(From the German)
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MATERIAL GROWTH AND GROWTH
By
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SECTION I.

INTRODUCTION.

"Any direct expression of a fact in science is valuable as temporary generalities and schemes, which are at times necessary to preliminary navigate theory, but need to be always checked or corrected, when a rule which has become a scheme, proves inadequate."
Julius Sachs, 'Fabric and Shape of Plant Organs'.

In this paper I will discuss on the basis of my investigations in recent years carried out some physical properties of the growth-promoting substance that is formed in the Coleoptile tip of Avena, and its role in the growth and the phototropic curvature.

As was the result of some preliminary tests, I already discussed (Went 1926), the methods should be briefly mentioned again. If you cut off a certain number of Coleoptile tip on Agar, gelatin or gelatin-silica, can stand for some time as a growth-promoting substance diffused into the jelly. The tops taken off again, then the concentration of this substance in the Agar is so high that it can increase growth significantly. This can be demonstrated by the Agar-side on decapitation.

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Seedlings sets, the growth of the flank below the Agar, is then increased compared to that of the other side, facing away from the Agar so that a curvature results. In addition, I further can show, that the curvature of the concentration of that substance is directly proportional, so it is possible to examine this material:

1.the formation in the tip.
2.transport from the apex to the growing parts.
3.the effect of the growing zone.
4 its role in tropism curvatures.

In this section I shall now give a brief historical overview of the issues that I have examined.

A more complete summary of the literature can be found at Söding (1927) and Stark (1927).

The above growth-promoting substance has been taken already by various authors under the name term *hormone*. Therefore, I would first consider this question in more detail.

A hormone in the body is *"a dissolved substance is transferred by any of the liquids of the body, usually the blood, from one to the other components of the correlation."*

By this definition, a hormone is functionally equivalent to the nerve conduction. The animals thus have two ways to get to an effective combination of various organs, namely the nervous system and hormones.

The plants do without the nerves, but many studies show us that a material relationship between the cells or organs of a plant exists, which is usually designated by the name correlation.

For these considerations are close to that need to be in the general physiology of plant hormones. On one hand they correlate, and support on the other. These are brought together under one term. However, it is perhaps better not to use the name for plant hormone support correlation, because otherwise it takes the concepts, even secondary concepts and other details, that bring the plant physiology by more than advantages. For this purpose, we may perhaps to mention the stimulus term that has been transferred, now associated with the nerve pathways in plants.

The important fact that correlations based on the plant of dissimilar influences in plant physiology was first recognized by Sachs. He discussed it in detail in his thesis: *Substance and Form of the Plant Organs* (1880 and 1882). This was before the hormone concept had been established in animal physiology. Since then it has not progressed very far in plants. Some correlations could be shown that occur on any substance, but hardly what the substance investigated.

Sachs (1887) described a bloom-forming substance in the leaves of a plant Tropaeolum under the influence of ultra-violet rays, created from the growing point. Without this substance, which can not be regarded as a nutrient, no flowers are formed.

Haberlandt (1913, 1914, 1919) was able to show that you get on small tissue fragments isolated from the potato tuber cell division only when Leptom *(sieve elements)* is in the piece of tissue. If Leptom is not present, it is still possible achieve cell division, if you it stuck a piece containing Leptom. Here it is to be done with a material correlated between Leptom and parenchymal cells.

Ricca (1916) had found a substance that is formed in the stimulation of mimosa sprouts, and its transport by a branch-twig, taking place with water-filled tube. He also points out the fact that this material is equivalent to the animal hormones. Although his attempts were often questioned. Snow has recently (1924 b) provided a complete confirmation. Seidel (1923) attempted the chemical nature of the irritant to come closer, at an unambiguous result, but it is not reached.

As Sachs (1880) had, well as van der Lek (1925), found for the rooting of cuttings, a hormone migrating down the phloem (Sachs *Root-Forming Substance*) which is formed in the sprouting buds.

Neulich has recently (1927), in connection to Miss Kastens (1924), again argued for a hormonal relationship between the shoots and leaves growing out the growth stratification of wood body.

I can still give some more examples, but because the substances were not found itself, it is unnecessary to further enumeration. Because in this work I give only correlated support, I need not continue on gall-forming substances to enter into necrosis wound hormones (Haberlandt 1921 a and b) and Auxin (Bottomley 1915), because either there are substances introduced from outside into the organism. These are to be regarded as degradation products of dead cells. These substances are not regarded as an intermediary in coordinating the various parts of a plant.

I can now proceed to discuss the material examined by myself.

It's only a matter of looking for a suitable name for this substance. In the preliminary communication (Went 1926) I have used the neutral name of *Growth Regulator* (Miss. Seubert 1925), because it still was not known whether or not it is present as co-growth promoting substances and growth inhibitors which influence the growth. Therefore, this designation is too vague. *Growth enzyme* is certainly incorrect, because there is no enzyme (see p. 64). For the above reasons, it is better not to use *growth hormone* (Söding 1923). *Auxin* also has been used (van Dillewijn 1927). However, using the name Bottomley (1915) had already been applied to substances that are present in culture media and the watchtower of the organisms that stimulate and penetrate from the outside. So, in the plant body it has nothing to do with correlation carriers. Although I have a possibility that the growth-promoting substance chemically related or identical to the Auxin is wise, not from the hand, I still believe that the name can not be transferred to the former. There are very different concepts. For one might establish the following parallelism between tie around plant physiology: *Growth Promoting Substances - Hormones, and Auxin - Vitamin.* Added to this is the *Growth Substance.* This name seems very appropriate because it implies that the material caused growth.

Firstly the substance in the seedlings of grasses have been investigated, after the opinions are obtained here on dicotyledonous seedlings (Beyer Cholodny 1925 and 1926) and Stark (Söding 1926) were transferred.

Paal (1914, 1919) had already concluded the growth-promoting effect of Coleoptile tip from his experiments. Söding (1923, 1925) has confirmed these results by direct growth measurements. Because decapitated Avena seedlings grow during the first five minutes slower than intact plants, but that is slower than the decapitated Coleoptile, where the cut-off point was again stuck. Also, Cholodny (1924), Beyer (1925), Miss Seubert (1925) and Dolk (1926) obtained similar results

The experiments with Paal's unilateral placement of the cut-off points, where the stumps are gone from the top curve, that was repeated (Nielsen 1924, Snow 1924 a, 1925 and Beyer Dolk 1926). The growth-promoting effect of the tip have been reached, therefore a complete match.

Putting to one side Coleoptile stumps, then the curvatures are positive directed (Stark 1921, Nielsen 1924, however, was an exception for the ring directly under the tip, Dolk 1926), it causes a growth-inhibiting effect of the rings.

After the experiments of Miss Gorter (1927), it is very likely that this growth inhibition is only simulated by the formation of a physiological tips which occurs 2-3 hours after decapitation. Only conclusive tests were carried out within this period.

In the experiments, to extract the growth-promoting substance from the seedlings, by mixing with peaks of press juice Agar, stumps stuck of one side, you always obtain a so-called *growth inhibition* (Stark 1921, Nielsen 1924, Miss Seubert 1925). Again, The same criticism: the growth inhibition is only apparent, and in fact extracts have no effect on growth.

Finally, the attempts by Miss Seubert (1925) and Miss Gorter (1927) mention that the influence of various chemical substances have been studied on growth. The result is here: saliva, diastase and maltose affect growth-promoting, even if they are cooked, not the growth promotion is so effected by enzymes. Until now the affect of all other examined substances give no more than 2-3 hours after putting a positive curvature, therefore there is no growth.

Another problem that can provide information about the investigations with the growth-promoting substance has further clues of conduction. The impetus for the recent investigations on conduction has Boysen-Jensen (1910, 1911, 1913) given by showing that in Avena coleoptiles the phototropic stimulus, which is known to be perceived in the head, even after the basal part when the organic connection, and subsequent reconstruction by cutting the tip sticking interrupted. In 1919 Paal has provided in his great work to prove that the change, which stimulates the light at the top, by materials forwarded. Second, he showed, as mentioned above, that the Coleoptile tip has a growth-promoting effect, and thirdly he has what I consider to be the best result of the relationship revealed between the tip growth and the promotion of phototropism. He considered namely a phototropic curvature as the result of a unilateral change in the amount of the downsides otherwise wandering correlation carrier.

He could also explain the positive trauma tropism curvatures. Unfortunately, one gets the impression that the theoretical results Pail's have never been properly appreciated. Lately, Beyer (1925) and Miss Tendeloo (1927) come back for Paal's statement from the and take a stand against Stark, who takes on specific trauma tropical irritants. Namely, heavy growth of the Coleoptile is probably encouraged by the growth-regulating substances which are formed in the tip, but this support is always constant. Any change in growth, which causes a curvature as a result of previous stimulation would be due to the formation of a specific irritant.

This review shall take place on the first trials of Boysen Jensen's (1910, 1911), which are contestable (Rama 1926, van Dillewijn 1927). In Section V I want to give a different interpretation of these experiments. In second place, he believes he has found specific traumatic tropic inhibiting substances, as well as described by Nielsen (1924) and Miss Seubert's (1925) as growth-inhibiting substances. As I said above, these results must be interpreted differently.

A very nice pair statement for the declaration of tropism curvatures was done by Dolk (1926); given by showing, at the very moment, that from recurring growth- promoting substances in the upper part a decapitated coleoptile, the phototropic and geo-tropic sensitivity has returned. The direct evidence against the pair, and Stark's theory, is not hereby provided, however I feel in Section V to prove the correctness of the view of the pair to phototropism.

Finally, I still must continue work that Priestley's (1926, 1927) mentioned. From a purely theoretical considerations, he rejects the assumption of growth-regulating substances in the Avena Coleoptile and believe all back bends in the first instance may be a different size water uptake of the cells. According to him the water is so in all cases *"limiting factor"* for growth. According to the results that I want to announce in Section IV (especially (38)) I feel I must reject the latter sentence. Söding (1927) has already objected to these remarks.

Without giving a detailed critique, I would just like to note the following.

1. Experiments that have I done by Auxanometer Koningsberger show no growth change with variations in humidity of 70% -92%.

2. When seedlings begin well, there are no bends..
3. The existence of a Growth Substance is proved in Section III perfectly.
4. Two experiments couple results of Priestley (1926) can only be explained if in the one with the tips, and the other on the other hand without gelatin are then replaced. I've repeated using gelatin.

It was in fact a whole series of decapitated coleoptiles. While some were of the tips of coleoptiles unilaterally glued using gelatin again, I stuck of the other tips (also using gelatin) with unilateral interposition of a mica plate, of all sides. But the result was that of Paal's the same, for example: : curvature by the tops, over one-sided patch $5.9^{o} \pm 1.4$.; curvature facing the mica platelets $6.2^{o} \pm 1.6$.

I think it is better to further literature on growth and phototropism in the related sections to mention, and am now going on to describe my own attempts.

In Section II, the raising of the material and the methodology is discussed.

In Section III, I give all the data I have collected about education, action and properties of the Growth Substance.

In Section IV attempts using the previously given analysis, a synthesis of growth to give, with some data to support my view and some conclusions.

And finally, I have tried to show in Section V, what you consider my method useful to one another, to analyze growth based problem, namely the phototropism.

SECTION II

MATERIALS AND METHODS.

1. THE DARK ROOM.

All experiments, their description will follow are in one the two in the basement of the botanical institute newly dark room had been carried out. Since they differ significantly in some respects from the earlier dark room, a brief description is given of both.

As said before they are installed in a basement, completely finished by the other institution, with its own ventilation So that it can never penetrate laboratory air. Before entering the room, you pass two small rooms, light-and air-tight manner, Which act as locks. Each room has its own thermo and hydro regulation and ventilation.

For the ventilation there is an electric fan blowing air from the second lock space into the room. The air comes directly from the outside, but however has yet to happen, a pipe. There is a central heating radiator for pre-heating use in cold weather.

The air leaves the room through a ventilation pipe, which leads to the roof of the Institute, is accomplished without the help of constant ventilation fans. Air is regulated at will by means of flaps which are above the inlet and outlet opening. This regulation of ventilation is important if one wants particularly to achieve a constancy of the humidity. For the heat, insulation is ensured by the double walls of a stone wall (with an insulating layer of air in between). Coarse preheating be can served by a central heating radiator. The actual exact regulating of the heating is done by means of electrical resistance wires which are stretched along the bottom of the four walls.

Thus, one reaches first, a uniform heating of the whole space, and secondly, the inertia of the heater until reduced to a minimum, the fluctuations of temperature in this way were about three times lower when using a contact thermometer, as if ordinary electric furnaces were installed.

The former metal thermal regulator could, just as a new very sensitive Toluolregulator, who was trying to reduce because of its inertia, the fluctuation of air temperature no further than to about 0.3° C. So I built a new toluene-thermal regulator, Which is very sensitive, first, second, third, a little sluggish and intermittent heating with very small periods (10 seconds). The regulator (FIGURE 1) consists of a long, thin, thin-walled glass tube, A, in the middle bent twice at right angles, tapers at one end to about 3 cm long extension B, at the other end of the electrical contact device C transmit, as the character is evident.

FIGURE 1
Thermo Regulator

To the very thin extension B, which is just like the tube itself, is filled with toluene, a piece of resistance wire is wound D, which is traversed by the electric heating current. To ensure that when the heater is closed, the toluene is heated in the extension, so that very soon the mercury contact C is closed, open thereby using the heater relay.

The extension B is then cooled off again, etc. If the temperature of the room, then the whole toluene volume is reduced by heat so much that the increase of volume is repealed in extension and the constant flow is closed. The normal fluctuations in room temperature are now no bigger than 0.1° C greater temperature fluctuations can be regulated very quickly. This type of thermal regulation is especially recommended for physiological study, as is achieved in this way even without ventilation of the room within a high constancy of temperature.

There was with my experiments, the humidity of the utmost importance, I have also attached to automatic regulation of the moisture that works extremely well.

On the ceiling of the room. There is a water tank A (FIGURE 2), Which is connected by a finely adjustable valve C to the water line. At the bottom of the container, an electric heater is mounted B, Which heats the water. The warm water flows through small holes in a discharge tube D to E along a cloth that is stretched over the entire height of the room. In this way, the humidity is firstly dependent upon the flow velocity of the water, secondly, thirdly, from its heating and ventilation.

If we now vary one of these three factors, while the other keeps constant, the humidity can get to any height. The easiest regulation is achieved when you can change the amperage of the electrical current in the radiator. By means of a relay in the circuit of G is a resistance heater B F on and off.

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FIGURE 2
Automatic Regulation of the Humidity

By a certain flow rate of water (which I let always be of equal size) and (closed valves of the inlet and outlet openings for the air almost) a very little ventilation, reached the humidity z. B. 95% if turned off the resistance and 85% if the resistance is on. If I now want to maintain a humidity of 91%, so I need only turn on the resistance to in appropriate manner, when the humidity rises above this value, and off when it drops below. This regulation is effected by a hair H, the extension of a lever arm at its K with contact tip, The latter is then dipped in mercury J, and so the primary current in the relay closes G. When the door of the room will not only open to often, the humidity varies only very slightly (about 1%), Which is quite sufficient for my purpose. Small (constant) temperature differences in different parts of the room have the consequence that there is also the moisture differently. These differences are constant, and when running experiments in the same place in the room you have the perfect consistency conditions.

2. REARING OF SEEDLINGS.

I only used test plants of seedlings of Avena *sativa*. I am very obliged to Dr. Akermann for sending me the seed material, it all came from a crop of Svalöf *"Victory"* oats and corresponded to the highest standards.

In order to achieve uniform germination, all seeds are Miss lled. Four days before each test, the grains are soaked in water de-husked for 2-3 hours, and on moist filter paper in a glass jar at 25º C. They were placed in a glass box in a dark room to germinate.

About 20 hours later, the germination is then advanced so far that you can plant them. Planting is done in two ways. The seedlings, the tips for the extraction of Auxin are cut later in the usual way, planted to 20 vessels with zinc in soil. But the seedlings that will later serve for the quantitative determination of the Growth Substance, and which I call the planned addition reaction, must be very carefully drawn. That is why I have the

FIGURE 3
Breeding Plants of the response in Glass Containers.

Raising the response abandoned plants in soil, and eventually I have come to production of small glass container (FIGURE 3). Each container contains one seedling, which develop roots in water. Instead of water I have also carried out experiments with Knoppscher Nutrient Solution, the plants develop in response very badly.

The container consists of a thin glass rod E, which is inserted into a resilient terminal B and the bearing at one end of a vertical glass tube C of 1.7 mm in diameter and about 6 mm in length carries. At the glass rod a few mm in front of the glass tube is a thin glass rod melted D, which passes obliquely downward and is bent on this eye-shaped end. The grain is between this rod and the glass tube is clamped in such a way that the coleoptile to grow through the pipe and the roots through the hole in the water of a vessel below it Zinc F.

The glass tubes are waxed on the inside, because they range so close to the surface of the water and capillary water, otherwise they would absorb, making the growth of the Coleoptile suppressed. The clamps of brass plate bearing the container, to 12 trapped in the columns of a wooden board of A 20 X 2 X 3 cm so that they can be rotated into a vertical surface (2). Since the containers can then be rotated in the clamps (3), one can stand the outgrowing of each Coleoptile. The advantages of this rearing method are many.

