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ON THE DISCOVERY OF THE LIGHT FACTOR IN PHOTOSYNTHESIS[1])

by

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1. INTRODUCTION

Photosynthesis is the process by which green plants are capable of producing organic matter from carbon dioxide and water, under absorption of sunlight. The overall process is a reduction, operated by the light energy, and oxygen is set free. The chief trend of this process may be rendered by the following simplified equation:

$$CO_2 + H_2O + \text{light energy} \rightarrow CH_2O + O_2$$

The meaning of this process, of course, is that plants produce "food": carbohydrates and other energy-rich substances from highly oxidized inorganic components, by fixing light energy in a chemical form. The light energy enters into the process by being trapped in the green substance, chlorophyll, and being conveyed to chemical reactions.

The discovery of the main "external" features of photosynthesis has been a gradual one. Photosynthesists preferably quote an experiment by J. B. VAN HELMONT (1), performed in the early 17th century, showing that the earth, materially, contributes only little to the increase in weight of plants. People who, in a more theoretical sense, can be denoted as precursors are, *e.g.*, MALPIGHI, MARIOTTE, HALES, in so far as they philosofied about the function of leaves from experiments or observations (1).

An interesting reflexion of the educated lay-man's knowledge about the nutrition of plants about the year 1775 is to be found, *e.g.*, in J. F. MARTINET's more or less famous 'Catechismus of Nature' (2).

He states that the growth of heavy trees on old walls with little soil clearly shows that plants don't derive all their nutrition from the earth. The remainder, he says, must be furnished by the air... Moreover, he adds, there is an un-

[1]) This paper was read before the Sixth International Congress for the History of Science, Amsterdam, August 1950. It was submitted for publication in the Proceedings of this Congress, but so far did not reach being printed, and no further volumes of these Proceedings will appear. It is, therefore, published here now. Apart from one or two slight changes, and the addition of section headings, the text, prepared May 1950, has been left unchanged. Only the plates, and the Comments on the plates have been added now. The paper has been provisionally listed as publication no. 91 of this Laboratory. Since so much time elapsed, it seemed advisable to change the number. The preprinted Summary (6th Intern. Congress History of Science, Amsterdam, August 14–21, 1950, Summary of Comm., p. 72) will furtheron be considered as publication no. 91.

suspected condition, necessary for the plants, a Celestial Food, namely, the excellent, fine fluid we call LIGHT which, mixed up with the first principles of the plants, sustains them, nourishes them[1]), makes them better, more healthy, and more vital... If you put a plant in darkness, it will gradually fade, and if you leave it there, it will at last die.

At about the time, MARTINET wrote his 'Catechismus', modern scientific study of photosynthesis started. A concise description of the early history is to be found, *e.g.*, in RABINOWITCH' book on Photosynthesis (3).

The initiator was PRIESTLEY, who was the first to observe that plants have the power to restore air, spoiled by respiration or by burning of a candle. Notwithstanding the fact that PRIESTLEY had no intimate knowledge about the "proximate cause" of the effect he observed, his investigations drew an extensive attention, which reflected in the fact that he obtained the yearly medal of the Royal Society of London, in 1773. On this occasion, PRINGLE, the President of the Society, delivered a speech, in which he interpreted the impression made by the observed complementary effect of plants and animals upon the atmosphere.

It may be worth while to quote his visionary presentation. "From these discoveries we are assured, that no vegetable grows in vain, but that, from the oak in the forest to the grass in the field, every individual plant is serviceable to mankind; if not always distinguished by some private virtue, yet making a part of the whole, which cleanses and purifies our atmosphere. In this, the fragrant rose and deadly nightshade cooperate: nor is the herbage, nor the woods that flourish in the most remote and unpeopled regions, unprofitable to us, nor we to them, considering how constantly the winds convey to them our vitiated air for our relief, and for their nourishment."

This advanced characterization may have much contributed to a diffusion of knowledge and admiration of PRIESTLEY's results. Lateron, PRIESTLEY himself became less sure about his discovery, since he did not succeed in reproducing it at will. It was clear that some unknown factor still interfered with the experiments. The discovery that this factor was *illumination* is generally ascribed to Joan INGEN HOUSZ. (He is generally quoted as Jan INGENHOUSZ, but I saw a letter of him, of 1786, in which he signed his name as brought here). The discovery of the action of light in the purification process plants exert upon the air may be discussed here in some more detail.

