# The Theory of the Growth of Cuttings; illustrated by Observations on the Bramble, *Rubus fruticosus*. By Francis Darwin, F.L.S.

[Read December 16, 1880.]

## *Theory of the Growth of Cuttings.*

When a cutting (for instance, a piece taken from the branch of a Willow) is placed in damp air, it produces roots at the lower end, while the buds at the upper end grow out into branches. The question as to what are the causes which determine the roots and branches to grow at these places has lately attracted a good deal of attention among physiologists. The works which are of especial importance on the subject are Vöchting's 'Organbildung im Pflanzenreich'* and Sachs's paper "Stoff und Form der Pflanzenorgane"†. Sachs's essay is in some measure a critique on Vöchting's work, and the latter author has replied in a paper in the 'Botanische Zeitung' (1880, p. 593).

Vöchting divides cuttings into two chief classes. First, there may be cuttings which consist of a simple piece of stem or branch, without buds (which may be either absent or destroyed), and without those beginnings or rudiments of roots which are called in German "Anlagen." When such a cutting develops buds, they must of course be adventitious ones; therefore both the branches and the roots produced by the cutting must be new growths, formed after the cutting has been separated from the mother plant. In these cuttings the roots tend to be developed at the basal ‡ end (in ordinary cases that which was the lower end when the twig was attached to the plant), while the branches grow at the opposite or apical end. And these growths take place, in large measure, independently of the external forces, light and gravitation. Thus (to confine the discussion to the effects of gravitation) the growth is of approximately the same character whether the cutting is placed with its basal end upwards or downwards. When a branch is divided into a number of cuttings, each of which produces roots at its basal and branches at its apical

* Bonn, 1878.

† Arbeiten des bot. Inst. in Würzburg, 1880, p. 452.

‡ "Basal" means the end of a stem or branch which is nearest the root of the parent plant. "Apical" means the opposite end.

end, every one of the cuttings is capable of developing into a new individual: such an individualized portion of a branch is called by Vöchting a *Lebenseinheit* or "*Life-unit.*" At the point where the knife divides the branch it separates a mass of similar cells into two sets, viz. cells which form part of the base of the upper life-unit, and which therefore form roots, and others which belong to the apex of the lower unit, and which develop into buds. The conclusion which Vöchting arrives at as to this simple form of growth is thus given *:—"A living vegetative cell which is capable of growth has not a specific and unalterable function." "The function assumed by a cell depends on the morphological position which it occupies in the life-unit, as the most important condition."

The second class of cuttings are those which already possess "Anlagen" of two kinds—that is, buds and rudimentary roots. Here the same relations hold good. The buds near the apex of the life-unit develop rather than any others, and the root-rudiments near the base develop rather than those near the apex; and this takes place in great measure independently of the position with regard to gravitation occupied by the life-unit.

Vöchting gives this law †:—"When there are a number of rudiments of equal strength and morphological rank, the energy of development of the individual rudiments will depend (as the chief condition) on their morphological position in the life-unit."

From a very large number of experiments, including both classes of cuttings, Vöchting concludes that there is an innate hereditary tendency ‡ in plants which leads to the production of roots at the basal and branches at the apical end of the life-unit. Besides this innate tendency, the external forces, gravitation and light, have an influence on the development of organs. Vöchting § gives two laws formulating his conclusions as to the action of the external forces, the chief point being that the external forces are of secondary importance in comparison to the innate growth-tendency. In summing up this part of the question,

* 'Organbildung,' p. 241.

† *Loc. cit.* p. 241. His second law about rudiments of unequal strength I have omitted.

‡ Vöchting's term "*morphological force*" seems to me a useful one to express the innate tendency to the production of organs in *morphologically* determined positions.

§ *Ibid.* p 243.

Vöchting concludes that a vegetative cell, or group of cells, has such a physical constitution that it requires a certain disturbing force (Anstoss) to make it develop into the rudiment of a root or bud. Disturbing forces or stimuli arise in the life-unit itself and influence the course of cell-division; but such stimuli may also come from external forces.

