

# GOETHE'S BOTANY

*The* METAMORPHOSIS *of* PLANTS (1790)

*and*

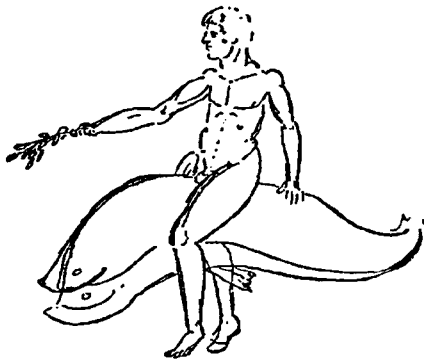
TOBLER'S ODE *to* NATURE (1782)

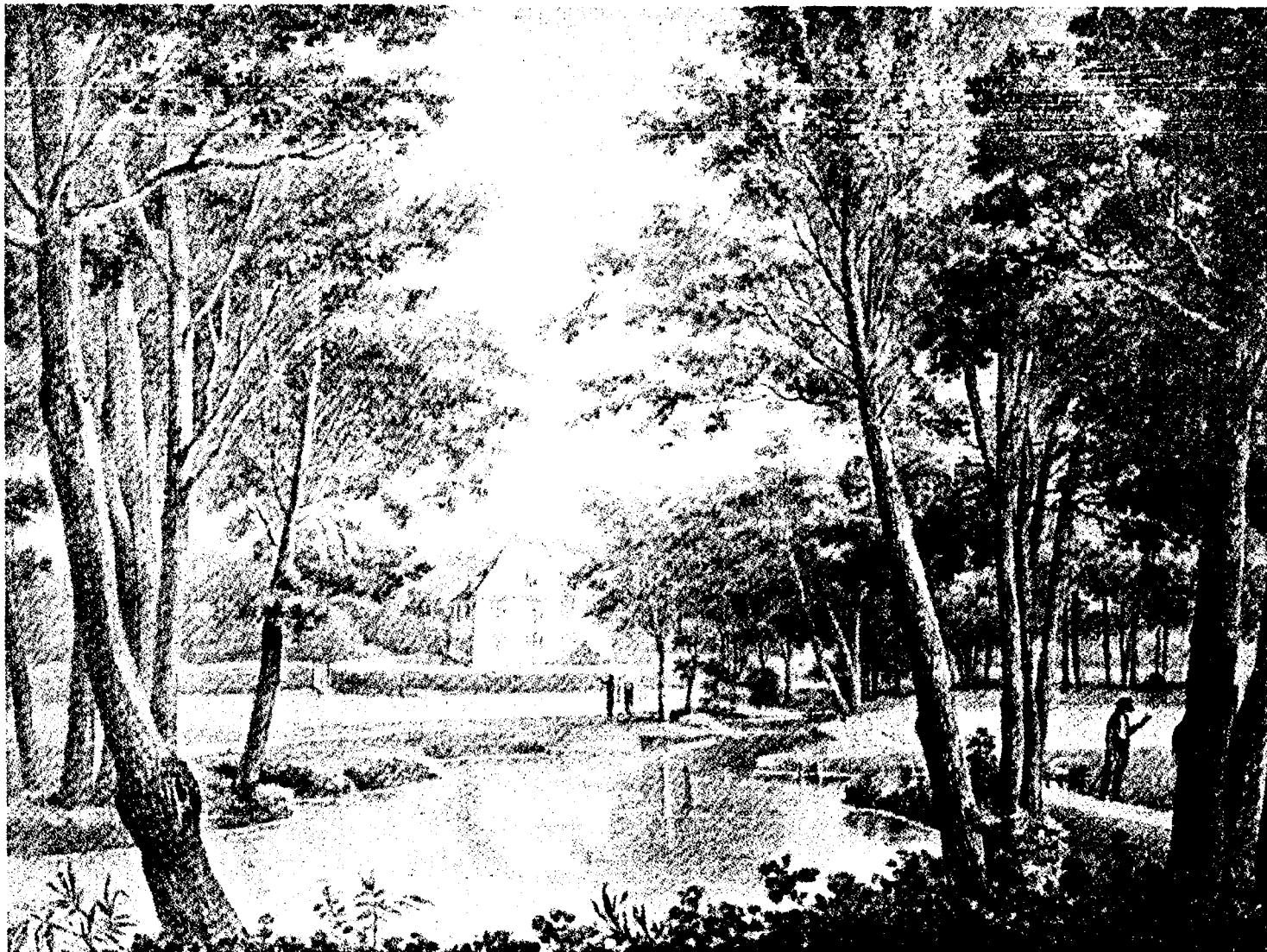
*With an introduction and translations*

*by*

AGNES ARBER, D.Sc., F.R.S.

*Author of 'Herbals', 'Water Plants: A Study of Aquatic  
Angiosperms', 'Monocotyledons: A Morphological  
Study', 'The Gramineae: A Study of Cereal,  
Bamboo, and Grass', etc.*





GOETHE'S GARDEN HOUSE ("GARTENHAUS AM STERN"), AFTER A DRAWING BY GEORG MELCHIOR KRAUS, FROM NEUBERT (1919): "GOETHE UND SEIN KREIS," LEIPZIG.

## CONTENTS

### VERSUCH DIE METAMORPHOSE DER PFLANZEN ZU ERKLÄREN

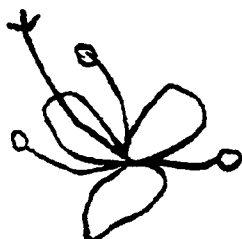
INTRODUCTION .....	67
A NOTE ON TRANSLATIONS .....	86
TRANSLATION .....	89
CONTENTS .....	90

### THE FRAGMENT AFTERWARDS KNOWN AS DIE NATUR

PREFATORY NOTE .....	119
ORIGINAL TEXT .....	121
TRANSLATION .....	123

## PLATES and ILLUSTRATIONS

Plate 23.—GOETHE'S GARDEN HOUSE .....	64
ARION ON THE DOLPHIN, DRAWING BY GOETHE (from WALTHER'S GOETHE als Seher und Erforscher, p. 8) .....	65
SCRIBBLES OF FLOWER STRUCTURE FOUND AMONGST GOETHE'S NOTES (after Sophien- Ausgabe, II, 13, p. 130) .....	66, 90, 122, 125
GOETHE MEDAL, DESIGNED BY HEINRICH FRANZ BRANDT (ca. 1825), from ROLLETT (1883): GOETHE Bildnisse, p. 211 .....	67
FACSIMILE OF TITLE PAGE OF THE FIRST EDITION OF "VERSUCH DIE METAMORPHOSE DER PFLANZEN ZU ERKLÄREN" (1790) .....	88
Plate 24.—ANOMALOUS SHOOT OF VALERIANA, AFTER A SKETCH BY GOETHE between 94/95	
Plate 25.—DIAGRAMMATIC LANDSCAPE TO ILLUSTRATE COMPARATIVE ALTITUDES IN THE OLD AND NEW WORLDS .....	between 94/95
Plate 26.—GOETHEA CAULIFLORA .....	between 94/95
THE OPENING OF A HORSE-CHESTNUT BUD .....	116
SKETCHES BY GOETHE ("Folge der Knoten", etc.) .....	118
SILHOUETTE OF GOETHE (ca. 1776). The original is still in the "Kleines Schloss" at Tiefurt. From ROLLETT (1883): GOETHE Bildnisse, p. 49 .....	126





**Introduction**<sup>1</sup>: — The botanist who attempts to study GOETHE's scientific work, finds himself dealing merely with one facet of a mental life unexampled in its many-sidedness. This one facet is so completely integrated with GOETHE's general productivity, that it cannot be understood except in connexion with the whole; but to see it thus in perspective demands an acquaintance not only with his own vast output of writings, letters, and recorded speech, but also with the immense corpus of GOETHE scholarship. This can scarcely be compassed by any man of science outside Germany.<sup>2</sup> Another difficulty with which the student of GOETHE's botany is faced at the outset, is that those scholars who have the fullest and most critical knowledge of his writings, differ radically in their estimate of his science, both in its relation to his work in general, and when considered in itself. At one

---

1. Throughout this Introduction the references to GOETHE's writings are given either from GOETHE, J. W. VON (1887 etc.): *Werke herausgegeben im Auftrage der Grossherzogin SOPHIE VON SACHSEN*, Weimar (cited here as Sophien-Ausgabe), or from TROLL, W. (1926): *Goethes Morphologische Schriften*, Jena (cited here as TROLL ed.; when, however, the reference is not to GOETHE's writings, but to TROLL's own introductory matter, the book is cited as TROLL, W. (1926)); or from the German part of GOETHE, J. W. VON (1831): *Versuch über die Metamorphose der Pflanzen*. Übersetzt von F. SORET, nebst geschichtlichen Nachträgen. Stuttgart (cited here as SORET ed.).

2. The references to the literature in the present Introduction have been limited by the inaccessibility of modern German work under the present conditions; I have not, for instance, been able to see SCHMIDT, G. (1940): *Goethe und die Naturwissenschaften*, pp. 618, Halle. To this bibliographical work, and to other titles, Dr. VERDOORN has kindly called my attention.

extreme we have authorities, such as J. G. ROBERTSON, who speaks with regret of the large share that science took in GOETHE'S activities, and who voices the doubt whether his scientific interests "were not as real a crime against the majesty of his poetic genius as his immersion in the routine of state government"<sup>3</sup>; and Sir CHARLES SHERRINGTON, who remarked in a recent lecture: "Were it not for GOETHE'S poetry, surely it is true to say we we should not trouble about his science"<sup>4</sup>. At the other end of the scale stands W. TROLL, who maintains, in a fully reasoned study of GOETHE'S morphology, that the centre and focal point of his whole mental life is to be sought in his scientific writings<sup>5</sup>. We meet with the same conflict of opinion when the value of GOETHE'S scientific work is assessed in itself, rather than in relation to his general output. SHERRINGTON, for instance, dismisses the metamorphosis idea as "no part of botany today", and adds that "GOETHE'S view has gone the way of unsupported theories"<sup>6</sup>; on the other hand, TROLL — a botanist — ascribes to him the credit of having actually founded the science of morphology, the name of which he invented<sup>7</sup>.

GOETHE himself was very far from considering his work in natural science as a mere side issue of his career as a poet. In old age, when reviewing his past, he declared that a great part of his life had been devoted to science, not only with inclination and with passion, but also with consistent effort; and he definitely claimed to be estimated seriously as a scientific worker<sup>8</sup>. Whether, with ROBERTSON, we should regard GOETHE'S science as a grievous lapse, or, with TROLL, as one of the fertilising sources of his creative life, or whether a somewhat different type of appraisal is needed, will become apparent after we have reviewed the botanical aspect of his work, and the tendencies of his thought in biological matters.

