Another reduction of surface is accomplished by the asparagus and by Switch plants which grow on islands near Australia and in the Mediterranean District. These latter are straight, slender and rigid, and have many

Plate I.

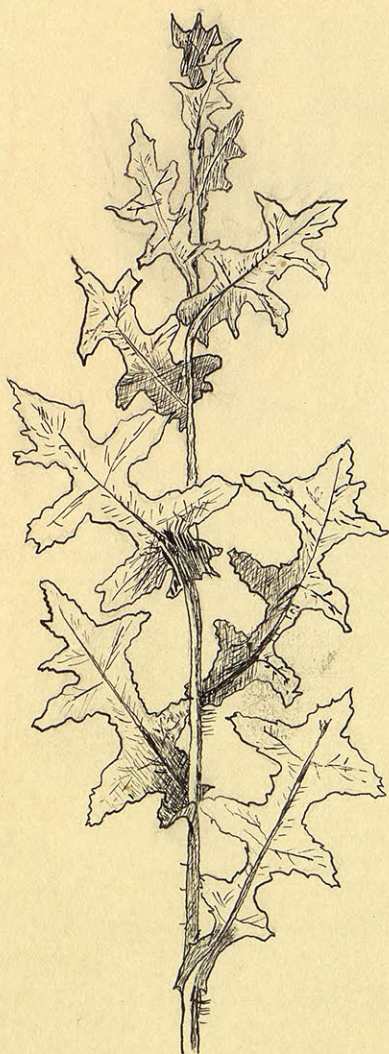


Cacti.

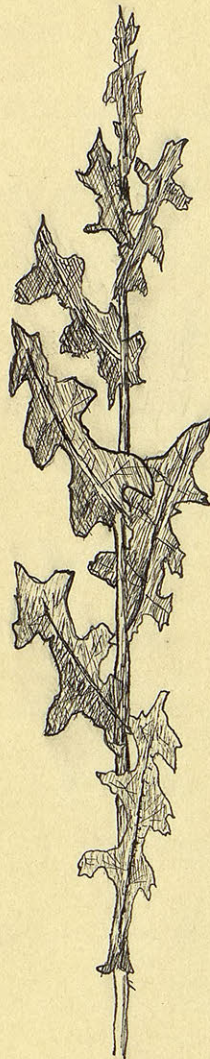
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long branches which take the place of leaves. They grow close together in large districts. In Australia the chief kind is Papilionaceae; and in the Mediterranean district, the Asparagineae Polygalaceae. They present a peculiar appearance, especially when they cover whole islands and are in bloom. The flower is a bright yellow, making it look like a golden island. A few Swiss plants, as the Spartium, have small leaves, which, however, are unimportant. Other plants of this kind are the reeds and rushes, and the horsetails. They are slender and upright, are sometimes flexible, and are rarely branched.

The second method to resist over evaporation is by plant movements to avoid light. And we find that an over abundance of light is injurious to the chlorophyll. The leaves of many plants take a position called "diurnal sleep" by turning their edges to the sun. The shadows cast by these leaves are very narrow, and the sunlight passes them, especially at noon. Sometimes there are whole forests of Eucalypti and Acacias, and there is very little shade

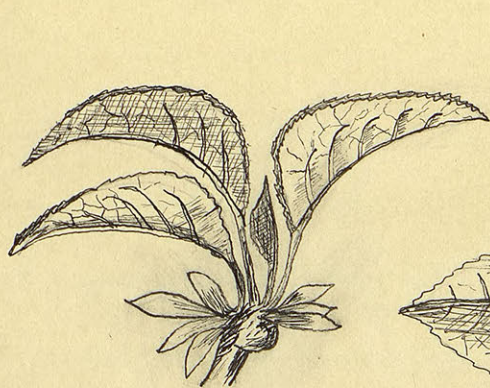


Seen from the east.

