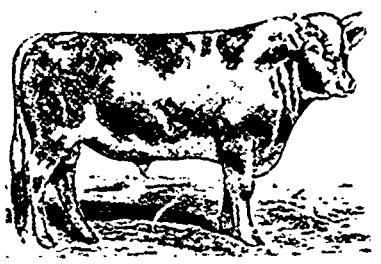
be taken out, hold in a vertical position, and the amount of butter-fat read off in the gradual tube.

It may be 3.2, 4.4, or 5.6, or more or less, and this determines the value of the milk, just as the assayer fixes the value of ores by testing samples. Ex.

GUERNSEYS.

The "ideal Guernsey" is thus described by the manager of the Hon. Levi Morton's well known herd:

"Our bull, Midas, pictured in last year's R. N.-Y. is about perfect in shape and color. We want a cow weighing 1,000 pounds, long, with well sprung ribs and plenty of room for feed. Color, orange fawn and white, with a handsome but substantial carriage. We shall not try to breed simply a large Jersey, but a different type entirely, with nothing of the delicate, deerlike head and neck or slenderness of the Jersey. It will be a stout, muscular, brawny dairy cow. It will be like the difference between a 25 and a 20 horse-power engine. We want 10 of our Guernseys to do the work of 12 Jerseys.



The following description of the Guernseys, as distinguished from the Jerseys, is taken from the R. New-Yorker, one of whose staff "interviewed" the manager of Mr. Morton's herd last month. The type of the Guernsey has been so long fixed, that we were rather amused at the second question. We have bred them ourselves, and know their value. Ex.

1 "In what respects do Jerseys and Guernseys differ?"

"Chiefly in size, vigor, disposition and feeding habits. The milk of the two breeds is just about the same—no expert can tell the two apart. The Guernseys are, on the average, heavier milkers and their milk may have a little higher color. They are heartier eaters as a rule. They average heavier than Jerseys, and never having been closely inbred or pampered, are freer from disease and more vigorous in constitution. The chief difference is in disposition. They are not nervous and high-strung like the Jerseys. A Guernsey is really a dignified Jersey—like one that has grown up and sowed all the wild oats in the basket and settled down for business only. Guernseys are the best barn dairy cattle in the world. They are perfectly at home at public shows or contests while Jerseys are usually too excited and frightened to do their best. The Guernseys can be shipped and handled easier and have a greater capacity for turning food into milk *when fed in a barn.*

2 "Shall you aim to make a general-purpose cow' out of the Guernsey?"

"Not at all. She will be bred for the dairy alone. She will be simply a larger, stronger and quieter animal than the Jersey; better suited to winter dairying because she is happier when confined to the barn."

(3) "What arguments can a Guernsey man give in favor of his breed?"

"Those I have given in regard to size, vigor and disposition. As to relative profit in breeding stock—the Jerseys are somewhat cheaper now, particularly for bulls, and Jersey families are well developed and lines of breeding have been carefully traced. The Jerseys have had their boom, however, and the day of high prices has departed. The interest in Guernseys is growing all the time—their boom is ahead of them, not behind. When both breeds come down to the business of contesting for the patronage of practical dairymen the Guernsey will win because she is a business cow made for the farmer rather than for the fancier. Men who now stock up with Guernseys will find their cattle constantly growing in favor and value as they become better known, and while the cost of starting a Guernsey herd may be greater, the possibilities of selling stock are also greater in the end."

H. W. C.

Science.

The Food of Plants.

III.

THE APPROPRIATION OF FOOD.

By D. P. Penhallow.

The appropriation of food, or the organs through which food elements enter the plant and the forms in which these elements are taken up, is at once one of the most interesting and important of the whole question of plant nutrition, since it constitutes the basis of those extended operations which are involved in the cultivation of crops.

As there are two principal sources of food, the soil and air, there are also, corresponding to these, two principal organs or sets of organs through which food from the surrounding medium gains access to the living cells. These are the leaves and the roots, and in order to gain a just appreciation of the way in which these organs operate, it will be well to briefly consider their structural adaptation to the functions they are called upon to perform.

If a section of a leaf be made in such a way as to expose its thickness, and examined microscopically, it will be seen that the upper and lower sides are bounded, each by a layer of cells, which, while similar to one another differ widely from those cells which lie between and constitute the principal part of the leaf structure. From the position occupied by this external membrane, as well as from other considerations, it is known as the epidermis or skin, the general function of which is protective, while it also serves in many cases, to limit certain functions and keep their operations within well defined limits. This is to be observed with respect to the function of transpiration where we find that in general, the thicker the epidermis, the slower will be the rate at which water is given off from the plant, and we may gain corroborative evidence of this statement in the observation that plants growing in very moist situations have their epidermal tissues developed but slightly, while plants growing in very dry regions usually have very thick and resisting skins. All this points directly to the fact that the more highly developed the epidermis becomes, the more completely does it resist the passage through it of water in the form of vapor. On the other hand such membranes are very porous with respect to gases, so that the ordinary gases of the atmosphere readily pass through the epidermis, inwardly or outwardly. This is susceptible of demonstration and has repeatedly been proved experimentally, and, as we shall shortly see, it has an important bearing upon the appropriation of atmospheric food by the plant.