1. There is no irritant contact with the soil that could cause its irregular curvature.
2. The event. Curvatures of unknown origin occurring in the upper primary parts of the Coleoptile, you can put the plants back upright so that the upper part grows straight.
3. The outgrowth of Mesokotyl is no longer a hindrance because it turns out that there is almost no curvature.
4. The roots continue to grow under the same conditions, uneven soil moisture can play no role, such that guttation (appearance of drops of xylem sap on the tips or edges of leaves) always begins at the same relative humidity
5. The plants can all be taken out separately from the wooden boards for decapitation, etc.

6. Seedlings of the same length can be collected, it is possible to choose in this way a uniform material for a test series.
7. Using the Auxanometer Koningsberger's (1922), these plants are very suitable.
8. The general conditions under which the seedlings are growing up, as evenly as possible, as evidenced by the fact that at least 70% of the seedlings can be used for the reactions.
9. A very remarkable difference between the physiological and raised in this way the plants growing in soil will be discussed later There is the possibility of a further analysis of growth on the basis of these facts.

Because the entire breeding always takes place in a dark room at a constant temperature of 25 ° C., so plants have the response 2 ½ to 3 days following the plant reaching the desired length of 30-50 mm.

3. PRODUCTION OF AGAR BLOCKS.

To always get the same thickness of Agar blocks, I used the following method. A 3-percent Agar solution is poured into a glass bowl, and from this are rectangular pieces A (FIGURE 4) cut of about 20 X 12 x 12 mm. This will be one. U-shaped sheath B paraffin poured around and remain free in such a way that the two smaller and one of the longer sides of the Agar. The whole frame is glued to the Microtome. Gillette blades used to cut one-meter, the C version is in a suitable set up perfectly horizontal. This knife is now being made in the horizontal direction, a cut in the Agar. Then, the screw that moves the Agar in the air, a certain number of teeth turned, and made a new incision.

Afterwards they are separated from each other. The resulting Agar slices are placed in water in order to flush, remove existing growth-regulating substances.

The number of teeth through which the Agar from two incisions in height is rotated and the 5.7 ∝ match, a measure of the thickness of the slices. The most commonly used thickness was 108, therefore 0.62 mm. The weighing of six of these cuts were as result: the most commonly used thickness was 108, for example 0.62 mm. The weighing of six of these cuts were as a result:
85.5, 88, 85.5, 84, 86.5 and 84 mg, or 0.63 mg per mm^2 surface.

FIGURE 4
The Cutting of the Agar Block.

The slices are stored in 90% alcohol, before use 1/2-1 hours in a petri dish soaked. The weight is after watering 0.66 mg per mm^2 surface.

From the Agar block you then punch with an apparatus of the same size pieces (see FIGURE 6, 1), which I'll call in the further course Agar plates. In the experiments, they were tall 1-430 4.2 x 4.2 mm, from 431 to test their surface was 4.5 X 6 mm. One can then store the Agar plates on numbered slides in a moist chamber.

Instead of ordinary microscope slide one can better use glass plates of black glass or hard rubber sheets with glued-on cover glass, against the black background. Raise the tips and the Agar performed better. It is particularly important to always carry out in not too strong red light.

The silica and Gelatin platen serving in various experiments to extract the Growth Substance, were prepared in a different ways. To 1 cc of water glass (11° Beaume) is about 0.75 cc of normal hydrochloric acid solution added and this mixture is now poured paraffin on a glass plate. This is down to about 1 mm high glass feet a second glass plate also paraffin. Once the silica solidified, the second glass plate is lifted and the silica plate, which is now free, placed in water for rinsing. Instead of hydrochloric acid, water glass and liquid mixture can be 15 percent gelatin glass plates between the paraffin to solidify.

4. THE WORK TABLE.

Before describing the actual tests will pass over, I noticed a few things. The test methodology is so subtle that there is true, the most embarrassing caution to be careful. When I am not completely calm during the experiments worked, then the immediate avenged by the average error was too large. Next I have everything set up in a dark room as comfortable as possible. Working on the raised table stands a wooden block provided with two armrests.

The plants are being operated on this block of wood are in exactly the same level with my eyes. Above the table there is a red lamp that casts its light only on the table so that no direct light hits the eye. Under the table I put the printed protocol forms, after which everything is recorded on the test.

The plants are behind me, so that need not stand up during a test series

5. EXTRACTION OF AUXIN.

Assure the shortest possible time for a certain number of Coleoptile tip cutting to be put on the Agar plates. Although, as we shall see later, there is no difference if the tips are placed immediately after cutting or only after some time on the Agar, so I have almost no attempt at more than 2-5 minutes between the performance and the placement can proceed.

FIGURE 5
The Decapitation Maker

To cut off the tips I used a so-called Decapitation Maker (FIGURE 5), with which I can cut about 20 points in 3 minutes. It consists of a metal plate A, B on the two small knives whose blades form an angle of 30°, are soldered. C. The wafer is moved in the direction and leads to de Coleoptile between two small springs to the knives, the handles with F, it can be done just so far that the Coleoptile is cut on two sides a little. If you now move the entire frame into the air, rips off the top of the Coleoptile, while the primary leaf through fall from the blades. The truncated Coleoptile tip remains on the knives; you can immediate cut off a new tip, so you can continue until the desired number by tips are standing next to each other.

As it turned out that the length of the cut. Tips have no noticeable effect on the amount of extracted Auxin exerts, so I have no special device to cut off the tops still attached in the same length.

Now, the placement of the points made on Agar (see FIGURE 6, 2). In the preliminary communication (Went 1926) I stated that the tips were only about 5 minutes on wet filter paper to remove the contents of cut cells. As some preliminary tests had shown that the amount of Growth Substance by the presence of this cell content was independent, I have in my other tests reported here always the tips of Decapitation Maker immediately transferred to the Agar. The transfer should be done very easily using a movable pair of tweezers, because otherwise one easily break the tips. On the previously dried with filter paper Agar plates the tips are distributed regularly and it is ensured that they touch with their entire cut surface of the Agar.

Now enter in a log: the date, the length of the decapitated plants, event. the length of the cut-off points, the thickness of the Agar, the time of the beginning and end of the touchdown and the mean between these two, the number of the slide, and finally all the other details.

During the whole time, which tips on the Agar, are the slides, including Agar and tips, kept in a moist chamber.

It was been shown that contamination of the Air in the moist chamber (for example: not yet completely oil dry stem) either the formation or the transport of Auxin adversely affected, or ineffective, after the tips are removed

After the spikes are removed, a small drop of alcohol placed on the Agar plates and when the Agar is more than a few hours should be kept to prevent even one drop of water to dry out. Then all the humidity chamber is lifted in a refrigerator. In this way the Growth Substance is a very long time, will be discussed later, such as bacteria that adversely affects the development of conservation (7).

It should again be emphasized here that the trick is sitting in the method of intercepting the steadily forming Growth Substance, and that is only in this way to extract the substance from the tips of living. Any attempt to get the material from dead and crushed lace has failed until now, and theoretically there is no grounds to expect that it will ever succeed.

The exposure is done in a box whose upper part contains an adjustable Argentalampe, while the plants are located in the lower part. With the help of mirrors can at will, either from above or one or both sides are exposed horizontally. Both parts are separated by a water tank with a glass floor to prevent the penetration of heat rays.

6. THE QUANTITATIVE DETERMINATION OF THE GROWTH SUBSTANCE.

As I said, the best raised response plants are used. I've carried out all my tests with plants from seed were measured from 40-60 mm long, 30-50 mm therefore tips from the glass tubes. Shorter plants are not quite useful, because by them under the curved portion substantially non-curved piece no longer remains, and therefore we can not determine the exact angle of curvature.

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FIGURE 6
Schematic Representation

Analysis of the Growth Substance.
1. punching the Agar plates from Agar slices.
2. touchdown of the tips on Agar.
3. the Agar plates divided into 12 cubes.
4. sided incision in the Coleoptile.
5and 6. removal of the tip.
7. pulling out of the primary leaf.
8. sided one touchdown Agar cubes.
9. Curved response plant.

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The decapitation is done in the usual way, about how Stark and Drechsel (1922) describe it. The plants, cut 5-8 mm from the tip (FIGURE 6, 4) with a sharp knife on one side. The tip is then bent slightly (6, 5) and pulled with a jerk (6, 6). Bünning (1927) indicates that this type of curvature is directed to cause decapitation.

I have watched before with great care the excellent primary leaf about 5 mm should be pulled far (6, 7), making sure you hold the roots so the plant from seed is not dissolved. The operations are easily carried by each plant in its container described above, can be treated individually.

After decapitation, I let the plants stand quietly for some time and only after 40-50 minutes the Agar glued on one side. This time is used primarily to discover any curvatures which occur as a result of decapitation. Directly before use the decapitated plants are selected and compiled into a wooden board to 12 marriages. Only those who are in their upper part, at least 25 mm long are perfectly straight, is needed for the reactions, all others removed.

The Agar plates whose Growth Substance content should be determined, it is now divided into 9 or 12 equal size Agar cubes (FIGURE 6, 3). Up to 430th attempt, I cut them out of hand, but later I used one proposed by Dolk apparatus that separates the Agar plates very accurate in 12 parts.

For affixing these Agar cubes I use 15-percent gelatin, which I believe to a small electric oven always liquid ready (at about 40° C). A small drop of gelatin is placed on the left or right side of the cut surface of the Coleoptile stumps and with a small spatula of Agar cubes is transmitted to the stump where it can immediately stuck (FIGURE 6, 8). Only at very high guttation it may come off again.

The most important test period starts now, because there is important to keep the humidity to continuously at such a height that, while not Coleoptile stumps on the other hand, the Agar cubes does not dry out.

A sufficient constancy of humidity is achieved but with the previously described regulation; only when the door opened to the dark room, often can fall temporarily below the desired moisture level.

After touching down again, all other data, such as the time of reaction, the length of the cut-off points, the time of decapitation and the touchdown, the number of cubes in which the Agar is divided, and the number of *Holzbrettehens* entered in the log.

After 120 (trials 1-282) or 110 (of 283 attempts at) minutes, the response plants photographed by means of an arc lamp, a silhouette of the plant will be thrown into natural Grässer on bromide paper. It need hardly be said that the beam direction was always perpendicular to the direction of curvature. The shadow image is pasted after developing its Protocol. Then we have put together all the details and the result of each experiment, so the result can be verified at will. All my records remain stored in the Botanical Institute in Utrecht.

7. MEASUREMENT OF THE CURVATURE.

Finally, I must still discuss the measurement of the curvature. Because the thickness of the Coleoptile was the same on average in each trial, the angular deflection is a direct measure of the growth differences between the opposed sides. Direct proof that the angle of curvature is in direct proportion to the concentration of Growth Substance, I will provide in Section III. The measurement of the curvature radius teach us something about the distribution of growth in the Coleoptile, the Growth Substance measurements but it is only in relation to the radius of curvature associated with each angle to use.

(26)

In contrast to the curvature angle is the deflection of the tip in mm Avena not a measure for the growth differences between the opposed sides, because the curved part is not always the same length and located almost never in one place, and the calculation of the growth differential, as Brauner (1922) she performed is therefore incorrect. To measure the curvature angle, I used a special degree arc. A half circle is divided in 180 0 and perpendicular to its base in 2 mm distance parallel lines are drawn (FIGURE 7). From this drawing is on a photographic plate taken a positive. In the center of the arc is a hole drilled through the glass, which serves as a pivot point A of a pointer.

FIGURE 7
Protractor to Measure the Bending Angle.

This pointer has an elongated, radial opening of about 3 x 30 mm; herein are two very thin, parallel metal wires in a mutual distance of 0.8 mm stretched. Will we now measure the angle of curvature of a response plant, then the above described arc diameter is placed on the shadow image B of the plant and the pointers so far turned that form until the two is strained metal wires exactly tangent to the outermost point of the response plant. Because of the Coleoptile stump over the whole length is the same thickness (the conical tip is indeed cut off) after some practice you can pretty much determine the tangent. Is it this far, then rotate the glass plate around so much that the lower parallel lines are directed exactly parallel to the non-curved part of the plant. The pointer is then connected directly to the curvature of the Coleoptile on the degree of arc.

SECTION III.

FORMATION, GROWTH, AND PROPERTIES OF THE GROWTH SUBSTANCE

1. BASIC EXPERIMENT: DISCUSSION OF THE LIMITS OF ERROR.

Before I make a beginning with the release of my results, we must first form an idea of the usefulness of the quantitative method.

If I have a Agar plates with a certain amount of Growth Substance for 24 hours are, then I am sure that the same has been distributed evenly over the entire plate (comp. page 55). I cut the plate into 12 equal pieces, then I get 12 equal portions of the Growth Substance. But I think after this 12 sided cubes are glued to 12 response decapitated plants, rather fluctuating values for the curvature.

(28)

It has also indicated that the response of plants identical with each other, not all are but I Determine the angle from a larger number of response plants on which all the same portion of the Growth Substance is placed on one side, then you can rearrange the numbers obtained in the form of a binomial curve. The result of this basic experiment is shown in TABLE I. Series of experiments, 496-501. All Agar plates 6, each of which four have been on top for 120 minutes, divided into 12 cubes. These 72-sided cubes are placed on 72 response plants and the curvature is photographed and measured after 110 minutes.

****

TABLE I

Curvature angle
Number of plants
Calculated number

****

In the top row are the angular spread over which the curvatures of the test series is 496-501. Among them is the number of plants which showed the aforementioned deflection angle, while the last row are calculated in these figures for a binomial distribution. *This distribution shows the typical physiological uniformity of the material* ... (1).

It occurs only at optimal experimental conditions. If the humidity was only slightly too low, then different Agar cubes dried up, so that the Growth Substance is not entering the stump, however, the humidity was too high, then the Growth Substance is diluted by guttation. In both cases, the resulting curves are too small and the curvature angle A series of tests are no longer in the form of a spread over the binomial curve classes, but the curve is skewed. As an example I give the test series (187, 188, 189 and 194), where the humidity was too low:

(29)

Curvature classes	0-1.5 º	-3.5 º	-5.5 º	-7.5 º	-9.5 º	-11.5 º
Discovered curves	3	4	6	11	9	2

Such trials are hardly useful and only be to utilized qualitatively ... (2).

In some cases it is possible that little or no curvature in otherwise good trials but one or two plants. If it's calculation shows that these values are far beyond the (binomial) distribution of the other curves, then they need not be counted because there are obviously experimental error. As an example, I am trying to 490: curvature of the individual plants 1°, 1°, 6°, 6°, 6°, 7°, 7°, 7°, 7°, 9°, 9° and 9°. Here I must turn off the curvatures of the calculation of the mean quiet. At trial, the figures were 483: 0°, 7°, 8°, 8°, 9°, 10°, 11°, 11°, 11°, 11°, 12° and 12°. Once again, we see immediately that the 0° value falls out of line. In general, *one may attach to the percentage of the curved Avena stumps no quantitative value, as determined in this way is only the size of experimental error* ... (3).

Paal, the first on the percentage of curved decapitated plants on which the phototropic to lovely top has been re-placed, has determined moves, only qualitative conclusions can be made from his experiments. Later, Stark (1921, 1922), Miss Seubert (1925) and others utilized this percentage but quantitatively. This is not allowed. I have whole series of experiments in which 100 percent of the curved response plants, and in other series, which were quantitatively the same curvature, only 90% curved. In the determination of so-called threshold for phototropic or geotropic stimulation of the matter is different, of course, there is actually determined

the variation curve, and the median threshold of the curvature is just visible. All the curves appear here, then even very small, this is not the case in Stark, where the curves, if they occur, are quite considerable.

On the one hand may include a series of experiments, never more than about 100 response plants, and usually consists of only 60, and the other a test number, also for practical reasons, consists of 12 response plants, so I must show you further how the curvature quantitatively from a single experiment number is useful. As an example I refer again to the test series, 496-501, of which I am above the variation curve

Compared with the binomial curve.
The individual tests are given in TABLE II.

****

TABLE II

Experiment Number - Curvature - Deviation from the Mean.

*****

For each experiment number 4 tips for 120 minutes have been on the Agar plates. The plate is divided into 12 cubes that were placed unilaterally on 12 response plants, mean of test series 11.20 ± 0.26 *).

This tells us something is good agreement between the individual experiments and their average;

****

*) The average error, which I add all my averages,
I have calculated for $m = \pm \sqrt{\sum(p\, x^2/n\, [n-1])}$

the deviation is not greater than the mean error. I could cite more similar series of experiments, it was sufficient but the message that is also found elsewhere, a similar agreement. (See test 417-421, page 41, there be differences between the extreme values of only 4%). *Because I've mostly made several test runs in order to secure a certain result, I can in the following experiments, the quantitative results within the limits of the average error thus be regarded as real* ... (4).

Bacteria can reduce the amount of Growth Substance during storage, such a change is not in the curvature or angle mean error expressed. Whether the amount has changed is to determine only by means of parallel experiments which I have almost always employed.

But I will not list all test series, because the match was very satisfying mostly, except when the differences are too large, it should be mentioned.

After these introductory experiments on I can go to release some control experiments.

2. CONTROL EXPERIMENTS.

The first experiments, which I quote, relate to the control of jelly. I use this cube of pure Agar, gelatin or silica jelly to one side of the decapitated seedlings. The result is clear, and the cubes are placed 40-50 minutes after the decapitation and the plant again after 120-110 minutes (or 160 minutes after decapitation) controlled, then all the plants are still perfectly straight, a single event. random (undirected) except curvature (for example: Verzuch 32). But if one does not wait for 160, but 170 or 180 minutes, various plants bend positively to sometimes 30%, Experiment 1).