This, though not any thing like a full account of Vöchting's results, may serve as an introduction to my own work. With the same object, Sachs's conclusions will be briefly summarized. The fundamental point of difference between Sachs's and Vöchting's theories is, that Sachs does not believe in a hereditary growth-tendency. Instead of placing gravitation and light in the second rank of causes, Sachs believes that the growth of organs in the life-unit is entirely regulated by these external forces. According to his views *, the force of gravity, acting on the developing cells of an organ, build up in it a predisposition to the production of roots and buds at the base and apex. This after-effect of gravitation he believes to produce the effects ascribed by Vöchting to a hereditary morphological force.

Sachs differs entirely from Vöchting in the view he takes of the mode of action of the external forces. We have seen that Vöchting considers gravity as an "Anstoss" or stimulus, which tends to produce certain kinds of growth because of the physical constitution (materielle Aufbau) of the formative cells. Sachs's theory rests on the belief that difference of material is a necessary concomitant of difference of form. According to this view, we must believe that the materials from which roots are formed are chemically (in a qualified sense, *loc. cit.* p. 456) different from those which supply branches. Sachs's theory supposes that the growth of roots or buds at a given place will be determined by the distribution of the root- and branch-forming materials; and, further, that the distribution of these materials is regulated by the force of gravity. The root-material is, in a certain sense, geotropic, and flows downwards; the branch-material is apogeotropic (negatively geotropic) and flows upwards. The impulses which cause the formative materials to flow in these directions are supposed to continue as an after-effect of the force of gravity; so that the production of roots at the basal end of a cutting hung upside down is an after-effect of the original tendency of the root-material to flow downwards.

* *Loc. cit.* p. 474.

With this part of Sachs's theory I am not specially concerned; my chief object was to determine whether the phenomena of growth in a cutting are the expression of a morphological force, or are produced by the after-effect of gravitation.

*Observations and Experiments on the Bramble.*

For reasons that will appear later on, I wished to study the behaviour of cuttings in relation to the natural mode of growth of their parent plants: with this object I chose the Bramble for observation, because of its habit of forming roots at the end of its branches. This curious habit does not seem to have attracted much attention from botanists. It is briefly described by Duhamel*, also by Nees and Weihe†, who refer to a mention of it in Pliny.

Lees‡ mentions the rooting of the branches in his paper, "On the Mode of Growth of the British Fruticose Brambles." The chief point of interest is, that the branches are by no means always biennial; the barren rooting-branches may produce barren side-shoots, which flower in the third year and then die; or the barren shoot, after flowering in the second year, may send out barren shoots in the third year, which do not flower until the fourth year §; and, under certain circumstances, life may be prolonged for at least five or six years.

Bell Salter's "Observations on the Genus *Rubus*" || contain some remarks on the habits of growth of Brambles. He describes the ordinary habit of *R. discolor* (Weihe & Nees), "the commonest of our English brambles," and agrees in the main with Lees as to the way in which the growth continues for several years.

Vaucher¶ mentions this mode of reproduction as common to *Rubus fruticosus*, *cæsius*, *villosus*, *laciniatus*, *hispidus*, and, generally speaking, to the biennial class of *Rubus* with palmate leaves.

More recently, Germain de St. Pierre** has called attention to the rooting of the Bramble, and gives a general description of the process.

The essential facts are, briefly, that the end of the shoot makes

* 'Traité des Arbres,' tom. ii. p. 233 (1755).

† Rubi Germanici, 1822–27, Introd. p. 4.

‡ Proc. Bot. Society Edinburgh, March 9th, 1843, vol. i. p. 171.

§ He describes six modes of branching.

|| The 'Phytologist,' vol. ii. p. 91 (1845).

¶ 'Histoire Physiologique des Plantes d'Europe,' 1841, t. ii. p. 272.