2. NOTE ON THE WORK OF JOAN INGEN HOUSZ

INGEN HOUSZ was, as is well-known, a physician, and his occupation with photosynthesis starts from his interest in the air as "the only substance without which we can scarce subsist alive a single moment... Therefore this universally diffused element deserves not only the pursuit of philosophers, but claims more immediately the attention of those whose profession it is to preserve health, and to cure diseases. I have bestowed some labour upon this subject, both as a philosopher and as a physician". – This "labour" started in 1779, in which year INGEN HOUSZ lived near London for about 3 months, in a quiet place, and made more than 500 experiments. The results of these experiments were published in his well-known monograph: "Experiments upon Vegetables, discovering their great power of purifying the Common Air in Sunshine, and

[1]) ! !

of Injuring it in the Shade and at Night", which appeared in the same year, 1779 (4). Already in the title of his work, INGEN HOUSZ suggestively mentioned his two major advances upon PRIESTLEY's work: the essential effect of sunshine in the amelioration of air by plants, and the reverse effect produced in the shade and at night. Expressed in modern terms: he found the evolution of oxygen by plants (which accompanies the uptake of carbon dioxide) in light, representing the essence of photosynthesis, and the uptake of oxygen (which is accompanied by the evolution of carbon dioxide) in darkness, representing respiration. Thus, a much more definite meaning could be attached to PRIESTLEY's observations, for whom the improvement plants imposed upon the air only was "something in the process of vegetation, or at least something usually attending it", a rather irreproducible effect which was brought into connection with a long stay of plants in a certain volume of air. However, INGEN HOUSZ found that the beneficial effect of plants is observable already after few hours. He succeeded, moreover, in demonstrating that only green parts of plants improve the air in sunlight, whilst non-green parts such as flowers, ripe fruits, spoil the air both in light and in darkness. He observed the influence of light intensity upon the beneficial power of the green parts and found that poisonous and mild plants were alike in their behaviour. He showed further that the sun as such does not improve air without the cooperation of plants.

These few quotations may be sufficient to reveal the importance of INGEN HOUSZ' contribution. Actually, he furnished a firm and sensible frame work in which his own and earlier observations could be fitted.

In the literature, rather sharp controversies exists as to INGEN HOUSZ' significance as a scientist. RABINOWITCH (3) characterizes him as a "passenger" who, more or less by accident, caught the game PRIESTLEY had startled. WIESNER (5) on the other hand, develops a picture from which one would take INGEN HOUSZ for a 20th century's scientist. As I hope to show elsewhere in the near future (16), the truth is somewhere between. No doubt he was one of the most skilful and inventive experimentalists ever concerned with the study of photosynthesis. But, especially his later work showed that he couldn't overcome the – indeed considerable – difficulties of his time, partly due to the phlogiston concept, with regard to the interpretation of his results. None of the workers in this period probably had a clear picture of the gas exchange processes in plants. It should not be forgotten, that some 60 years later the, in relation to overall conversions, very keen LIEBIG did not take plant respiration for a vital procces (7)!

No doubt, INGEN HOUSZ has very great merits for the completion of the early concept of photosynthesis especially as to the influence of the light factor, which definitely extend beyond the scope of an incidental success.

3. THE WORK OF W. VAN BARNEVELD.

Meanwhile, it should be mentioned that, very probably, at least one other investigator should share in the discovery of the beneficial rôle of light in this respect. To enter in some more detail into this matter is the main object of this communication. The author in question is another Dutchman, W. VAN BARNEVELD, who, about a year before the appearance of INGEN HOUSZ' book, sent a paper to the "Provinciaal Utrechts Genootschap", a learned society in Utrecht, founded a few years before. In this paper VAN BARNEVELD communicates the discovery of the stimulatory effect of sunshine upon the air-purifying property of plants.

The paper is entitled: "Proeve van onderzoek omtrent de hoeveelheid van bederf, 't welk in onzen dampkring ontstaat, nevens deszelfs verbetering door den groei der plantgewassen"[1]) (8). The reason for his investigation is outlined as following: "Since the Provincial Society of Arts and Sciences at Utrecht is so much interested in the health of the fellow-men that it prefers the answer to a question concerning this matter; since the very learned Mr. PRIESTLEY, by his important and for the health very promising investigations concerning the restoration of putrid air by plants has induced many people to continue his work and discover other paths still unknown, I found myself stimulated to render some service with respect to this dark field to the Society[2]) or to Science, by way of my zeal and experiments, (*l.c.* § 1, translated from the dutch).

