If again we suppose l_1, l_2 and l_3 to lie in a plane φ then in the first place we have to deal with all the conics through one of the points of intersection P of those three lines resting on the remaining five lines, whilst their planes pass through M.

Now, according to § 4, P is a twelvefold point of the locus of the conics through P resting on five given lines; this locus proving to be of degree 18, the right line PM is intersected twice by six conics of the surface. In this way we find 18 proper conics satisfying the given conditions.

The line connecting the traces of l_4, l_5 on φ determines with M a plane on which l_6, l_7 furnish two points of the second right line of a degenerated conic. This consideration furnishes 6 conics.

If the line connecting M with the trace L_4 is intersected by the transversal t of l_5, l_6, l_7, the line of intersection of φ with the plane (Mt) completes the line t to a degenerated conic answering the question. In this way 8 new solutions are found.

Finally we find 2 more answers by connecting each of the transversals of l_4, l_5, l_6, l_7 by a plane with M; each of the traces of those planes on φ is then the second right line of the degenerated conic.

Thus we arrive at the conclusion, that $\mu\nu^4 = 34$.

Botany. — Dr. W. BURCK, presents a paper: „*On the irritable stigmas of Torenia Fournieri and Mimulus luteus and on means to prevent the germination of foreign pollen on the stigma.*"

While occupied last year in Batavia with an investigation about the question whether or no there exist contrivances on the stigma to prevent the germination of foreign pollen, concerning which I presented a paper in the Meeting of September 29, 1900, my attention was drawn by a biological particularity of the irritable stigmas of *Torenia Fournieri*. This induced me to a nearer research, which I have been enabled to continue in this country on another plant with irritable stigmas: *Mimulus luteus*.

Irritable stigmas have been known for a long time. Already LINNAEUS and KOELREUTER mentioned them, and later they have been repeatedly discussed, in particular for the various species of *Mimulus* [1]).

[1]) See on irritable stigmas: DELPINO, Bot. Zeit. 1867. pag. 284.
BATALIN, Bot. Zeit. 1870 pag. 53.
CH. DARWIN, Cross- and self-fertilisation. Chapt. 3. Mimulus luteus.
A. HANSGIRG, Phytodynamische Untersuchungen in Sitzungsberichte der Konigl. Böhmischen Gesellschaft der Wissensch. 1889 II, p. 308.
KERNER VON MARILAUN, Pflanzenleben II. p. 260.

Personally I observed them, besides in the above named plants, in *Mimulus Tillingii*, *M. hybridus*, *Incarvillea Delavayi*, *Martynia fragrans*, *M. formosa*, and *M. proboscidea*.

In all these plants the stigma consists of two broad lips which, in normal state diverging under a considerable angle, on being touched approach each other and close.

In nature this closing of the lobes of the stigma is caused by some insect penetrating the flower in order to get to the nectar. The structure of the flower does not allow the insect to reach the honey without touching the lips. So if an insect withdraws from the flower, the before widely opened stigma is seen to have closed during the visit.

Furthermore it has been observed that if the stigma is only touched by the insect, the lobes will soon open again, but that they remain shut when the insect has at the same time rubbed off on them some of the pollen it carried along.

In my experiments on fertilisation with *Torenia Fournieri* my attention was roused by the different behaviour of the lobes of the stigma, according as the pollen was taken either from the two shorter or from the two longer of the four didynamous stamens.

If the pollen was taken from the *shorter* stamens, the stigma reopened after a few minutes, but the lips remained closed when the pollen had been taken from one of the *longer* ones.

It should now be remarked that the anthers of the two longer stamens of this *Torenia* burst during the flowering and bring their pollen to the surface; those of the short ones, however, don't open. As a rule we find after the fertilisation the anthers of the short stamens still closed in the fallen corolla.

For the rest they are completely developed and their remaining closed is the only difference to be observed in these anthers.

A soft pressure of the anthers with a piece of glass will suffice to collect on it all the contents of the two cells, and now it also appears that the pollen freed in this way does not differ from that of the longer stamens. As a proof of its complete maturity may be added that just as well as that of the longer stamens it begins to germinate in a drop of distilled water, after 2 hours, if the precaution has been taken to put at the same time a stigma of *Torenia* in the drop of water.

I have moreover found that fecundation is as well effected by it as by the other pollen.

So the only difference, between the freely expelled pollen from the longer stamens and that enclosed in the shorter ones is found,

— save in what will presently be said, — in their relation to the lobes of the stigma.