Here and there in the epidermis may be seen openings which pass through and connect with spaces in the interior of the leaf, or if we look down upon the epidermis, these same openings will appear as oval structures with a central orifice or mouth. Such openings are known as the stomata and are often called, though erroneously, the breathing pores. These organs are very sensitive to varying conditions of light, and under its influence are capable of opening or closing accordingly as they are brought, under the operation of bright light or of darkness. It therefore follows that as these conditions vary, the amount of gas and vapor of water passing through these openings must vary within a given time. It should be pointed out here, however, that these organs are almost wholly connected with the liberation of water in the form of aqueous vapor, and are of subordinate value only, in promoting an interchange of gases, since as we have already seen, these latter are capable of passing through the epidermis when devoid of stomata, and moreover, such interchange of gases is a common function of plants which never possess stomata. We may thus say that, while stomata are not essential, they may facilitate diffusion of gases, since this always takes place more readily though definite openings than through closed membranes.

With respect to the distribution of the stomata it may be well to point out that they occur on the young parts of all green plants, on leaves, flowers and fruits. They may often be found on certain underground structures, but are never to be observed on roots. They always occur most abundantly on leaves and in the majority of cases are most numerous on the lower sides of these organs. There are notable exceptions to this, however. In grasses where the leaves are equally exposed on both sides, the stomata will be uniformly distributed above and below. Leaves growing horizontally show an excess above and below according to surrounding conditions, while leaves growing with the lower surface in water, have all their stomata on the upper side. These facts will be made clear by the following tables:

NUMBER OF STOMATA PER SQUARE CENTIMETER.

	Upper	Lower
Box, Buxus sempervirens	0	208
Sunflower, Helianthus annuus	175	325
White Water Lily, Nymphæa odorata	160	0
White Pine, Pinus strobus	142	0
Pinus sylvestris	50	71
Black walnut Juglans nigra	0	464
English walnut " regia	0	299
Olive, Olea europea	0	1072
Brassica lyrata	158	243
Ficus elastica	0	145

Or, taking the whole number of stomata upon leaves of average size, we find the following:

Acer platanoides	2,127
Quercus cerris	2,136
Nymphea alba	7,650
Brassica oleracea	11,500
Helianthus annuus	144,000
Victoria regia	1,035,000

It commonly happens in woody plants as trees and shrubs, that the epidermis is very soon replaced by a layer of cork which is in itself impervious to gases, and, therefore, the interchange which formerly took place through the bark is wholly terminated and the leaves are thereby forced to perform more than their normal share of work. To compensate for this, it is found that as the cork layers form, the structure becomes modified at frequent intervals, in such a way as to establish more or less spongy structures called lenticels, which contrive to maintain communication between the external atmosphere and the interior of the plant, and thus permit a continued interchange of gases. These structures are familiar objects on the bark of trees and are particularly conspicuous in the birch, where they form transverse marks of a light brown color and tend to hold the various layers of the bark together. For agricultural purposes these organs are of minor importance, except so far as we take into consideration the cultivation of fruit trees, but for an intelligent discussion of the question now under condideration, it is important that we keep their physiological value clearly in mind.

Passing on to the principal structure of the leaf, it will be found that immediately below the upper epidermis there are one or more rows of cells of cylindrical shape arranged in compact rows and placed vertically. These cells from their form and arrangement constitute what is known as the palisade tissue. The cells are very active and contain numerous granules of green colouring matter known as the chlorophyll. During active growth they also contain great quantities of starch. Extending from this tissue to the lower epidermis, and generally occupying about two-thirds of the thickness of the leaf, is a tissue which differs materially in its structure. It is composed of irregularly rounded cells so arranged that the whole structure is traversed by numerous spaces which connect with one another *throughout* the leaf, and they outwardly connect with the air through the stomata. This structure as a whole, is called the sponge tissue in allusion to its characteristic structure. The cells are very active and contain a large amount of chlorophyll. These and the cells of the palisade tissue, are the working cells of the leaf, since it is in them that respiration and all the changes incident to the fixation of carbon take place.

The atmosphere of the earth will be found to contain in every one-hundred parts:

Nitrogen	(N.)	79.01984
Oxygen	(O.)	20.94000
Carbon dioxide	(CO2.)	00.04000
Ammonia		00.00016
		100.00000

We may therefore say, as commonly stated that the air consists of four-fifths nitrogen and one-fifth oxygen, with small quantities of carbon-dioxyde. Of these the nitrogen and ammonia are not capable of being taken up by the aerial portions of the plant, but, as we shall see later, they may and do pass down into the soil where they are taken up by the roots and constitute most important elements of food. We may thus leave them out of the present consideration.

The oxygen furnishes the element which is essential to the respiration of the plant. Without it all growth would cease. By diffusion it passes through the outer membranes of the plant, and also through the stomata when present, into the interior living cells where it comes in contact with various forms of carbonaceous substances. These latter are consumed or oxidised, and in the process carbon dioxide and water are formed and given off into the surrounding air, while at the same time a certain