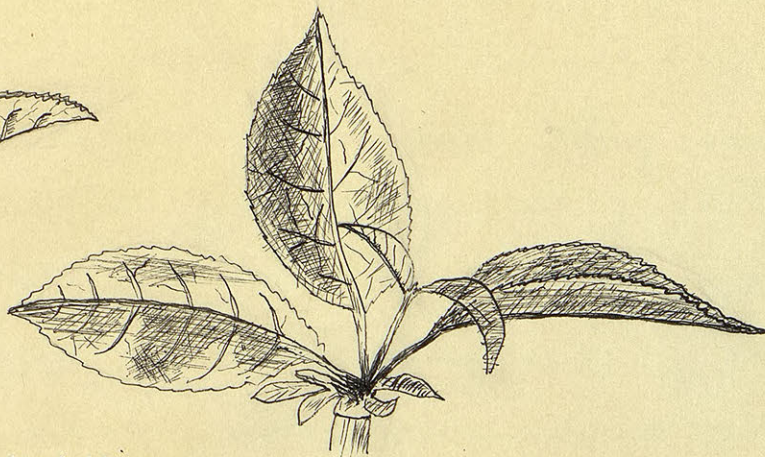


Seen from the south.

Compass Plants.

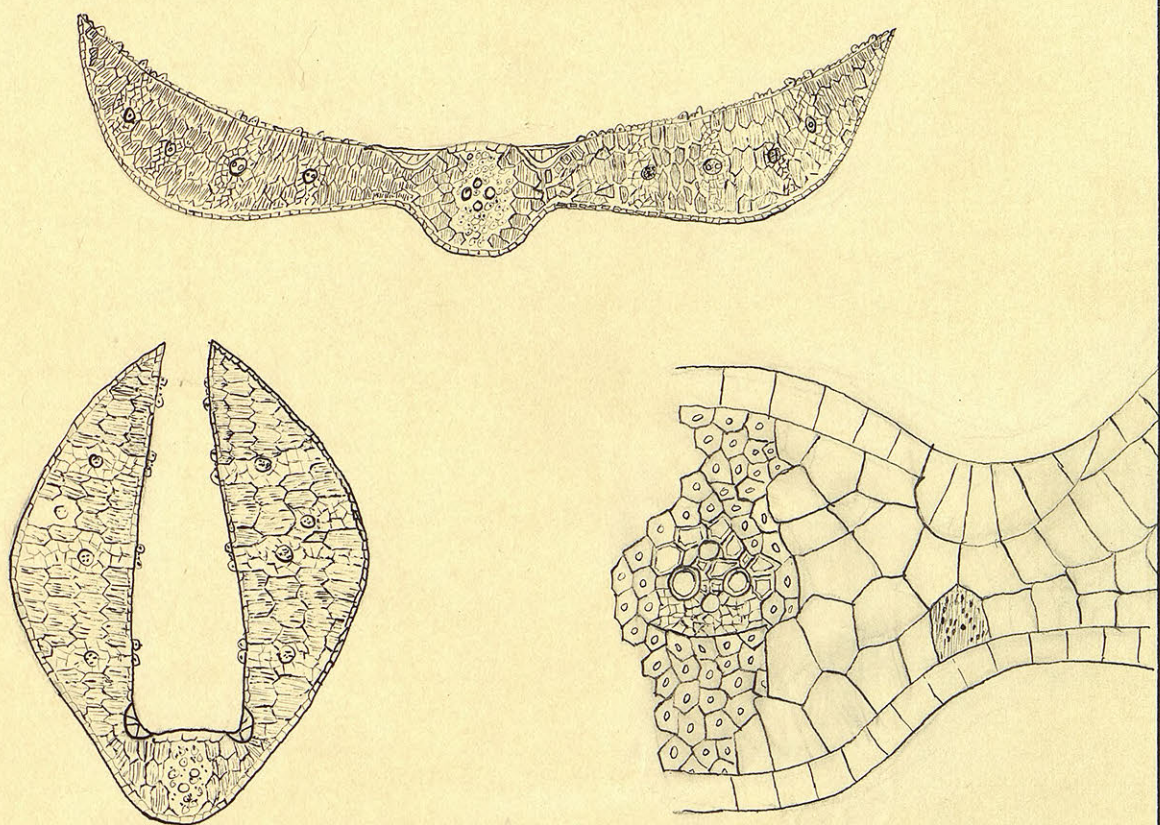


Leaf-unfolding.