This introduction issued from the fact that the Society, upon the fame of PRIESTLEY's discoveries had asked for award essays on the mentioned subject. VAN BARNEVELD studied the subject, and sent the paper, under *motto*, but, as it seems, not as an award essay. In view of our particular question, the most important part of his paper is constituted by the §§ 37–43. In § 37 he mentions different results as to the restoration of an amount of air, "phlogisticated by respiration" to a certain extent, as measured by the "nitrous air" test, a procedure used by PRIESTLEY and by INGEN HOUSZ also, in the details of which I cannot enter here. In one experiment the restoration of the air by a *Veronica* lasted as much as 6 days, another time 4 days, in a third experiment only $2\frac{1}{2}$ days, about which difference he was very surprised. In § 38 he states: "Meanwhile this furnished the occasion to trace its cause, and this depended upon the sunshine, for I had observed that the sun during my last experiment" (the third one mentioned above) "was very strong, and during the first one, the sky was sometimes clouded... Next, I have been convinced in this supposition by experience during the following experiments" (translated from the dutch). In § 39 he describes an intentional experiment, with *Sempervivum tectorum* which, placed in a certain amount of phlogisticated air, did not restore it in three days outside the sunshine, exposed to the sun the *Sempervivum* restored the air in a few hours. He repeated this experiment with several other plants: *Mentha*, *Tropaeolum*, *Vicia Faba*, with the same result. He found that moist soil exposed to the sun did not restore the air (§ 40), not even in weeks, and neither with water alone. He philosophies about what occurs when the sun is hidden by clouds for weeks, or in winter, and sees the solution in the fact that the winds transport the air quickly from one place to another in which more favourable conditions may obtain (§ 41). In § 42 he states: "Thus, I had arrived at the knowledge that by Vegetation, as the proximate cause, putrid air is restored, but not than with interference of a second working cause, namely, sunshine. Or, we as well could put the sun in the first, and the vegetation in the second place. Meanwhile we have reason to wonder that Mr. PRIESTLEY has not observed nor communicated this" (translated from the dutch). In § 43 he states: "It is, therefore, utterly necessary, for the restoration of air by plants to choose a place which is freely exposed to the sun" (translated from the dutch). Also in the following sections he stresses the rôle of sunlight on various occasions. At the end of § 70 a note is placed: "So far this paper has been composed in 1778, and delivered October 23 of that year". (translated from the dutch).

[1]) "Investigation on the amount of pollution of the air and its restoration by the growth of plants."

[2]) *Viz.*, the Provincial Utrecht Society.

Then, a new chapter begins, entitled "Vervolg der vorige proeven" (Additional experiments), comprising §§ 71–90 included, dated March 6, 1780. At the end of § 88 an extensive note is placed, containing newer observations, dated Sept. 5, 1780. The volume (*cf.* 8) was published in 1781, it contains two extensive award-essays, and further delivered papers, in chronological order, from 1775–1779. VAN BARNEVELD's paper is placed in this sequence, as a paper of 1778.

4. AN ATTEMPT TO ANALIZE THE CONTROVERSY BETWEEN INGEN HOUSZ AND VAN BARNEVELD

It is interesting that INGEN HOUSZ has tried to deny the originality of VAN BARNEVELD concerning the action of the sun, and has even suggested that VAN BARNEVELD has not actually performed any experiment, but copied the results from INGEN HOUSZ's works (9). The reason INGEN-HOUSZ could try to make believe this, was that VAN BARNEVELD has had his manuscript in his hands again by the end of 1779 and the beginning of 1780. In order to obtain any more definite idea about this controversy, it is of importance to trace briefly the history of VAN BARNEVELD's paper after its delivery on October 23, 1778. This history can be traced for its greater part with the aid of the Archive of the (still existing) "Provinciaal Utrechts Genootschap", the society under the auspices of which VAN BARNEVELD published his paper. I wish to express my most sincere thanks to Dr. J. C. BRANDT CORSTIUS, secretary of the mentioned Society for his very valuable aid in finding the relative informations, which I could consult lateron myself.

Briefly, the history is as follows, for which we may consult both the minutes of the Society meetings, and a correspondence between INGEN HOUSZ and the Society in relation to this matter. From a letter of the Society to INGEN HOUSZ of April 11, 1786 we learn: The paper by VAN BARNEVELD has been delivered to the Society October 23, 1778 from § 1 to § 70 included, except an addition to § 6 (printed p. 413–416) which VAN BARNEVELD communicated lateron (This regards the description and plate of the eudiometer used for air analysis, asked by one of the commentators, see below). The paper was sent under *motto*; Dec. 3, 1778, it was ascertained that VAN BARNEVELD was the author. On March 30, 1779 the paper was submitted to the judgement of Prof. ROSSYN, Prof. LUCHTMANS and Dr. NIELEN. On Dec. 6, 1779, it was decided to have the paper printed, but to send it back to the author before, "with the remarks of the advisors, leaving it to the author to make use of them". On Feb. 7, 1780 the paper was sent again to M. M. NAHUYS and ROSSYN, and it was decided to ask VAN BARNEVELD to send the continuation. April 3, 1780 this continuation was received, and it was decided to print it directly behind the paper itself.

INGEN HOUSZ, in a letter to the Society, of March 8, 1786, suggests that VAN BARNEVELD, probably has not actually made the experiments, mentioned in § 39 of his paper (see above; the discovery of the action of light), because he does not mention the effect of plants on air in darkness, and suggests moreover, that VAN BARNEVELD copied from INGEN HOUSZ' work the part relative to sunlight. In order to collect support for the latter view he asks the Society:

1. whether the paper, sent to the Society by VAN BARNEVELD in Oct. 1778 has again been in his hands. If so,
2. when it was sent back to him,
3. when it came back to the Society,

4. whether it came back together with the additions, dated March 6, and Sept. 5, 1780, so nearly two years after its first delivery.