These results are fully consistent with those of Miss Gorter's (1927), she says the same through the formation of a new physiological tip. May be later I will point out to you as greatly reduce the regenerating tip of the physiological curvature. *I can therefore conclude that within 160 minutes after decapitation of pure Agar, respectively. Gelatin and silica jelly has no measurable influence on the growth* ... (5).

Another question is, are perhaps the tips performance of released substances, such as content of the body cells, to be held responsible for the growth factor effect? This was not expected from the outset, because experiments *have also demonstrated. Namely 12 Coleoptiles be cut from intact coleoptiles, for 120 minutes set on agar, you get no detectable curvature*. (Experiment 249: curvature of 0.08 ± 0.4, see also attempt 166-170, Table XI) ... (6).

The first time I had in my experiments, the difficulty was that the Growth Substance disappeared in the course of 12-24 hours from the Agar. It turned out that bacteria were most likely guilty thereto. For the experiments 61 and 66 show that gelatin with the Growth Substance after 18 hours of storage at 25 0 is still effective (7° curvature), but after another 18 hours begins to liquefy and is no longer bend. In the experiments, 67, 68 and 69, the jelly with the same amount of Growth Substance has been partly warm (25°) partially kept cold (below 5°) 70 hours. In the first case, the curvature of 1.2° (test 68) is, in the second, 13.3° and 14.3° (silica-gelatin and gelatin, trial 67 and 69) ... (7).

(33)

In order to exclude any bacterial action, I have with the other experiments, the jelly with the Growth Substance always kept in a freezer, and still before the jelly is disinfected with a drop of alcohol, I only had to examine whether in this way will not affect the Growth Substance. *Result: it has no effect when alcohol is added to the Agar with Growth Substance* (alcohol 11.1 ± 0.8, 10.3 ± 0.85 without alcohol, try 236 and 237) ... (8).

For practical reasons, I must say before I go on with the discussion of the control experiments, the main experiments.

3. THE MAIN EXPERIMENTS

So far I have discussed only the question of how a certain amount of Growth Substance in the different response plants the same curvature causes. The most important question is the whether the curvature is a quantitative measure of the amount of Growth Substance? Suspect from the foregoing it can be, and the proof must be provided, but still. I have to leave only a pair of 6 Agar plates tips during 60 min. Later on is such a growth-plate with an equally large pure Agar plates down for several hours until the concentration in the two plates has become the same. (For the proof of this claim see (28)). This procedure is repeated again, so I also get a four-fold dilution. The curvatures arising after the platelets have, I measured and summarized in TABLE III.

****

TABLE III.

Experiment Number -
Number of Tips - Undiluted - Spray One Time - Spray Two Times

(34)

We can conclude that the Curve Angle is proportional to the concentration of Growth Substance ... (9).

A limitation of this rule is given in (14). Here join immediately to the trials in which I use a different number of tips the same time on Agar. I can not possibly mention all the experiments, the following may suffice, however.

Experiment 496-504. It will put two or four points during 120 minutes on Agar. Each is Agar plates. cut into 12 cubes, each cube is glued to one side of a response plant.

Test number 496-501, 4 tips 120 Min on Agar 11.2° ± 0.26
" 502-504, 2" 120 "" " 5:47° ± 0.25

The curves, which occur when two tips are placed on Agar are so half of those who have 4 points, same time on Agar yield, the difference is within the limit of the average error ... (10).

Because when I double curvature of the two tips, so I get 10.94° + 0.50; the difference with the curvature of four tips is 0.26 ± 0.57 and can therefore be neglected. In TABLE IX, we find another case of perfect proportionality between the curvature and number of spikes attached, at least at 3 and 4 tips.

****

TABLE IV

Experiment Number
- Number of Top Isolated on Agar - Curvature - Time on Agar - Curvature

(35)

If one makes the same point at a constant number and varying extraction time, so you get slightly different results, the curves at the shorter Extraction time are always a bit too high for an exact proportionality between the curvature and the time during which the tips on Agar. TABLE IV gives the numbers found in three test series.

****

TABLE V.

If one converts these numbers, we obtain TABLE V, where I've doubled the numbers for the shorter extraction time and indicate the difference with the other numbers in the last column, *one sees from the fact that percentage table for a long time putting the tips in the first period more secrete growth-promoting than later and that the difference is constant and real* ... (11).

To decide whether the cause of this phenomenon, a physical or biological is-that is, whether about the diffusion of small from the tips is at increasing concentration of Auxin in the Agar in the immediate vicinity of the tips, or whether the tips less growth-I form, have the following experimented. Be 20 points, after standing for 30 minutes on one Agar plates, about to set a new Agar plates on which they stand again for 30 minutes, which is repeated twice so still, so I finally the amount of Growth Substance, which in 2 hours formed in the tips, will have divided into four portions formed in equal times.

TABLE VI gives the results of two test series. *One can conclude from this that in the same time same amount of Growth Substance diffuses from a point beyond* ... (12).

****

TABLE VI.

Chronological Order Standing up - Curvature

Trials Trials

The exceptions are the FIGURES for the third half hour, whether these are just random experimental error, as I suspect, or whether there are real differences, I have not been studied in detail. The tests, which are shown in TABLES XX and XXI show, but no deviation in the third half hour. But one sees in any case that the differences are in TABLE V can not be explained with a modified diffusion out of the Growth Substance from the tip during the second half hour.

We have analyzed that if two more points are placed on the Agar, diffuses out one twice as large amount of Growth Substance. This can only be explained by the fact that the concentration of the substance in the tip is very high compared to that in the Agar therefore if you find that is lower in successive equal periods, the amount of Auxin also diffused in the same Agar plates, so herein lies the explanation seems that now the diffusion gradient is less.

****

1) Because the roots of the plants do not show any response in water, some Agar cubes were dried up, the curves are therefore too small.

The proof of the proportionality between the concentration of Auxin and Angle of curvature is still continued, as I have explained the Agar plates dilutions with different thickness. As an example, the experiments are 190 and 194. To a 0.61 mm thick Agar plates 8 tips have been during 125 min. After a pure Agar plates, 0.46 mm was still thick, and placed on exactly the same diameter, on the first tile and it's so long to be assumed that the Growth Substance had been distributed evenly. After in (9) could be predicted a distribution of Growth Substance in the ratio 0.61: expect 3 (proportional to the thickness of the Agar plates): 0.46 = 4. When I received curvature: 0.61 mm thickness of Agar: 8.6° + 0.5; 0.46 mm thickness of Agar: 6.4° ± 0.7. In an ideal distribution in the ratio 4: 3, these figures should have been 8.57 and 6.43.

In the experiments 333-335 I had been on a Agar plates (0.61 mm thickness) on the top 10 for 180 minutes, still down two pure Agar plates containing a 0.46 mm and 0.92 mm thick and the other. The ratio was thus 4: 3: 6 The 0.46 mm thick plate is divided into 9, the other two are in 12 cubes. 7.2° ± 0.6; 7.1° ± 1.0 and 10.3 ± 0.4: The curvatures of these three experimental numbers were. The ratio would need to be

(See (13))
4 / 12 : 3 / 9 : 6 / 12 = 7.0 : 7.0 : 10.5

The agreement is again perfect, so I have confirmed here in a slightly different way, the result of (9).

There are still a couple of tests carried out to prove that the curvature of the absolute amount of Growth Substance is proportional. Because until now the one-sided cubes with attached Growth Substance is always the same size, had only the concentration determined the curvature.

But I have two of the same size Agar plates divided into nine one and the other in 12 cubes. In this way, no longer corresponds to the absolute amount of Auxin concentration. When trying 176 had 8 points stood for 60 min on Agar, while attempting to ISO (the same test series) 4 points 60 min, the concentration behaves in the two plates as 2: 1 176 is cut out in 12, 180 at 9 dice. The absolute quantities of each cube contained in Auxin behave 2/12: 1/9 = 9 : 6
Trial 176: 9.1 ± 0.4 and 180 experimental: 6.0 ± 0.5.

The curves are found:

Experiments 181 and 182 181: 4 tips were for 120 min on a Agar plates, which was later divided into 9 cubes. Curvature: 8.3 ± 0.6. Trial 182: 4 tips were for 180 min on an Agar plate, which is divided into 12 cubes. Curvature of 9.1 ± 0.6. Should be the ratio would try 181: try 182
= 120/9 : 180/12 = 8.3 : 9.2

The curvature is thus proportional to equal and unequal in substance cube of the absolute amount of Growth Substance
... (13).

4. THE CRITICAL ANGLE.

I have already referred a few times in the discussion of quantitative results the fact that the proportionality between the curvature and the amount of Growth Substance is unlimited. The few examples in TABLE VII are sufficient to clarify the above statement.

****

TABLE VII

Time on Agar
****

In this table the figures are compiled from four test series, ie in the 1st column experiments 62, 63 and 64 in the 2nd and 3rd column experiments 139-144, in the 4th and 5th column experiments and in the 125-129 6th and 7th column of the tests 153, 154, 156, and 158.

Is a curvature angle reaches 10° -20°, so this is not exceeded, even if you have more tips on Agar can be a long time. There are two possible explanations. First, one could imagine that the concentration of Growth Substance can exceed a certain limit. Second, it is possible that the plant response can not bend more.

To test the first possibility, I have tried the following. Test series 91-97. 4 tips for 30 minutes on Agar were set, the curvature is 5.8°, but when 8 or 12 tips, 30 minutes, or 4, 8 and 12 tips have been 60 minutes on Agar, the curvature is in all cases approximately the same and on average 10.0 degrees. So I have 4 Agar plates, depending on the 5 tips had been standing for 90 minutes, another set and dry out until they had achieved together, the thickness of one Agar plates. The curvature of this system which was revealed on average 10.5°. This is not a result of the drying, the water content of the Agar is decreased only by 97% to 88%. Since each of four plates contained as much Growth Substance, that there is a curvature could arise from 10° so you can see from this experiment that the amount of Growth Substance beyond a certain limit can be increased at will to surrender without a stronger curvature.

(40)

Internal factors limiting plant response in this case, therefore, the possibility of curvature, which I will indicate below the name, that the critical angle is reached the response plants ... (14).

In other experiments I can do the above, more descriptive. First I will discuss in detail the series of tests 153-165 in the hands of TABLE VIII in TABLES III, IV and VII, I've removed some data from it.

****

TABLE VIII

Numbers 153-165 Taken from the Test Series:
Diluted
One Time Is Diluted by Half;
Two Times Diluted up to a Quarter.

So you can see here: the response plants can not exceed a certain curvature (critical angle = 17°).

The amount of Growth Substance but corresponds exactly to the number attached tips, which can be proved for 12 points only 60 minutes of dilution. 6 tips for 60 minutes to give Agar 11.2°, 12 points 60 minutes on Agar should be 22.4 degrees, but in reality the curve is 17.1°. When diluted to half the curvature is 11.2°, what you also must be obtained from exact proportionality.

(41)

The test series 414-421 tells us about the issue as the critical angle is reached. From previous experiments had already emerged, for example, that 2° of the critical angle, the curves still do not influence while it was already completely restricted at 170. The data obtained are summarized in TABLE IX, and because of the importance of the results are the curves that occur with increasing tip number recorded in FIGURE 8.

****

TABLE IX

Experiment Number - Number of Tips - Curvature

The points have all been standing for 120 minutes on Agar. The treated Agar plates are divided into 12 cubes and put to one side of each 12 plants reaction.

The discussion of the results can be best carried out by the hand of the FIGURE 8.

Tips at 3 and 4, the curvature of the tip number is proportional. 7, 8, 9 and 10 points all give approximately the same curvature, mean 15.9°. The critical angle is achieved so much. Consider now the curvature resulting five tips, we see that they are closer to proportionality with the number of tips in the dashed

Line passing through the 0-point, would have to fall. The curvature should have been 14.8° So, it is 14.3°, the deviation (0.5°), although still quite small, yet distinctive. The deviation of the curvature of 6 points is much larger,
namely 17.8° -15.5° = 2.3°.

That is, of course, because the critical angle is 15° and therefore the curvature of 17.8° could be impossible. The deviation from the critical angle, however, is only 0.4° Thus we see that all curves are arranged in two straight lines, the greatest deviations of no more than 0.5° and 0.4°.

FIGURE 8
Relationship Between Auxin and Bend Angle Amount.
Abscissa: Amount of Growth Substance.
Ordinate: Angle of Curvature.

The first line corresponds to a proportionality between the curvature and the amount of Growth Substance, you could also say that the curvature is limited by the amount of Growth Substance (the Growth Substance is thus *"limiting factor"* for growth in the sense Blackman's). The second line runs parallel to the ordinate and has no relationship to the amount of Growth Substance.

Their course is a series of internal factors that are limiting for growth. These two limiting factors give rise to a typical Blackman-Curve, with a very small transition area ... (15).

The result to myself happens to be quite surprising because in recent times the validity of the theory of Blackman's designed for growth, has been questioned (Romell 1926). In my case, but there are internal factors that translate directly and completely limiting, occur while the other attempts, there are always external factors, such as the amount of the supplied nutrients that affect growth indirectly, and it does not limit completely, and the other more or less able to represent. The situation here is much more complicated than in the case of Auxin, which explain the contrast is to 1).

The critical angle is actually another every day and it varies with the water drawn in plant response between 10° and 20°. So I have every day when I perform a quantitative test to determine again the critical angle. Because the amount of Growth Substance, diffuses out during specific time ranges from a tip, so I also have this amount determined in each experiment.

Thus, only the numbers of a series of tests that will be executed each time in a day, compared with one another. Unfortunately I can not explain the reason for this vacillation with certainty.

However, I believe that the weather (cloudy or sunny) exerts even more influence in a dark room on the plants.

****

1) Here I must point out the fact that found by Brauner (1925) in the leaf joints of Phaseolus Lichtturgorreaktion a complete restriction on the movement of an inner factor. Whether a comparison between this restriction and the critical angle is allowed, I can not decide.

I have collected no data to support this claim, after all, what we know about the sleep movements of plants (see Brouwer 1926) but it is not impossible that, despite the most uniform growth conditions in the experimental space changes some are due to an externally induced factors. But it must be that bacteria that grow more and more or less in the water in which the roots of the plant response, develop, grow and affect mainly the critical angle, with the possibility counted.

Following these attempts, I can mention a few that I will only indicate in Section IV. I had gotten the impression from other experiments that the critical angle response of plants grown in water, had to be different from that of normal plants grown in soil (the same I will call *"terrestrial plants")*. The test series 448-452 solves this issue and shows at the same time, that is formed in the tips of these two groups of plants the same amount of Growth Substance (see TABLE X).

****

TABLE X.

The Agar plates were cut into 12 parts. Every 12 to 12 cubes have been response plants, whose angle of curvature was determined afterwards, placed on one side. From Table X it shows that: first, *the response in water drawn plants and the soil-grown plants respond the same amount of Growth Substance with the same curvature* (trials 449 and 451) ... . (16)

(45)

Secondly, *the tips of these two groups of plants at the same moment are also the same amount of Growth Substance* (trials 450 and 451) ... (17) Third, *the critical angle of plant response not even reached half of that of the plants* (trials 449 and 452) ... (18).

Because if you calculate how large the curvature of 12 tips for 150 min on Agar is the case that the curvature of her seven points 66 minutes would be proportional to Agar, the result is 31.4°, which is practically equal to the found curvature (31.2°). The critical angle is therefore in the plants grown in soil even higher than 31.2°

One might ask why I always have used the response in water drawn plants although their critical angle is quite small. Some of the reasons I have already explained (page 16-17). Add to this that the variability, and thus also the mean error increases at higher angles, so that the probative value of the smaller trials.

5. ANALYSIS OF ERROR SOURCES.

Actually, I would discuss the next few attempts have been more, but without the knowledge of the proportionality between curvature and amount of Auxin had no sense of the meeting.

First, I need to discuss the formation of Auxin in the tips of plants of different length. This is important, firstly, for practical reasons relating to the extraction of the Growth Substance, and second, theoretically a possible explanation for the great period of growth. Therefore, it is regrettable that I can not give more attempts over here. In the first place as I can give my subjective impression that the formation of Auxin in the tip is independent of the length of the seedling.

Only one case I can prove this view with numbers. In the series of experiments 149-152 I cut off tips of 20-30 mm long, seedlings, and 55-65 mm long from plants. There were six tips in each set 40 or 80 minutes on Agar, with the following result. Tips on Agar as:

40 min	(plants	20 mm long,	7.1 ± 0.5 Curvature
	("	60-65 mm	6.8 ± 0.5
80 min	("	20-30 mm	12.0 + 0.8
	("	55-60 mm	11.8 ± 0.8

So *I can conclude that most probably the length of the Coleoptiles did not influence the formation of Auxin in the tips of exercises* ... (19).

Would other researchers do not find such an influence, then the rest of my conclusions hardly change because I'm in the extraction of Growth Substance as much as possible to ensure through cut in a series of experiments, the tips of plants of the same length. Incidentally, I've registered on any protocol that length, so that later would be a possible correction of my numbers possible.

Yet another question is how the length of the cut-off points affect the amount of diffusing into the Agar Growth Substance. In the series of experiments 166-170 I have this question, studied at the same time with that of the localization of Auxin formation. I cut off 10 points of a certain length and also the immediately following Coleoptile cylinder of 1-1/2mm of a length. These two groups I have subsequently set for 60 minutes to 2 Agar plates. The resulting curves are given in TABLE XI.