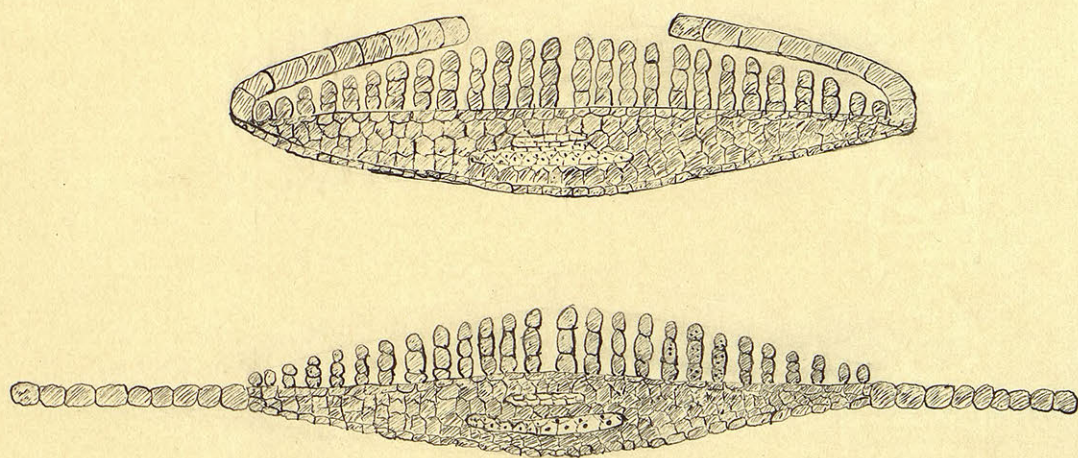


cast to the ground. This accounts for the shadowless forests of Australia. Compass plants have the appearance of being pressed with their foliage pointing north and south. This occurs only in dry regions, for in places where there is plenty of moisture, the leaves take no special direction. The turning is brought about by alterations in the turgidity of the leaf-stalk.

In other plants, the chlorophyll corpuscles themselves avoid the light, by moving so as to be on the lateral walls of the cells, and not on the front walls. This is found in some Algae. Many times, we find leaves which fold to avoid sunlight, especially in grasses. Their leaves are flat before sunrise; but when the sun begins to come up they fold lengthwise along the midrib, and remain so all day unless a storm comes up, when they open out. Then when the sun goes down they flatten out for the night. This proves that the movement is indirectly caused by the humidity of the air. The *Scirpus*, or moor-grass, opens and shuts its leaves very rapidly by closing nearly together over the midrib with the stomata inside. The lower surface, which then faces



Folding of Moss-leaf. $\times 40$ & $\times 300$.



Folding of Moss leaves. $\times 30$.

the sun, has no stomata, but is composed of thick cuticle. Many other grass leaves shut similarly, the direct cause being changes of turgidity of the leaf. The true mosses fold over when the air begins to dry, and although the edges do not meet over the leaf, those cells which are exposed have thickened walls. In Brazil, there are many shrubby, thorny plants which have this leaf-movement, and like these, they open if the weather is bad or windy.

Many experiments have been performed which show that transpiration is much more rapid in sunlight than in the dark. A plant of Indian corn transpired in one hour from 100 cm² of surface

In the dark,	92 milligrams water		
In diffused daylight,	114	"	"
In sunlight,	785	"	"

The third method of resisting over-evaporation is by closing of the stomata. When dry weather sets in, it is important that the stomata be closed, and this is done by the guard-cells. There are two for each stoma; they touch at the ends, and are bean-shaped, with the concave sides toward the

stoma. This method is a good preventive against excess of transpiration. The stomata of some plants close in the dark, and they partly close when a leaf wilts, and also when it is covered with water. The position of the stoma, in a depression having a narrow neck, serves to keep water out, and to restrict transpiration.