From the answer the Society sent to INGEN HOUSZ, which answer was discussed above, the german translator of INGEN HOUSZ' works, SCHERER, and, probably also INGEN HOUSZ himself, concluded that it was practically certain that VAN BARNEVELD had used INGEN HOUSZ' results to complete his paper. SCHERER even goes so far as to suggest that the Society had required that VAN BARNEVELD should bring about every possible improvement, and that the Society might have blamed him for not taking from INGEN HOUSZ' works everything he might have thought apt to improve his paper "..denn er hatte nicht nur alles Recht hierzu, sondern es ward ihm selbst von der Gesellschaft aufgetragen seiner Abhandlung alle mögliche Volkommenheit zu verschaffen" (9, p. XXIII).

It is clear that the answer of the Society does not give rise to this as such rather absurd supposition, because the governers of the Society only suggested that VAN BARNEVELD should use the comments of the advisors to this purpose.

Of course, the last paragraph gives no absolute proof of the honesty of VAN BARNEVELD. The fairly absolute proof could be furnished if the original manuscript of VAN BARNEVELD's paper were found back, and the later additions could be clearly distinguished (by ink, paper, type of writing, etc.) from the earlier parts. Notwithstanding that many manuscripts from that time still are present in the Archive of the Society, so far I could not find this one. But, the following further informations may serve to arrive at a fuller judgement as to the honesty of VAN BARNEVELD.

In his letter, accompanying his manuscript, *dd.* Oct. 23, 1778, VAN BARNEVELD, commenting previous observations by DEIMAN and PAETS VAN TROOSTWIJK (10), states: "I don't ask more belief than these gentlemen might deserve, but would leave the judgment to an independent investigator in the next season, whom I recommend to read again § 39 and § 66" (translated from the dutch). It should be observed that § 39 (of the printed paper) contains the first crucial experiment on the influence of light, which may serve as an indication that § 39 in the original manuscript was the same as printed!

From the "Adviezen en Bijlagen tot de Verhandelingen 1775–1782"[1]) in the Archive of the Society, we learn furthermore that Prof. NAHUYS agreed with printing of VAN BARNEVELD's paper January 18, 1779.

On March 16, 1779 DEIMAN and PAETS VAN TROOSTWIJK sent an extensive comment in which they state among other things that they do not agree with VAN BARNEVELD's views expressed in § 41, as to the means of restoration of the air in winter when there are no plants. As such their comment is not very interesting, but it seems of importance for our discussion because *it indicates that § 41 of the manuscript is the same as printed. Since §§ 38–43 treat the importance of light in a closed sequence, it seems utterly improbable that* VAN BARNEVELD *should have left § 41 unaltered and invented all data in, e.g. § 39*!.

On April 22, 1779, ROSSYN agreed with printing but asked for a clear description and picture of the eudiometer, in § 6. On July 24, LUCHTMANS agreed with printing. On November 4, 1779, NIELEN agreed with printing, but drew attention to a paper in "Vaderlandsche Letteroefeningen", he remembered only vaguely. (Very probably, DEIMAN and PAETS VAN TROOSTWIJK's sequence of papers (10) is meant here.)

[1]) Advices and Documents to the papers.

On January 4, 1780, VAN BARNEVELD sends a letter accompanying the redelivery of his paper after having made use of the advisors' remarks (which were sent to him Dec. 6, 1779, together with his manuscript, see above). In this he expresses his satisfaction that the paper will be printed. He states to have made only two slight alternations, *viz.*, in § 52 and in the note on p. 8[1]) and has added a description of the eudiometer, which he hopes, will not be found too long, and also a picture of the things described in § 6. He enters into DEIMAN's and PAETS VAN TROOSTWIJK's criticism, and will send a continuation of his paper (*cf.* above).

It seems to follow from these comments that indeed, the changes suggested by the advisors are restricted to minor details, virtually restricted to the addition of some technical details concerning the eudiometer, and that VAN BARNEVELD *actually didn't change more than this.* At any rate there are no indications of extensive rearrangements, as INGEN HOUSZ suggested, and the conclusion lays at hand that not VAN BARNEVELD tried to rob INGEN HOUSZ from the sun and leave him the darkness (see below) as INGEN HOUSZ suggested with about these words in his above mentioned letter, but that, actually, INGEN HOUSZ, or SCHERER in his favour, tried to deny VAN BARNEVELD the modest place in the sun he may claim aside of INGEN HOUSZ' bigger one!