From this table it is clear that the Growth Substance is formed only in the outermost tip (<0.7 mm) ... (20).

and that for the formation of Growth Substance, as long as the tips are cut off ... (21).

In all my tests, the length of the tips is about 1.5 mm, and ranged between 1 and 2 mm as the outermost limits.

****

TABLE XI.

I've also re-examined whether the growth-would be concentrated in the tips cut off by the tips after the cutting is not immediately on Agar, but they kept until some time at 100% humidity on a slide. Experiment numbers 454, 455 and 458th Critical angle = 18.7° ± 0.7. 8 tips for 75 min on Agar yield a curvature of 12.8° ± 0.6. The corresponding curvature of 7 points for 30 min on Agar should therefore be about 4.8 0th And 7 tips that have stood before it for 30 minutes on Agar, only 73 minutes are kept on a slide, give a curvature of 4.7 ± 0.5 0. *So I can conclude that if no transfer takes place from the top of Auxin, the concentration inside the top do not yet increased* ... (22).

(48)

The following experiments will relate to the response of plants. First I will discuss the influence of its length to the curvature. In addition I have of a series of tests the various test numbers, which showed the same curvature, and asked the selected response plants along its length and divided into several classes. Of every class I have determined the mean angle of curvature.

****

TABLE XII.

TABLE XII does not allow any certain conclusion. For in two of the three cases, no influence of length and can be seen in the third case, the influence of even very clear. I do not know how this contradiction can be explained. I obtained during my tests the impression that the shorter plants bend more than the longer ones. *So I can best express the result as follows: the same amount of Growth Substance on one side set to different lengths of plants, so the bend shorter plants are probably stronger than the longer* ...(23).

This finding, as I have already emphasized (19), also of minor importance for the quantitative results, because the response of plants have the same numbers from a different experimental test series, but on average the same length.

The thickness of the response plants could exert a marked effect on its curvature. I have only one set of experiments then examined in the same way as I have indicated in TABLE XII for the length. When I test numbers 150, 151, 154, 158, 159 and 165 used. The plants are divided into three classes,

(measured thickness using a microscope to the shadows) namely 34-35, 36-38 and 39-41 ticks of the ocular micrometer. The curvatures of these 3 classes were, respectively. 6.44°, and 6.36°, 6.39°. *It appears, therefore, thus, as-if the curvature of the plant response is not influenced by their thickness* ... (24).

I have also examined whether the breaking of the first leaf through the Coleoptile curvature of the asset reduces the plant response. There are 12 selected plant response, which protrudes at the first leaf had 2-5 mm of the Coleoptile. Of those in the usual way, cut the top 6 mm of the Coleoptile and the leaf primaire been pulled out. In this plant, I then flake the 12 cubes of Agar, have stood on the top 10 for 60 minutes, placed on one side. The curvature is 6.6° ± 0.5. response to 2 x 12 plants of about the same length, which is but the first leaf not yet broken through, 2 x 12 cubes are two Agar plates, which have been on 20 points each for 30 minutes stuck. Of these

Plants is the curvature 7.1° ± 05th Taking into account that by (11) the curvature of 20 points -30 min should be greater than that of 10 points -60 min on Agar, *we come to the conclusion that the curvature property of the response is quantitative plant completely independent by piercing the Coleoptile through the first sheet.*
... (25).

On page 43, and 44 already given an example of changes in qualitative and quantitative terms, which occur in the decapitated seedlings and 170 minutes after the decapitation of the formation of a new physiological tip are due. There, I've noticed that the angle of curvature is reduced from that moment on strong. This emerges very clearly from the data listed in TABLE XIII.

(50)

The tests are 92 and 95 the day before, an attempt 103 is one day after the tests carried out 98-101. The Agar cubes of 98-101 are about 30 minutes after the decapitation, placed on one side, and were photographed again after 180 min.

****

TABLE XIII.

One sees that the curvature resulting 12 tips 60 min on Agar (which would have to be about 17°) has decreased to 7.3°. The experiments with four tips 30 and 60 min on Agar give exactly the same result. In another series of experiments (114-118), the plants were photographed only 170-175 min after decapitation, there were curves, the 6° - 7° and 3° - 3.5° would have to be up to 4.5° and 0.4° declined. Hence *the conclusion is drawn that from the moment of emergence of new physiological tip at (25° to about 170 minutes of decapitation), which go back quickly with an attached one-sided Growth Substance produced negative curvature* ... (26).

My preliminary tests (Went 1926) are performed at 20° C. Was therefore probably the physiological tips after decapitation formed until later, as in the experiments discussed here, so that the curves still only 210-220 min after decapitation were photographed, not too large errors result.

When unilateral placement of pure Agar were always about 50% of the plant weak positive curvature, the influence of the regenerated physiological tip is very clear.

Following the trials Dolk's (1926) I have tried the Growth Substance from the regenerated tip physiological extract.

I have to cut 20 points from Coleoptiles and let it stand 90 minutes on Agar. Curvature as I obtained 15.6° ± 1.1 (critical angle). 7 hours after decapitation, I cut 12 of the new physiological tip (the upper 2 mm of the decapitated seedlings) and set at 105 min on Agar. The curvature, which resulted in this Agar plates was 6.4° ± 0.6. This result should be compared with (6) and (20), so I to the same conclusion as Dolk succeeded, namely, *the tip is cut from a Coleoptile, then the upper part of the stump, which forms in intact Coleoptiles no Auxin to go over his training* ... (27).

6. THE DIFFUSION COEFFICIENT AND THE MOLECULAR WEIGHT OF THE GROWTH SUBSTANCE.

As I shall show in more detail, the absolute amount of Auxins, which is formed in a tip, is vanishingly small. Hence his analysis of the physical constants are inaccessible. An exception is the diffusion coefficient, which I have prepared. This measurement approximates the molecular weight calculated. And especially because Thovert Öholm (1909, 1912) have shown that the square root of molecular weight (M) is a function of diffusion (D) is:

$$D \sqrt{M} = C$$

It turns out that for non-electrolytes in water for
$D_{\sim 20}$ C = 7.0 and that within the

Interval = 50-500 M, the above empirical formula is valid with great accuracy.

Be made in determining the molecular weight of the diffusion coefficient, the condition that the Growth Substance is not or only very weakly dissociated. I must confess right away that there is no priori reason for such an assumption. However, the found diffusion coefficient is quite small, so is that the molecular weight between 300 and 400, so it is hardly possible that we are dealing with a strongly dissociated material, since carbon compounds (see also page 58) the dissociation with increasing number of carbon atoms decreases sharply.

In the determination of diffusion coefficients have to have confidence that it has a single substance and not dealing with a mixture of substances. Even before this were a priori no compelling reasons. One would then either make the assumption that there are several growth-promoting substances, which are formed together in a point, or you need to argue that the Growth Substance is composed of two or more components, which together have only one growth-promoting effect. By these assumptions, the whole thing becomes unnecessarily complicated, and we are from the diffusion experiments will also be seen that the diffusion of the Growth Substance of the legality of a simple substance follows.

Now I can go on to describe the attempt to do this. In some preliminary tests (260-268, 269-274), the diffusion rate was determined approach. The test series 277-282 gives us a useful measurement that is listed in TABLE XIV.

On the Agar plates N. 278, 0.61 mm thick, 12 tips have been standing for 180 minutes. Afterwards are 3, 0.61 mm thick and also the same size chips

pure Agar plates placed on the former, in the way that they line up completely covered. After 30 minutes, the four plates were again separated from each other so that the diffusion was interrupted. The curvature of each of four plates was then determined.

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TABLE XIV

Since the curvatures can even directly connect to the concentration of Growth Substance in the platelets, can be calculated using these curves the diffusion coefficients. Only one should take into account the influence of the Agar as diffusion medium. After Voigtländer Agar-Agar brings in 1, 2, 3 and 4-percent solution, no appreciable change in the diffusion coefficient. Öholm has found little impact of 2-10% gelatin on the diffusion.

It is however pretty sure that if the diffusion coefficient in 3% Agar is identical to that found in water. The error thus made is certainly small in relation to other sources of error (determination of the concentration of Growth Substance!). The calculation of diffusion coefficients is carried out by means of interpolation by Bruins (1922).

In TABLE XV in the first column, the resulting curves are registered. The second column shows the relative amounts of Growth Substance in the 4 platelets

converted for a total amount of 10,000 in the 4 tiles together. In the third column shows the values for 10,000 x to Bruins (1922) are calculated. For this x can calculate the diffusion coefficient D, according

$D= h^2 / 4tx$

h is the thickness of the Agar plates in cm, t is time in Days.
$h^2 / 4t = 0.045$ in our case

*****

TABLE XVI.

The values for D are given in the fourth column, while finally p (the relative weight of measurements) and the product p D in the fifth and sixth column was the actual diffusion coefficient at 25ºC then after this experiment:

Σ pD / Σ p = 0.40

After Öholm is:
$D_{20} = D_{25} / 1 = \propto X 5$

x is equal to 0035 in the diffusion coefficient in the amount of about 0.4, which in our case can be used to calculate D 20 = 0.34.

The test series is another provision 472-478

the diffusion coefficient. But here are five Agar plates for 30 minutes each set, so I had to interpolate between the numbers of detected curvatures. In TABLE XVI, the experimental data are given; for explanation see TABLE XIV that of the last column contains the interpolated FIGURES for diffusion by 4 per Agar plates of 0.76 mm thickness.

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TABLE XVI.

For D_{20} can be in the same way as in TABLE XV for the Test series 277-282, a value of 0.39 calculated. As for the mean diffusion coefficient from the two test series 277-282 and 472-478, we obtain $D_{20} = 0.36$ ... (28)

In our case we can equate quiet D20 D 0j 20, and it can then calculate the molecular weight:

$D \sqrt{M} = C$

$\sqrt{M} = 7.0/3.63 = 19.4$
$M = 376$

... .(29)

The molecular weight is therefore quite large and the magnitude of cane sugar. My conclusions as to the dissociation of the Growth Substance was therefore justified.

7. THE TRANSPORT OF AUXIN IN THE COLEOPTILE.

Although the issue is one of the transport of material not in the Coleoptile living here so they can perhaps best be discussed here because it is closely linked with the question of diffusion.

In the plant, the material can be forwarded not only by diffusion, because it would take far too long otherwise the transport (no consumption on the road would be after 2 hours, the concentration of 25 mm below the tip about 4 X 104 of those at the top). There must therefore another mode of transportation.

With de Vries (1885), one can consider the flow of protoplasm as the most important transportation factor. Brauner (1922) also believes that its hypothetical turn awake retardant material is transported by cytoplasmic streaming, and describes how he has really seen this in the intact Coleoptile. I have repeated this experiment and was observed in intact seedlings under microscopic observation with red light cytoplasmic streaming, even in the cells near the tip, although the current was too slow there. Some measurements of flow rate gave a value of 0.5-1 mm per minute at 25° C. *This value is quite sufficient to explain the transport rate of Growth Substance* ... (30).

Theoretically, one can also think of the matter as follows. Within the cells, the transport occurs accordingly using light Proto plasma streaming, from one cell to another must be a diffusion be assumed by the cell wall (the shorter the cells, the smaller the transport rate will be and this will be to diminish after the tip). The diffusion is done so through the cell wall from protoplast to protoplast, the cell remains the most likely Growth Substance in the cytoplasm and is able to

Transport are not transferred into the vacuole, because otherwise it would have to happen every time two more boundaries. Since I do not believe that the protoplasm of two young adjacent cells is discontinuous, that it also is a boundary between the two, so I do not think that permeability changes, if at all present, some have an influence on the rate of transport of Auxin can (for example, compare 1922 and Brauner 1924).

I've also performed some experiments to demonstrate the transport of Auxin through Coleoptile cylinder. This set of four Coleoptile cylinder be exactly the same length with their basal cut surfaces on a pure Agar plates. On top of this cylinder is then placed Agar plates with growth, and after some time the whole system is broken again. If you have chosen the length of the cylinders and the transport time properly, it will be found in the ex post analysis, that part of the Growth Substance of the upper plate is transported to the bottom. In the test series 508, 511, 514, 519 and 520 as 10 points during 120 minutes on Agar have been. This Agar was then able to produce a curvature of 26.0°, 4 points for 120 min on Agar yield 1004 ± 0.5. For a transport time of 75 minutes and at a barrel length of 2.3 mm in the lower reaches platelets 10.2 ± 0.6; in the upper left is 13.5 ± 0.7, is thus used in the cylinders were 2.3. With a barrel length of 4.2 mm, these numbers: 5.1 ± 0.4, 14.9 ± 0.4 and 6.0.

The conclusion from this experiment is, first, *that evidence in truncated Coleoptile cylinder an active transport of Auxin is (a rough calculation has shown that about 200 times more Auxin is transported, as would be possible by simple diffusion)* ... (31)

(58)

Second, *that a certain amount of Growth Substance, which is approximately the length of the cylinder, is used in the cylinders ...* (32)

From (31) and (32) is close to the idea that the pair (1919) of Auxin transport can not be right, because no new substance is formed and only the original amount will be further promoted.

From other trials (523-531 and 542-549), but do not have a quantitative value that can be fired, *that the transport of Auxin in inverse Coleoptile cylinder asked not to take place so that it is polar ...* (33)

For normal state of the 2 mm-long cylinder and 60 minutes transport time, the amounts in the upper and lower plates 9.9 ± 0.8 and 5.3 ± 0.3; with inverse level, these numbers are 12.7 ± 0.9 (critical angle) and 0.2 ± 0.3 and in another case was detectable even after 120 minutes with inverse able at a barrel length of 2.0 mm, no transport (13.2 ± 0.4 and 0.2 ± 0.3)

8. THE CHEMICAL NATURE OF THE GROWTH SUBSTANCE.

About This can unfortunately only very little, and mostly negative things to say, what was to be expected. Because the amount of Growth Substance, diffuses out 100 points for 4 hours, is vanishingly small, and little or no residue after evaporation than detectable. And what's more, that this residue is composed largely of the substances dissolved in the cell sap. From tests van Dillewijn's (1927, p. 565) show that diffuse a long time after being cut from lace or electrolytes from the cells. This is of course also with the other in the cell sap solutes such as sugar, etc., of the case.

Is that the Growth Substance is not an inorganic nature, can be regarded as very likely.

For the toning of these substances must be managed as such from seed or from roots to tip, then one would expect a correlation between seed and growing zone occurs between the tip and growing region. Even Miss Seubert (1925) has found no single inorganic substance is a growth-promoting effect.

And finally, the high molecular weight of evidence against the inorganic nature of the Growth Substance, since - must bear in mind that the same is soluble.

Of specific organic materials you can very well imagine that they are formed in the top of nutrients. The only way to get closer to the chemical nature of these substances will be well to consider all possible pure organic substances with a molecular weight between 300 and 400 on their effect. It should not begin with such complicated materials as diastase or saliva, as Miss Seubert (1925) does. Because the growth-promoting effect of this is in any case the presence of very small amounts of some attribute of an impurity, namely the enzymes themselves are ineffective, because 15 minutes long cooking exercise of saliva, etc. have no influence on the growth promotion.

But I have still some exploratory reactions of the Growth Substance studied:

1.Reduction of Fehling. For this, in the usual way and cut Coleoptile tip cylinder set during different times on plates of silica jelly. The curd is subsequently examined for their reducing effect. The result is shown in TABLE XVII.

The values are the means of various provisions. O is not the name, +? very weak, ++++ strong and significant reduction. From this table it is seen that the largest quantity of reducing substances, the first

(60)

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TABLE XVII

Number Tips or Cylinders - Jelly Time - Response

5 minutes after cutting pass into the jelly. Because the sugar will cause most of this reduction, and because these occur mainly solved in the cell sap, this result can be understood quite well. The contents of cut cells will emerge that is equally at touchdown. Since the length of the growing cells in basal direction, the amount of the exiting cell sap and grow at the same time reducing the impact. If you tip a long time on Agar can be so worn away the original, reducing substances, so they will resume from the tips (see van Dillewijn, 1927, p. 565). *The amount of Growth Substance is therefore in no way the amount of reducing substances leaked proportional* ... (34).

2. Diastatic enzymes. In the literature one encounters now and then (for example: Janse 1922) for theoretical discussions, in which growth is attempted to be explained by a splitting of starch into sugar, which causes a higher osmotic value of the cell sap. To explain the growth then you need only to accept a diastatic activity, and here is also looking at probably one of the reasons why Miss Seubert

(61)

Examined (1925) is precisely the action of diastase and saliva. Therefore it was necessary to the formation of enzymes in the Coleoptile diastratic investigate. Their determination is done by spikes or Coleoptile cylinder on silica jelly, which during their manufacture something is added for strengthening in the solution. With iodine is subsequently examined whether and how much power has been implemented by the diastase.

On the excretion of enzymes diastratic can almost say the same punch as the reducing sub. Also, they are best viewed as Poorer content of the cells, because they run mostly during the first ten minutes after cutting into the jelly. Some proportionality between the time during which the tips on the jelly and the diastratic effectiveness can not be found. Coleoptile cylinder tips are not for the secretion of enzymes. In summary we can say that *just as in (34) here is a link between the formation of Growth Substance and excretion is to find the diastratic enzymes* ... (35).

It remains for me now to discuss the attempts I've made over the photo and thermal stability of the Growth Substance.

Only the tests come on the influence of light on the isolated growth-promoting substance, because the question is after this impact is of interest for a more detailed explanation of phototropism, also Lange (1927) discussed that.