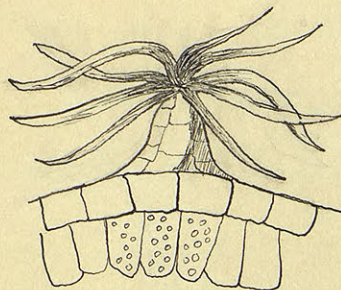
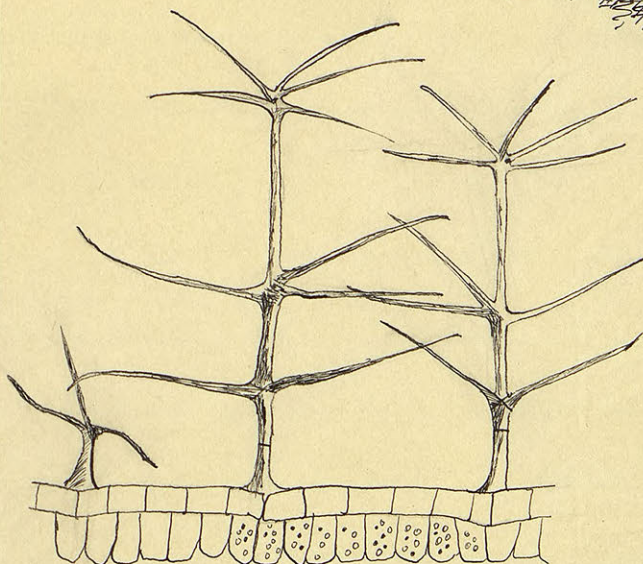
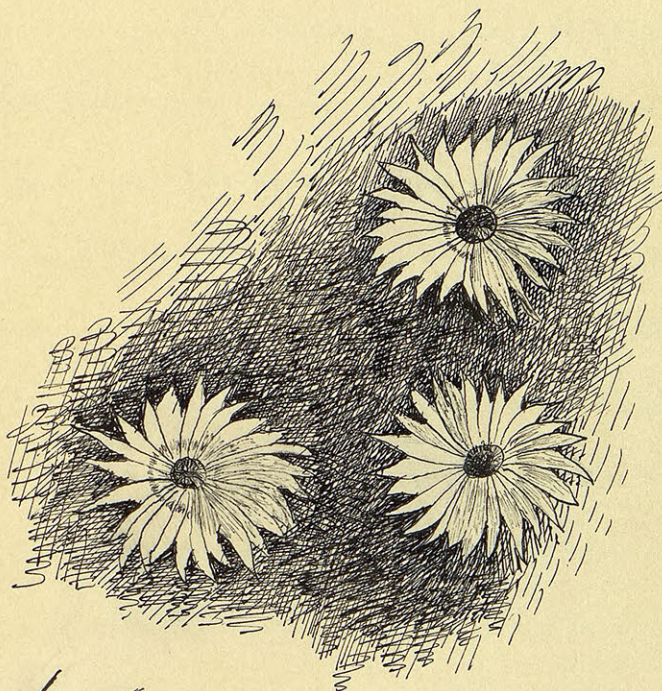
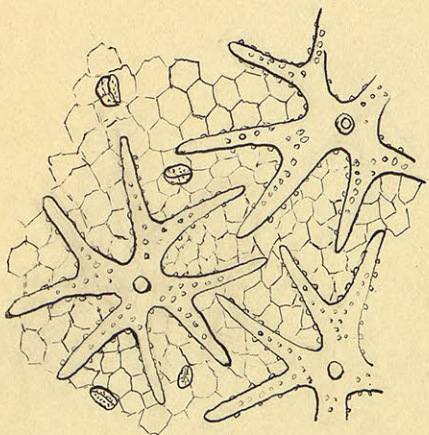
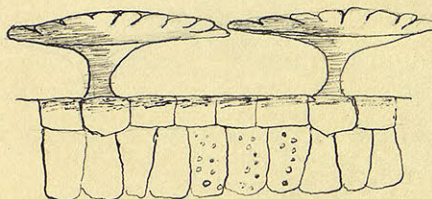
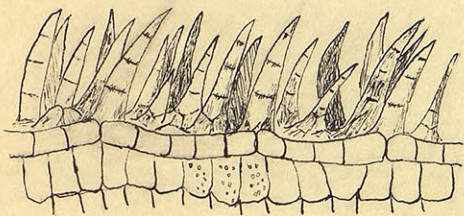
The fourth method of preventing too rapid evaporation is by covering the leaves with hairs, scales, etc. Plant hairs are called trichomes, and they must be dead and filled with air, to be of special value, or else the plant would be obliged to protect them also from evaporation.