5. RAUWENHOFF'S DISCUSSION (1853)

Without knowledge about something of this background, the comments on VAN BARNEVELD in INGEN HOUSZ' work may appear rather convincing, and, perhaps I would never have entered into this matter without the careful discussion in the thesis, now itself already over a century old, of N. W. P. RAUWENHOFF, later professor of botany in the University of Utrecht. The thesis is entitled: "Onderzoek naar de betrekking der groene plantendeelen tot de zuurstof en het koolzuur des dampkrings, onder den invloed van het zonnelicht"[2]) and appeared in 1853 (11). In a detailed survey of the early literature he comments on the discovery of the action of light by VAN BARNEVELD, and he has also been able to see the Archive of the Provincial Utrecht Society. He states: "SCHERER... has accused VAN BARNEVELD, to have copied from INGEN HOUSZ' work and to have appropriated INGEN HOUSZ' discoveries, whereas later authors never mentioned VAN BARNEVELD any more, either because of this accusation or because the dutch papers... were less well known. I have discovered that the facts of pp. XX and XXI of SCHERER's preface to INGEN HOUSZ' work (Vol. II, Vienna 1788) are true but that it is not justified to derive herefrom the suppositions of pp. XXIV and XXV"[3]) (translated from the dutch).

Pages XX and XXI of SCHERER's preface contain the history of VAN BARNEVELD's manuscript as mentioned above (3 April 1781 should be 1780), pp. XXIV and XXV (again a few times 1781 should be 1780) suggest that VAN BARNEVELD has intentionally changed his paper in such a way that he should be considered to be the discoverer of the action of light on plants (taking the conclusions from the work of INGEN HOUSZ).

RAUWENHOFF continues: "For, the committee of advice consisted of MM.

[1]) Presumably, the note on p. 416 of the printed volume.

[2]) Investigation of the relation of green parts of plants to the oxygen and carbon dioxide of the atmosphere, under the influence of sunlight.

[3]) The reader is requested to compare RAUWENHOFF's careful analysis with the strongly one-sided and tendentious presentation (in favour of INGEN HOUSZ) by WIESNER (5, pp. 110–111).

ROSSYN, DEIMAN and PAETS VAN TROOSTWIJK, so just those men who had written about the subject themselves. After having been given back to VAN BARNEVELD, the paper has been examined again by MM. ROSSYN and NAHUYS, so that when the author had fundamentally changed his results and had described experiments he had never made, this no doubt would have been perceived. If one considers further that VAN BARNEVELD was not the only person blamed like this by INGEN HOUSZ, that the latter also quarrelled with PRIESTLY and SENEBIER and behaved very unfavorably... I believe to be right in concluding that probably van BARNEVELD has discovered the peculiar action of sunlight on plants, independent of INGEN HOUSZ" (*l.c.*, p. 18, translated from the dutch).

As exposed above, I believe that RAUWENHOFF's conclusion exists to the right.

6. FINAL CONSIDERATIONS

In a second paper (12) VAN BARNEVELD comments with appreciation several observations of INGEN HOUSZ. In § 11 we read "...one day... the sky was dark, when, like I observed in my experiments of the year 1778, and Mr. INGEN HOUSZ observed a year later, trees and plants are less favorable in the amelioration of unsalutary air" (translated from the dutch).

It seems fully justified, to consider VAN BARNEVELD as a co-discoverer of the action of light in photosynthesis. On the other hand it should not be overlooked that his experiments are of definitely lower quality than those of INGEN HOUSZ. So, *e.g.*, he did not succeed in demonstrating the unfavorable action of plants on air in darkness, and even denied this action with a curious *à priori* reasoning: "that is seemed unnatural to find that any salutary means, devised by the Creator to produce good should be harmful at the same time without being misused by stupidity or carelessness of men" (*l.c.* § 55, translated from the dutch). A quite similar view is expressed by SENEBIER, who denotes INGEN HOUSZ' results as "une vraie calomnie contre la nature et contre les sages et sublimes procédés, une calomnie, dont la nature se vengera elle-même" (quoted from INGEN-HOUSZ(13)). These statements are typical manifestations of a strongly anthropocentric conception of Nature. One need not wonder that INGEN HOUSZ jeered not too mildly at the "generous defenders of Heaven"! In INGEN HOUSZ' comments on this controversy one finds the view that those who do not find the action of the plants in darkness, can never have observed that in the light. This criticism doesn't seem fully justified, since we now know that, under favorable conditions, the rate of photosynthesis may be many times that of respiration.

It is a well-known fact that the remarkable start the study of photosynthesis made in the last quarter of the 18th century, practically fully leaked away in the first half of the 19th one, until LIEBIG and SACHS (14) initiated its rediscovery and further development. The revival also incorporates the fundamental recognition by Robert MAYER that the light energy is the thriving force in the chemistry of the process. His view was summarized in the statement: "Die Pflanzen nehmen eine Kraft, das Licht, auf, und bringen eine Kraft hervor, die chemische Differenz" which RABINOWITCH characterized as "the concluding chapter in the history of the discovery of photosynthesis" (3).