Under this influence of light, white light is naturally understood because the presence of red light in the experiments can not be avoided. For our purposes, suffice it because Coleoptile are almost insensitive to red light phototropic.

The experiments were performed in the following way. For a test series in a certain number Agar plates by the same amount of Growth Substance extracted by making all the same number of points equal to last long. Later, these platelets in the previously described exposure box in a dark room at 25º C. exposed to large amounts of light differently. Which are then analyzed in the platelets contained Auxin response quantities with the help of plants. TABLE XVIII contains the numbers of two test series.

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TABLE XVIII.

In the test series 397-401 each have eight points during 65 minutes standing on a Agar plates; was in the test series, 407-411 4 The tips during 210 min exposure with a Argenta lamp running perpendicularly across the Agar plates.

From this TABLE we see that the used amounts of light do not exercise the slightest influence on the Growth Substance. That's why I'm still running a pair of experiments with natural light and ultraviolet light. But even that light behaves towards the Growth Substance is completely indifferent. Experiments 198 and 202: Growth Substance in the dark: Growth Substance 1000 s at the window in the bright daylight = 8.7°: 8.1°; trials 462 and 466 (critical angle 19.3°) Growth Substance in the dark: growth-60s with arc light (4 amps at 10 cm distance) exposure = 12.5° ±: 1.1: 12.8° ± 0.9.

(63)

The result of these experiments is therefore that *the Growth Substance at any light intensity and composition is completely stable* ... (36).

The heating of the Auxin in Agar caused me more difficulty, so that I can actually only reported qualitative results.

First I have gone into hiding in the small Agar plates Weighing bottles in warm water to the desired temperature. A major disadvantage of this method is the drying up of Agar plates by prolonged heating. This difficulty, but you can meet by the dried Agar plates clean a tile is placed (test 426). These two plates are then divided into 12 cubes together and so glued to one side of 12 response plant. Try 425, I min at 60° C. warmed 8.3° ± 0.8: The resulting experimental curves were 426, heated for 10 min at 90° C. 7.20 ± 0.6: Experiment 427, control, unheated, 8.20 ± 0.6 .

Later, in another way Agar plates have been heated. In an about 0.6 mm thick plates of celluloid, a rectangular hole of the same size of a Agar plates is cut. To heat the latter is placed in this hole, the celluloid plate is clamped between two object glasses waxed and immersed in warm water the whole frame. This method also has disadvantages because detach small air bubbles formed during heating, a portion of the Agar. Series of experiments, 479-481 (critical angle 15.2° ± 0.7) test 479: heated Agar for 10 min at 92° C., lost 10-20% of the Agar produced by air bubbles, curvature 7.6° ± 0.40; test 480, Control, not heated , curvature of 9.2 ± 0.8.

I take from these experiments, *forces suggest warming to 90°C. causes no change in the effectiveness of the Growth Substance* ... (37).

Through these experiments, nor of the molecular Weight aside, the proven non-enzymatic nature of the Growth Substance. Miss Seubert (1925) had already proved that the promotional material that could be detected in saliva and diastase, was heat resistant.

Finally, I must mention a series of tests that has been carried out at the suggestion of Prof. Dr. L. Baas-Becking and together with him. We have taken very different groups of substances authorized and tested for their effect increased growth-regulating. All investigated substances have been issued in the form completely ineffective. Were tested: distilled water, Na_3 P 0_4 0.5%; Na_2 H P 0_2- 0.5%; Na H_2 P O- 0.5%; Glycerin 1%; Stearic acid 0.5% NH_4CNS 0.5, 0.1 und 0.003%; Uric 0.5, 0.1 and 0.003% Glycol 0.1 and 0.003% Kreatin 0.1 and 0.003%; Coffee, Hippuric, Guanine and Asparagine saturated; Thorium 0.5 and Hexo-bi- phosphate 0.01%

SECTION IV

ANALYSIS AND SYNTHESIS OF GROWTH OF INTACT COLEOPTILE.

1. INTRODUCTION.

In the previous section, I analyze one of the components of growth and yet I have come to certain conclusions. Now the question naturally arises whether these results can not be recycled in order to get a deeper insight into the growth of the Avena Coleoptile

Emerged from my experiments, (9) that the growth response of plants is quite limited on the amount of Growth Substance. So it was very likely that in the complete absence of Growth Substance is no growth.

The following set of data is extremely important. I am pleased to inform the results of unpublished experiments by Dolk. For this kindness I am indebted.

With its previously described methodology (Dolk 1926) he examined the question of striated top by means of direct growth measurements. He had already shown that one-decapitation growth decreases sharply until it rises again after about 3 hours, as a new physiological tip occurs, so that will be formed anew a growth-promoting substance. In his experiments, he has now carried his decapitated plants after 2 hours for the second time, to any formation of Growth Substance (27) to prevent. The result was that growth fell further and further to nearly complete suspension growth. This stoppage could be waived at will by the addition of Growth Substance. After attempts by Dolk so *there is no growth without Growth Substance* ... (38).

From this result, combined with (9), it follows immediately that *the growth of Coleoptile corresponds to each zone of all their crowd of Auxin* ... (39).

Because the growth in the absolute amount of Growth Substance is proportional to (3) and because growth can be reversibly reduced to 0 (38), you must assume that the Growth Substance is consumed during growth and thus disappear ... (40).

By (20) Auxin only in the outermost tip is formed, where its concentration is therefore the highest, while it decreases basal, because there is no new substance is formed and it is used up the road ... (41).

From (39) and (41) would now be seen that the growth intensity of the base to the tip to constantly increasing. *Growth can not increase indefinitely with increasing amount of Growth Substance, because at a certain moment, a new factor*

(in addition to ZSM mentioned, because I will show further below, that it is probably based on the amount of cell elongation material) is limiting, as has been shown in (14). Is expected to decompose thus the growth intensity of the different zones of the coleoptile in two areas. First, there is a distance from the tip to where the factor limiting ZSM acts, and at a certain distance from the tip begins the second area, where the growth-restricted growth. How these two areas are to each other, so how the growth intensity in individual cases, designed, can be determined only by direct measurements. Therefore I have the rate of growth of the fields Avena seedlings studied under different conditions.

2. METHODOLOGY OF THE MEASUREMENTS.

n the literature several such measurements are already to be found. Rothert (1893) has in fact the distribution of growth with different lengths Avena plants measured by marking the coleoptiles 3 mm long transverse zones, whose extension is determined after 24 hours. Since my own determination totally with those Rothert's (TABLE on page 28) match, I need not discuss them here in detail. I just want to repeat his conclusions. At 12-15 mm long seedlings increases the basal growth without reaching a maximum. With longer (18-24 mm) plants, the growth of the peak intensity increases to maximum (approximately 6-9 mm from the tip) to rapidly, only to drop just gradually.

Pinkhof (1924) gives a method for measuring the growth zone, he gives figures just monitored around the rate of a zone (2-3 mm from the tip) to. Other provisions monitored around the distribution relate to other objects and are therefore not usable for my purpose.

Run my reported here measurements are all in the dark room 25C, and 85-90% humidity was, on the to be measured Coleoptile are periodically (½ - 2 mm) mounted as fine ink marks., When I used a magnifying reading it is not possible to mark zones of the same length, because, I have mostly made several measurements on an object. The zones were already at the second determination were of unequal size. I have put no particular value to a uniform zone marker, A big disadvantage of this is that it requires time-consuming conversions when plotting the growth curves. The readings are horizontal with a magnifying glass (magnification about 10 - fold) was built with a micrometer eyepiece executed at certain time intervals (2, 6, 8 or 12 hours), whereby the distances between the upper edges of ink marks determined. The seedlings will be measured by reflected red light, even though pretty much triggers, no perceptible phototropic curvatures. I omit the measurement results in tabular form to lead, either because it would be confusing (for accurate reproduction), or just moving closer (with interpolation). In the used measuring method, one can add the numbers of different plants not too readily, because the zones have the same length. Accurate interpolation is impossible, because sometimes the measurements fluctuate around a mean, as the FIGURE 10a between 8 and 16 mm shows. It would be easy to manage by his own subjective opinion, so I reproduce here only the curves 9, 10, 11 and 12 associated with the observed figures.

But they comply to the image I of the growth, unequal distribution of long and have won under different circumstances, plants grown to play well. For it turns out that plants arise from the same length, which are grown under the same conditions, often almost exactly the same distribution of growth, so that their corners meet.

3. LIMITATION OF NORMAL GROWTH BY THE GROWTH SUBSTANCE.

Now I will, before I provide an explanation of all the growth going on, for a case to prove that the Growth Substance in the normal plant really limited the wax from the base. From below to be notified attempts I had gotten the impression that if the basal zone of Coleoptile grow no more, the cause of this phenomenon is to be sought in the fact that the concentration of Growth Substance has become too low. To check this perhaps I have followed the distribution of growth in a number of Avena seedlings, and grow as long as they can until the base grew no longer than a length of 10-20 mm and even shorter (see the explanation this phenomenon, page 88). In this way, I had to dispose of normal, no longer growing cells that were grown by the usual idea that can not grow, but they had set in my opinion due to lack of their growth promotion. Of these seedlings I have growing then the upper part cut off, pulled the first sheet and on this one stump Agar cubes placed with growth *).

***

*) The growth-rate was not analyzed in detail, because I was only trying to show qualitatively the re-growth. I obtained the cubed Agar plates, had stood on the 7 tips for 4 hours, was divided into 9 cubes.

(69)

Then I have the growth during the first 3 hours after the mounting of Growth Substance measured, and placed after this time a new cube with growth and measured the growth of the next 3 hours. To test the possibility that renewed growth is no longer growing this part is only a result of decapitation, I have a plant in this part measured without the addition of Growth Substance. The results of the measurements I've compressed presented as mean value in TABLE XIX.

****

TABLE XIX.

The growth I've been following for 15 hours before the plants were decapitated. From this we see that the zones that were used by decapitation, in the first 12 hours are still grown substantially. The following three hours but they are no longer grown, and most zones have been even shorter. Then I cut off the upper part and on growing plants in a three Agar cubes is set with growth, only one other plant has been decapitated. Practice the result is decapitation; the stumps with growth beginning to grow again immediately, and remain six hours long growing. Without Auxin through the plant shows no growth at all while the first 3 hours, because I'm not after that time, decapitated a second time, a physiological tip could be regenerated. And this explains the fact that in the second 3 hours, this plant has grown a bit again. From this experiment we can conclude *that in a normal Coleoptile adjust the basal cell growth by their lack of Growth Substance, and that the latter allows basal cells to adjust their growth again* ... (42).

This has been proven that really limited the growth in the base material growth. The adult state of a cell is very relative, and the cells have not reached their absolute final length, only by a certain stimulus, they do not grow out of. This phenomenon is probably widespread in the Plant Kingdom. Because many cells can greatly increase in bile production, what they do in the normal case. Maybe dwarf and giant stature in many cases with a change in the amount of Growth Substance will be explained.

4. LIMITATION OF NORMAL GROWTH BY A FACTOR OF ZSM

By the proof. be that the growth-limited growth in the base, has now shown that in the limited tip another factor. The easiest way to test this claim, will be caused by the tip of a unilateral change in amount of Growth Substance. This change may not come immediately then in a curve to the expression, but only at some distance from the tip, where the material begins to limit growth to occur at the first hint of a bend.

To achieve the unilateral amendment of Auxin in the tip, I have this exposed on one side with 20 or 1000 MKS In Section V, I'm going to prove that is transported as a result of this exposure on the front less Auxin basal than on the back. This change is due to phototropic curvature. After Arisz (1915) begins with the first visible curvature of an asymmetry of the tip. This observation has been disputed, but several times (Brauner 1922, Long 1927).

Because of the uncertainty in this regard, I have tried to follow the phototropic curvature exactly.

In addition I have a *"Universal Kinamo"* - Camera film used with panchromatic film. The seedlings are as described by Lundegardh (1922) and Buder (1926) recorded as silhouettes, the background is formed by a weak red light with illuminated glass of milk. The drive of the film camera is done via the new intermittent cinema de Bouter's (whose description yet to be held).

This method has the great advantage that the exposure time is doubled compared with a conventional drive-cinema. Intermittent cinema is regulated so that every two minutes is a complete revolution and the film is so suddenly turned to one frame (the cinema axis is connected to the frame crank). The seedlings are exposed to 6 or 7 installed in a row in front of the camera and the first image is already taken one to three minutes after exposure. The curve is thus traced for 2 to 3 hours. Because I was concerned only with the first stages of curvature, I can not rotate the plants on the cinema intermittent. The images are enlarged to development with a projector and traced the contours of the seedlings at the beginning of the experiment on a paper. Then all of the following images are projected, and the picture painted is placed so that each time the tip coincides exactly with that of the projected image. It is possible in this manner, very accurately reveal the writhing zone. And really seems (at 25° C. and 91% humidity), the first visible curvature in unilateral exposure of terrestrial plants by 1000 MSK about 3 mm from the tip, and after about 20 minutes.

(72)

With a solid response in water zone plant is this curvature even 8-10 mm from the tip and occurs 30 minutes after an exposure of 20 days on foot. Some more precise measurements of the curvature of course I still hope to publish later. But here is sufficient to note the fact that *the first visible curvature occurs at a distance of 3-10 mm of the tip. At its tip, the amount of Growth Substance, the growth of Grässer not determine, however, the latter is limited by another Factor We have called ZSM* (page 66) *) ... (43).

5. THE DISTRIBUTION OF GROWTH CURVES.

We have seen that in a Coleoptile at least two factors are that determine the growth intensity in the different zones. We are now asking whether the whole distribution of growth can be explained consider using these two factors in more detail. For this we need only discuss the obtained curves of intensity growth. In these curves, the abscissa gives the zones from the tip to expect in mm, and the ordinate the extension of the zones in a given time in hundredths of course the original length.

First, I discuss the curve, which is shown in FIGURE 9, and which I regard as the prototype of the growth distribution. I have received many curves that are very similar. Like the Reaction, this plant has been pulled into the water. From the top to increase the growth of the deeper zones almost logarithmically (beautifully pronounced in the 10 to be discussed after a curve, FIGURE 10),

***

*) As will be shown at once, these are probably not capable of growth zones writhing.

shows up to 10 cm from the tip of a sharp bend to the curve of unworthy, decreases rather regularly, up to almost complete standstill growth. The presence of the sharp kink, I insist, in particular, although different curves do not show, it is unmistakable to many (see also FIGURE 11). For here is really the case realized that was expected theoretically on page 66 already, namely that two mutually independent factors limiting the growth of each of them in a certain part of the Coleoptile

FIGURE 9
The Distribution of a Solid Growth in Water Plant.
Abscissa: Coleoptile Zone mm Distance of the Tip.
Ordinate: Percentage of the Zones During Extension Tables for 8 Hours.

Before I try to explain the behavior of each curve parts, I will discuss it first, nor the other curves. FIGURE 10 shows the growth of the individual zones of intensity of a 16 mm long in solid earth Coleoptile (a) for 8 hours, during which time it has lengthened by about 8 mm. Then I have of it, but now measured 24 mm long Coleoptile (c) the growth distribution in the next 8 hours.

It is clear that in the curve just a factor of ZSM emerges. This case is always shorter plants in front, the longer they get, the stronger the effect of another limiting factor (W = Growth Substance).

So I obtained another one under a curve 20 mm long in solid earth plant, whose first course completely covers the curve a, but showing at 11 mm distance from the tip of a sharp bend, so the growth intensity of 62 to 44 drops in the zones from 11 to 20 mm.

FIGURE 10
The Growth Distribution of Terrestrial Plants, with a 16 mm Long, with B 24 mm Long.
Abscissa: the Distance in Mm Coleoptile Zones Top.
Ordinate: Percentage of Zones Extending Tables for 8 Hours.

An important difference between the earth and in plants grown in water consists herein, that the factor in the former ZSM allows a much larger growth rate than the latter. This is best seen with short plants, since their only factor of ZSM limited. Here the solid in water for 8 hours to reach plant never an extension of 50%, usually it is only 40-45%. Plants that are pulled into the earth, have the same length in a zone extending up from 60-70%.

Finally, we consider FIGURE 11 It is made according to measurements in water drawn from a plant whose Mesokotyl had grown strongly (in the first measurement: Coleoptile length 20 mm, 15 mm long Mesokotyl).

The first measurement was performed during growth of the Coleoptile of 20 mm to 25 mm in 8 hours (dotted line), the second curve (dashed line) is for growth of 25 mm to 32 mm again in 8 hours while the unbroken the growth curve in the last 8 hours, indicating from 32 mm to 38 mm. The dots mark every time Al A2 and A3, the place where the Coleoptile is excreted in the Mesokotyl; the curve of the Mesokotyl has been drawn thinner.

It is striking that the three curves on the whole are equal and uniform so that all three have the same *"surface area"*. The ZSM factor is to pursue only briefly because of the relatively large length of the plant, will be so hard to deduce from these curves, a possible influence of length on this factor. When you Factor W can be observed no influence of the length. This is very conspicuous, but easily understandable when one (42) takes into account, the growth will be purely physiological basis and is completely independent of the morphology and anatomy of the Coleoptile

FIGURE 11
The Distribution of a Solid Growth in Aquatic Plant with Mature Mesokotyl, the Zones of the Right A_1 A_2 and A_3 Are Mesokotyl Zones.
Abscissa: Removal in Mm of Coleoptile Tops.
Ordinate: Percentage of Zone Extending Tables
For 8 Hours.

Because the zones of Growth Substance Because the zones of Growth Substance telescoping out, once they obtained in the way outside the range of Growth Substance, they learn to grow, their growth seems then fixed.