Covering hairs are divided into two classes. Those with one cell are the first, and those having two or more cells are the second. The unicellular has one epidermal cell, which protrudes beyond the others, sometimes at short, and sometimes at long distances. One kind bends at right angles, is parallel, and is very small, so that when the light strikes them they have a "silky" appearance. Where there are many short

ones, they are called "velvety", and when longer and thinner than these, "shaggy". Some are very long, are bent and twisted, and are called "wooly". These last are sometimes circular in the cross-section, but are oftener ribbon like.

The multi-cellular cells are epidermal cells which grow and divide. The division walls may be parallel or perpendicular to the plane of the leaf. In the former, they are parallel, making the hair like the links of a chain. This form is called jointed or articulated. When they are short and straight they resemble the velvety unicellular hairs, and when long and twisted, they are much like the woolly unicellular hairs.

Sometimes the trichomes divide at the top, growing both ways, and forming a T shaped arrangement. Several Crucifers of South Russia, the Aster *Argophyllum* of Australia, and many worm woods have this silky, odd-looking appearance. The hairs called stellate derive their name from their star shape, having a few or several rays, and having a large round center,



Covering Hairs

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with short pointed edges, or a small center with long rays. The short-rayed hairs resemble tiny parasols. The Cruciferae and Malvaceae have stellate hairs. When the top cell of a hair is divided by perpendicular separating walls, a branched hair results, and the branches are all one-celled. The pedestal, or foot-stalk, may be very short, or quite long, making the hair tree-shaped. Some hairs have a short pedestal with branches, which remain joined in a flat plate, indented at the edges, making another star shape; these are level with the leaf, and are flat, covering it well. They have a "scaly" appearance, an example of which is buckthorn. If the plates are bent, irregular and dark, they are "clayey".

The tree-shaped branches are whorled so that they resemble small forests of fir-trees when viewed under the microscope, and especially when there are short branches to form the underbrush. Looking at them with the naked eye, they are sometimes rolled into balls like a coarse white powder.

In all the above cases, the cells were long and thin; but some hairs are

cube-shaped, caused by their being distended and pressing against each other. This form is called the "coat of mail", and they contain a large amount of silica, which, when the cells are burned, leaves a perfect skeleton. This makes a splendid protection for the leaf.

The *Hieracium Pilosella*, or Hawkweed, in the dry, hot Mediterranean region, has green leaves which are white on the under surface, an effect which is caused by the multitude of star-shaped hairs. When the margins of the leaf roll up, the upper side of the leaf is rolled in, and the lower side is protected by the hairs. When showers are lacking in the alps, and the swift wind dries up the thin soil, no moisture supply is provided for the plants, but they are prepared for it. The leaves and stems are covered with hairs, and the succulent plants and saxifrages are ministered with lime. The famous beautiful Edelweiss has a covering of dull white, and on examining it, the cross-section shows that the walls of the epidermal cells are thin, but have a structure filled with air. Other

plants in other mountainous regions have this same peculiarity.

Where it is very dry for a long period, plants have to sleep, and it is the covering hairs which aid them. In the Mediterranean District, plants of all kinds, from trees to undergrowth, have this same coating of gray or white hairs. These plants are also found in Egyptian and Arabian deserts and in Persia and Hungary.

Many plants have cells which excrete a waxy substance called the "bloom", which is white, gray or blue. It grows on both sides of the leaf, and experiments have been made, showing that when the bloom is rubbed off, almost $\frac{1}{3}$ more water is lost than when left on.

The cherry, peach, sweet willows, etc. have a varnish-like covering on the young leaves, and not on the old. But the *Centauria Balsamita* of Persia and the *Grindelia Squarrosa* of North America, retain this varnish-like protection all their lives.

Some plants have incrustations of lime or salt; but where they have these, they have no covering hairs, and vice versa.