7. Summary

Generally, Joan Ingen Housz is considered as the discoverer of the *importance of light* in green plant photosynthesis (1779). Notwithstanding that, no doubt, the work of Ingen Housz is the far most important produced at that time concerning this question, it has been advanced in this paper that W. van Barneveld very probably may be considered as an independent contemporary co-discoverer (1778). Ingen Housz' german translator, Scherer, tried to throw doubt upon the originality of van Barneveld's communications (1788). Rauwenhoff (1853), after a critical study, defended van Barneveld's independence. The present author thus agrees with Rauwenhoff's view.

8. References

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10. J. R. Deiman, A. Paets van Troostwijk, Hedend. Vaderl. Letteroefeningen 7, (2), 338–348, 436–445, 481–490 (1778).
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12. W. van Barneveld, Verhandel. Prov. Utregtsch Genootschap v. K. en W. **2**, 251–302 (1784).
13. J. Ingen Housz, Expériences sur les Végétaux, **2**, Paris (1789), *cf.* p. 453.
14. J. Sachs, Handbuch der Experimental - Physiologie der Pflanzen, Leipzig (1865).

9. Comments on the plates

Plate 1.

Willem van Barneveld, a precursor (1778) and independent codiscoverer of Ingen Housz regarding the action of light in photosynthesis.

After a photograph from an oil painting at Hattem (Neth.).

Born at Hattem 20.1.1747, died at Hattem 23.6.1826. From 1770 till 1818 apothecary at Amsterdam, during which period he carried out much scientific work and prepared several publications on various subjects. Married to Walburg Fundrik, 3 sons, 5 daughters. In 1819 appointed burgomaster of this native town Hattem.

I owe the photograph and the information as well as my knowledge of the existence of the picture to the kindness of Dr. J. H. Sypkens Smit, Hattem; the information is from the Old Biographical Dictionary (Oud Biographisch Woordenboek).

It is interesting that van Barneveld was only 31 years old when he described the experiments discussed in the present article.

Plate 2.

Joan Ingen Housz, the main discoverer of the action of light in photosynthesis, and the discoverer of respiration of green plants in darkness.

Born 8.12.1730 at Breda, 1756 physician at Breda, 1765 to London, 1769 member of the Royal Society, 1768 to Vienna for inoculation of the imperial children against small-pox, 1775 marriage with Agatha Maria Jacquin (daughter of the botanist N. J. Jacquin), no

children. 1779 in England, where he carried out his brilliant work on photosynthesis (at the age of 48), 1780 back to Vienna, 1788 to Paris, 1798 via Breda to London, died at a country house near London 7.9.1799.

Information and picture from: H. W. HEINSIUS, in: Album der Natuur 1897, p. 1, The inscription refers to INGEN HOUSZ' succesful inoculation of the imperial children at Vienna.

PLATE 3.

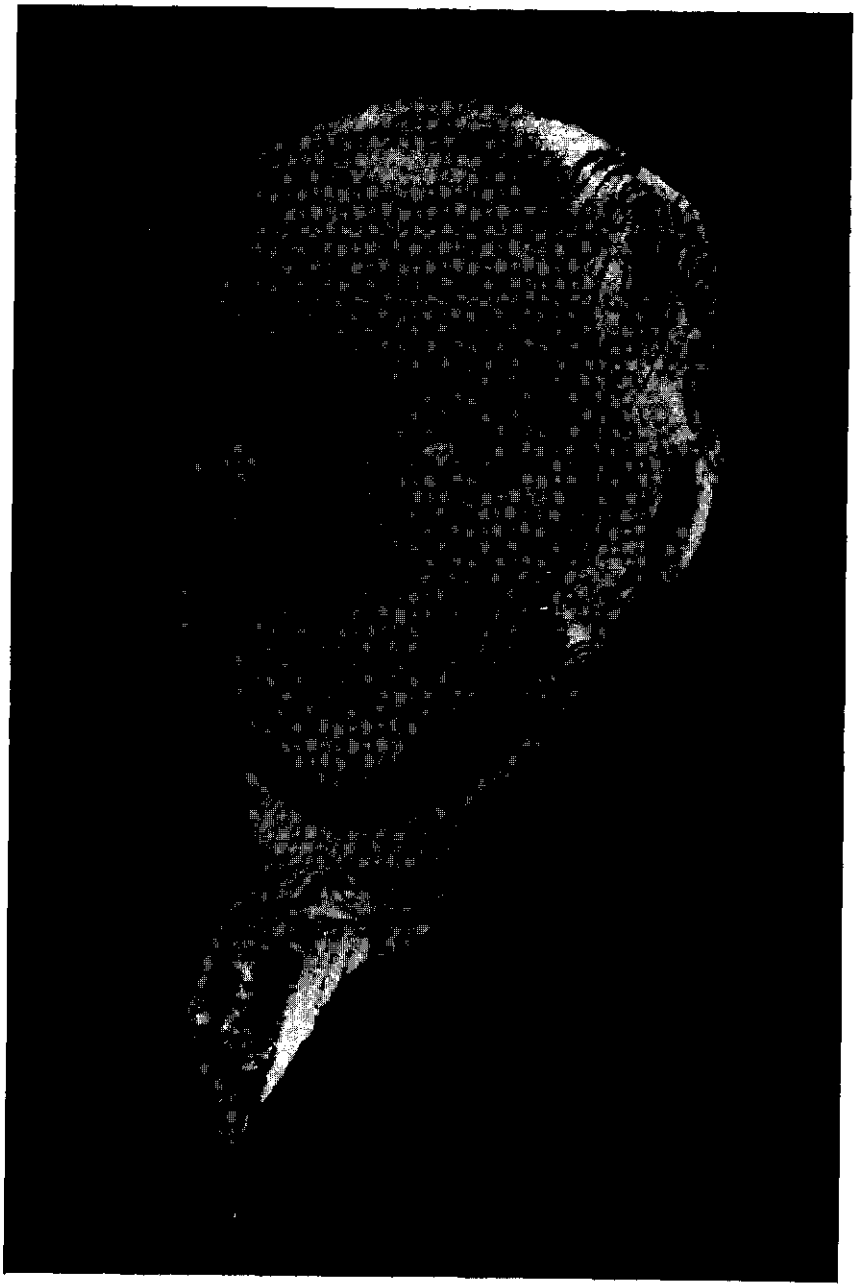
N. W. P. RAUWENHOFF, without whose careful analysis in his thesis (1853) the participation of VAN BARNEVELD in the discovery of the light factor in photosynthesis most likely would have remained suppressed and forgotten.