** Bull. Soc. Bot. de France, t. xxii. 1875, Seance Extr. d'Angers, pl. liii.

its way into the soil, where it puts out numerous strong roots, which fix it firmly in its place. The roots may arise within a few millimetres from the apex, and extend for some two or three centimetres. If a well-rooted bramble-shoot be pulled up, the growing end of the shoot may be seen surrounded by a nest of radiating roots; this growing end rests during the winter months, and shoots up into a new branch in the spring (Vaucher and Germain de St. Pierre). The end of the shoot is much thickened, and is covered with scale-like rudimentary leaves, and with small prickles densely crowded together; it forms, as Germain de St. Pierre calls it, a "*tubercle bulbiforme*," supplying a store of nutriment for the new growth in the following spring. Branches which have not yet produced roots, but which have grown in shady places, such as among tufts of coarse grass, present a peculiar appearance, which precedes the production of roots: the shoot does not taper, but is cylindrical, or even thicker at the apex than further back; it is generally pale in colour from being semietiolated, and its leaves are dwarfed or scale-like. Germain de St. Pierre notices this fact.

The natural growth of roots in the Bramble differs strikingly from their growth in an ordinary life-unit or cutting; for in all ordinary cases the roots grow at the basal end, whereas in the Bramble they are developed at the apex of the branch. It may be objected that since the growing end of the Bramble develops into a new growth in the spring, the autumnal roots are potentially at the base of a future branch, and not at the apex of the present one. If we look at the facts by the light of Sachs's theory, that the materials for the formation of roots and branches are endowed with specific powers of flowing in different directions, we shall be obliged to consider the growth at the apex of the bramble-branch as true apical growth; since the flow of formative material can have nothing to do with the future continuation of the branch, but must have taken place in the existing part of the branch, and therefore towards the existing apex. It is sufficient for my purpose to be able to say that the roots appear at what is, for the time being, the apex of the shoot.

It is the long trailing branches of the Bramble which usually reach the soil and take root; and since these branches must necessarily have been directed downwards during the latter part of their period of growth, it naturally occurs to one as probable that the roots may be developed at the apex of the branch in obedience to gravitation. For if gravitation and its after-effect determine the distribution of roots, then their growth at the lower end of a bramble-branch would correspond with their growth at the lower end of a cutting. But further observation of the habits of the Bramble make it almost certain that this cannot be the case. Where a Bramble grows on a steep bank, a large number of the branches grow simply down the slope, a further number grow more or less horizontally along the bank and ultimately grow down hill. But a few branches will be found which grow up the slope, and some of these form roots. I have observed this fact among the Brambles clothing a steep bank, cut in the chalk, many parts of which are inclined at 55° to 65°.

The following are the details of some observed cases. The measurements are taken from the root of the plant to which the branch belongs. At the apical end of the branch the measurements are taken to the surface of the soil where the branch enters it, which is almost equivalent to the spot where the roots are produced.

1. A branch grew well above the horizon for several feet, then 6 inches at 10° above the horizon, ending with a single inch 2° or 3° below the horizon, and then produced roots.

2. Grew for 2 feet 10 inches nearly vertically upwards (including the parent branch, from which the branch which ultimately took root sprung), then 8 inches at 15° below the horizon, and produced roots.

3. Grew upwards and highly inclined for 2 feet 3 inches, then 8–9 inches at 5° below the horizon, and produced roots.

4. The first 4 feet were at 10° above the horizon, then came 1 foot 2 inches, which formed a curve (concave towards the bank) whose chord was at 55°. The terminal 2 inches were at 5° below the horizon; and the extremity had taken root.

5. The first 1 foot 6 inches were at 60° above the horizon, then came 2 feet 3 inches horizontal, then 2 feet 8 inches 30° above, and at last 2 or 3 inches at 5° below the horizon, then the roots at the end.