More, can you infer from the Figure 11, we see that *the growth of Mesokotyls by a Factor W is determined; it is not there any more, so it ceases to grow. The only physiological difference between coleoptile and Mesokotyl is to be found in the fact that the growth rate, due to the Factor W, is 2-3 times stronger in the latter than the former.* ... (44).

I have observed in several cases. One should therefore perform physiologically not excessive separation of these two morphological units. Photo Tropical attempts of mine. Father about the attempts by Miss Bakker (1924) reported for seedlings of Paniceen-Keimlingen the justification of this set have already been established.

About the outgrowth of Mesokotyl much has been written, and almost every author has discovered another cause of this phenomenon. Only Pisek (1926) and Beyer (1927a) have recently been the view to which I also get so rich, argued that the outgrowth of a natural phenomenon that can be put down but by changes in external conditions, be. I can now define a little sharper than Beyer, namely that the outgrowth of Mesokotyl is determined by the amount of Growth Substance, which was obtained there. Any reduction in the amount of Growth Substance will prevent outgrowth thus be more or less. Thus, the effect of exposure of the germinating seeds may be explained in this way as well as the result of decapitation (Beyer 1927a).

Now I have the most important facts I've found in studying the growth intensity discussed, and can tie some considerations thereto.

6. MORE DETAILED CONSIDERATION OF THE FACTORS AND W AND ZSM

First we shall look closely at the factor ZSM. This factor is only detectable, which makes the Growth Substance to be induced by the growth of intact Coleoptiles only within certain limits (43). In decapitated seedlings, the growth is also limited by some factor, so that in my experiments, a certain critical angle can not be exceeded (14). As mentioned above, the ZSM factor increases with soil-grown plants much higher than that drawn in water, while it has been shown in (18), that the critical angle is much greater in the former. This shows that *the phenomena that represent, in both cases the only detectable "limiting factors" the effect of Growth Substance, basically the same, because they depend in the same way by the culture of plants* ... (45).

It is not difficult to give a likely cause of this phenomenon. Because the growth of a cell is still primarily due to the presence of a certain amount of organic and inorganic materials, which form the plasma, the cell wall and the osmotically active substances 1). You also need plenty of water, of course, the growing cell, but this is in my experiments with 91-92% humidity in sufficient quantity available to the cells begin to guttier because just at the point of the plant. And otherwise the suction force of the cells is sufficiently large to

1) To this end might come even more specific natural substances that are formed in specific organs or cells (as in the roots) and are necessary for growth.

include any desired amount of water (in contrast to the view Priestley's 1926, 1927) Through the above analysis one comes to the conclusion that the above substances, Which are the best under the name of cell elongation material (ZSM) sums must be performed only after the cells growing before growth is possible. This nutrient can flow only from the endosperm or from the roots originate, so expect a correlation between the growing zone and the seed must. This correlation is actually by Beyer (1925) has been demonstrated for Avena . We can then close that the ZSM factor is really attributable to the diet of growing cells.

As already discussed rather what, the transport of Auxin and mutatis mutandis of cell elongation of the material to be mainly due to cytoplasmic streaming, or else the huge transport speed is not to explain. The transportation cell walls would cause the greatest difficulties in this. The length of the cell takes in all the tissues of the Coleoptile to the tip (are accurate measurements of parenchymal cells of Zea Coleoptile by Miss Tetley and Priestley (1927 before)) off to transport The rate case after the tip will suddenly be much smaller and finally only a fraction of its original speed. If you imagine now how the distribution of cell elongation material on the cells of the Coleoptile turns out, *it is expected to find according to this view, the highest concentration near the seed, and it does not shrink until only a little, and near the top more and more, so that we really come to a theoretical distribution of cell elongation material, Which completely agrees qualitatively with that found* ... (46).

Here, perhaps to be pointed out that the distribution of water in the Coleoptile can never explain the shape of the curve factor of the ZSM.

The Factor W must be now considered in more detail. In (41) has already been said anything in advance about its history, Namely that it would be on it's highest tip and decline Gradually towards the base would. And we can say that this view is for longer plant has been fully confirmed. Because of 3-8 mm from the tip of the growth takes off on a regular basis. Because the amount of Auxin at the base is necessarily smaller than the tip (compare (42)) and after (39) the growth of each zone there are crowd of Growth Substance meets, *we come to the conclusion that the Factor W. is simply due to the amount of Auxin in the Coleoptile* ... (47).

To buttress this conclusion, I have performed measurements on decapitated plants to the amount of Growth Substance, And thus change the Factor W. Doing so is the action is off the top, and the growth takes place only where Auxin is present still. Twice by decapitation (the second time 2 hours after the first) I have turned off any new formation of Auxin during the first fourth hour Growth of these plants, then the distribution has been measured. One of the measurements is shown graphically in FIGURE 12 . The curve a (solid line) is the growth during the first 2 hours later after decapitation. The line c (dotted) shows the distribution of growth during the second two hours and the curve d (dashed line) represents the whole. Growth during in interpreting these repressive four curves, we are the growth areas, more than 20 mm from the tip away, not being considered because it relates only to the Mesokotyl.

Curve d shows us the distribution of Auxin in the Coleoptile, where it is impossible at a given moment each formation makes. The first piece shows a bit of a Factor ZSM But from that point on the curve regulation drops and runs in the same sense as the Factor W, as we expected. *The amount of Growth Substance is present at which a particular moment in the zones of a Coleoptile is also a factor proportional W.* ... (47a).

FIGURE 12
The Growth in Water Distribution of a Decapitated Plant

a after a while the first two hours of decapitation;
b while the second two hours;
c together during these 4 hours
Abscissa: Distance in Mm Coleoptile Zones the Top.
Ordinate: Percentage Tables extension of the zones for 2 or 4 hours.

I'm still not so far that I can give my attempts by a completed picture. Why is it that the curve of a 5-20 mm, nearly parallel to the abscissa runs, can not be explained without auxiliary hypotheses. Because actually it would have been there several times because W. and decreases the factor most likely already but this seems restrictive.

The rise of the tip to be naturally explained by the limitation of the growth Factor Will be the ZSM. Curve C seems to me entirely understandable interpreted the Growth Substance as a *"limiting factor"* because it is only very little of that left.

Finally, we still can say that the growth of Mesokotyl really was like in (43) have concluded, with a smaller amount of Growth Substance amount is greater than the one of the coleoptile.

The shape of the growth curves Dolk (1926) and twice after a decapitation would received with the help of the above tests are explained. Since I have but too few measurements, I will not try.

There is still another reason for the claim that the Factor W is the quantity of Growth Substance and not of another intra-determining factor due to the outgrowth of support plans in (19) I have shown for a case that the length of the exerts no influence on the formation of Auxin in the tip. Consequently, even with longer wants to plant as soon as the growth-restricted, the total growth is difficult to. change Looking at the FIGURES 9, 10 c and 11, then it is immediately apparent that the content of the growth curves (for example, the total growth) is about the same in the different cases, except that the plants moved with their roots in soil or water have been (compare (17)). This information does not agree with those Sierp's (1918), Koningsberger's (1922) and Miss Tetley and Priestley's (1927) agreed on the great period in their growth. They all find a pronounced optimum in the growth of a certain length and there is no horizontal line in their curves. I placed plants in the Koningsberger's Auxanometer

(1922) observed that there are often grew plants that have a very long time on a regular basis the same growth rate. Individual plants are the least different sizes in its period. A partial explanation of the above contradiction is to be comfortable.

Is in first place after the above-mentioned conception of growth, the same increase only upon renewal of the plans, because there are probably enough Growth Substance-over-the-zone can not grow faster by a factor of ZSM The longer the plan is, the more zones are one have certain growth rate and the greater the growth. It is the moment when the growth-limiting one of this surplus is present in the plans not, because everything has been exhausted. Soon, however, decreases the growth until the formation growth of a substance corresponding value. This is the case with a length of about 20 mm. Is this the moment of silence in Mesokotyl growth, Which will gradually cease to grow and in this way thus decreases the total growth (43). And finally, I will not deny that from about 40-50 mm in length, either the formation of Growth Substance is reduced or the growth of the Latter no longer affected equally. For the Latter view, however, not proven fact, would say that longer give plants a smaller curvature in unilateral placement of Agar with growth (23). And finally, my own growth distribution measurements so no absolute value.

But there are at least even plants adjust their growth even more. So you take the average of various plants, it is hardly possible for the individual variability to be found in the great period, a track where the growth does not change with changes in length.

From the foregoing it can be seen in any case, it still requires detailed studies to explain the great period of the growth- promoting factor and the ZSM. Not on the possibility of seeking an explanation, I doubt. Only should we exclude the growth of Mesokotyl and use the individual provisions, without averaging calculations.

7. THE USE OF THE ABOVE EXPLANATION OF THE GROWTH ON OTHER OBJECTS.

Of course there is the question of how far the lessons have to Avena views about the reasons for the growth and distribution is still valid. There lie in the first place, the growth measurements of seedlings of Secale-Keimlingen of Bünning (1927). At first glance, the conditions there seem to be quite different. Secale-Keimlingen seedlings with longer has to be only one of very short high-growth area, with 24 mm tall plants, for example 11 to 15 mm from the tip. After both sides is the rapid growth of the zones to almost zero. Wounded to the seedling on one side above or below the growing zone, to meet as in both cases, strong curvature in this. zone Although Bünning refuses to explain these curves by Correlating faults, still I believe that they are most easily explained by this. Bünning relies on measurements of growth stimulated Coleoptile, but this did not agree with the observed curves. According to the edge of the growth measurements, location of the incision, have grown faster than the edge facing away, while it has grown into reality less (see curves on page 451, and growth measurements on page 441 and 442). Apparently the conditions are either being too complicated for one-sided incision or the measuring method is unreliable 1).

Bünning has not taken that to wound surfaces of (at least Avena) Coleoptile regeneration of a physiological tip occurs (Dolk 1926, Miss Tendeloo 1927). Returning now to the correlation noise disorder, thus making the bends it is very likely that there is a correlation between both peak as the base and the growing zones. The case is completely comparable with Avena Therefore, with the difference that the two factors act on each other faster and more likely to disappear, and where they come together, there is an explosive growth.

In other aboveground organs (I infer from the root growth, while the ratios are different because of the growing zone in cell proliferation takes place) with tip growth are in similar conditions as for the Avena Coleoptile. there even, the strongest growth is due to cell elongation, not cell proliferation. It is impossible to discuss here all details about the distribution of growth in stems, flower stalks, etc. But with many objects you have found a similar distribution as with Avena, where shows so at some distance from the tip of the growing zone of a maximum. This growth will be explained in the same manner by two factors. The one factor, the growth-promoting effect of the tip (flowers, buds, etc.) in this process is already well known (Söding 1926). But also details of growth failure in such stems, if they are separated from the plant are a common occurrence.

This parallelism between Avena Coleoptile and flower stalk appears recently (unpublished)

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') Led in the distribution of Coleoptile growth, on page 445, example is to find the maximum extension in the zone V, while it would have on the TABLE on page 437 in the zone must lie II.

Investigations into the Utrecht Institute go much further. It is Miss Uyldert namely succeeded with the Growth Substance from the growth of the decapitated Avena blood stalks of Bellis perennis accelerate again. Cholodny After (1926) The growth of Lupinus hypocotyl is stimulated by the Zea- Coleoptile tip diffusing substance. And finally it seems after the investigations of Stark (1921) and Stark and Drechse1 (1922) that the growth of grasses Coleoptile stump by tip of other species and genera will be affected. *Because there are probably only growth-promoting substances (51) is the Growth Substance (even with the graminaceous seedlings) are not specific to one) ...* (48).

As pathways for growth, we can assume in general with Miss Kastens (1924), the sieve tubes. But I believe that the sieve tubes, or the form will never Leptom Growth Substance.

The attempts by Beyer (1925) and Cholodny (1926) show very strong in this direction. Namely, the Leptom (sieve elements) in Lupinus hypocotyl cut away so the remaining cylinders Grow Significantly less than intact isolated hypocotyl. Coleoptile are an exception because it is hardly trained Leptom.

8. THE INTERNAL PROCESSES INVOLVED IN GROWTH.

At the end of this section I want to reflect the idea that I've made from the inner processes in the cell during growth.

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1) I suspect that the difference in sensitivity of the stumps for irritated tips of other species, etc., revealed by Stark, is due: at first the more or less well connected of the tips of the stumps, which influences the number of plants significantly curved (see page 29), second the amount of Growth Substance formed in each peak and of the third. Sensitivity of the tips for light difference.

This part of my work is purely theoretical, and not supported by direct experiments, as elsewhere in this and the previous section. And this part is to show just how I imagine the way for further analysis.

About the physiology of cell growth in higher plants, we still know very little, most studies have been performed on single-celled or filamentous organisms because of the simple observation of lower ability and because of the (probable) simplicity of operations, in comparison with higher plants. Some of the recent work of Baas-Becking, those (1926) and Baas-Becking and Baker (1926) Spirogyra. But in this case we have next to each other and by cell growth and cell division. And this is the case with many other lower organism. The growth of the Avena Coleoptile is pretty easy to call in comparison with Spirogyra, because it only comes into existence by cell elongation. I believe that with the cell elongation in Avena based on principle not discontinuous, in the Ways I am like so Baas-Becking disagree (1926), because of the Auxanometer Koningsberger (1922) is to discover almost no periodicity.

As the main cause of growth we want, after Sachs (1874) and de Vries (1877), to consider the pressure exerted by the cell contents to the cell wall. By the fact of expanded growing cells, the cell wall reaches its elastic limit, as required by the theory of Sachs, who has requested Lepeschkin (1907) for a case, even if it was not perfectly detected (in Spirogyra).

Next is Overbeck (1926), a strain of cell walls during normal growth are proven in the cells convincing. Also, Ursprung and Blum (1924) came with geotropically curved roots to this result. This view facing the views of Pfeffer (1893), who takes an active wall growth as the cause of the extension of plant organs. But how has Overbeck (1926) had shown; this conclusion of Pfeffer's is not mandatory. In my opinion, there is the theory of Sachs, in particular by the experiments of Overbeck (1926), and rightly so. Therefore, I would consider this together with the experiments of Ursprung and Blum (1924) more accurately and presented in a slightly different way, use to explain the growth-promoting effect. By (9) the growth of Avena cell is dominated quantitatively by the amount of Growth Substance, and without Growth Substance, there is no growth (38). Growth in this case, therefore, secondary and non-growing state primary. Attempts by the authors mentioned above are now so important for me because they investigate fully comparable to the cells have little or no part in the growing state (concave side of curved root geotropic) and partly in the growing state (convex side).

If we compare now the primary state (no growth) to the secondary, so we will see the following differences. The osmotic value of the cell content is about the same in both, perhaps even a bit The Latter smaller. The growth is not Achieved by an increase in the osmotic pressure. The situation is even reversed when the turgor pressure of growing cell is the smallest, the suction force of the cell is usually much higher than high and in the end non-shaft cell. From this it is found that of the wall pressure decreases rapidly during growth, the cell wall is much more elastic. Ursprung and Blum (1924) have confirmed this conclusion by direct measurements, as many authors had done before them to other objects.

And Overbeck (1926), it makes it very likely that this elasticity is purely passive, and not, such as pepper and sometimes my origin and Blum, active. In this way, the distribution of values and the osmotic suction explain informally in a normally growing organ. Necessary As a conclusion from the above notion of growth, and at the same time as I come to completion, the Growth Substance as the cause of the expansion to take over the cell wall. The Growth Substance *Thus increases the elasticity of the cell wall, so that the Latter is plastically stretched by The osmotic pressure of cell sap and extended irreversible* ... (49).

At the same time must be provided, however, that will continue during osmotic enough material in the cell is formed So that the osmotic pressure is not lowered too far. For this condition there is a good support. Namely, the amount of Growth Substance in a cell too small and it is no longer growing in length, it begins to shorten (see FIGURE 11). This reduction may persist for many hours long. For this phenomenon could be up to several hypotheses. First, the osmotic value could decrease the cell sap, so that the wall is less extensive and Consequently shortened. Then the Coleoptile but would have to limp, and the opposite is the case. The cause must be found in so just to increase of turgor, through the sharp increase in Which cell length in the more or less spherical shape to take on the endeavor and is shortened in this way. For the root shortening has been de Vries (1879) given a similar explanation. This capital increase turgor pressure can take place while the suction force of the cell is initially quite high and the cell gradually absorbs more water. The amount of water coming into consideration is so low that they could be included within one to two hours because the cells so long as sufficient water is available.

(89)

There remains only the possibility that there is a constant formation of osmotic substances in a cell that does not stop when the cell is not due to lack of Growth Substance grows in length ... (50)

As is understood, however, the idea of the effect of Auxin on cell wall with our present knowledge of the construction of the cell wall? Frey (1926) has proved beyond doubt that the mature cell wall made of cellulose micelles, Which are embedded in a inter-cellular substance exists. How the Latter substance presents so the cellulose micelles are only Gradually incorporated into this matter (the young cell wall is not even a cellulose reaction, see Ziegenspeck (1925). The micelles are not fused. According to Frey, so it's very possible that the Growth Substance will only change the elasticity of inter-mi cellular substance. The micelles may have already formed then move along each other and the mi-cellular structure of the cell wall requires does not produce discontinuity in the growth.