GOETHE'S childhood and youth were passed in towns, and it was not until he went to Weimar that vegetation came prominently under his eye; for there he found himself in the midst of fields and gardens, while hunting — a favourite pastime of the court — led him into the Thuringian forests. His responsible concern for everything local made him interest himself in the technique of forestry, which had been brought to a high pitch in the duchy. Moreover, owing to the Duke's amicable relations with his neighbours, even those forests which lay outside his boundaries were freely open to GOETHE. In this woodland country, which he came to know intimately, he made acquaintance with the herbalists to whom the apothecaries in the towns owed their supplies. These herbalists made all kinds of medicinal extracts, handing on their secret recipes from father to son. It was under their auspices that he learned to know, in particular, the different kinds of gentian, which were valued for the curative properties of the root; this was

3. ROBERTSON, J. G. (1932): *The Life and Work of Goethe. 1749-1832*. London. pp. 312 and 97.

4. SHERRINGTON, C. (1942): *Goethe on Nature and on Science*. Cambridge, England; p. 23.

5. TROLL, W. (1926): *l.c.*, p. 5.

6. SHERRINGTON, C. (1942): *l.c.*, p. 21.

7. TROLL, W. (1926): *l.c.*, p. 7.

8. SORET ed.: *Nachträge und Zusätze, I. Der Verfasser theilt die Geschichte seiner botanischen Studien mit*. Pp. 107-63 (German and French version). Our knowledge of GOETHE'S botanical history is largely derived from this piece of autobiography, which is to be found also in TROLL ed., pp. 187-209.

the first genus in which he studied specific distinctions. In retrospect GOETHE took pleasure in the analogy between his personal botanical history, and the history of botany in general; for his interest was first aroused by practical considerations, and it was only gradually that he came to be attracted by the subject in its theoretical aspect. GOETHE's botanical tastes were stimulated especially by contact with a remarkable family—the DIETRICHs of Ziegenhain<sup>9</sup>—amongst whom, through a series of generations, a passion for botany asserted itself again and again. In 1688 a certain SALOMO DIETRICH, an exile from Bohemia for religion's sake, had fled to Thuringia, where he took a farm. In 1711 a son ADAM was born to him. ADAM succeeded his father in the farm, and one of his undertakings was to send weekly supplies of plants, for botanical purposes, to the University of Jena. He became well known as the Ziegenhain "Botanicus"; he treasured a letter written to him by LINNAEUS with his own hand—a document which he honoured as a patent of botanical nobility. Love of plant study extended to the fourth generation from ADAM DIETRICH; his great-grandson, A. W. S. DIETRICH, made and sold herbaria, and trained his wife, a village girl of Saxony, in all the necessary technique. Though not a DIETRICH by birth, she proved to have a supreme flair for field work, and she is remembered for the adventurous and solitary years she spent in North Australia, collecting for GODEFFROY; she lived into the last decade of the nineteenth century. The member of the family, who was specially associated with GOETHE, was AMALIE's uncle by marriage, F. GOTTLIEB DIETRICH, born in 1768. GOETHE met him in the seventeen-eighties, and was so much pleased with his knowledge of Linnean botany, and his ecstatic happiness in it, that he took him as a companion when he went to Carlsbad for a cure. On the journey, GOTTLIEB searched for plants, bringing them to GOETHE's travelling carriage, while proclaiming their Latin names like a herald. When GOETHE had settled at the spa, GOTTLIEB was away among the mountains by sunrise, hunting for flowers, and was able to bring the spoils to GOETHE before he had finished his morning draught of the waters.

For a time, GOETHE remained wholly devoted to the Linnean system, giving himself up to it with absolute confidence. As books which he was constantly studying, he names LINNAEUS' *Fundamenta botanica*, *Termini botanici*, and *Elementa botanica*, and also JOHANN GESSNER's *Dissertationes*. The latter work, which explained the principles of LINNAEUS, was published under his aegis<sup>10</sup>. Even when GOETHE had lived through the first ardour of enthusiasm for studies of this type, and had published refutations of certain erroneous views held by LINNAEUS<sup>11</sup>, he still retained a reverence for the master himself, but the nature of this reverence has sometimes been

9. BISCHOFF, C. (1931): *The Hard Road: The Life Story of Amalie Dietrich*. Translated by A. LIDDELL GEDDIE. London. (C. BISCHOFF is the great-great-granddaughter of ADAM DIETRICH, on whom see BENEDIKT, E. (1945): *Goethe und Linné*. Svenska Linné-Sällskapets Årsskrift, 28, pp. 49-54; this paper appeared after the present Introduction was in print.)

10. The title is GESNER (GESSNER), J. (1743): *Dissertationes physicae de vegetabilibus. Quarum prior partium vegetationis structuram, differentias et usus, posterior vero partium fructificationis structuram differentias, ac usus sistit. In quibus elementa botanica Celeb. Linnaei dilucide explicantur*. (Printed with LINNAEUS, C. (1743): *Oratio de necessitate peregrinationum intra patriam*. Lugduni Batavorum.)

11. See p. 76.

misunderstood by GOETHE students, and its degree exaggerated, on the strength of a sentence in a letter to ZELTER, written on November 7, 1816<sup>12</sup>. He says, speaking of LINNAEUS, "Except SHAKESPEARE and SPINOZA, I am not aware that any man of the past has had such an influence upon me." This is, at first sight, a startling remark, for it is impossible to believe that a man of GOETHE'S mental calibre could have ranked LINNAEUS actually with either SHAKESPEARE or SPINOZA. A careful reading of this and preceding letters sets the matter, however, in a different light; for it becomes clear that GOETHE'S words do not relate to these three men, appraised in themselves, but merely in their effect upon his own personal development, an effect depending largely on his individual circumstances. It is important to notice that, in the letter just cited, he avows that, though he has learned an infinite amount from LINNAEUS, what he has learned has not been botany. In the previous month<sup>13</sup> he had told ZELTER that a return to the study of LINNAEUS, many years after he first came to know his work, had brought him to recognise that he has used the Swedish master in symbolic fashion only; that is to say, he has sought to transfer LINNAEUS' method and mode of treatment to other subjects, thus gaining an efficient mental instrument. We have to remember that GOETHE had undergone no explicit training in scientific discipline, and that he apparently knew little about pre-Linnean plant study. His tendency was to regard the whole corpus of systematically-developed biological thought as being the outcome of the genius of LINNAEUS alone. This attitude, which was very common in those days, was condemned by BATSCH, a botanist with whom GOETHE was acquainted<sup>14</sup>. BATSCH greatly admired LINNAEUS, but, in a book published in 1787, he protested against the injustice of exalting him at the expense of the many other writers who, in the eighteenth century, had promoted the knowledge of plants<sup>15</sup>. We can completely understand GOETHE'S share in this overestimate, when we consider his intellectual history. When he first read LINNAEUS' writings, they supplied what was his crying need at that stage—an objective and scientifically methodical approach to botany; none of his previous studies in literature, law, or art, had been able to do him this particular service.

Despite the fervour with which, in his earlier pursuit of plant science, he had followed LINNAEUS, nothing could make detailed systematic botany really native to GOETHE. Although, stimulated by GOTTLIEB DIETRICH, he learned something of the application of the Linnean system in the field, he came gradually to the conclusion that the minute analysis and counting of the floral parts, which it involved, were not in his line: "Trennen und Zählen lag nicht in meiner Natur". At that date, when optical aids were not as advanced as they are today, a disinclination for the study of small objects must often have arisen simply out of visual difficulties; but, in GOETHE'S case, the reaction against such occupations seems to have been

12. *Goethes Briefe*. Sophien-Ausgabe, Abth. IV, Bd. 27, p. 219.

13. *Goethes Briefe*, l.c., p. 200, Oct. 14, 1816.

14. For an account of BATSCH, and his relations with GOETHE, see HANSEN, A. (1907): *Goethes Metamorphose der Pflanzen*. (2 pts. Text and Plates). Giessen. Chapter VII.

15. BATSCH, A. J. G. C. (1787): *Versuch einer Anleitung zur Kenntniss und Geschichte der Pflanzen*. Halle; see p. 8.

primarily a deep-seated mental one. He himself contrasts the way of studying Nature which consists in proceeding analytically into the individual particulars, with that which consists in following the clue holistically through breadth and height<sup>16</sup>; it was to the latter method that his limitations as well as his powers inclined him. He realised that the devotion of a lifetime, and aptitudes of a special order, were necessary for comprehensive and intensive systematic work, and he held that for him there was another way, more in keeping with the rest of his course through life, namely the contemplative study of the phenomena of change and mutation in the organic world — phenomena which had created a deep impression upon his mind<sup>17</sup>. In process of time the systematic aspect of botany seems, indeed, to have lost its appeal for him altogether. Late in life he wrote that Nature has no system, but that "she is the transition from an unknown centre to a limit which is not discernible", and that "Natural System" is thus a contradiction in terms<sup>18</sup>. Even in the earlier period, when GOETHE's ideas about biology were in their plastic phase, he was not alone in feeling a certain dissatisfaction with the way in which systematics, in the Linnean sense, had come to dominate botany. HEDWIG, a writer with whose work GOETHE was acquainted, pointed out in 1781 that plant study had been too much concerned with the examination of new material from all parts of the world, and with detailed descriptive work, to give much consideration to the "inner economy" of the plant on which all depends<sup>19</sup>. It was this "inner economy", and the morphological signs through which it expresses itself externally, on which GOETHE's interest was finally concentrated. He could not however have thrown light upon this aspect of the subject but for his earlier apprenticeship in looking closely at plants for the purpose of detecting their taxonomic marks. His practice in handling them impressed him with the contrast between the inevitable rigidity of the classificatory system, and the versatility of the organs themselves. Certain plants, for instance, came to his notice in which the same stem bore a *crescendo* series of leaves, of which the earliest were entire, and the next lobed, while an ultimate, almost compound-pinnate shape was succeeded by a *diminuendo* series of simplified forms, gradually reducing to small scales, and thence to nothing. The systematic botany of the period paid little attention to the plasticity of leaf structures, and GOETHE was unable at first to find any clue to the part which these transformations played in the general scheme of things. It was his journey into Italy, with the sight which it yielded him of a flora, both wild and cultivated, which was rich to a degree undreamed of in his more northerly home, and to which his mind was not deadened by familiarity, that finally set in motion a train of ideas which was to dominate his conception of the plant world for the rest of his life. A glimpse of the southern vegetation which so delighted him is revealed in his sketch of fig tree and maize.

One of his crucial experiences was his visit to the botanical garden at

16. *Probleme*, TROLL ed., p. 221.

17. *Entstehen des Aufsatzes über Metamorphose der Pflanzen*. TROLL ed., p. 208.

18. *Probleme*, TROLL ed., p. 221.

19. HEDWIG, J. (1781): *Vom waren Ursprunge der männlichen Begattungswerkzeuge der Pflanzen*. Leipziger Mag. zur Naturkunde, Math. und Oecon. (Leipzig und Dessau), pt. III, pp. 257-319; see p. 299.



Padua. Here he saw a palm, *Chamaerops humilis* L., from which he collected a series of leaves, ranging from early lanceolate forms, up to the mature fan, and then, by a sudden transition, to the spathe enclosing the inflorescence. These leaves he carefully preserved, and, thirty years later, he confessed to still regarding them as fetiches, because of the way in which they had arrested his attention at a critical juncture. The botanical garden at Padua has the longest history of any in Europe, having been founded in 1542, and GOETHE's palm, which still flourishes,<sup>20</sup> is said to date from as long ago as 1584. Though his suite of palm leaves set GOETHE pondering, it did not give him immediate illumination; this came after, in April 1786, he reached Sicily—the ultimate goal of his travels—and during his return journey to Rome<sup>21</sup>. The conviction of the original identity (ursprüngliche Identität) of all the members of the plant then became explicit in his mind. The *Versuch die Metamorphose der Pflanzen zu erklären*<sup>22</sup>, published in 1790—the year in which GOETHE was forty-one—is the reasoned outcome of the meditations which began to take shape beside the palm tree at Padua. GOETHE realised, in the first place, the identity of the various forms of foliage leaf and bract, and then extended this conception to the parts of the flower. It was by no means the first time that ideas of this kind had occurred to botanists; to equate at least the outer members of the flower with leaves, has, indeed, always been natural to any acute observer. In the fourth century before CHRIST, THEOPHRASTUS had used the word 'leaf' (τὸ φύλλον) for the corolla<sup>23</sup>. Some 2000 years later, NEHEMIAH GREW<sup>24</sup> gave excellent anatomical reasons for considering sepals and petals as equivalent to foliage leaves, and—as regards the sepals—he called in also the evidence of abnormal forms. GREW's contemporary, MARCELLO MALPIGHI, again, described and figured the intermediates which may occur between petals and stamens in the rose<sup>25</sup>. These seventeenth-century anticipations were somewhat fragmentary, but, in 1768, more than twenty years before the publication of the *Metamorphose*, C. F. WOLFF<sup>26</sup> made a remarkably complete though brief statement of views closely related to those which GOETHE afterwards developed. WOLFF wrote that in some plants it is obvious that the calyx is a collection of relatively small and imperfect leaves, and that the pericarp is no less evidently composed of true leaves, which are, however, united. Petals and stamens, also, are *folia modificata*. Transitions between sepals and petals can be observed, and, in flowers with numerous stamens, these often degenerate into petals<sup>27</sup>. GOETHE was un-

20. Information by letter from Professor G. GOLA, Sept. 14, 1945.

21. TROLL, W. (1926): *l.c.*, p. 52.

22. Throughout this Introduction, this work, of which a translation follows (pp. 88-115), will be cited as *Metamorphose*.