In order to see how the stigmas behaved toward the pollen of another origin, they were covered with that of *Cassia florida*, *Morinda citrifolia*, *Begonia spec. div.*, *Canna indica*, *Calonyction speciosum*, *Argyreia speciosa*, *Impatiens sultani*, and of many other plants selected at will, whereby I found that whichsoever pollen might be used, the stigma always reopens within 10 to 15 minutes and thus behaves towards it in the same way as to the pollen from the shorter stamens.

Only then when the pollen from the long stamens has been deposed on the stigma its lobes remain closed, no matter whether the stigma, in previous experiments, has already been dusted with the pollen of one or more other plants.

I have now found of late that the irritable stigmas of *Mimulus luteus* display the same particularity with this difference, however, that the stigma of *Mimulus always* remains closed when dusted with its own pollen, no matter whether it is taken from the shorter or the longer anthers.

Dusted with pollen of another origin the closing was always of short duration. Experiments were made with the pollen of *Hemerocallis fulva*, *Digitalis purpurea*, *Epilobium angustifolium*, *Tropaeolum majus*, *Torenia Fournieri*, *Pisum sativum*, *Datura Stramonium*, *Ononis spinosa*, *Maurandia erubescens*, *Lathyrus odoratus*, *Impatiens noli tangere*, and other plants.

A nearer examination of the stigmas of these two plants proves that the inner surface of the lips is highly irritable. The slightest touch makes them close directly. The outer surface, on the other hand, can bear considerable irritation without this causing the closing of the lobes. Few minutes, — in the mean a quarter of an hour, — after the lobes have closed in consequence of the stimulus, they open again and may then anew be induced to close in the same way. This can be repeated many times consecutively without the stigmas losing their irritability. The stimulus acts locally, that is, touching the inner surface of one of the lips does not affect the other but only makes the directly touched one move. If the style is cut through this changes nothing in the sensibility of the lobes, which are neither thereby brought to a temporary closing. Moreover, either of the lips may be cut away wholly or partly; the remaining portion continues irritable in the same degree. In consequence of the wound the stigma will shut, but within the determined time it is open again.

The closing of the lobes when pollen is deposed on them is exclus-

ively due to the thereby nearly unavoidable touching of the irritable inner surface.

If very cautiously a quantity of pollen is shedded on the stigma, so that the grains adhere to the stigmatic hairs, the lobes remain open; if it is effected more or less rudely, so that the cellular tissue is touched, they close.

What has been stated here about the closing in consequence of some mechanic stimulus, and the again opening of the stigmatic lobes when that stimulus has ceased to act, clearly points to the fact that the irritable stigmas, in their movements, show many points of accordance with what has been observed in other irritable organs, for instance, in the articulations of the leaves of *Mimosa pudica*, the stamens of *Centaurea jacea*, and other *Cynareae*, so that by analogy it may be admitted, that touching the inner stigmatic surface is accompanied by a loss of water in the turgescent cells at that place, in consequence of which the cell-layers at that side lose their tension, whilst that at the outside increases by the absorption of a part of the expelled water. Hence, the tension of the outer side becomes greater than that of the inner one which explains the closing of the lobes.

When now the stimulus has ceased to act the flaccid cells at the inner face again absorb water, by which the turgor is restored and the lobes reopen again.

Hence it follows that the reopening of the stigmatic lobes, after they have been temporarily closed by only touching or by covering them with pollen, may be referred to well-known phenomena, but that the *not* opening of the lobes when pollen is shedded on them, of the same species (*Mimulus*), or from special stamens of the same species (*Torenia*), requires some explanation. It is clear that here, in dusting a stigma with this special pollen, a factor appears which prevents the restoring of the turgor.

In order te explain this phenomenon it should be observed that the stigmatic fluid of different plants not only varies in qualitative composition, concerning which some particulars were given in the account of the Meeting of Sept. 29, 1900, but that, besides, to all probability, the different constituents of this fluid can occur in varying proportions; that the concentration of the stigmatic fluid can vary very much, and that pollen-grains of distinct origin diverge considerably in their power of drawing water from one and the same stigmatic fluid. The latter fact may at once be seen by putting pollen of distinct plants in a solution of saccharose of a

certain degree of concentration, which solution might be called a stigmatic fluid of the simplest composition.