Although it is still not sufficiently informed about the chemical composition of young growing cell wall, one is still generally believe that it is constructed of only a few substances, Which substances in higher plants about are the same (pectin, cellulose, perhaps hemi- cellulose cells and fats. The fact that the Growth Substance is not specific (48), is hereby in good agreement, it would be very difficult to imagine the effect of a single substance on otherwise disparate cells, because the result is the same in all cases.

Actually, I would have rather have to make when discussing the attempts by Dolk (page 65) a visit. It can be done but here. Namely there is growth inhibitory substances'?.

Previously that was universally accepted. But gradually this question for specific cases is denied. Paal (1919) was the first of all the surveyed curvatures (trauma and phototropic) with a disturbance in the supply of growth-accelerating substances declared. Against this view have raised strong and many others, because they assume the existence of growth-inhibiting substances, Beyer (1925) and Miss Tendeloo (1927) have, however, any involvement of inhibitory substances during awake turn able to come from trauma tropisms curvatures rejected. Miss Gorter (1927) has demonstrated for a number of substances previously regarded as a growth retardant, that they do not affect the growth of primary. And now that we can (38) that there is no primary growth. Only when Growth Substance is there, can grow a coleoptile. Primary growth may not be thus inhibited. *This is just possible if the Growth Substance either not formed or destroyed, or its effect on the cell is rendered impossible. Wax inhibition thus is secondary, because it presupposes the presence of Growth Substance and according to our present knowledge there are no reasons at all to explain it other than by reducing the amount of Growth Substance. ...* . (51)

SECTION V.

THE ROLE OF GROWTH SUBSTANCE IN PHOTOTROPISM.

1. INTRODUCTION.

In this section we will deal with the changes undergone by the formation and transport of Growth Substance under the influence of light. My experiments on the Growth Substance initially had the purpose, an explanation of phototropism to Establish experimentally.

During the experiments the problem but moved more and more in the direction of the normal growth, so that the phototropic questions fell into the background. However, the results obtained seem to me important in two respects. First, they demonstrate that the method for extraction of Auxin also for analysis of abnormal growth processes, such as Taoist curves, useful, and leads to relatively easy way to achieve compelling conclusions. And secondly, I believe that the attempts, though not completely, throw in several more controversial issues, a new light.

2. THE EXPLANATION OF THE LIGHT GROWTH RESPONSE (TIP RESPONSE).

I'll start with the discussion of the light growth response. This has been studied by many researchers already in Avena, but I need here only the work of van Dillewijn's (1927) to consider, because it contains by far the best analysis of this phenomenon, and that is because his experimental conditions correspond to at most with mine. The relevant literature is read to him.

I suspected (Went 1925) and van Dillewijn (1927) thus Assume that the tip response (reaction time =) able to transport through a change in the formed or expectant crowd down comes the Growth Substance, as a result of exposure of the tip. With the Possibility that the Growth Substance is formed by the light changed, need not be calculated (see (36)). The above assertion is now accessible to direct analysis and I will give my attempts to do so here.

Only a few words about the methodology used. The main thing has been already Described in Section II But the plants are in the box before decapitation exposure

(Page 22) illuminated from above with 100 MK 10 seconds. From my preliminary experiments (Went 1926) had emerged that the amount of light causes a reduction of the extracted amount of Growth Substance. Immediately after exposure, or until an hour later, the tips are cut off as usual and placed on a Agar plates. After they have been on this for some time (½ -1 hour), they are transferred to a pure Agar plates, and this event is the repeated treatment. The amount of Growth Substance is analyzed as usual by means of 12 plants reaction. The experimental results are Summarized in TABLES XX and XXI. To calculate a mean value from these FIGURES, I have a lot of Growth Substance, Which diffuses out from unexposed tips at 100th The conversions I've done all with regard to the results obtained in Section III. TABLE XX contains the results of three trials.

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TABLE XX.

In all three of the diffusing tip growth of unexposed material amount is compared with those that diffuse 13-43, 43-73 and 73-103 minutes after exposure for 10 seconds vertical with 100 MK of a certain number of points.

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TABLE XXI

In TABLE XXI, the amount extraction time 1 hour, then double the previous TABLE. Exposure Are So with 1000 MKS Again, some of the same tips, after standing for hours on Agar, transferred to a new Agar plates On which they stood again for 1 hour. plans in two series of experiments I had the tips only an hour at the in order to extract only the subsequent hours on Agar. load in the two tables it is noticed that the individual trials show Considerable differences sometimes led, in contrast to the results in the third section, whenever a complete agreement between the various qualitative

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*) Auxin apparently destroyed in storage by bacteria.

Test series is found. These differences are not an indication of Thus a faulty methodology, but they are the manifestation of a great variability of symptoms occurring after exposure. But this can not be surprised if you even look at the results of quantitative analysis of the light growth response. Even with Dillewijn van (1927), it is noticeable that the responses vary according to tip exposure usually. Take for instance his TABLES 79 and 80, enter the top six responses after exposure to the extreme tip with 10 X 80 foot so with a light amount corresponding to the use, in my opinion. For comparison of the responses I use the growth deceleration during the first and the first 3 hours after exposure, the delay is in the individual cases: 50, 100, 140, 150, 160, 180 in one hour and 500, 600, 670, 750, 780 and 940 in three hours. These differences are certainly no attempt to ascribe failures, but they are like, me, a manifestation of the variability of the light growth response after tip exposure.

The results set out in TABLES XX and XXI, but are qualitatively and quantitatively useful in broad terms For clarification, I have plotted in FIGURE 13 The numbers of the third and fourth columns are added together in TABLE XXI. For obviously the amount of Growth Substance, diffuses out during the second hour, The Same Regardless of Whether the tips are the first hour after exposure to Agar or be left on the plans.

The FIGURES a and b are drawn So that the unexposed tips diffuses out Growth Substance amount is shown at 100. The collected after exposure Auxin quantities are entered in chronological order.

The first 5 to 10 minutes, between the spread exposure and placement on Agar, the amount of Growth Substance yet indicated at 100th The lack of Growth Substance has been hatched. For comparison, I have the light growth response (see FIGURE 25) for 3-sided exposure of the tip at 500 MKS (Went from 1925, FIGURE 4) shown in the same way *). But here was used instead of the amount of Auxin, growth, and growth retardation is hatched. Looking at the graphical representation of a (FIGURE I3), it is noticeable that the light of a strong reduction in the amount of growth in Flagstaff during the first half hour causes. In the second half hour and even after the equilibrium is more or less restored by the formation of Growth Substance to the dark value again approaches (52). FIGURE 13b shows something similar. Consider now FIGURE 13c, we see immediately that the growth retardation is of the same magnitude as the reduction in the amount of Growth Substance, and that these two effects of light have only a temporal difference . The explanation of this phenomenon is very simple. We can say that the light causes a reduction of the primary diffusing out of the tip Growth Substance. This change manifests itself immediately in a growth delay, because it is not in the top So the growth is limited by The amount of Growth Substance. If the change is propagated but further down, and the limited area where the Growth Substance, is reached, it will express itself in a growth delay.

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*) I have made some attempts at control, whether an exposure is two-sided from above with a comparable. That could be really out of the test series 375 - 378 closed because exposure on 2 sides with 10 sec X 100 MK are 7.2 ± 0.4 and exposure from above with 20 sec X 100 is 8.2 ± 1.0 MK. But it is clear from the experiments leading to further be seen with a unilateral exposure (57).

The FIGURE 13a is nothing more than a premature registered light growth response. So my opinion is rendered in the above lines of evidence *that the light growth response after tip exposure is a consequence of a light-induced reduction of the out of the top growth diffusing out* ... (53).

FIGURE 13
a and b: Effect of Exposure to the Extracted Amount of Growth Substance, C the Same on Growth. Hatched: Auxin Deficiency or Growth Retardation.
Abscissa: Time in Minutes after Exposure.
Ordinate: Percentage of Extracted Growth Promoter Amount of Growth or after Exposure. 100% = Molar Growth or Growth in the Dark.

3. GROWTH CURVE AND THE THEORY OF BLAAUW.

We have to know precisely the light growth response as a function of the formation of Growth Substance studied, and it must now be checked naturally 'to what extent the growth retardation curve van de Sande Bakhuyzen's (1920), the Growth Curve van DiIlewijn's (1927) with the analysis of the Growth Substance understandable. Originally, I had introduced to work out exactly this curve. For if the theory of Blaauw (1914) for the tip response is correct, and the phototropic curvature is actually based on the difference of the light growth reactions of opposed edges, the photo would be tropical mood symptoms and

the *"amount of stimulus law"* in a wonderful way to tell from the changes in the formation of Growth Substance under the influence of light was *). But also an extreme quantitative agreement between the amounts of Auxin, which are formed in different experiments with a certain amount of light would be expected. As TABLES XX and XXI show but is not the case, the lack of Growth Substance after exposure varies from 7% to 33%. This made me skeptical of the theory of Blaauw. There was added something else. I'd be tempted (Went 1926) from the Auxin quantities diffuse after exposure to different light doses in the Agar, to construct the growth curve change. I was very surprised when I could not release the results of my preliminary to reproduce at this point. Because I was not able to an increase of Growth Substance upon exposure to large quantities of light (5000-500000 FMD) detected. Every time I obtained other growth curves changes which showed a similarity in the fact that no rose at 10000-100000 foot on the dark value. I've done it from attempts at lower temperatures (16° and 20°). The results were so variable that I have not the tests continued, apparently because there were unknown factors that caused this variability. That is why I refrain from the exact release of test results.

At the same time I have tried to quantitatively calculate the growth curve of change van Dillewiin (1927), the curvature at a one-sided exposure with for example: 800 MKS.

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*) Bakhuyzen Van de Sande (1920) has reversed its growth delay curve derived from the curves that occur after unilateral exposure and derived atmosphere phenomena.

And strangely enough I have come to the conclusion that even in a constellation, as low as possible for the theory of Blaauw, the curvature calculated at many times in the back is really occurring.

A calculation using my own numbers leads to the same conclusion. For suppose that the rear side of the tip at one-sided exposure with 1000 MKS (supplied in 10 seconds) receives no light, and so is the normal growth of amount of substance, and gives the front of the maximum reduction in the above-mentioned amount of light as in the TABLES XX and XXI is headed, so it can calculate the resulting curvature. Assuming that the growth of a Coleoptile is around 2.4 mm for 2 hours at the formation of the normal amount of Growth Substance, it would in these two hours, the front only
83 / 100 x 24 = 2 mm

(After TABLE XX) or 87/100 x 24 = 2.1 mm to be (according to TABLE XXI) has grown, if indeed the whole growth-reduction has been discernible in a growth delay, which needs not to be the case. The curvature angle (°) of a Coleoptile growth is determined by the difference, (1 x -1 v) the concave and convex side and by their diameter (d), the 1.4 mm. Because
$2 \pi d x \propto 1_x - 1_v$

In our case
2π x 1.4 x $\propto$/360 = 2.4 - 2.0 or 2.4-2.1
$\propto = 16.3^o$ or $\propto = 12.2^o$

We can say with certainty that these values are calculated by a few times too high because we have accepted the light falling in the top of infinitely large;

a light fall of 4/5 to 1/10 in the top (as Lundegardh 1922) believe the curves would probably only one-quarter to one-fortieth of the amount calculated here. And yet these bends of 16.3° and 12.2° 3 to 4 times too small for experiments in a dark room at 25° C. yielded curves of intact Coleoptiles of 48°, 2 hours after the one-sided exposure with 1000 MK So you see in the investigated case, not the theory of Blaauw that phototropic curvatures explain quantitatively This fact is not new, it is considered by many researchers have expressed and demonstrated by some with numbers has been to these last I count primarily Pisek (1926) and Beyer (1927b). An overview of the current state of the theory is by Stand Blaauw'schen and theory by Bruner (1927).

The criticism of Brauner's attempts to Pisek (1926) is incorrect because the growth of the upper 14 mm, only one part of the total growth (is in my five FIGURE 10 for example, only 5/9).

The criticism van Dillewijn's (1927) against Pisek is not valid. Of course, Pisek would be able to determine with the used methodology is no light growth response, which was not his intention. But probably the difference in the growth front and rear would have to find a writhing Coleoptile, and this has not just found. why is his conclusion that Blaauw's theory has, in his case are not valid, fully justified.

Beyer, (1927b) has provided recently in a case of a perfect argument against the theory of Blaauw.

Except in the case of Brauner (1922), but in which the calculation of curvature occurring incorrect, has arrived at using each quantitative test of the theory of Blaauw one dis-proportionality between calculated and actual curvature. So I'm like Pisek and Beyer concluded that *the induced phototropic curvature in the tip of Avena is not alone as a result of the different light intensity occurs in the reacting halves* ... (54).

4. THE EXPLANATION OF THE PHOTOTROPIC CURVATURE.

The above result is quite negative. Now we still do not know how the phototropic curvature because actually comes to pass. However, it is possible to solve this question by analyzing the amount of Growth Substance. Because without Growth Substance there is no growth (38) and the latter is proportional to the amount of Growth Substance (9). Except in the event that the amount of cell elongation material is changed unilaterally, but first mark near the base would make cash. Accordingly, *there would have to be any one curvature caused by a one or two-sided change in the normal amount of Growth Substance, which is usually at the bend point* ... (55).

Such must be modified in the examined cases (20-1000 FMD) have increasingly induced in the tip because of the effect of exposure remains the same, if only the outermost tip is exposed. The phototropic curvature must therefore necessarily be based on one in the tip by unilateral exposure caused changes in the formation or the transport direction of the Growth Substance ... (56).

This assertion (56) is accessible to scrutiny. In addition I have the amount of Growth Substance

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') Even those curves, which are caused by changes in the osmotic value of cell sap, are excluded, in my opinion, but these are rare, some are probably thermo tropic curvatures can be expected among them.

which at the light and the one which diffusing out to the shadow edge from the top, are collected separately. This is done by the tips are cut off one side of exposed plants and placed on two Agar plates so that their light is at one edge and its shadow side to the other plates. The platelets have an oblong shape (about 2 x 12 mm) and are separated from each other by a mica plate, which rises as far from the surface so it has exactly the same height as the Agar plates. Although it is not possible in this manner to avoid any diffusion from one to the other Agar plates, the results are qualitatively useful but in any case. They are quantitatively and recycled, if one only thinks that the real differences between the growth-promoting amounts of light and the shadow edge are still larger than the maximum found, while their sum remains the same.

I can not refrain from giving my number material to publish in detail, precisely because it has no absolute value, below I will give only the conversions. The latter have been executed in the following way: the amount of Growth Substance that is extracted from unexposed tips within a certain time is set at 100. Then, the amount drawn from the front as well as from the rear side of an equal number of tips diffusing out to this value. The FIGURES are comparable with those of TABLES XX and XXI, and are summarized in TABLE XXII. In the second column, also the time which have been standing on the tips of the two Agar plates is specified.

The following results can be recorded:

(102)

First, the entire amount of Growth Substance that comes from unilaterally exposed tips is about that which is in TABLES XX and XXI in an extraction time of 84 min in vertical exposure can be calculated (82 and 83), and the individual 'variability is even the same. *The formation of Growth Substance is so one-sided otherwise affected by a vertical exposure* ... (57).

****

TABLE XXII.

Second, *the growth-promoting amount diffusing out at the shadow edge is always greater than that which can be collected from dark tips* (on average 57 to 50) ... (58).

Third, *only 54% of the dark value of the Growth Substance are on the light side* ... (59).

From (57), (58) and (59) can be deduced the remarkable fact that the total amount of Growth Substance that is formed after unilateral exposure, is distributed in a manner typical of the light and shadow edge. The amount formed is that is mainly supplied to the shadow edge, so that on the light side but little remains.

Even if one-sided one hour after the exposure determines the difference of the two sides, we find very significant differences. In the test series 12 spikes 389-394 are exposed on one side with 1 x 100 foot, directly on the tips cut off and placed with their light and dark edge on two different Agar plates.

75 minutes later they have been transferred to two new Agar plates. TABLE XXIII gives the resulting curves. One can see that even 2 hours after the exposure of one-sided transport of Auxin is still in full swing. The fact that the phototropic curvature is several hours after exposure even more, is hereby also.

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TABLE XXIII.

Already been concluded 16.8 (54) that the phototropic curvature can not occur as a direct result of the different light intensities in the tip. Now there are two possibilities. First, the light fall, so the difference in intensity, be decisive (Darwin 1880, Nienburg, 1918, Buder 1920) and secondly, the direction of light as a cause of phototropic curvature would consider (Lundegitrdh 1919, 1922). The attempts to Lundegardh cites himself but for his opinion 'are not convincing, and the attempts Buder's (1920) speak very strongly against the light direction. We must therefore assume *that by the light fall in the forefront of Growth Substance tram, which otherwise runs basal sides evenly, and is deflected in the direction now induced a time goes on* ... (60).

Because Auxin is strongly polar in the Coleoptile, however, (33), it can not be surprised that the polarity in the top and there is also influenced by the light. This result can be well with that of Sierp and Seybold (1926) and especially with that Long's take (1927) in line.

Looking at Long's work in FIGURE 10 shows and compares this with FIGURE 9, one sees that in the upper part of the solid Coleoptile tip (of 200µ) does not decrease the sensitivity in the same degree as in the weather zones. In the various zones of this part but also the lateral transport of Growth Substance is about the same encounter resistance.