23. THEOPHRASTUS (1916): *Enquiry into Plants*. Translated by Sir A. HORT, London. I.xiii.2; vol. I, p. 90.

24. GREW, N. (1672): *The Anatomy of Vegetables Begun*. London; see pp. 129-32, etc., discussed in ARBER, A. (1942): *Nehemiah Grew (1641-1712) and Marcello Malpighi (1628-1694)*. *Isis*, vol. 34, pp. 7-16; see p. 12.

25. MALPIGHI, M. (1675): *Anatome Plantarum*. London; p. 46 and pl. 28, fig. 160, "mixtura staminis et folii."

26. For details of WOLFF's career, and a critical appreciation of his work, see KIRCHHOFF, A. (1867): *Die Idee der Pflanzen-Metamorphose bei Wolff und bei Goethe*. Berlin.

27. WOLFF, C. F. (1768): *De formatione intestinorum*. *Novi Commentarii Acad. Scientiarum Imperialis Petropolitanae*, vol. 12, pp. 403-507; see pp. 404-6.

acquainted with WOLFF's work when he wrote the *Metamorphose*; at that time, indeed, his knowledge of the relevant botanical literature was far from complete. He had no conception of the modern code according to which the scientist is under an obligation to read all that has been published on any problem before putting forward a solution of it as being his own. On the contrary, GOETHE undoubtedly felt himself entitled to full credit for any notions, which he had himself evolved without conscious borrowing, even if others happened to have expressed them before. He maintained<sup>28</sup> that the savant should use his predecessors' work without indicating his sources at every turn, although he ought to express his gratitude to those benefactors who have unlocked the world for him. Despite GOETHE's keen desire to be regarded by professional workers as a fellow scientist, the technique of his approach remained essentially that of the literary man, who is not expected to give a detailed enumeration of his sources in, for instance, a poem or a play. The *Metamorphose* must be judged, not as if it were a modern scientific treatise, but as a presentation of a nexus of ideas, much of the material for which was already in existence. These ideas GOETHE alone succeeded in developing into a unified organic whole, by adjusting them to the living framework of his thought, and thus creating one of the minor classics of botany<sup>29</sup>. It has been claimed that, on his Italian journey, his passion for the scientific study of nature closed with and worsted his creative instinct<sup>30</sup>; but such a view cannot be accepted by those who hold that creative insight can find its play in morphology as well as in poetry. It is this very quality which has given GOETHE's botanical work its permanent life.

GOETHE met with some difficulty in connexion with the appearance of the *Metamorphose* in book form<sup>31</sup>. His regular publisher, GOESCHEN, declined it, but ETTINGER of Gotha produced it in 1790; as GOETHE himself notes with satisfaction, it was beautifully printed in Roman type. The title-page is shown in facsimile on p. 88. A reprint, not identical in format, was issued by ETTINGER in the same year<sup>32</sup>. On casually turning over the pages of the *Metamorphose*, one may get a somewhat *staccato* impression, since it consists of a series of 123 short numbered paragraphs, which in the first edition were spaced rather far apart; these paragraphs are grouped into eighteen Parts. The sense, however, tends to run on without a break even from Part to Part. Extreme examples are the transition from the end of Part III to the beginning of Part IV, which opens, "This (dieses) seems still more probable"—"This" being inexplicable without reference to

28. *Meteore des literarischen Himmels. Plagiat.* Sophien-Ausgabe, Abt. II, Bd. 11, p. 252.

29. For a detailed review of the history and influence of GOETHE's ideas, see WIGAND, A. (1846): *Kritik und Geschichte der Lehre von der Metamorphose der Pflanze.* Leipzig. In reading this book, allowance must be made for its date, and for the fact that WIGAND's turn of mind was laborious rather than illuminating. Some criticisms of WIGAND's work will be found in KIRCHHOFF, A. (1867): *l.c.*

30. BUTLER, E. M. (1935): *The Tyranny of Greece over Germany.* Cambridge, England; p. 113.

31. *Schicksal der Handschrift.* TROLL ed., pp. 211-2.

32. On the editions see HANSEN, A. (1907): *l.c.*, p. IX. Those who wish for a modern reprint will find the one in TROLL ed. valuable, as it is beautifully illustrated with early, and also with new, figures.

Part III; or the transition from the end of Part X to the opening of Part XI, which begins, "On the contrary", (Dagegen), thus carrying on the argument continuously from the preceding Part. Paragraph 92, also, may not be understood unless it is recognised that it is an abstract of the conclusions of GAERTNER, to which reference has been made in the previous paragraph.

The word *Metamorphose*, in the title of GOETHE'S book, was not altogether a happy one for his purpose. From classical times it had had poetical associations, which might well lead the reader to expect a work of fancy rather than of science, especially when the author was already famous for his imaginative writing. GOETHE himself complains that, on telling one of his friends that he had published a little volume upon the metamorphosis of plants, the friend expressed his delight in the prospect of enjoying GOETHE'S charming description in the Ovidian manner of narcissus, hyacinth and daphne<sup>33</sup>. There was also a certain confusion inseparable from the term metamorphosis, because it had been not only used in describing the life history of insects, but had, in addition, been taken over by LINNAEUS into botany, in a sense different from that of GOETHE; LINNAEUS employs it in connexion with the change from the vegetative to the flowering phase, which he seems to have regarded as analogous to the change from the caterpillar stage to that of the perfect insect<sup>34</sup>.

Apart from these questions of accepted usage, the term metamorphosis was not in itself exactly applicable to the events with which GOETHE dealt. As JAEGER<sup>35</sup> pointed out in 1814, the expression cannot be more than symbolic, since we do not, as a rule, witness an actual process of transformation; to say that any organ, as we know it, has been "transformed", is thus merely a figure of speech. The term metamorphosis can only denote a change which we imagine happens in the formative force (*Bildungskräfte*), rather than anything detectable in the visible members, though it is from the observed differences in the visible members that we deduce the existence of this underlying metamorphosis. JAEGER'S criticism is fully justified, and it is useful as stressing the elusiveness of the ideas in which GOETHE dealt, and the fact that even he himself did not always succeed in grasping them firmly.

The development of GOETHE'S theory in his little book is on the whole so limpid in expression that commentary is seldom needed to make it fully intelligible today. The thread, upon which the whole exposition is strung, is the idea of metamorphosis in its two main aspects: *normal* or *progressive*; and *abnormal* or *retrograde*. Normal metamorphosis is the change seen in the successive types of lateral appendage, from the cotyledons, through the foliage leaves, and bracts, to the final reproductive goal in the fruit. In abnormal metamorphosis, on the other hand, there is, in the ascent towards

33. MARTINS, C. F. (1837): *Oeuvres d'histoire naturelle de Goethe, traduits et annotés par CH. FR. MARTINS avec un atlas in-folio contenant les planches originales de l'auteur, et enrichi de trois dessins et d'un texte explicatif sur la métamorphose des plantes* par P. J. F. TURPIN. Paris. Destinée de l'opuscule imprimé, p. 267. This discourse, which GOETHE called *Schicksal der Druckschrift*, took more than one form, and I have not found the passage cited except in MARTINS' translation.

34. LINNAEUS, C. (1767): *Systema Naturae*. Vol. 2, Editio Duodecima, Reformata. Holmiae; p. 8.

35. JAEGER, G. F. VON (1814): *Ueber die Missbildungen der Gewächse*. Stuttgart; p. 252.

reproduction, a back-sliding to a level which has already been passed, as, for example, when a stamen is developed in petaloid form. It should be noticed that GOETHE uses the term 'leaf' (Blatt) for the member which undergoes successive changes, appearing in the guise of one lateral appendage after another<sup>36</sup>. GOETHE himself recognised that this terminology is unsatisfactory, since the word 'leaf' is inseparably associated in daily usage with the foliage leaf, whereas, on his view, the foliage leaf has no more claim to be itself the typical 'leaf' than has, for instance, the cotyledon or the stamen. A generalised term, such as 'phyllome,' which was given currency in the nineteenth century especially by NAEGELI<sup>37</sup>, meets the case better than 'leaf', since it is not hampered by special associations. GOETHE'S recognition that neither the foliage leaf, nor any other appendage, is in itself the 'type' leaf, is perhaps the most original feature of his theory. It represents an advance beyond the position adopted by WOLFF, who seems to have regarded the other appendages simply as modifications of the foliage leaf. This difference may be associated with a general difference between the outlooks of the two men; WOLFF was primarily a scientific observer, and GOETHE, primarily an intuitive thinker<sup>38</sup>.

GOETHE was not satisfied merely to note the outward signs of metamorphosis; he wanted also to understand its mechanism. The theory at which he arrived was that the changes in the passage from cotyledons to reproductive appendages are due to the gradual elaboration and refinement of the sap as it travels from node to node. At GOETHE'S date there were no means of developing such a theory in detail, but the view he tried to express may well be regarded as foreshadowing modern ideas upon the relation of chemistry and form<sup>39</sup>. It has also been suggested that the process of metamorphosis, as visualised by GOETHE, may be restated in twentieth-century terms by interpreting it on genic lines<sup>40</sup>.

A notion upon which GOETHE laid much stress in the *Metamorphose* was that the annual plant shows six alternating stages of expansion and contraction. He considered that expansion took place in the passage from the cotyledons to the foliage leaves; the calyx to the corolla; and the sexual organs to the fruit. Contraction, on the other hand, occurred in the passage from the foliage leaves to the calyx; the corolla to the sexual organs; and the fruit to the seed<sup>41</sup>. The artificiality of this scheme is obvious, but GOETHE may have been dimly groping after a conception of periodic rhythm in the development of appendages at the growing apex.

Another hypothesis which GOETHE used in his interpretation of plant life, but which is out of accord with modern views, is that—derived from HEDWIG<sup>42</sup>—of the prime importance of the spiral vessels or tracheids

36. *Metamorphose*, § 119.

37. NAEGELI, C. VON (1884): *Mechanisch-physiologische Theorie der Abstammungslehre*. München und Leipzig.

38. Cf. KIRCHHOFF, A., (1867): *l.c.*, pp. 28 and 31.

39. LAKON, G. (1921): *Goethes physiologische Erklärung der Pflanzenmetamorphose als moderne Hypothese von dem Einfluss der Ernährung auf Entwicklung und Gestaltung der Pflanze*. Beihefte zum Bot. Centralbl., Bd. 38, Abt. I, pp. 158-81.