It is likely that among these different kinds of pollen there may occur some, — if at least concentration be not too high — which by a too energetic absorption of water burst at once, and whose contents stream out into the liquid in the same way as is seen with many species of pollen brought into pure water. Among the species of pollen which do not burst there are some which increase in size under absorption of water.

Pollen-grains which in the dry state are elliptical, such as those of *Hemerocallis fulva*, *Torenia Fournieri*, *Digitalis purpurea*, *Maurandia erubescens*, are rounded thereby into balls.

A few species form their germinal tubes [1]) in the fluid, and finally, there are some which not only don't germinate but neither suck water from the liquid, and retain the shape and size which they possessed in the dry state. The higher the degree of concentration, the less the pollen-grains are able to draw water from the saccharose solution.

Also pollen-grains of plants of the same genus frequently possess in a very different degree the power to absorb water from a solution of saccharose.

---

[1]) It is known that many species of pollen which do not germinate in water, may be induced to do so in solutions of sugar, agar-agar, gum, dextrine, or in mixtures of these substances in a certain degree of concentration for each species. Hereabout informations have been given by VAN TIEGHEM *a*), KNY *b*), STRASBURGER *c*) and MOLISCH *d*).

MOLISCH determined for 60 plants the degree of concentration which should be given to the canesugar solution in order to call forth the germinal process. From his statement it appears that there are pollen species which no more germinate when the saccharose solution is higher than 2 pCt. (*Platanthera bifolia*) or 5 pCt. (*Allium ursinum*), whilst some can still germinate in solutions of 40 pCt. a few even in solutions of 50 pCt. (*Epipactis latifolia*, *Lilium Martagon*). It is now supposed that this proves that special relations of nutrition govern the germination, and that distinct species of pollen have in this respect distinct requirements. However, considering the fact that a great many pollen-grains want no food at all to germinate, and that others form their germinal tubes in water with addition of a special chemical substance, which can serve as a stimulus, it is my opinion that we should rather think here of an adjustment for the absorption of water required for the germination.

a) Annales des s. c. nat. Bot. 5me Série, tome XII, 1872.

b.) Sitzungsber. des bot. Vereins d. Provinz. Brandenburg XXXIII, 1881.

c.) STRASBURGER, Neuere Untersuchungen ueber den Befruchtungsvorgang bei den Phanerogamen, etc. Jena, 1884, PRINGSHEIM's Jahrb. Bd. XVIII, 1886.

d.) H. MOLISCH. Zur Physiologie des Pollens. Sitzungsber. der math. naturw. Classe der K. Akademie der Wissensch. Wien. Bd. CII, Abth. I, 1893.

Impatiens sultani, for instance, can do this from solutions of 0—20 pCt., *J. balsamina* of 0—10 pCt. and *J. latifolia* of 0—8 pCt.

Beneath the limit mentioned for each species they are all three able to form their germinal tubes; above that limit the germination ceases, together with the absorption of water and the accompanying increase of volume.

In the same way as the pollen behaves towards saccharose solutions, it behaves towards *the fluid of the stigma*, and now it is my opinion, that as a rule it may be admitted that pollen, which does not besides put special requirements to the qualitative composition of the stigmatic fluid (of which my paper in the Meeting of September 29, 1900 treats), can only then germinate on a stigma when the concentration of the stigmatic liquid does not exceed a certain maximum, varying for each species of pollen.

The fact, now, that the stigmas of *Torenia* and *Mimulus* open no more after being dusted with their own pollen (*Torenia* with the pollen from the longer stamens) should be ascribed to the faculty of these kinds of pollen to withdraw considerable quantities of water from the stigmatic fluid of those two plants.

This withdrawing of water is the factor which counteracts the restoring of the turgor.

Direct observation taught me that none of the other pollen species with which experiments on fertilisation had been made possess the same property.

If the elliptical pollen of *Hemerocallis fulva*, *Maurandia erubescens*, *Digitalis purpurea*, or *Lupinus Cruykshanksii*, is put on the stigmas of *Mimulus* or *Torenia*, and if it is again examined after the stigmas have reopened, it is seen to have retained the shape which it possessed in the dry state; none of the grains has been able to become globular.

The pollen of *Torenia*, on the other hand, also elliptical as long as it is dry, and that of *Mimulus*, which on the optical section shows an oblong square, is directly after the stigma has closed found back between the lobes strongly swollen and rounded into balls.