Born 6.7.1826, started lecturing on plant physiology (as first in the Netherlands) at the Utrecht University in 1858, professor of botany (and some other fields) at Utrecht 1871–1896. Successor to F. A. W. MIQUEL, predecessor to F. A. F. C. WENT. Married 1872 to Anna P. KOOPMANS, no children. Died 17.12.1909.

Data from "De Utrechtsche Universiteit", 1636–1936, vol. 2, Utrecht, 1936, and in part kindly supplied by Mrs. Dr. J. G. VAN CITTERT-EYMERS, Museum of the University, Utrecht. Picture: After a photograph, published in print at Utrecht. Supplied by Dr. H. P. BOTTELIER, Botanical Laboratory of the University, Utrecht. Source unknown; probably a Students' Yearbook around 1871.

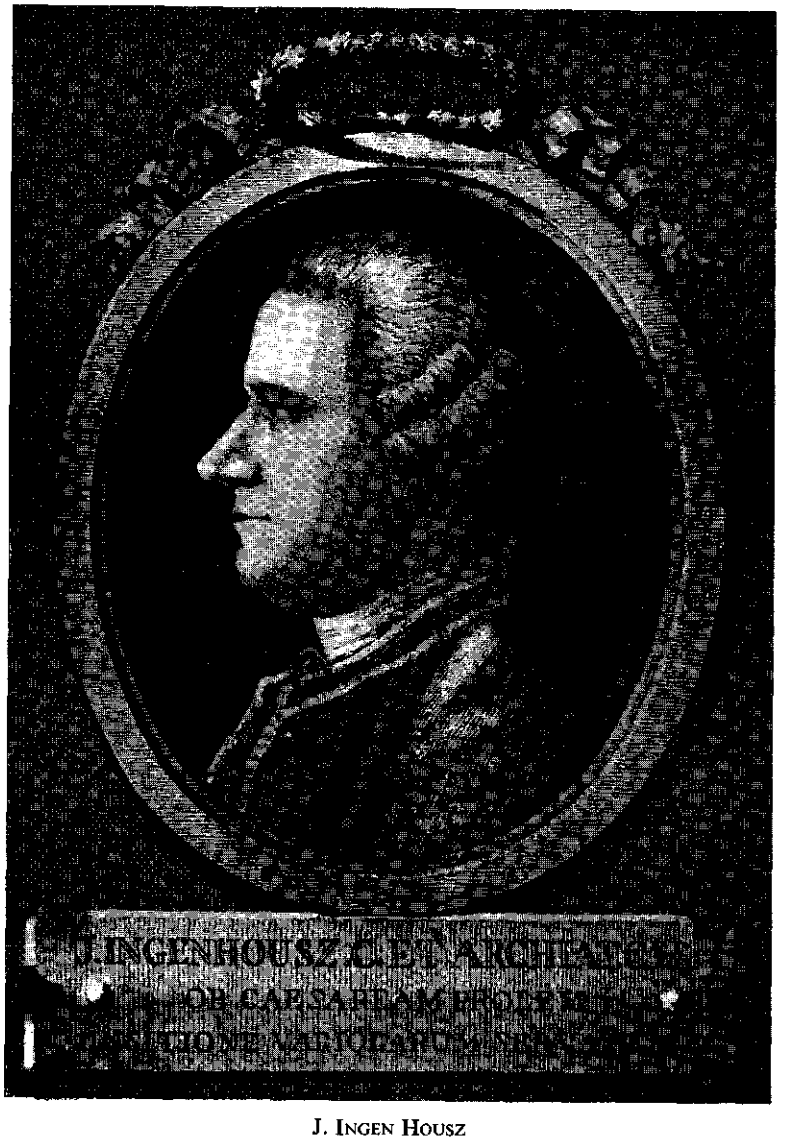
It is remarkable that RAUWENHOFF was born very close to the date of VAN BARNEVELD's death.