40. HAYATA, B. (1921): *An Interpretation of Goethe's Blatt*. Icon. Plant. Formos. X, pp. 75-95. I know only the referat in Bot. Jahrb., vol. 57, 1922, Literaturbericht, pp. 47-8.

41. *Metamorphose*, § 73.

42. HEDWIG, J. (1781): *l.c.*, p. 308.

(Spiralgefäße)<sup>43</sup>. It is not surprising that almost magical qualities should have been ascribed to these elements in the early days of anatomy, for the crudest technique revealed them distinctly, and it was natural that their spring-like form should suggest peculiar powers. We cannot reproach the earlier writers with their over-emphasis on spiral vessels, when we recall the way in which, even today, the conspicuousness of xylem in stained sections leads botanists at times to treat it as if it were something with an independent identity of its own, merely embedded in the rest of the tissues, like the waterpipes in a building. GOETHE was so much intrigued by the ideas aroused by the spiral tracheids, that, after the *Metamorphose*, he carried his speculations on spiralness in general to a further point in an essay *Ueber die Spiral-Tendenz der Vegetation*<sup>44</sup>.

The small amount of controversial matter to be found in the *Metamorphose* includes a disclaimer of the fanciful theory put forward by LINNAEUS under the name of *Prolepsis*<sup>45</sup> or Anticipation. LINNAEUS supposed that vegetative buds consisted of a succession of buds within buds, going on to the sixth generation; no doubt this was an offshoot from the doctrine of preformation<sup>46</sup>, which had so widespread an influence in the eighteenth century. He accounted ingeniously for the occurrence of the reproductive phase by postulating that, when a bud produced a flower instead of a vegetative shoot, the six generations enfolded in the bud all came to light at once—future years being as it were, anticipated, and the leaves of successive years being transformed in their due order into bracts, calyx, corolla, stamens, and the pistil with its seeds. LINNAEUS also believed that he had hit upon the mechanism by which the plant achieves this metamorphosis; he supposed that the leafy shoot becomes changed into the flower by the conversion of the cortex into the calyx; the liber into the corolla; the wood into the stamens; and the pith into the pistil with its contents. GOETHE rightly demonstrated the futility of this attempt to relate floral parts to successive zones of tissue<sup>47</sup>.

The theory embodied in the *Metamorphose* has had to face much opposition, part of which has been due to careless and often second-hand misinterpretation, but, apart from this, which can easily be remedied, a residue of genuine difficulty is left, due to certain inadequacies in the theory as GOETHE conceived it. The artistic economy of his exposition was achieved at the expense of deliberate and ruthless exclusions, which to some extent reduce the significance of the work. He limited his consideration, for instance, to the annual herb<sup>48</sup>, paying very little attention to other life forms, and he specifically omitted monocotyledons in discussing seed-leaves<sup>49</sup>.

43. *Metamorphose*, § 60.

44. Sophien-Ausgabe, Abt. II, Bd. 7, pp. 37-68. French translation in MARTINS, C. F. (1837): *l.c.*, pp. 329-33.

45. LINNAEUS, C. (1767): *l.c.*, p. 8; see also ULLMARK, H. (1760): *Prolepsis plantarum*, in LINNAEUS, C. (1764): *Amoenitates Academicæ*. Lugduni Batavorum. Vol. 6, No. cxviii, pp. 324-41.

46. For GOETHE'S attitude to preformation see *Der Inhalt bevorwortet*, p. 120, in *Zur Morphologie*, TROLL ed.

47. *Metamorphose*, § 111.

48. *Metamorphose*, § 6.

49. *Metamorphose*, § 17.

Within the plant itself, his interest scarcely extended beyond the lateral appendages of the stem, and the root he practically ignored. It is true that, in some notes not included in the *Metamorphose*, he spoke of the root as a leaf that absorbs moisture under the earth<sup>50</sup>. He did not, however, follow out this suggestion, and later in life he went so far as to ask how he could be expected to concern himself with such an organ as the root, which shows no ascending progress (*Steigerung*)<sup>51</sup>. Indeed, as TURPIN<sup>52</sup> pointed out long ago, GOETHE's treatise cannot be said to deal, as he claimed, with the metamorphosis of *plants*, since it is only the metamorphosis of the *appendicular organs* of the stem which comes within its purview. Such limitations of the scope of the work would have been entirely harmless if GOETHE had recognised that the problem, as he set it to himself, and consequently the solution which he proposed, were in their very nature incomplete, and represented, not a full morphological interpretation, but merely a single step towards such an interpretation. He did not, however, see the matter in this light, but he treated his theory, of which he was enamoured, as having the finality of a work of art, rather than the provisional character of a work of science. Though he lived for more than forty years after propounding his thesis, and remained deeply interested in it throughout that time, he was inclined to treat it as something achieved once and for all, rather than as a stepping-stone to further developments. He was prepared to amplify it, and offer additional evidence for it, but he did not feel the urge to leave it behind, as an outgrown phase in a continued progress. It was a defect of GOETHE's amateur pursuit of science that he was too much attached to his personal notions and never attained the professional's hard-earned capacity for seeing his own work in due proportion in the general stream of thought. He himself defended the amateur standpoint, on the ground that the non-professional, being free from the obligation to strive after completeness of knowledge, is better able to reach a height from which he may gain a broad view<sup>53</sup>. He failed, however, to realise that detailed knowledge, not limited to the worker's own special line, though it may seem of little value considered in itself, is yet essential as forming a framework of reference for general principles. He would not have sympathised with the artist who said that the best way to get a broad and generalised effects is, not to ignore the detail, but to paint it in, and afterwards to scrape it out remorselessly with the palette knife.

The confinement of GOETHE's interest to the lateral appendages of the stem was one of the effects of his amateur outlook. This limitation led him to consider the leaf as a primary member. He treated it as 'given', and therefore never attempted to ask the question, "What is the leaf?" This question would have seemed to him to fall outside the sphere of legitimate enquiry. It was characteristic of his approach to problems of thought that he drew a definite distinction between those problems which were suit-

50. Quoted in TROLL, W. (1926) : *l.c.*, p. 52.

51. *Sophien-Ausgabe*. Abt. II, Bd. 6, *Zur Morphologie. Verfolg*, p. 331, *Unbillige Förderung*, 1824.

52. TURPIN, P. J. F. (1837) : *Esquisse d'organographie végétale, . . . pour servir à prouver . . . la métamorphose des plantes de Goethe*. Paris et Genève; see p. 7.

53. TROLL ed.: *Der Verfasser teilt die Geschichte seiner botanischen Studien mit*. p. 197.

able for investigation, and others which should be quietly revered and left untouched<sup>54</sup>. If he had felt himself justified in trying to understand the nature of the leaf, he might have come to visualise this member, not merely in itself, but also in its relation to the plant as a whole; and he might then have realised that the shoot is a more fundamental unit of plant construction than the leaf, and that the leaf should be explained in terms not of itself but of the shoot. As it was, the leaf was not clearly seen in relation to the shoot until much later, when CASIMIR DE CANDOLLE<sup>55</sup>, in the latter half of the nineteenth century, suggested that the leaf might be regarded as a *partial-shoot*. He supposed that the limited growth, and the dorsiventrality, of the leaf as compared with the shoot, might be interpreted as due to the atrophy of the apex and ventral face of the terminal meristematic cone. More recently, as a development of this view, the idea has been propounded that the leaf is a *partial-shoot, which shows an urge towards whole-shoot characters*<sup>56</sup>. It should be understood, however, that this modern version of the partial-shoot theory of the leaf, even if it be an advance on GOETHE'S view, makes no claim to be a final morphological interpretation of the plant body. As a further step, an attempt has been made towards a parallel explanation for the root<sup>57</sup>. This attempt is, admittedly, most tentative, and no doubt some generalisation of a more inclusive character will eventually grow out of this sequence of opinions, absorbing and transcending them. Unfortunately, in the long period that has elapsed since DE CANDOLLE'S theory was set forth, little notice has been taken of it by botanists, while, on the other hand, GOETHE'S treatment of the leaf as an irreducible unit has remained permanently influential; this is partly, perhaps, because the suggestion that anything may be accepted as 'given', and therefore not to be questioned, often receives a ready welcome as a trouble-saving device. Even today, modern German morphology, of the school that sees all hope for the future in a return to GOETHE, takes as a postulate that the leaf is a 'Grundform', in no way derivable from any other member of the plant body<sup>58</sup>. This is indeed scarcely fair to GOETHE, since he himself had moments when—though sometimes in an inverted fashion—he made an approach towards the partial-shoot theory of the leaf. In one of his notes, after saying that "Alles ist Blatt," he suggests that the stem is a leaf that becomes radially symmetrical (Ein Blatt, das sich gleich ausdehnt)<sup>59</sup>. Again, he writes of compound leaves as "in reality branches, the buds of which cannot develop, since the common stalk is too frail"<sup>60</sup>.

At the time when GOETHE published the *Metamorphose*, he intended

54. TROLL, W. (1926) : *l.c.*, p. 8. See also SAUNDERS, [T.] BAILEY (1893) : *The Maxims and Reflections of Goethe*. London. No. 577, p. 200.

55. CANDOLLE, C. DE (1868) : *Théorie de la Feuille*. Arch. Sci. phys. nat., Genève. Vol. 32, pp. 31-64.

56. ARBER, A. (1941) : *The Interpretation of Leaf and Root in the Angiosperms*. Biol. Rev., Cambridge, England, vol. 16, pp. 81-105. This paper includes a fuller account of the partial-shoot theory, and the evidence on which it is based, than can be given here.

57. See preceding footnote.

58. TROLL, W. (1938) : *Vergleichende Morphologie der höheren Pflanzen*. Berlin, Bd. 1, Teil 2, p. 957.

59. Quoted in TROLL, W. (1926) : *l.c.*, p. 52.

60. Sophien-Ausgabe, Abth. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 7. Paralipomena 130, p. 125.

eventually to produce, as a sequel, a more comprehensive account of the subject, fully illustrated. His commitments—literary, scientific, and administrative—increased, however, so rapidly, that the scheme was never fulfilled. It is at least arguable that this failure is not to be regretted. In its own small-scale *genre*, the *Metamorphose* is a finished work, and it is doubtful if any attempt to expand it, without a definite strengthening of the thread of theory that runs through it, would have been happy in its result; the book in its 1790 form was, in GEOFFROY SAINT-HILAIRE's phrase, "immédiatement complète"<sup>61</sup>. Though the larger work projected was never written, GOETHE continued all his life to amass material bearing on his theory of plant morphology. As well as the writings printed in his lifetime, all his extant notes on the subject have been retrieved and published with pious care<sup>62</sup>, including even the scribbles with the aid of which he jotted down his ideas on plant form; an example of these "characteristischen Federstrichen" is reproduced on p. 118. Fragmentary as his notes are, they are still rich in suggestion for thinkers of the present day. Judging him by the *Metamorphose* alone, modern botanists have been liable to underestimate GOETHE's actual botanical knowledge. We have now learned, however, that he was not only active as a collector, but that the pictures which he got together with a view to illustrating his definitive work, bear witness to acute observation and a keen, if selective, insight. These drawings were made under his direction, and, in part, with his own hand. He had a number of them engraved, so that they would be ready when he required them; but one of the hindrances to the production of his intended book was that, when the copper-plates were wanted, they had been mislaid, and they do not seem to have been found during his lifetime<sup>63</sup>. In the present century many of GOETHE's figures have been brought to light and printed. One set of pictures is from a small portfolio dating from 1795<sup>64</sup>, preserved in the GOETHE-Nationalmuseum at Weimar; it was published by HANSEN in 1907<sup>65</sup>. Another set, including drawings from a large portfolio of 1830 in the Weimar Bibliothek, has been exquisitely reproduced by SCHUSTER<sup>66</sup>, with a full critical commentary, and some reconsideration of HANSEN's material. This corpus of botanical drawings, in which teratology is strongly represented, and which also includes beautiful studies of seedlings, shows that GOETHE was fully alive to those aspects of factual detail which bore upon subjects which interested him. One illustration, which is of special significance in connexion with GOETHE's morphology, shows the various forms of compound leaf met with in *Aegopodium podagraria* L. (goutweed)<sup>67</sup>. These coloured drawings were made by a professional artist on the basis of pencilled outlines, which SCHUSTER believes were GOETHE's own. GOETHE's attention is known to

61. GEOFFROY SAINT-HILAIRE (ÉTIENNE) (1831): *Sur des Écrits de Goethe lui donnant des droits au titre de savant naturaliste*. Ann. d. Sci. nat., T. 22, pp. 188-93; see p. 190.