It seems hardly possible that the terminal portion (from 1 to 9 inches in length), being a few degrees below the horizon, can determine the production of roots at the apex. We must, I think, conclude that when the apex of a branch can, as in these cases, reach the soil without hanging downwards, it is able to produce roots at the apex. This is quite inconsistent with the belief that the distribution of root-development is determined by gravitation; since the relation between the chief direction of growth and the force of gravity is exactly reversed in the above cases when compared with the rooting of pendent bramble-branches. It seems only explicable according to Vöchting's law, that there is a tendency to the production of organs in certain morphological positions, a tendency in large measure independent of external forces. This conclusion is supported by the results of the following experiments:—

Two Brambles, which were growing horizontally, or slightly above the horizon, were (Sept. 14 and 23) tied apex upwards to vertical sticks. They were at first wrapped up in yew-branches; but as this did not seem to give the necessary amount of dampness nor to exclude enough light, they were subsequently covered up with damp moss, which was wrapped round with waterproof cloth. At one time both of them bent over so as to become nearly horizontal, and were then tied up again so as to remain vertical. They remained in this position until Nov. 16. It was then feared that the cold weather would prevent the development of the rudimentary roots, which could just be distinguished, and they were accordingly freed from their connexion with the parent plant, the apex remaining uninjured. They were placed in damp air and kept dark, the cut ends being immersed in water. Under these conditions, in an ordinary room, a root, about a centimetre in length, was (Nov. 22) developed at the apex of one of them; and by Nov. 26 the terminal 4 cm. was studded over with roots breaking through the epidermis. The growth at the apex of the branch seemed to be checked, and several minute root-bearing shoots were developed in the axils of the terminal leaves.

In concluding that there is a morphological force in the Bramble which leads to the production of roots at the apical end of the branches, I am far from denying that gravitation has an effect on their production. At the same time that the above-described experiment was made, two other Brambles were tied (Sept. 14) apex *downwards* to vertical sticks, and were covered with moss and yew-branches. On Oct. 14th one of them had produced a number of strong roots at its apex, the other one had grown out below the mass of moss &c. and had not rooted. This fact makes me suspect that gravitation is an accessory stimulus for the production of roots at the apex. This question I hope to decide next autumn.

### *Observations on Cuttings and Mutilated Branches of the Bramble.*

The secondary branches which develop when the end of the primary branch is injured are of two types, which, however, graduate into one another. The first kind is the ordinary leaf-bearing branch, which does not differ from the primary or parent branch. The second type may be called a root-bearing branch*. I found two examples of this kind springing from the apical buds of a branch which hung down into a mass of thick vegetation. The end of the primary branch had become etiolated and thickened, but had been in some way injured before it could produce its roots. The result was that the two most apical buds had grown into semi-etiolated, root-producing branches. These are distinguished by being short (12 and 7 millims.), thick (3 or 4 mm.), and club-shaped, *i. e.* thicker at the apex than the base, by having scale-like leaves, and by producing a crown of rudimentary roots at their club-like ends. In fact they differ from an ordinary side-branch exactly as the root-bearing extremity of the primary branch differs from a common leaf-bearing branch. This type of root-bearing branches I have frequently produced artificially; but the above is the only instance occurring in a state of nature which I have met with.

Figs. 1 & 2 (p. 414) will give an idea of the general appearance of these curious objects. Fig. 2 is drawn from the above-mentioned branch tied vertically up in damp moss, and which produced a few side-shoots.

In the other cases which I have observed of primary branches injured in a state of nature, the root-bearing secondary branches were not of the pure root-bearing type, but rather leaf-bearing branches, which ultimately became root-bearers. Thus I found a primary branch which seemed to have been injured by being trodden on, and the most apical bud had grown into a thin cylindrical branch 9 centims. long, which had then developed roots. Another injured Bramble had produced, from near its apex, a side-shoot $17\frac{1}{2}$ centims. in length, which in like manner bore roots at its extremity.

* It is probably to this type that Bell Salter refers (*ibid.*) when he says:—" The part nearest the end bears no buds, as a general rule, capable of producing shoots, but only of rooting; for I know, from very recent observation, that not only the extreme point, but also the buds near it, are capable of rooting, and occasionally do so."

Fig. 1.

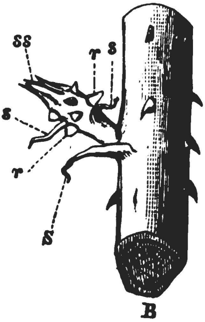


Fig. 2.