Following the results of Tables XXII and XXIII that the lateral change in the amount of growth substance in 1000 and 100 foot-, I give plants on one side with 20 M.K. 1 second with 100 M.K. Exposed for 100 seconds. At 20 M.K.S. I got out of the light side and 75 ± O.5 from the shadow edge 10.8 ± 1.2, the difference can enough explain the end curvature. At 10,000 foot, in which case my little amount of light in. curvatures occurred, were the numbers of light and shadow edge 13.8 ± 1.1 and 14.4 ± 0.9 and are thus the curvature accordingly.

5. THE EXISTENCE OF PHOTOTROPIC STIMULI.

Boysen Jensen (1910, 1911, 1913), Miss Purdy (1921), Stark and Drechsel (1922), Snow (1924a), Boysen Jensen and Nielsen (1926) and Stark (1927) are of the view that as a result of exposure growth-promoting substances, called irritants phototropic, arising at the side of an Avena Coleoptile reverse light. Brauner (1922), however, claimed that a growth-inhibiting substance growth inhibiting quickly to the front as a result of exposure. Paal (1919) believes that the constantly formation of growth forming substances pass through the light stimulus in unequal amounts of the heathens sides of the Coleoptile and thus give rise to phototropic curvature. Finally, says van Dillewijn (1927) that an increase or decrease in the formation of Growth Substance on the front or the rear side

the curvature conditions. The majority of authors therefore assumed phototropic irritants.

The cause of this assumption has not placed well with me (58). I observed the fact that the rear side of a tip stimulated phototropic growth promotion are greater than one unprovoked tip. But I believe *that it is clear from (57) and (60) with a certainty that is formed during exposure, no new phototropic irritant, but that the phototropic curvature by forming the normal Growth Substance can be explained. So I think there are no greater phototropic stimulus* ... (61).

If you now the theory of Paal those Stark's contrasts (see Note 7 and 8), we can say that the principle Paal has it turned out to be correct and although some details of his idea a little differently, so Paal has but the nature of phototropic curvature detected. Let's go now a little further into details, we see that the phototropic curvature is not solely a growth promotion on the rear side (Boysen Jensen and Stark c.s.) or only to a growth inhibition at the front rests (Brauner) and not as a result various degrees of growth inhibition or growth promotion of two sides (Paal, Rama, van DiIlewijn) occurs, but that I have examined cases of curvature by simultaneous inhibition of growth of one and growth (promoting the other hand, appears, as in van Dillewijn's case c (page 481, 1927). A nice support for my view are the experiments Beyer's (1927b). Let us look at his TABLE 4 (page 432-433), we see that one side exposed plants (Cm) have approximately the same average growth as two sides exposed (A) or darkened plants (B) (0.22,0.20 and 0.23).

The distribution of growth the plant is curved so that the rear side (Cx) is growing as much more than the growth front (Cv) has been delayed (033 and 0.11). His results can be explained so completely with the assumption that the Growth Substance formed in the tip amount is fed to a large part of the rear side.

In this section, until now only talk of a light effect on the tip has been. The investigation of the influence of light on the base, which I had planned originally (Went 1926), had to be unfortunately omitted, and the release of isolated facts, which I have observed concerning basic exposure, so it can remain calm under.

SUMMARY.

The main findings of this study can be summarized as follows. The continuing education (12) of a physical-to-use growth-promoting substance (Auxin) in the outermost tip of an Avena Coleoptile is shown (I), (5), (6), (20).

A method for quantitative analysis of this material has been worked out (1), (4), (9), (10), (11), (12), (13) and has made it possible to determine the following properties of the same.

Within certain limits the growth-restricted growth completely (9) and the growth is proportional to the amount of Growth Substance (9), (13), without growth-no growth (38), (42). *)

The fabric is light-growth (36) and heat-resistant (37), has a molecular weight of 350-400 (29), and is consumed during growth (32), (40). Lent probability is not specific (48) and causes only an increased extensibility of the cell wall (49).

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*) The Growth Substance can never be regarded as *"irritant"*.

(107)

In the Coleoptile of polar Auxin flow (31), (33), the concentration of the substance decreases basal (41). Another factor, called cell elongation material, limited by the Auxin-induced growth (14), (15), (43), (45), its concentration increases in the Coleoptile to basal (46).

Auxin and cell elongation material are the only detectable inner *"limiting factors"* of growth (14), (15), (39), using 'these two is the normal growth of a coleoptile fully understandable (47), (47a).

Are no longer growing basal Coleoptile zones have ceased to grow only by Auxin deficiency (42). The growth of Mesokotyl is also caused by Auxin (44).

A small amount of light (1000 foot) immediately calls forth a short-lasting reduction of diffusing out of the Auxin from the tip amount (52), which causes the light growth response (53).

One-sided incident light deflects the other sides coming out of the top Growth Substance flow from Surprisingly, the light edge very little (58) and receives the shadow edge an excess of Growth Substance (56), (59), (60), which Auxin difference is quite sufficient for the phototropic curvatures to explain, so there is no phototropic irritants (51), (61).

Be rejected as a consequence of the results obtained, the Blaauw theory to explain the phototropic curvature after tip stimulation (54), the light falloff is decisive for the emergence of the latter.

At the conclusion of this work, which was edited entirely in the Botanical Institute of the Utrecht University, I have my father and teacher Prof. Dr. F.A.F.C. Went my special gratitude for so many instructions and especially for its extremely sharp criticism, by which he has constantly supported my work. To Professor Dr. L. G. M. Bass-Becking. I thank for much stimulation. I am finally indebted to Mr. H.E. Dolk much for all the help and the provision of some very important test results.

LITERATURE.

Arisz, WH 1915, research on phototropism. D. Rec Trav. offered. neerl. 12 p. 44

Baas-Becking, LGM 1926, Studies on Growth I. Stanf Univ. Publ Biol Sc. 4 p. 61

Baas-Becking, LGM and Baker, LS 1926, Studies on Growth II Ibid p. 99

Bakhuyzen, HL, van de Sande, 1920. Analysis of photo tropical mood symptoms.. Thesis Utrecht 1920th

Beyer, A. 1925, Studies on the Traumatic tropisms the plant. Biol Zentralbl. 45 p. 683 and 746
--- 1927a. The Keimung physiology of Avena sativa. Ber. dd bot. Ges 45, p. 179
--- 1927b Experimental studies on Blaauw's theory. Planta, Arch f. wiss Bot 4 p. 411

Blaauw, AH 1914, first light and growth Very time. f. Bot 6 p. 641

Bottomley, WB 1915, A Bacterial Test for Plant Food Accessories (Auxins). Proc. Roy. Soc. London, 89 B.

Boysen Jensen, P. 1910, The management of the phototropic stimulus in Avena seedlings.. Ber. dd bot. Ges 28 p. 118
--- 1911, The phototropic irritation of Avena. BiH. d.l 'acad. roy. Danemark S. d. 1911, 3

Boysen Jensen, P. 1913, about the management of the phototropic stimulus in the Avena Coleoptile. Ber. dd bot. Ges 31 S. 559th
--- And Nielsen, N. 1925, studies on the hormonal relationship between the tip and base of Avena Coleoptile. Planta, Arch f. wiss Bot 1 p. 32l.

Brauner, L. 1922, light curve and light growth response Zeitsehr.f. Bot 14 p. 497
- 1924, permeability and phototropism. 16 Ibid p. 113 --- 1925, on the relationship between stimulus quantity and irritant success. F. wiss Bot 64 S.770.
--- 1927, The theory of phototropism Blaauwsche. Ergebn. d. Biol 2 p. 95

Brouwer, G. 1926, Periodic movements of primary leaves in the seedlings of Canavalia ensiformis Thesis Utrecht 1926.

Bruins, HR 1922, Viscosity and diffusion speed. Thesis Utrecht 1922nd

Buder, J. 1920, New phototropic fundamental experiments. Ber. dd bot. Ges 38 p. 10
1926, Cinematographic registration with the darkest red, and short exposure. Ibid p. 44 (47).

Bünning, E. 1927, research on traumatic irritation of plants. Zeitsehr.. f. Bot 19 p. 433

Cholodny, N. 1924, on the hormonal effect of the organ at the tip of geotropic curvature. Ber. dd Bot Ges 42 p. 356
--- 1926, contributions to the analysis of the geotropic reaction. F. wiss Bot 65 p. 447

Coster, C. 1927, in The Anatomy and Physiology of growth increments and annual ring formation of the tropics. Thesis Wageningen 1927.

Darwin, C. 1880, The Power of Movement in Plants. London.

Dillewijn, C. va n 1927, The light growth responses of Avena. D. Rec Trav. offered. neerl. 24 p. 407

Dolk, H E. 1926, Concerning the sensibility of decapitated Coleoptile of Avena sativa for light and gravitation. Proc. Kon. Akad v. Wet. Amsterdam, 29 p. 1113.

Frey, A. 1926th The submicroscopic structure of cell membranes. F. wiss Bot 65 p. 195

Gorter, C. 1927, About preventing growth and accelerating growth retardant materials. Versl. Kon. Akad v. Wet. Amsterdam, 34 p. 418

Haberlandt, G. 1913, 1914, 1919, The physiology of cell division I, II, III. Seat-ber. d. preuss. Academy of Sciences 1913, XVI, XX 1919.
--- 1921a, On experimental production of adventitious embryos in Oenothera Lamarckiana. Calc seat d. preuss. Ak. d. Wiss. 1921 XL.
--- 1921b, wound hormones as the cause of cell divisions. Beitr zur. allgem. Bot Ir. SI

Janse, JM 1922, Irritation at rectification column and vertical growth. F. wiss Bot 61 S.590.

S Box, E. 1924, contributions to the knowledge of the function · the sieve tubes. General Inst Mitt ad. Bot Hamburg 6, 1 P. 33

Koningsberger, VJ 1922, tropism and growth. D. Rec Trav. offered. neerl. 19 SI

Lange, S. 1927, The distribution of light sensitivity in the tip of Hafer Coleoptile . F. wiss Bot 67 p. 1

Lek, H. A. A. va n der, 1925, Of rooted cuttings, Diss Wageningen 1925

Lepeschkin, WW, 1907, To knowledge of the growth mechanism of the plant cell. Beih. such offered. Centralblatt 21 p. 60

Lundegardh, H. 1919, The importance of the direction of light for phototropism. Ber. dd bot. Ges 37 p. 229

Lundegården h, H. 1922, A contribution to the quantitative analysis of phototropism, Arkiv för Botanik 18 No. 3.

Nielsen, N. 1924, Studies on the transmission of stimuli in the Coleoptile of Avena. Dansk bot. Arkiv No. 4. 8th

Nienburg, W. 1918 About phototropic curvatures on the long side partly obscured AvenaColeoptiles. Ber. dd bot. Ges 36 p. 491

Öhol, LW 1912, The Free Diffusion of non-electrolytes. Meddel. fran Vet-Akad. Nobelinsritut Vol 2 No. 23.

Overbeck, F. 1926, Studies on the mechanism of the geotropic curvature and growth of the radicle of Vicia Faba. Zeitschr. f. Bot 18 p. 401

Paal, A. 1914, over phototropic stimulus lines. Ber. dd bot. Ges 32 p. 499 --- 1919, over phototropic conduction. F. wiss Bot 58 p. 406

Pfeffer, W. 1893, pressure and work performance. D. Abh Math-phys. Cl. d. Royal. Saxon. D. Ges Wiss. 20 p. 235

Pinkhof, M. 1924, Methodological analysis of voorzorgen bij de Nadere lichtgroeireaktie. Versl. Kon. Ak.v. Wetensch. Amsterdam, 33 p. 678

Pisek, A. 1926, Studies on the light at Hafer Coleoptile Auto-tropisms of the curvature of the conduction and the connection between light growth response and phototropism.] AHRB. f. wiss Bot 65 p. 460

Priestl y, H. 1926, Light and Growth UI and IV New Phytologist 25, p. 213

Purdy, A. 1921, Studies on the path of transmission of phototropic and geotropic stimuli in the Coleoptile of Avena. Danske Vid. selsk. biol. medd. 3·

Ramer, H. 1926, Tropical Photo curvatures of seedlings of Avena Which appear when response of the distal side is excluded. Proc. Kon. Akad v. Wetensch. Amsterdam, 29 p. 1118.

Ricca, 1916, Solution d'un de Physiologic probleMiss Arch ' ital de biol. 65th ecause Rome, LG 1926, about the interplay of factors of production. F. wiss Bot 65 p. 739

Rothert, W. 1893, over heliotropism. Cohn's Beitr Biol Plant d. 7 p. 1 S S oh, J., 1874, Textbook of Botany. 4th edition. 1880, 1882, the planting material and form; enorgane. D. bot. Inst Würzburg II p. 452 and 689th
--- 1887, about the effect of ultraviolet rays on the flower formation. D. bot. Inst Würzburg 3 p. 372

Seidei, K. 1923, Experiments on the conduction in Mimosa pudica. Beitr a11. Bot 2 p. 557 Se Ubert, E. 1925, on growth regulators in the Coleoptile of Avena. Very time. f. Bot 17 p. 49

P Sier, H. 1918, A Contribution to the knowledge of the influence of light on the growth of the Coleoptile of Avena sativa. Very time. f. Bot 10 p. 641
--- And A. Se y bol d 1926, studies on the sensitivity of the tip and stump in the Coleoptile of Avena sativa. F. wiss Bot 65 p. 592

Snow, R. 1924a, Further Experiments on the Conduction of Tropic Excitation. Ann. of Bot 38 p. 163 --- 1924b, Conduction of Excitation in Stem and Leaf of Mimosa pudica. Proc. Roy. Soc. , 96 p. 349

Söding, Will H. 1923, Ber-formed from the top of Hafer Coleoptile growth hormones. dd bot. Ges.41 p. 396
--- 1925, The knowledge of growth hormones in the Haferkoleoptile. F. wiss Bot 64 p. 587

Söding. H. 1926, On the influence of the young inflorescence on the growth of its shaft. F. wiss Bot 65 p. 611

--- 1927, over growth hormones. Cell-Stim. Research 2 p. 381

Stark, P. 1921, Studies on trauma tropic and Haptotropic conduction processes. F. wiss Bot 60 p. 67

--- 1927, The conduction problem in the plant in light of recent experiences. D. Results Biol 2 p. 1

---, And O. D was legal in 1922, Tropical Photo Reiz1eitungsvorgänge with interruption of the organic connection. F. wiss Bot 61 p. 339

Tendeloo. N. 1927, Investigations into so-called tropical curves trauma in seedlings of Avena sativa.. Versl. Kon. Akad v. Wetensch. Amsterdam 34th P. 661.

Tetley, U. and JH Priestley, 1927, The histology of the Coleoptile in relation to its phototropic response. New Phytologist 26, p. 171

Ursprung A. and G. Blum, 1924, A method for measuring the wall and the cell turgor pressure, along with applications. F. wiss Bot 63 p. 1

Vries, H. de, 1877, Investigations on the mechanical causes of cell elongation. Leipzig, W. Engelmann, Opera periodicis collata I p. 357

--- 1879, over shortening of plant cells by absorbing water. Bot Zeitung 37 p. 650

--- 1885, transport on the importance of circulation and the rotation of the protoplasm of the substance in the plant. Bot. 43 p. 1 Opera by e.. collata 4 p. 159

Went FAFC 1924, Communication on Miss A. Bakker 's *"Investigations regarding the existence of separate zones of Perception and response in the Seedlings of panicea."* Proc. Kon. Akad v. Wetensch. Amsterdam, 27 p. 501

Went, FW 1925, Concerning the Difference in Sensibility of the tip and base of Avena to light. Proc. Kon. Ak. v. Wetensch. Amsterdam, 29 p. 185 1926, On growth-accelerating substances in the Coleoptile of Avena sativa. Proc. Kon. Akad v. Wetensch. Amsterdam, 30 p. 10

Ziegenspec, H. 1925, through intermediate products of carbohydrate structure of cell walls and their mechanical properties. Bot Archive 9 p. 297

CONTENTS.

(From the Dutch)

PROPOSITIONS.

I

The *"Q_{10}"* is from the physiology of disappearance, only in exceptional cases, the term *"temperature coefficient"* is maintained.

II

It is not lawful. where acids or bases an organism correct chemical attack, the hydrogen ion concentration of the external environment is only of secondary importance for the life of this organism.

III

Turgor changes in a cell-able permeability changes seeming to call forth, the influence of light on the *"permeability"* can thus be explained.

IV

It is not lawful. The light growth response comparable to photochemical processes. that periodically fluctuate with the amount of light used.. (Plotnikow. Zeitsehr. F. Physik 32 p. 942).

V
The dry iventra quality bends in Avena, described by Bremkamp, must be explained by a unilateral change in the amount of *"elongation material"*.

VI
The microscopic spores of Diatoms are understood as micro-gametes.

VII
The tripolar Radiolariën Peridineeen need to be calculated.

VIII
The genera Trombone, Piptocalyx Idenburgia and form a separate family among the Ranales

IX
Unlike the constitution of an organism, which is not income Mendel plasma characteristics, needs the external form, for example including all the matching attributes are considered as a result of taking income, based companies anywhere in the core gene constellations. Form convergences are nothing but the same genes in different combinations once adopted, this constitution plasma brings the necessity of it, the origin of species Polytop as very likely to be considered

X
Immunity against wheat rust attack is a function of plasma properties of both the host and the parasite, the acidity of the cell fluid has no meaning there.

XI
The emergence of highly specialized. obligate parasitic fungi can not be explained. because a number of the diverse parasite hosts shrinks.

XII
For desert animals metabolic water is their water need.

XIII
The tertiary Brauner coal deposits are not native or formed in swamps.