PLATE 1.



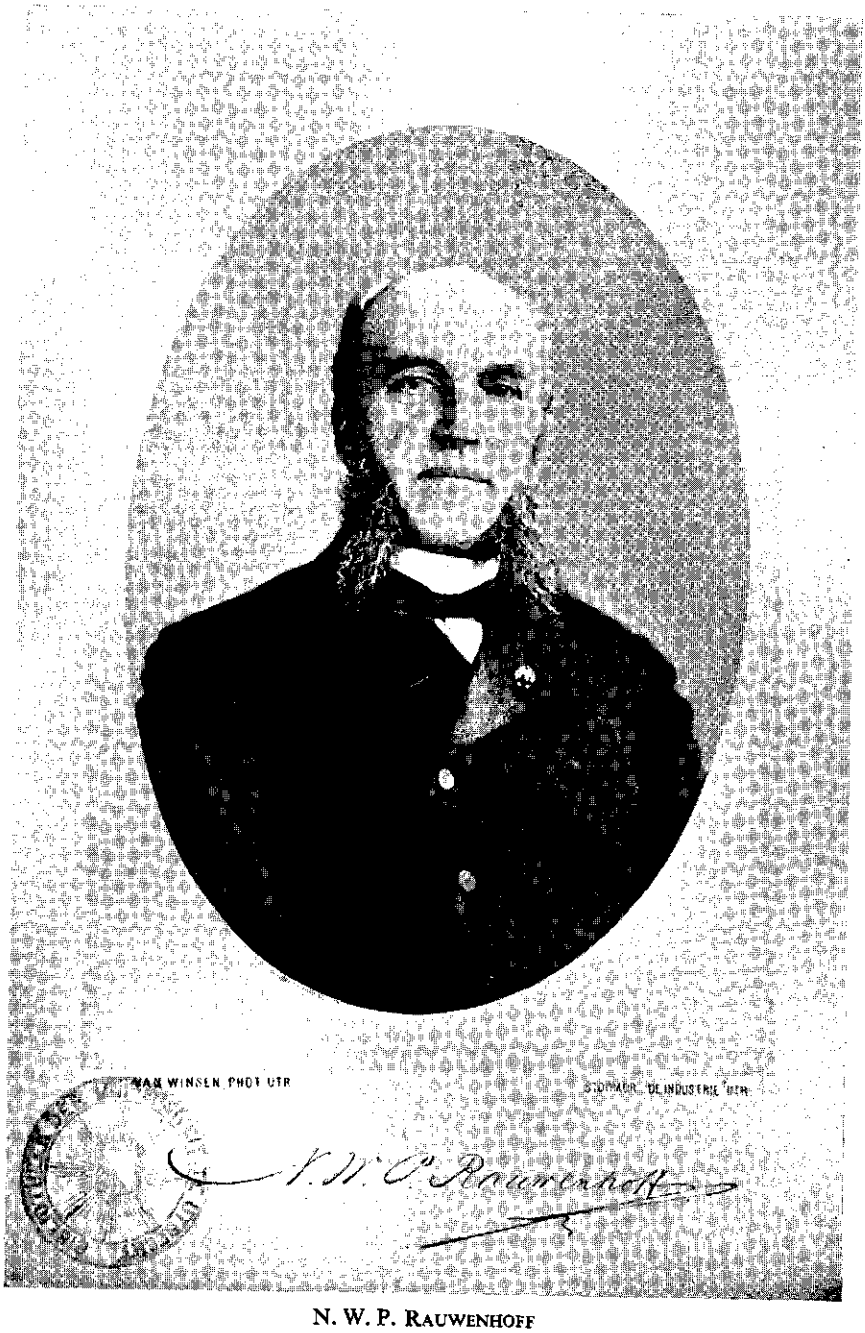
W. VAN BARNEVELD
1747—1826

PLATE 2.



J. INGEN HOUSZ
1730—1799

PLATE 3.



N. W. P. RAUWENHOFF
1826—1909