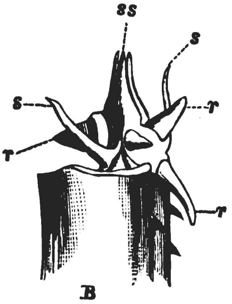


Fig. 1. Root-bearing shoot produced by a bramble-cutting made from a depending branch, but placed apex upwards in the jar. B, the cutting; S, one of its scale-like leaves, in the axil of which the side-shoot is produced; *s s*, the tuft of scale-like leaves at the end of the side-shoot; *s*, the similar scales from among which the roots, *r*, are produced.

Fig. 2. Root-bearing side-shoot, produced from the Bramble tied vertically up in damp moss (see p. 412). The main branch has been cut off on the apical side of the shoot, and the leaf from whose axil it grows has been removed. Lettering as in fig. 1.

Or such cases as the following occur. A bramble-branch, being injured, produced branches from the three most apical buds. Of these one was 123 centims. long, and had developed roots at its apex; then the apex seems to have become unhealthy, for, 7 centims. from the end, it had produced a tertiary branch 16 centims. long, which also developed roots at its apex. It is probable that in the first-described case the damp and dark situation into which the end of the primary branch had grown caused the side-shoots to assume at once a root-producing character, while in the other cases the side-branches (like the main branch) do not produce roots until they have found a suitable situation.

It is this tendency to produce root-bearing shoots which makes it possible to study the growth of roots in the Bramble by means of cuttings.

The experiments with cuttings were made according to Vöchting's method. Pieces of Bramble, generally about 40 centims. in length, were hung vertically inside tall glass jars. The air was kept damp by a lining of filter-paper, which was constantly moistened by a few centimetres of water at the bottom of the jar. The vessels containing the cuttings were then placed in the dark, either in an ordinary room or a cool greenhouse.

Unfortunately but few experiments were made before the frosts killed the buds on all the Brambles in the neighbourhood, so that further work was impossible.

Exp. I.—Sept. 6th. Four cuttings were made, each being 40 centims. in length, and consisting of well-formed wood, the turgescent parts near the apex of the branches being removed.

1. Grew nearly vertically upwards. Placed apex downwards in the jar. The most apical bud grew out with a branch, but no roots were developed.

2. Grew about 10° above the horizon. Placed apex upwards. The most apical bud did not develop, but the next one grew out into a thick shoot, 15 millims. in length, which, on Oct. 11th, bore two small roots, growing out at 5 to 6 millims. from the apex and from the lower side of the shoot.

3. Grew originally 10°–20° below the horizon. Hung apex downwards. On Sept. 23 the three most apical buds had developed into shoots, which curled up apogeotropically. The apical shoot was the best developed, being 14 millims. long and 5·5 thick at its base. All three had produced roots 2 to 5 millims. long, growing chiefly from the lower side of the new shoot. The root-production was more vigorous than in 2.

4. Thin shoot growing 20°–30° below the horizon. Hung apex upwards. On Sept. 21 its apical bud had produced a shoot 15 millims. in length, which, however, never produced roots.

The production of roots from the side-shoot (2) is not conclusive that the root-growth tends to take place at the apical end of the cutting when the apex is upwards; for, since the most apical bud did not develop, there was a piece of stem above the developing 2nd bud, so that a believer in the action of gravity might say that the formative materials flowed down from this piece of stem to the bud.

Exp. II.—The next experiment was made entirely with such parts of branches as had grown inclined above the horizon, and they were all at first hung the apex upwards. They were all about 40 centims. long; and after a soaking in water for 16 hours (apex upwards) they were placed in the jars on Sept. 23.

1. On Oct. 4th the apical bud had grown best, although badly, but had produced no roots. It was now hung in the inverse position; and on Nov. 3rd (possibly some days earlier) the apical shoot had produced a few small roots.

2. The most apical bud, 3 centims. from the end of the cutting, was the only one which was developed; and on Nov. 9th it had grown into a shoot 4 centims. long, 3 millims. thick at the base, and tapering towards the tip. At 9 millims. from the apex of this shoot was a shining projection, which was proved by microscopical examination to be the rudiment of a root. I had observed this swelling several days previously; but as it had shown no signs of increasing in size I thought it useless to continue the experiment.