62. See especially the Sophien-Ausgabe, and TROLL ed.

63. TROLL ed. *Nacharbeiten und Sammlungen*, p. 239.

64. SCHUSTER, J. (1924): *Goethe, die Metamorphose der Pflansen mit dem Originalbildwerk*. Berlin. Pp. 116, 118, 121.

65. HANSEN, A. (1907): *l.c.*

66. SCHUSTER, J. (1924): *l.c.*

67. SCHUSTER, J. (1924): *l.c.*, pl. VII.



have been specially attracted by the foliage of this plant, for one of his notes<sup>68</sup> mentions its "remarkable *folia composita*", of which "the single leaflets are in part composite again, in part more or less indented, or completely simple"; and GOETHE records his intention of making a collection of them. His strong and wide-ranging artistic gift, shown, for instance, in the drawings on pp. 65, 116 and plate 25, was invaluable to him as a botanist. His preliminary sketch of an opening horse chestnut bud with its "calyx" of bracts is reproduced on p. 116. Another picture, which is of peculiar interest to students of GOETHE's botany, is that of a proliferating pink<sup>69</sup>. This delicate pencil outline is apparently by GOETHE himself, for in the summer of 1787 he found such a specimen in Italy, and mentioned that, since he had no means of preserving this marvellous form (*Wundergestalt*), he attempted an exact portrayal of it<sup>70</sup>. It was evidently a labour of love, for he wrote of the plant in question as embodying all his ideas, and giving him rapturous delight<sup>71</sup>.

This rapturous delight seems to have been aroused in GOETHE's mind primarily by any fulfilment of his desire to resolve the antithesis between the Many and the One—a desire which is the keynote to the whole of his biological work. In this connexion the prose poem, *Die Natur*, reprinted here with a translation (pp. 121-124), has special significance. Whatever answer may ultimately be found to the riddle of its authorship<sup>72</sup>, we know from GOETHE's own statement<sup>73</sup>, made nearly half a century after the '*Fragment*', as it was originally called, appeared, that, in looking back over his scientific career, he regarded *Die Natur* as representing the views which he had held in the earlier part of the decade preceding the publication of the *Metamorphose*, and which he considered that he had since outgrown. Throughout the poem runs the thread of an intense awareness of the antithetic and paradoxical attributes characterising those aspects of the universe which the writer personifies as *Die Natur*. GOETHE may well have been for a time overmastered by the consciousness of such contradictions, but his mental bias would not let him rest permanently at this stage; he soon began to seek, and to believe that he had found, a reconciliation of the antithetic elements in existence. His solution was not, however, truly synthetic, since it led him to stress the One, and to absorb the Many into it. It is possible to hold that his devotion to the idea of the One led to a certain sacrifice of his intellectual integrity. Hankering, as he did, to regard Nature as unified and directional, rather than inconstant and capricious, he came to see her apparent inconsistencies merely as masks for essential oneness. It was from this viewpoint that his morphological work was developed. According to the theory of plant members, which he put forward in the *Metamorphose*, he visualised the indescribably various appendicular organs of plants all as expressions of one form—the leaf. In his wider study of morphology he went further in the same direction, and he reached the concept of a single

68. Sophien-Ausgabe, Abth. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 7. Paralipomena 137, p. 132.

69. SCHUSTER, J. (1924): *l.c.*, Fig. 2, p. 79.

70. Sophien-Ausgabe, Bd. 32. *Italiänische Reise. III. Zweiter Römische Aufenthalt. Störende Naturbetrachtungen*. P. 47 (July 1787).

71. Sophien-Ausgabe, Bd. 32, *Lesarten* (June and July 1787), p. 389.

72. On this question see pp. 119-120.

73. Letter to Kanzler F. T. A. H. VON MUELLER, May 24, 1828, TROLL ed. p. 447.

*type* in accordance with which everything was fashioned (den Begriff des Typus, nach dem sich alles bildet)<sup>74</sup>. Though he made this idea peculiarly his own, he did not originate it. It is a device for figuring out the problems of existence to which those who see these problems on broad lines have frequently resorted<sup>75</sup>. In the *Metamorphose* the type concept is implicit rather than explicit; the word *Urblatt*, for the type leaf, does not occur<sup>76</sup>. In his other notes and writings the idea of the type is more fully developed, but the meaning which he attached to it defies exact definition; he thought of it as a Proteus that eludes any one form of expression and can only be glimpsed in a piecemeal and paradoxical fashion<sup>77</sup>. Moreover, in trying to convey his views in another tongue, we are faced with the difficulty that in English we have nothing really equivalent to those words with an *Ur* prefix which GOETHE employed in this connexion (*Urbild*, *Urtier*, *Urpflanze*, etc.). Fortunately the significance of the type concept is revealed in the examples which he cites, rather than in any verbal formulation. He suggests, for instance, that the *Orchidaceae* might be described as monstrous *Liliaceae*<sup>78</sup>; that is to say, he thought of them as a teratological deviation from the *Liliaceae* type. He would, indeed, have been pleased with a recent account of an abnormal flower of *Cypripedium*, which was trimerous and perfectly regular<sup>79</sup>. It would be an error to suppose, on the ground of his ideas upon the relation of flower structure in the *Orchidaceae* and *Liliaceae*, that GOETHE thought of the "type" as an ancestral form, which had had actual existence at some previous period, for he was not an evolutionist in the modern sense<sup>80</sup>. On his view the "Urpflanze" could neither be described adequately in words, nor represented pictorially—an essential limitation which some of his followers unfortunately ignored. His type concept has frequently been equated with the *forms* or *ideas* of PLATO<sup>81</sup>, and some of GOETHE's expressions may be interpreted as indicating that he so regarded it, but it<sup>82</sup> is doubtful if this identification can be accepted. HANSEN<sup>83</sup> is probably right in his opinion that GOETHE's "Blatt" is, on the contrary, a conjectural concept, enabling a hypothetical situation to be visualised. On this reading it is recognised as comparable with such terms as atom and molecule, and as thus being merely a tool of thought. From this standpoint, which has much to favour it — though GOETHE himself would by no means have accepted it — the type concept is seen as having merely provisional status, so that we are justified in discarding it when it has served its turn in leading us to something more

74. Note appended to a letter to NEES VON ESENBECK, April 2, 1828. *Goethes Briefe*. Sophien-Ausgabe, Bd. 44, p. 54.

75. See especially an interesting study of J. B. ROBINET and the type concept in LOVEJOY, A. O. (1936): *The Great Chain of Being*. Harvard University Press; pp. 269-83.

76. On this point see HANSEN, A. (1919): *Goethes Morphologie*. Giessen; p. 26.

77. *Vorarbeiten zu einer Physiologie der Pflanzen. Einleitung*. Sophien-Ausgabe, Abth. II, Bd. 6, Theil I, p. 312-3.

78. *Nacharbeiten und Sammlungen*. TROLL ed., p. 251.

79. CURTIS, J. T. (1941): *Peloric Flowers in Cypripedium reginae Walt.* Amer. Midland Nat., vol. 25, pp. 580-3.

80. It seems scarcely possible to accept SHERRINGTON's suggestion that GOETHE's views were akin to those of LAMARCK; *l.c.*, p. 20.

81. See, for example, SHERRINGTON, C. (1942): *l.c.*, p. 22.

82. GOETHE speaks, for instance, of the type animal (Urtier) as "den Begriff, die Idee des Tieres"; see *Der Inhalt bevorwortet*, in *Zur Morphologie*, TROLL ed., p. 122.

83. HANSEN, A. (1907) *l.c.*, p. 91.

adequate. For instance, if we adopt the partial-shoot hypothesis of the leaf—as representing an advance upon GOETHE's thought—we need no longer postulate a type-phyllome from which all the lateral appendages of the stem have been derived; for on this view they are not derived *from one another*, but are related merely in so far as they are all incomplete shoots. They are therefore parallel but independent members, rather than divergences from a single primaeval leaf form. GOETHE in 1784 spoke of “paralleling” organic parts which are alike in their inner nature, but wholly unlike in appearance<sup>84</sup>, but he did not develop this suggestion, nor did he realise that the notion of parallelism might eventually replace his naiver type concept<sup>85</sup>.

In GOETHE's eyes the type principle was the clue to the interpretation of animals as well as plants. It was through this principle that in zoology he reached an important factual discovery—which was not, however, as completely new as he believed it to be<sup>86</sup>—that of the intermaxillary bone in man<sup>87</sup>. None of GOETHE's thinking was ever isolated from his whole mental activity, and the type concept, or, more widely, the idea of *Ur* phenomena, was to him a clue to be followed not in science merely; it was, rather, one of the keys which gave him the freedom of the universe as a whole. He applied this concept to man (*Urmensch*), and even to the landscape which forms his background (*Urlandschaft*). This development of the type concept lies outside our present scope; for a stimulating study of it, the reader may be referred to HUMPHRY TREVELYAN's work<sup>88</sup>.

It was not until late in GOETHE's life that he came into contact with A. P. DE CANDOLLE's cognate ideas. In 1828, F. J. SORET, a Swiss friend, introduced him to DE CANDOLLE's *Organographie végétale*, which had been published in the previous year. GOETHE was greatly impressed by the doctrine of symmetry there developed, a doctrine which bore some affinity to his own views. He planned a work<sup>89</sup> to include a French version of the *Metamorphose*, and also the chapter in DE CANDOLLE's *Organographie*, “Sur la symétrie des plantes”, and other representative extracts from this book, and from DE CANDOLLE's *Théorie élémentaire* (1813), accompanied by German translations. The work as eventually published was much reduced, and the projected DE CANDOLLE section was omitted, but the fact that GOETHE had intended to introduce it, shows that he felt no jealous rivalry; on the contrary, he expressed his wonder at the power shown by the Master—as he calls DE CANDOLLE—in handling an infinity of detail<sup>90</sup>. DE CANDOLLE's views had been reached independently, for it is recorded by his son<sup>91</sup> that his

84. *Versuch aus der vergleichenden Knochenlehre*. (1784). TROLL ed., p. 380.

85. On the replacement of the type concept by that of *parallelism*, cf. ARBER, A. (1937): *The Interpretation of the Flower: a study of some aspects of morphological thought*. Biol. Rev. (Cambridge, England), vol. 12, pp. 157-84; see pp. 173 etc.

86. SHERRINGTON, C. (1942): *l.c.*, pp. 21-2.

87. *Versuch aus der vergleichenden Knochenlehre, dass der Zwischenknochen der oberen Kinnlade dem Menschen mit den übrigen Tieren gemein sei*. (1784). TROLL ed. p. 363 et seq.