That this is indeed the explanation of the observed phenomena is shown by control experiments. In the first place we see that when the stigma of *Torenia* or *Mimulus*, is covered with pollen which beforehand has been enabled to absorb water and become globular, — simply breathing over the pollen will suffice to this end, — this pollen acts in the same way on the stigma as foreign pollen, namely, as concerns the reopening of the lobes. Just the same is seen to occur when the stigma, previously to the fertilisation, is moistened by means of a pulverisator. Furthermore the fact that, when using

the pollen from the shorter stamens of *Torenia*, the stigma opens again, and not when that from the longer is taken, may likewise be referred to the difference in the ratio of water of these grains.

If the pollen from the closed shorter stamens is collected on an piece of glass and exposed to the air for some time until, by loss of water, it has assumed the elliptical shape, it acts in the same way as that of the longer, and if, inversely, that of the longer stamens is used when these have not yet opened, it behaves on the stigma like the pollen from the shorter.

Finally, to determine whether both species of pollen possess the faculty of absorbing water in an equal degree, pollen of *Torenia* was put on the stigma of *Mimulus*, and inversely, that of *Mimulus* on the stigma of *Torenia*. It appeared now that the stigma of *Torenia* remained closed when dusted with pollen of *Mimulus*; inversely, however, the stigma of *Mimulus* opened again after being dusted with pollen of *Torenia*, whence it is evident that the power of absorbing water is greater in *Mimulus* than in *Torenia*.

In reference to an earlier paper on contrivances on the stigma to prevent the germination of foreign pollen, in which it was inferred that for some plants the pollen-grains want a special chemical stimulus in order to form their germinal tubes, I will now call to mind, in accordance with what has been mentioned above, how also the concentration of the stigmatic fluid should be considered as a means to prevent the germination of foreign pollen.

Torenia and *Mimulus* have hardly any chance of foreign pollen-tubes developing on their stigmas. The composition of their stigmatic liquid warrants them from it.

What has been stated here is by no means an isolated fact but should be considered as a special case in the appearance of a frequently occurring means to prevent the germination of foreign pollen. Accordingly, in many cases it explains the phenomenon mentioned by STRASBURGER [1]) that very often the pollen of closely allied plants cannot germinate on each other's stigma, whilst foreign pollen does.

The description of a few more experiments will nearer elucidate this point.

The pollen of *Impatiens sultani*, *I. Balsamina*, and *I. latifolia*, belong to those kinds which easily germinate in distilled water.

---

[1]) STRASBURGER, Ueber fremdartige Bestaubung. Pringsheim's Jahrb. fur w. Botanik, Bd. XVIII, 1886.

As a rule, it begins to form the germinal tubes directly after being laid in water, whilst other species only after 2 or 3 hours show the first signs of germination. In a quarter of an hour already the pollen-tubes have got a considerable length. Hence, that pollen does not want a special chemical stimulus, nor a germinal fluid of a higher degree of concentration.

In dilute solutions of saccharose, levulose, dextrose, and mannite, it germinates as well as in water.

How indifferent this pollen may appear, it is still far from being able to form germinal tubes on all possible stigmas.

If the pollen of *Impatiens sultani* is introduced into the thick viscous liquid which covers the stigmas of *Uvaria purpurea*, it does not try to form germinal tubes, and when, after residing for several hours in this fluid, it is again put in water, the germination leaves nothing to desire. If then again a portion of the viscid matter is put on a piece of glass and diluted with water, the pollen-grains of *Impatiens* directly begin to germinate, whence may be inferred that only the higher concentration prevented the germination on the stigma.

If now the experiment is inverted by covering the stigma of *Impatiens sultani* with pollen of *Uvaria*, then, after about 24 hours, the germinal tubes are seen to appear. Such like cases, where the pollen of a plant *A* germinates on the stigma of *B*, but inversely, not that of *B* on the stigma of *A*, STRASBURGER has frequently called attention to. The above observations give a plain explanation of the phenomenon, though, of course, for other plants other causes may be active too.

As little as on the stigmas of *Uvaria* does the pollen of *Impatiens* germinate on the stigma of *Pentas carnea*, *Begonia goegoeënsis* and *Torenia Fournieri*. It can remain for days on these stigmas without any change being observed. If then the stigmas of *Begonia* and *Torenia* with the pollen of *Impatiens* upon them are put in a drop of water, they will begin to form germinal tubes within a few minutes. For *Pentas carnea*, however, the high concentration of the stigmatic liquid is not the only cause that the pollen-grains do not germinate in it. After having been on the stigma of *Pentas carnea*, the pollen of *Impatiens* is dead, no matter whether it has been for some days, or only for a few hours in contact with the stigmatic fluid. This evidently poisonous influence on the pollen of *Impatiens* is, however, only exerted by the concentrated liquid of the stigma. If a stigma of *Pentas carnea* is placed in a drop of water in which pollen of *Impatiens* has been sown the germination is quite satisfactory.