The fifth method of resisting drought is by the changing of the epidermis. At first, it is composed of cellulose, and is thin and delicate, but the outer wall becomes thick and divides into two parts. The inner one does not undergo change, but the outer one does. A compound called suberin, which is corky, takes its place, and keeps water from passing in and out so easily. Sometimes another layer forms between these, and is of large size. This is found in the Holly and Oleander and others.

Young leaves are prevented from over-evaporation by diminution of surface, vertical inclination and protection by plant. Young leaves are rolled or crumpled or plaited, to avoid the sun's rays. Nearly all young leaves emerge from the bud with the leaves vertical, the blade placed upright.

Under the third division, the protection is offered by stipules and other parts. This is found in oaks, beeches, magnolias, etc. Nearly always, the leaves die and fall to the ground when they attain their growth; but in the case of the tree of life (*Arbor vitae*), Juniper, etc., the leaves are small and

scale-like, and they protect the branches, and are protected themselves. The protection of young leaves by stipules, is often peculiar, as in the Tulip-tree. The stipules form a large cup in which the leaf grows.

Fern leaves, the *Thelypteris Filix-mas*, have the midrib and veins covered with a scaly substance, which afterwards falls off. But when the fern grows in especially dry places, it stays on through life.

Leaf veins protect the young leaf by being folded so that the veins are exposed to the sun, and not the delicate green tissue. The ribs and veins have a tough epidermis containing no stomata.

The storing of water by the plant occurs in several different ways. One is by the thick, fleshy leaves of the Umbelliferae, Compositae, and Portulacaceae, which grow in dry stony places.

The Cactiform plants have thick stems which take the place of leaves, and they also have thorns. The epidermis is tough and leathery and is covered by a deposit of oxalate of lime. Other plants having a deposit of silicic acid, or

suberin, also have water tissue in the soft leaf, which keeps the liquid store of the plant. This store lasts from one rainy season through the drought, till the next rain. In the cacti, the water tissue is inside the leaf, but in the orchids which have thickened stems and leaves, the tissue is scattered between the green cells.

The epidermis often stores water. The cells may be distended and sac-like and tightly fitted together, or they may be scattered irregularly. When silicified, the water can go only into the leaf, but when not, the appearances are that the leaf would soon become dry. This is not the case, and the reasons probably are that

(1.) the formation of the cell will not permit it, and (2.) because there are substances in solution which prevent the evaporation. These fluids are gummy and contain salts. In plants of the desert, or salt-steps there are much more salts of magnesium and chlorine than the gum. This, in part, enables the plant to retain its freshness and strength long after others have perished. However, not

all water tissue finds its use as a store for water, but for the transmission of CO_2 , which falls under another subject.

In the plants above mentioned, which have the coat of mail, the silica in them forms a splendid protection. The cells contain protoplasm and cell sap, and liquids can run into the plant from the storing tissue, but never can run out. The outside of the leaf may be used to store water for the plant, as found in the oak and others. The upper surface of the oak leaf has a deep groove in the midrib which closes over the top, except at the base. Here, in this groove, are tiny hairs which catch the water which runs through, to absorb it. This is done when there is not enough water to supply the roots. The epidermal cells are adapted especially for this absorption.

Another method is that of the saxifrage. The leaf has teeth along the margins, with a cavity in each tooth. There are very thin cells here, to suck up the water from the bottom of the cavity, and the cells are closed by carbonate of lime. When rain

or dew falls on the leaf, it soaks through, fills the depressions, and is taken up by the cavities.

Roots also absorb water from the air, as found in orchids. These grow on the bark of trees etc., and when the air is the only source of moisture, the roots have a thick porous covering which provides for a continuous supply of water in the rainy season, and for resistance to over evaporation in the dry season.

Other forms of adaptation for storing water are found in tubers, bulbs and others of that class, which have a fleshy, moisture holding tissue.

Thus we find that plants are extremely adaptable to their surroundings, and that they can survive long periods of drouth. This seems absolutely essential for them, considering that rain is only comparatively regular in the temperate zones, and is extremely rare in many sandy, desolate places.