88. TREVELYAN, H. (1941): *Goethe and the Greeks*. Cambridge, England. See Chap. IV, especially pp. 159-78.

89. UHDE, H. (1877): *Goethe Briefe an Soret*. Stuttgart. Letter to SORET dated August 3, 1828, pp. 56, 57. Also Sophien-Ausgabe, Abt. II, Bd. 13 (Nachträge zu Bd. 6-12), Nachträge zu Bd. 6, paralipomena 70, p. 63.

90. UHDE, H. (1877): *l.c.* Letters to SORET, July 14, 1828, p. 51, and June 28, 1828, p. 43.

91. CANDOLLE, A. P. DE (1862): *Mémoires et Souvenirs*. Genève et Paris; p. 573.

father did not read German, and that he knew nothing of the *Metamorphose* until 1823—more than thirty years after its publication—when a friend sent him an epitome of it in French; he was thus not fully acquainted with it even when he produced the *Organographie* in 1827. GOETHE showed no bitterness at this disregard of his work, which was, indeed, eventually more than compensated by the part which DE CANDOLLE's pupils played in disseminating the ideas developed in the *Metamorphose*<sup>92</sup>. One is tempted to think that there would have been more effective contact between GOETHE and DE CANDOLLE if they had been born two centuries earlier, when Latin was the *lingua franca* of scientific men.

DE CANDOLLE's morphology centred in the notion of the basic symmetry of all plant forms — “la symétrie normale ou primitive des êtres”<sup>93</sup>. The asymmetry that, in fact, frequently occurs, he regarded as secondary, and as requiring in each case some special explanation. We cannot here trace the history of the symmetry conception; it was not new when DE CANDOLLE propounded it, but he was the first to give it full expression. DE CANDOLLE's law of symmetry, and GOETHE's principle of metamorphosis, were in no way incompatible. They were concerned with the same phenomena, though seen from somewhat different standpoints; each contained something of the truth, though neither was the whole truth. Like GOETHE, DE CANDOLLE was not far from taking the step which would have set him on the way to the conception of the leaf as a partial shoot; his doctrine would indeed have fitted exactly with the notion of the leaf as a shoot which — owing to its relation to the parent shoot — has lost its radial symmetry and retained dorsiventral symmetry alone. But for his close adherence to root, stem, and leaf, as rigidly discrete units (*organes fondamentaux*)<sup>94</sup>, which cannot be interpreted in terms of one another, he might have seen how to relate the leaf to the shoot, instead of leaving this feat to be accomplished by his grandson, CASIMIR, many years later.

So far as we know, DE CANDOLLE never concerned himself about the differences between his own mentality and that of GOETHE. GOETHE, however, with his intense interest in psychological problems, discusses these differences, and their results, in a way which throws light upon his own general attitude to scientific work. In a letter to SOROT of April 2, 1828<sup>95</sup>, GOETHE treats DE CANDOLLE's work and his own as exemplifying the contrast between analysis and synthesis. He held these two modes of approach to be reciprocal, mutually helpful even in their antagonisms, and equally indispensable both in theory and in practice. Though he knew that analysis was essential, and respected and admired it in DE CANDOLLE, it was synthesis to which the whole of his mental and psychical equipment inclined him personally. How deep-seated his feeling for synthesis was, is indicated by his prophecy that poetry and science, which in his day dwelt in total isolation, would eventually come to a happy meeting on a higher plane.<sup>96</sup>

92. See p. 86.

93. CANDOLLE, A. P. DE (1827): *Organographie végétale*, Paris, vol. 2, p. 240.

94. CANDOLLE, A. P. DE (1827): *l.c.*, vol. 1, pp. 139-40.

95. See SCHUSTER, J. (1924): *l.c.*, pp. 107-8.

96. *Schicksal der Druckschrift*. TROLL ed., p. 215.

In the fragmentary *Zur Morphologie*, published in 1817, GOETHE emphasizes the disadvantages to biology of the analytical approach through chemistry and anatomy. He says that, by this method, the living creature is dissected into its elements, but that from these elements it is impossible to reconstitute and reanimate it<sup>97</sup>. Those today who advocate a holistic or organismal view of life, have often used expressions almost identical with this of GOETHE's, but without realising that he had been there before them.

GOETHE's synthetic views share the difficulty which besets holistic interpretations in general — that they tend to carry the enquirer out of the sphere of science, which, in the stricter sense, is a discipline obtaining its results by the application of methods of a manageable kind. SCHILLER, in a letter to GOETHE written in 1794<sup>98</sup>, points out that to embark on the heroic path of taking all Nature together, and seeking in the totality of phenomena for the explanation of the individual, is to reach after a goal which there is no hope of attaining in a lifetime. GOETHE's own solution of this difficulty did not lie in the attempt to apply scientific method where he felt it to be out of place, but in the development of symbolic thought. Faced with the manifoldness of phenomena, he tried to reconcile it with his basic idea of the unity of all things, by striving to discern the Whole in the tiniest individual thing<sup>99</sup>. Any subject, however small and limited, with which he concerned himself, became for him the microcosm of something universal; it is not surprising that he was conscious of a special appeal in the Old Testament story of SAUL, the son of KISH, who went forth to seek his father's asses, and found a kingdom<sup>100</sup>.

Symbolic interpretations of experience came to be more and more important to GOETHE, especially in the latter part of his life<sup>101</sup>. Such interpretations involve a special stress upon *comparison*, and GOETHE's great service to morphology lay in the recognition that its basis must be essentially comparative. This comparative way of viewing nature contrasts with the method that is 'scientific' in the rigid sense, and consists in the attempt to treat biological phenomena on mechanical lines. The latter method had little attraction for GOETHE; he wrote that "The application of mechanical principles to organic Nature has only made us the more aware of the wholeness of the living being"<sup>102</sup>. In order to appreciate GOETHE's attitude, it is necessary to consider how his ideas were related to 'explanation', as this is generally understood in science. The word 'explanation' may be held to correspond to the German word 'Erklärung', TROLL's definition<sup>103</sup> of which includes setting forth the cause of a phenomenon, or finding the orderly place for a special fact in a causal sequence. This idea of explanation — as equivalent to the locating of the thing-to-be-explained in a chain of causation — was alien to GOETHE's mind; he held the view that "The thinker

97. *Die Absicht eingeleitet*, in *Zur Morphologie*. TROLL ed., pp. 114-5.

98. *Briefwechsel zwischen Schiller und Goethe*. Theil I, 1794 und 1795. Stuttgart und Tübingen, 1828, pp. 13-4.

99. "das Ganze im kleinsten erblicken". Quoted in TROLL, W. (1926): *l.c.*, p. 36.

100. *Wilhelm Meister's Lehrjahre*. Sophien-Ausgabe, Bd. 23, pp. 309-10.

101. TROLL, W. (1926): *l.c.*, p. 97 et seq.

102. *Betrachtung über Morphologie überhaupt*. TROLL ed., p. 229.

103. TROLL, W. (1925): *Gestalt und Gesetz*. Flora, N. F. Bd. 18 and 19 (G. R. Bd. 118 and 119), GOEBEL Festschrift, pp. 536-65; see p. 556.

makes a great mistake when he asks after cause and effect; they both together make up the indivisible phenomenon"<sup>104</sup>. He recognised, however, that to range appearances under the various forms of causation was an activity arising inevitably from the construction of the human mind, and he was prepared to regard this as justifiable, even when it fell outside his own scheme of things. For instance, in discussing VAUCHER'S work, GOETHE speaks of this author's explanations of physiological phenomena in terms of purpose, as being foreign to his own outlook, but adds that he quarrels with no one who chooses to adopt the standpoint of teleology<sup>105</sup>.

For the type of explanation based on cause and effect, GOETHE substituted a process that can be described only by the untranslatable German word, 'Darstellung', which may be defined, approximately, as the demonstration or representation of an object, brought into relation with others in such a way that its significance is revealed<sup>106</sup>. GOETHE himself spoke of morphology as a discipline which "nur darstellen und nicht erklären will"<sup>107</sup>.

We know that GOETHE'S actual visual impressions were peculiarly intense, and greatly influenced his mode of thought; indeed, his inclination always drew him to 'picture thinking'. For this way of apprehending nature, TROLL<sup>108</sup> uses the expression "intuitive Anschauung", which might be called, "thinking with the mind's eye"; it lies midway between sensuous perceptions reached through bodily sight, and the abstract conceptions of the intellect. Actually to "see", as it were, the solution of a problem, is, to most biologists, an experience as rare as it is delightful; but GOETHE'S mind worked in this way all the time. He even made a vigorous and prolonged attempt to apply the 'Anschauung' method to physics, an attempt which was obviously foredoomed to failure. He tried to tackle the problems offered by colour<sup>109</sup>, on the assumption that such physical questions could be studied non-mathematically. Even here, however, it is possible to hold that his attitude — fantastic as it may appear when judged from the standpoint of modern physics — was not entirely devoid of value. There is a modicum of truth underlying the picturesque exaggeration of CROCE'S statement that GOETHE, "emerging from a century intoxicated with mathematics, understood and had the courage to assert that mathematics do not lead to the knowledge of reality, and that in them there is nothing exact but their own exactness"<sup>110</sup>.

GOETHE was not at home in thought which was purely abstract; he says of himself that for philosophy in the strict sense he had no capacity (kein

104. SAUNDERS, [T.] BAILEY (1893): *l.c.*, No. 394, p. 146.

105. *Wirkung meiner Schrift*. TROLL ed., p. 259; for GOETHE'S views on teleology, see ECKERMANN, J. P. (1836): *Gespräche mit Goethe in den letzten Jahren seines Lebens*. 1823-1832. Theil II. Leipzig; p. 282; and *Conversations of Goethe with Eckermann and Soret* (1850): Translated by J. OXENFORD. London; vol. 2; p. 347.

106. TROLL, W. (1925): *l.c.*

107. *Betrachtung über Morphologie überhaupt*. TROLL ed., p. 228.

108. On this subject see TROLL, W. (1926): *l.c.*, p. 78, etc., and HANSEN, A. (1907): *l.c.*, pp. 277-8.

109. For an interesting and clear account of GOETHE'S *Farbenlehre*, see SHERRINGTON, C. (1942): *l.c.*, pp. 8-18.

110. CROCE, B. (1923): *Goethe*. Translated by E. ANDERSON, with an introduction by D. AINSLIE. London; p. 14.

Organ)<sup>111</sup>. SCHILLER<sup>112</sup>, with his keener power of thought on the philosophic plane, criticised GOETHE as apprehending all too much through the senses. Despite such drawbacks, GOETHE's mode of approach had, and still has, a special and original quality; for in including and emphasizing visual perception, and relating it to thought on the non-tangible plane, it points the way towards a reconciliation of the purely abstract with the purely sensuous. Early in this Introduction, we spoke of the vexed question of GOETHE's scientific status. After a consideration of his biological thought, this question still remains fraught with difficulty, for the catholicity of his mind, and the kaleidoscopic character of his activity, defy neat labelling. As a botanist, he began with a simple utilitarian interest in plants; he passed through a brief period in which he studied the multiplicity of the plant world from the standpoint of the descriptive naturalist; this was succeeded by a phase in which his mind was entirely possessed by comparative morphology, a subject to which the value of his contribution, and the inspiration which later workers have derived from it, are undeniable; and, finally, by a transition natural to his mental growth, he reached a stage in which his morphological thought reached out to the reconciliation of the antithesis between the senses and the intellect, an antithesis with which traditional science does not attempt to cope. It has been suggested by a literary critic that GOETHE was "a great poet who *grew out of poetry*"<sup>113</sup>. Approaching him, as we have done here, through the medium of his plant studies, we may perhaps offer the comparable conclusion, that GOETHE was a great biologist, who, in the long run, overstepped the bounds of science.