3. The most apical bud did not develop; the next three buds, distant 15, 28, and 34·5 centims. from the apex, were well developed on Oct. 24. The most apical shoot was 25 millims. in length to the tip of its scale-like leaves, 7 millims. thick, and had two or three roots growing out from its lower side, and many others just visible as rudiments. The other two shoots showed no sign of root-formation. This case is irreconcilable with the belief that the root-forming matter in the cutting tends to flow downwards; for if this were the case, the lower, not the uppermost, shoot would have produced roots. We may therefore attach more value to the case of bramble No. 2 in the first experiment (see p. 415).

4. The apical bud, 25 millims. from the end, was the only one which developed; and on Nov. 9th it had grown into a shoot 5 centims. long, 5 millims. thick at its base, and tapering towards the tip. At 8 and 13 millims. from the tip were two shining swellings, about 1 millim. in height, which were proved microscopically to be undeveloped roots.

5 & 6. The most apical bud developed in both, but decayed without rooting.

7. Oct. 4th, the apical bud was developed, but had not rooted. It was then hung in the inverse position; and on Oct. 20th it had made a few small roots.

As already pointed out, the cases such as No. 2 in Experiment I. and No. 3 in Experiment II. are not quite conclusive; but Nos. 2 and 4 in the second experiment leave no room for doubt. The part of the branch from which the root-bearing side-shoot was developed had always grown above the horizon; it had hung apex upwards during its life as a cutting; the shoot was developed from the most apical bud, close to the end of the cutting; and the rudiments of roots were developed near the apices of these side-shoots *.

* Some other experiments were made on cuttings and mutilated branches

Before finally giving the conclusions for which these facts give part of the data, it will be well to state clearly what is meant by the after-effect of gravitation, which is not a well-defined term. Thus, for instance, Vöchting * believes that his innate growth-force has arisen as a "gradually accumulated function" of gravitation and light. Such an effect might, no doubt, be called an after-effect; but it is not in this sense that I use the word: I take it to mean the growth-tendencies which are produced in an organ through the action of gravitation *during the development of the constituent cells of the organ in question.* It is in this sense that Sachs † alludes to the effect produced by the previous action of gravitation; for he speaks of an organ kept in slow rotation during its growth as being thus freed from the predisposing influence of gravitation.

Since, then, we have seen that Brambles, whether they have grown above or below the horizon, tend to produce both leaf-bearing and root-bearing branches near the apex, we cannot account for the fact through the after-effect of gravitation, but must believe in some internal morphological force.

Thus the result of the experiments confirms the conclusions arrived at with regard to the normal growth of roots at the end of branches (see p. 412).

Vöchting has made the interesting observation (Bot. Zeitung, 1880, p. 595) that cuttings made from branches of weeping varieties of various trees behave like cuttings of ordinary trees, and produce roots at their base and branches at their apex. This fact shows that the distribution of root-growth and branch-growth is exactly the reverse of that in ordinary cuttings, *when considered in relation to gravitation*; but it does not, I think, prove the existence of a morphological force. It might be assumed, by a modification of Sachs's hypothesis, that the sensitiveness to gravitation has been reversed in the branches of weeping trees, and that the tendency to produce shoots at the apex is a consequence of this kind of sensitiveness. The cutting of a weeping tree would thus differ from an ordinary cutting just as an apogeotropic organ differs from a geotropic organ, in having a reversed sensitiveness to gravitation. But such an objection cannot be urged against the

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which had grown apex downwards in a dependent position, with the result that the most apical buds grew into side-shoots, which assumed in some cases a root-bearing character.

* Bot. Zeitung, 1880, p. 596: "Eine allmählich accumulirte Function der genannten beiden Kräfte."

† *Loc. cit.* p. 475.

conclusions with regard to the growth of Brambles; for a Bramble, which may be said to produce weeping and erect branches on a single plant, could not, by any kind of sensitiveness to gravitation, always produce its roots at the apex of the branches.