Inversely, the pollen of *Pentas* germinates on the stigma of *Impatiens sultani*.

Finally I wish to observe that the 3 mentioned species of *Impatiens* can form germinal tubes on one another's stigmas.

Returning to *Torenia* and *Mimulus* we have to pause a moment at the question what use those plants can draw from the possession of an irritable stigma. This question should be considered regardless of the advantage which many plants, — albeit not all[1]), — can have in possessing a stigmatic fluid of such a composition that not each kind of pollen can develop in it.

That advantage the plants would likewise enjoy if their stigmas had not the power of shutting.

It is the general opinion that the movements of the stigmatic lobes of *Mimulus* will prevent the self-fecundation of the flowers.

It is i. a. asserted by BATALIN [2]), that when a bee without pollen on its back penetrates a flower, it touches the stigma and when then the bee laden with pollen flies away, it cannot rub off the pollen on the stigma of the same flower. When entering *another* flower, however, the pollen is brushed off on the stigma, by which cross-fertilisation is effected. I doubt, however, whether the insect can actually contribute to the fecundation of *Mimulus* by pollen of another individual.

Mimulus being a profusely flowering plant, the *other* flower referred to: the one visited after the first, is all but always a flower of the same plant. That flower gets pollen from the first, the third from the second, the fourth from the third, and so on. Finally the bee, still laden with pollen of *Mimulus*, leaves the plant and may carry this pollen to the first flower of another *Mimulus*; but the chance that it will directly return again to a *Mimulus* does not appear greater to me than its visiting quite another plant.

But let this be as it may, albeit that the structure of the flowers of *Mimulus* has given rise to the opinion that the irritable stigmas prevent self-fertilisation, because first the stigma is touched before the insect comes in contact with the anthers, this holds only good

---

[1]) From STRASBURGER's experiments may be inferred that often germination of foreign pollen on the stigma and the entering of foreign pollen-tubes into the style-canal and the ovarium do not prevent the development and growth of the plant's own pollen-tubes and the normal course of the fertilisation.

[2]) A. BATALIN. Beobachtungen ueber die Bestaubung einiger Pflanzen. Bot. Zeit 1870. p. 53.

for *Mimulus* and not for *Torenia*, as for the latter the relation is just the reverse. In *Torenia* the two longer stamens are placed in such a way with regard to the stigmas, that a bee first loads its back with pollen, in order to rub it off on the stigma on its farther penetrating the flower.

Hence, if the irritable stigmas of *Torenia* had first been examined instead of those of *Mimulus*, the opinion would never have prevailed that they should serve to prevent self- and promote cross-fertilisation.

The view of KERNER VON MARILAUN [1]) that the movement of the stigmatic lips should serve to carry the pollen to a spot of the stigma where it can further germinate is based on the double supposition that the pollen on the stigma changes its place by the movement and that not each part of the stigma is fit for its germination. Neither the one nor the other assertion I have found confirmed.

In my opinion, therefore, there has hitherto not been given a right explanation of the advantage which a plant may draw from the possession of irritable stigmas.

The closing of the stigma after fertilisation with the plant's own pollen is undeniably accompanied by the advantage that not on each consecutive visit of insects it runs the risk of being rubbed off the stigma to be replaced by pollen of perhaps quite another origin. But this advantage is counter-balanced by the drawback that the inferior pollen from a flower of the same plant, can neither be replaced by pollen of another individual If the stigmas did not close, then, with frequent visits of insects and after its own stamens had been emptied, many a flower of *Torenia* might be crossed and for *Mimulus* the same might take place still before its own stamens had been brushed out.

To this, however the way is closed, and the said consideration leads to the conclusion that the advantage can in no case be of great importance.

Physics. — "*On the origin of double lines in the spectrum of the chromosphere, due to anomalous dispersion of the light from the photosphere*". By Prof. W. H. JULIUS.

(Will be published in the Proceedings of the next Meeting).

---

[1]) KERNER VON MARILAUN, Pflanzenleben II, p. 260.

(October 23, 1901).