**A Note on Translations:** — Two French translations of the *Versuch die Metamorphose der Pflanzen zu erklären* (1790) were published in GOETHE's lifetime, both by Swiss botanists who had been pupils of DE CANDOLLE. The earlier, by F. GINGINS-LASSARAZ, appeared in 1829<sup>114</sup>; in GOETHE's own copy of this work there are manuscript notes pointing to its infidelity and incompleteness<sup>115</sup>. The second translation, by F. J. SORET, came out two years later: *Essai sur la Métamorphose des Plantes . . . suivi de notes historiques*, Stuttgart, 1831<sup>116</sup>. SORET, who criticised GINGINS-LASSARAZ as having used nineteenth-century technical terms, which were an anachronism<sup>116a</sup>, described his own version as "travaillée avec soin sous les yeux mêmes de l'auteur". GOETHE was enthusiastic about this translation, which he spoke of, while it was in progress, as being "more and more felicitous"<sup>117</sup>; but it is too free to be as helpful as might have been expected in the interpretation of obscure points. It seems probable that GOETHE, in his old age, did not, in reality, criticise it intensively, and also that he gave SORET con-

111. *Einwirkung der neueren Philosophie*. TROLL ed., p. 285.

112. *Schillers Briefwechsel mit Koerner* (1847): Teil II. Berlin. Letter of Nov. 1, 1790, p. 207.

113. *The Centenary of Goethe*. Times Literary Supplement. London. March 24, 1932, p. 210.

114. *Essai sur la Métamorphose des Plantes, Traduit de l'Allemand sur l'Édition originale de Gotha* (1790) par M. FRÉDÉRIC DE GINGINS-LASSARAZ. Genève, 1829.

115. SCHUSTER, J. (1924): *l.c.*, p. 110, footnote 3.

116. For the German title see citation in footnote 1, p. 67.

116a. UHDE, H. (1877): *l.c.* p. 93.

117. *Conversations of Goethe with Eckermann and Soret* (1850): *l.c.*, vol. 2, p. 374; ECKERMANN, J. P. (1836) *l.c.*, p. 317.

siderable latitude, because he held that the differences between French and German mentality made it necessary for his ideas to be presented in a somewhat different guise when they were intended for a French audience. He feared that a nation, which demands in everything entire clarity of expression and thought, might suspect him of falling into mystic reveries if he wrote for them in the style which it was natural for him to use in addressing his compatriots<sup>118</sup>.

Five years after GOETHE's death, another French translation appeared from C. F. MARTINS<sup>119</sup>.

It was not until 1863 that a version was published in English: *Essay on the Metamorphosis of Plants*, Translated by EMILY M. Cox; with Explanatory Notes by MAXWELL T. MASTERS (*Journal of Botany*, vol. 1, pp. 327-45, 360-74, 1 pl.). My own translation, which follows this Note, was made independently, but, when it was completed, I compared it throughout with the *Journal of Botany* version, and, wherever the latter seemed to me to convey the sense more accurately than my own, I modified mine in accordance with it.

Another English translation appeared in the *Notes and Correspondence of the Anthrosophical Agricultural Foundation*, vol. 4, No. 8, April 1937. I am indebted to Mr. W. T. STEARN for showing me this version in the year of its publication, but I have not been able to consult it during the preparation of my own rendering. It is described as based on the *Journal of Botany* translation, and on another by Mrs. MIRBT; it has an introduction by G. KAUFMANN.

Those who are curious in such matters may find amusement in certain specimens of poetical versions which appeared in the *Gardener's Chronicle*, vol. 4, 1844, pp. 117 and 133.

In translating the title of GOETHE's book, I have used the word "Attempt", instead of "Essay", for "Versuch", because I believe that "Attempt" more nearly expresses GOETHE's intention. BATSCH's introduction to botany, which was published three years before GOETHE's work, and which he cites, may have suggested the form of the title, for it is called *Versuch einer Anleitung zur Kenntniss und Geschichte der Pflanzen*. BATSCH's work is a solid and detailed textbook; it cannot be called an "Essay", if the word is used in the sense which has in general been attached to it from the days of MONTAIGNE onwards. It seems safe to assume that GOETHE, in his first edition, followed BATSCH in employing the term "Versuch" in the modest sense of "something attempted" — a sense which the English word "essay" conveyed in former days, but which it has now lost. In SORET's French and German issue of 1831, the title losing something of its humility, is changed to *Versuch über die Metamorphose der Pflanzen*; here the word "Essay" seems to be the best equivalent for "Versuch", and "Essai" is used in the French translation.

In the following version, those footnotes, or parts of footnotes, which are not in the original text, are initialled (A.A.). Readers who wish for fuller annotation will find it in TROLL ed., p. 455 *et seq.*

118. See SORET's translation, p. 225.

119. Title cited on p. 74.



TRANSLATION

An  
ATTEMPT *to* INTERPRET  
*the* METAMORPHOSIS  
*of* PLANTS

*by*

J. W. von GOETHE

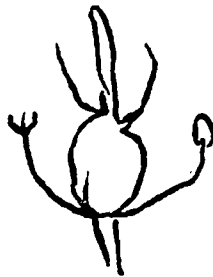
---

1790

*[For facsimile of title page of original  
edition, see opposite page]*

## CONTENTS

INTRODUCTION .....	91
I. CONCERNING THE SEED-LEAVES .....	92
II. DEVELOPMENT OF THE STEM-LEAVES FROM NODE TO NODE .....	94
III. TRANSITION TO THE FLOWERING PHASE .....	96
IV. FORMATION OF THE CALYX .....	97
V. FORMATION OF THE COROLLA .....	98
VI. FORMATION OF THE ANDROECIUM .....	100
VII. NECTARIES .....	100
VIII. FURTHER NOTES ON THE ANDROECIUM .....	102
IX. FORMATION OF THE STYLE .....	103
X. CONCERNING THE FRUITS .....	105
XI. CONCERNING THE IMMEDIATE ENVELOPES OF THE SEED .....	106
XII. RECAPITULATION AND TRANSITION .....	107
XIII. CONCERNING THE BUDS AND THEIR DEVELOPMENT .....	107
XIV. FORMATION OF COMPOUND FLOWERS AND FRUITS .....	109
XV. PROLIFERATED ROSE .....	110
XVI. PROLIFERATED PINK .....	111
XVII. LINNAEUS' THEORY OF ANTICIPATION .....	111
XVIII. SUMMARY .....	113



*I am indeed not unaware that this path is obscured by clouds, which will pass over from time to time. Yet these clouds will easily be dispersed when it is possible to make the fullest use of the light of experience. For Nature always resembles herself, although she often seems to us, on account of the inevitable deficiency of our observations, to disagree with herself. (LINNAEUS, Anticipation in Plants, Diss. 1120).*

## INTRODUCTION

### § 1

Anyone who pays a little attention to the growth of plants will readily observe that certain of their external members are sometimes transformed, so that they assume — either wholly or in some lesser degree — the form of the members nearest in the series.

### § 2

Thus, for example, the usual process by which a single flower becomes double, is that, instead of filaments and anthers, petals are developed; these either show a complete resemblance in form and colour to the other leaves of the corolla, or they still carry some visible traces of their origin.

### § 3

If we note that it is in this way possible for the plant to take a step backwards and thus to reverse the order of growth, we shall obtain so much the more insight into Nature's regular procedure; and we shall make the acquaintance of the laws of transmutation, according to which she produces one part from another, and sets before us the most varied forms through modification of a single organ.

### § 4

The underlying kinship of the various external members of the plant, such as the leaves, calyx, corolla, and stamens, which develop after one another, and, as it were, from one another, has long been recognised by naturalists in a general way; it has indeed received special attention, and the process, by which one and the same organ presents itself to our eyes under protean forms, has been called the *Metamorphosis of Plants*.

### § 5

This metamorphosis displays itself in three modes: *normal*, *abnormal*, and *fortuitous*.

### § 6

*Normal* metamorphosis may also be called *progressive*: for it is that which may be perceived always working step by step from the first seed-leaves to the final development of the fruit. Through the change of one form into another, it passes by an ascent — ladder-like in the mind's eye

120. This is the translation of the citation as given by GOETHE; the full reference is ULLMARK, H. (1764): *Prolepsis plantarum*. In LINNAEUS, C., *Amoenitates Academicæ*, Lugduni Batavorum. Vol. 6, No. cxviii, p. 341. (A.A.).

to that goal of Nature, sexual reproduction. It is this progression which I have studied attentively for a number of years, and which I shall attempt to elucidate in the present essay. This being our standpoint, we will consider the plant, in the following demonstration, only in so far as it is an annual, and passes by continuous progression from the seed up to the fructification.

## § 7

We may give the name of *retrograde* metamorphosis to that which is *abnormal*. As in the normal course, Nature hastens forward to her great end, so in the abnormal, she takes one or more steps backwards. As she there, with irresistible impulse and the full exertion of her might, fashions the flowers and prepares them for the works of love; so here she slackens, as it were, and leaves her creation before it reaches its goal, in an undetermined and powerless condition. Though in this state it is often agreeable to our eyes, in its true inwardness it is feeble and ineffectual. From our acquaintance with this abnormal metamorphosis, we are enabled to unveil the secrets that normal metamorphosis conceals from us, and to see distinctly what, from the regular course of development, we can only infer. And it is by this procedure that we hope to achieve most surely the end which we have in view.

## § 8

We will, on the other hand, avert our eyes from the third kind of metamorphosis, which comes about *contingently*, as a result of external causes, especially through the action of insects; for this phenomenon might frustrate our purpose by diverting us from the direct path which we ought to follow. Perhaps there will be an opportunity to speak elsewhere of these excrescences, which, though monstrous, are still subject to definite limitations.

## § 9

I have ventured to draw up the present work without giving illustrative plates, which however in many respects might seem necessary. I propose to reserve them for the sequel, which can be done the more easily, since enough material is left over for the elucidation and further development of the present short and merely preliminary essay. It will not then be necessary to produce so formal a treatise as this one. I shall have the opportunity of bringing forward much cognate matter; and passages extracted from authors of a like way of thinking will then find their natural place. Especially I will not fail to make use of any suggestions from the experts who today are the glory of this noble science. It is to them that I commit and dedicate these pages.

## I. CONCERNING THE SEED-LEAVES

## § 10

Since we have undertaken to observe the sequence of stages of plant growth, let us turn our attention forthwith to the plant at the moment when it germinates. At this stage we may easily and exactly recognise the parts which directly belong to it. It leaves its husks more or less completely in the earth; these we will not now investigate. In many cases, when the root

has anchored itself in the soil, the plant brings forth into the light the first organs of its upper growth, which were already present, hidden within the seed-coat.

### § 11

These first organs are known under the name of *Cotyledons*. They have also been called seed-valves, kernel-pieces, seed-lobes, and seed-leaves; these names are an attempt to denote the various forms which the cotyledons assume.

### § 12

They often appear shapeless, crammed, as it were, with crude matter, and as much extended in thickness as in breadth<sup>121</sup>; their vessels are unrecognisable, and scarcely to be distinguished from the mass as a whole. These cotyledons bear scarcely any resemblance to a leaf, and we may be misled into taking them for organs belonging to some special category.

### § 13

Nevertheless in many plants they approach leaf form; they increase in area and become thinner; when exposed to light and air they assume a deeper green; the vessels which they contain become more recognisable, and more similar to the veins of a leaf.

### § 14

Finally they appear before us as true leaves, the vessels of which are capable of the finest development. Their resemblance to the succeeding leaves prevents our taking them for special organs; we recognise them, rather, as the first leaves of the stem.