The second object which I had in view in working at the Bramble was to answer the questions, Why is it that a plant is divisible into cuttings having certain growth-tendencies? How can it help the plant in its normal growth, to possess the properties which exist in the artificially produced life-unit? I have been able to form a hypothesis with regard to the Bramble which may prove to be applicable to other plants. When any injury happens to the apical end of a bramble-branch (the basal end being in continuity with the parent plant), one or more buds grow out into side-branches. These side-branches may either be ordinary leaf-bearing or else root-bearing branches. In either case they perform the function which the injured part of the parent branch would have performed. And this power of carrying on the *function* of a part, in spite of an injury received, must clearly be advantageous to the plant *. The question then arises, Which bud is in the best position to carry on the disturbed function? And it seems quite clear that the buds morphologically nearest to the apex must be in the best position for carrying on the function of the apex. If, for instance, a branch growing down towards the earth is injured, and thus prevented from bearing roots at its natural apex, the most apical bud will be in the best position for producing a rooting branch at least cost of growth. Again, the distribution of the Bramble is facilitated by the power which the branches have of creeping along the ground, and taking root many feet (*e. g.*, 8 feet) distant from the parent plant. If such a branch is injured, the most apical bud will be in the best position for continuing the duty of providing for the distribution of the plant, and thus carrying out this function of the injured apex.

* Vöchting says ('Organbildung,' p. 107) that "If the actually or potentially unlimited growth of the stem or root is interrupted by section, it (the growth) is continued at the ends thus formed, either by rudiments (Anlagen) already present there or by new formations. The roots at the apical end of a root, and at the apical end of a branch, represent the continuation of the interrupted apical growth of the root; the buds at the apical end of a branch, or at the basal end of a root-cutting, represent the continuation of the interrupted apical growth of the branch." (The phrase which I have translated "represent the continuation" &c. is "stellen die Folge der Unterbrechung des Spitzenwachsthums . . . dar.")

The same kind of argument might, I believe, be applied when any other function of a branch is interrupted through injury.

If this conclusion as to the growth of the most apical bud on mutilated branches of the Bramble be correct, it may, I believe, be directly applied to explain the growth of bramble-cuttings.

In a bramble-cutting the only growth which takes place, whether of roots or branches, tends to occur at the apical end. Such a cutting resembles, in fact, one of the above-mentioned mutilated branches, except in that it has been separated at its base from the parent plant. And the morphological force which resides in the cutting is the same thing as the regenerative impulse which makes the more apical buds take up and continue the function of a branch whose apical part has been injured.

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## A Revision of the Genus *Vibrissea*. By William Phillips, F.L.S.

[Abstract. Read January 20, 1881.]

In this communication the author in his introduction reviews the genus as established by the late E. Fries of Sweden; and he refers to the various species added by subsequent writers. He notices the curious characteristic phenomenon of their projecting their long slender sporidia with great force, and their giving a velvety appearance to the hymenium when removed from the water in which they grow. Crouan's *Vibrissea Guernisaci* differs in form from the genus as originally defined by the absence of a stipes; and hence some authorities have inclined generically to separate it; but Mr. Phillips finds it projects its sporidia, and for this and other reasons retains it and three other species in a sessile division of the genus. He selects *V. truncorum* as a typical form, and describes in detail its minute structure and other peculiarities. Thereafter he amends the definition of the genus as follows:—

Vibrissea, *Fries, amend.*—Aquatic fungi (except *V. rimarum*) bearing the exposed hymenium on a plane or cup-shaped membranous receptacle, stipitate or sessile, fleshy in texture, firm, ejecting from the asci slender elongated sporidia, which often remain attached by their extremities to the surface of the hymenium, giving it a velvety appearance. *Hab.* On decayed wood, submerged in water.

Descriptions of eight stipitate and four sessile species follow; and *V. Persooni*, Corda, and *V. pubescens*, Rabh., are rejected. The paper in full, with plates, will appear in the Society's 'Transactions.'