### § 15

But since we cannot think of a leaf without a node, or of a node without a bud, we may be allowed to conclude that the point where the cotyledons are attached is the veritable first nodal point of the plant. Confirmation of this view is afforded by those plants which put forth young buds immediately at the base of the cotyledonary wings, and produce complete shoots from the first nodes, as the horse-bean (*Vicia Faba* L.) is wont to do.

### § 16

The cotyledons are generally twinned, and this leads us to make an observation, the significance of which will be more fully appreciated at a later point. This is that the leaves of this first node are often *paired* when the succeeding leaves of the stem stand *alternately*; there is here an approach and association of parts which Nature, later in the sequence, disjoins and separates from one another. This is still more noticeable when the cotyledons take the form of numerous small leaves assembled round a common axis, while the stem, developing gradually from their midst, bears the succeeding leaves singly, round about itself. This can be observed to perfection in the growth of conifers. Here the wreath of needles forms, as it were, a calyx. We shall have to recall these cases in connexion with similar phenomena which we shall meet later.

121. SORET ed., p. 9, translates this incorrectly as "aussi épais que longs". (A.A.)

## § 17

We will not now occupy ourselves with the single cotyledons of indefinite form belonging to those plants which germinate with one leaf.

## § 18

We will, however, notice that even the most leaf-like cotyledons themselves are always relatively undeveloped as compared with the later leaves of the shoot. Their outline, especially, is extremely simple, and bears as little trace of indentations as their surfaces do of hairs or other vessels (Gefässe)<sup>122</sup> characteristic of the mature leaf.

## II. DEVELOPMENT OF THE STEM-LEAVES FROM NODE TO NODE

## § 19

We are able now to study accurately the successive formation of the leaves, since the progressive operations of Nature all take place, step by step, under our eyes. A variable number of the succeeding leaves are often already present within the seed, and lie enclosed between the cotyledons; while still in their folded condition they are known under the name of the plumule. The relation of their form to that of the cotyledons and of the following leaves differs in different plants, but they generally diverge from the cotyledons in being expanded and thin in texture; on the whole fashioned as typical leaves; fully green in colour; and attached to an obvious node. Their relationship to the later stem-leaves is indubitable, but they are commonly inferior to them in the fact that their periphery or margin has not reached its full elaboration.

## § 20

The leaf shows a continuous development from node to node, as the midrib elongates, and the lateral veins arising from it stretch out more or less on either hand. The various characters of the nervation are the principal cause of the multifarious forms met with in leaves. Leaves may be indented, deeply incised, or formed of many leaflets; in the last case they prefigure complete small shoots. The date palm affords a striking example of such graded diversification of the simplest leaf form. In a sequence of several leaves, the midrib is carried progressively further into the lamina; the fan-like simple leaf becomes torn and divided; and the end result is a highly complex leaf, vying with a branch.

## § 21

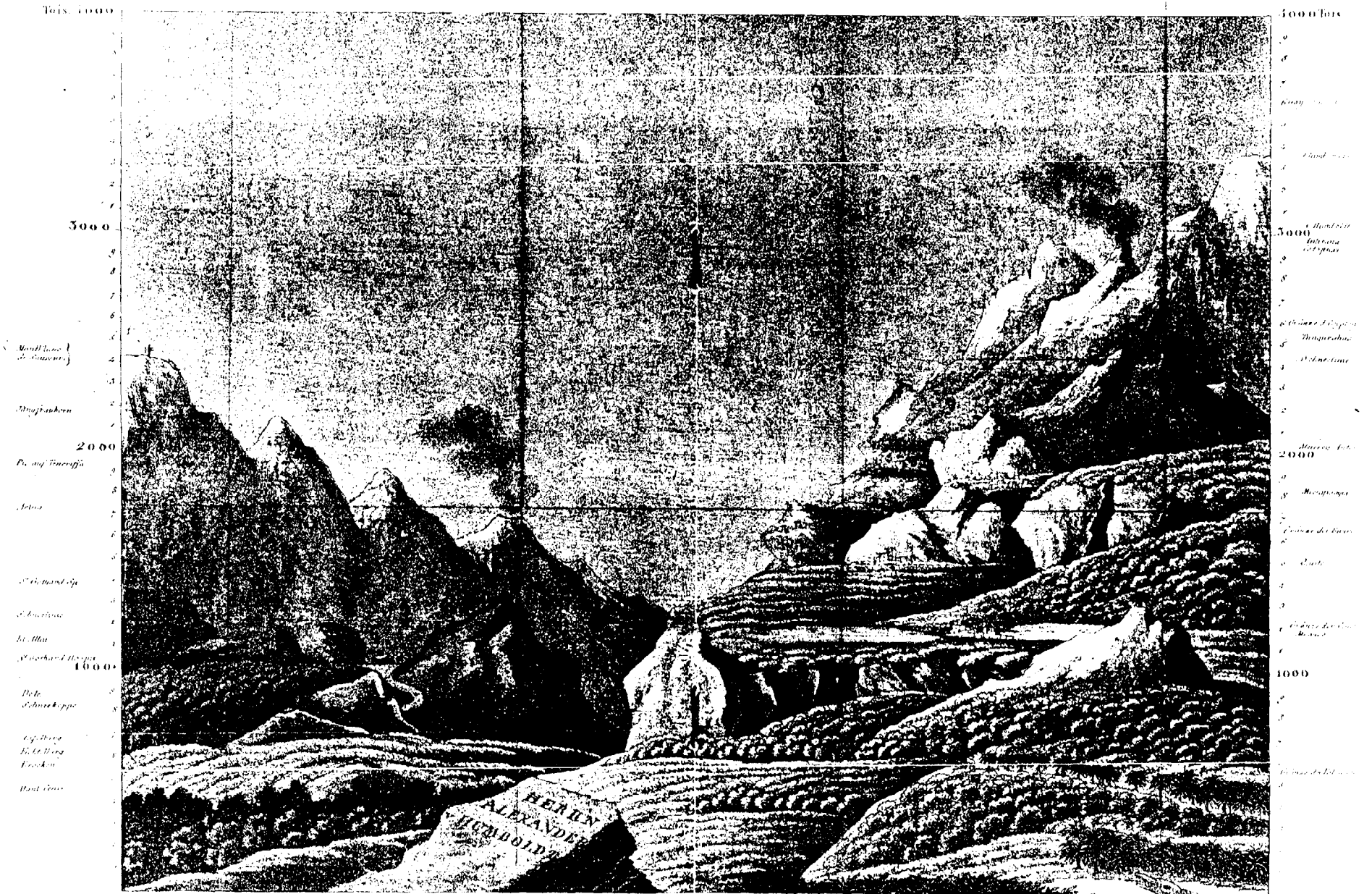
As the leaf itself arrives at the perfection of its form, so the leaf-stalk also develops correspondingly; it may either make a continuous whole with its leaf, or it may form a distinct stalklet, easily detachable at a later stage.

---

122. GOETHE uses *Gefässe* as a vague general term for anatomical elements forming the leaf (cf. also § 25). See SACHS, J. VON (1890): *History of Botany*. Trans. by GARNSEY, H. E. F. and BALFOUR, I. B., Oxford, p. 254, for the indefinite use of the word vessel in the eighteenth century. (A.A.)

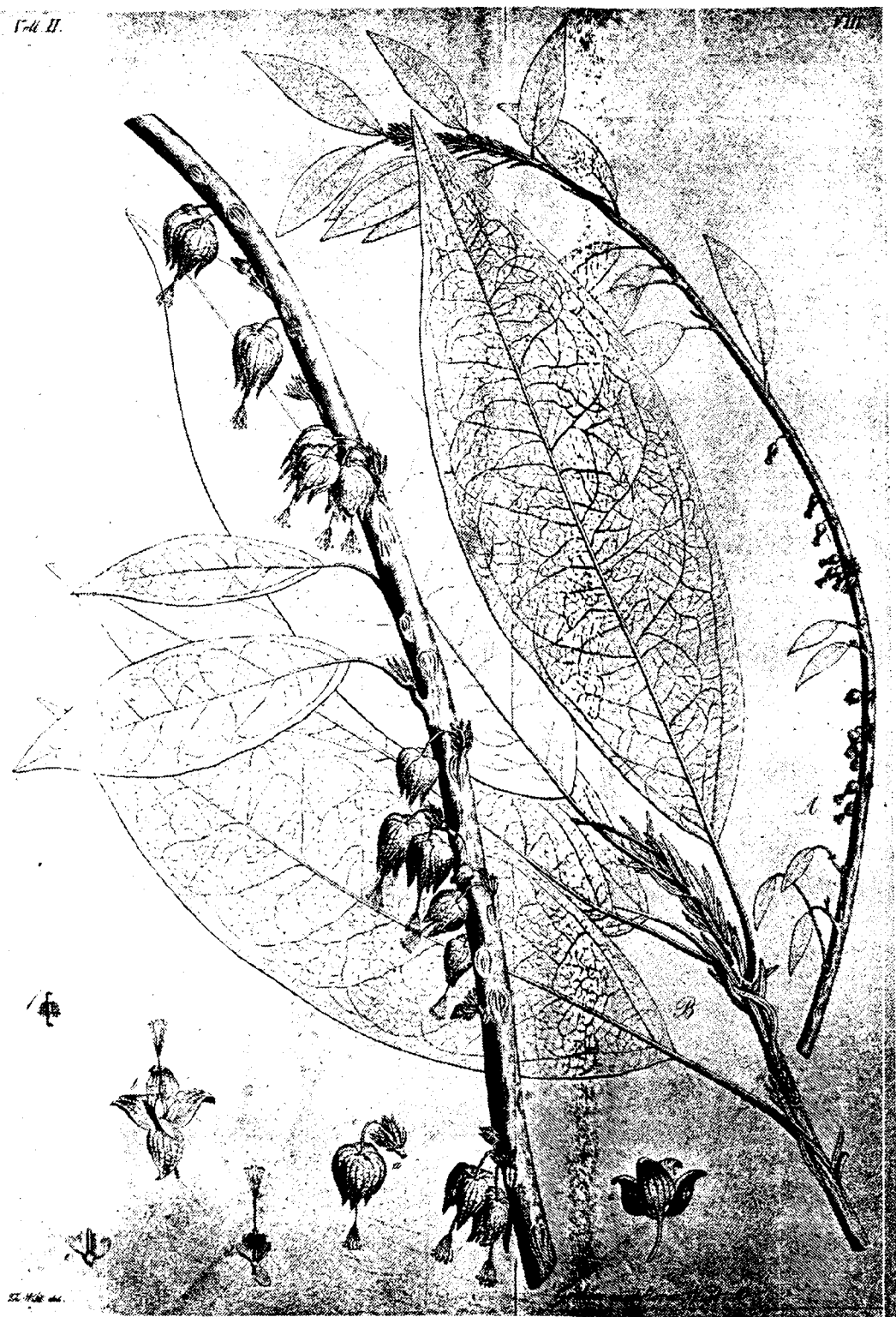


ABNORMAL, FUNNEL-SHAPED, SPIRALLY CONTORTED SHOOT OF *VALERIANA OFFICINALIS* L., FROM TAF. 5 (CF. P. 72) OF SCHUSTER, J. (1924): L.C., AFTER STARK'S DRAWING FROM A SKETCH BY GOETHE. (SEE P. 79 OF TEXT.)



Höhen der alten und neuen Welt  
*bildlich verglichen*





GOETHEA CAULIFLORA H. ET M., TYPE SPECIES OF THE GENUS GOETHEA. AFTER J. H. WILD'S DRAWING IN NOVA ACTA, VOL. 2, PL. VIII.

THE  
NATURAL PHILOSOPHY  
OF PLANT FORM

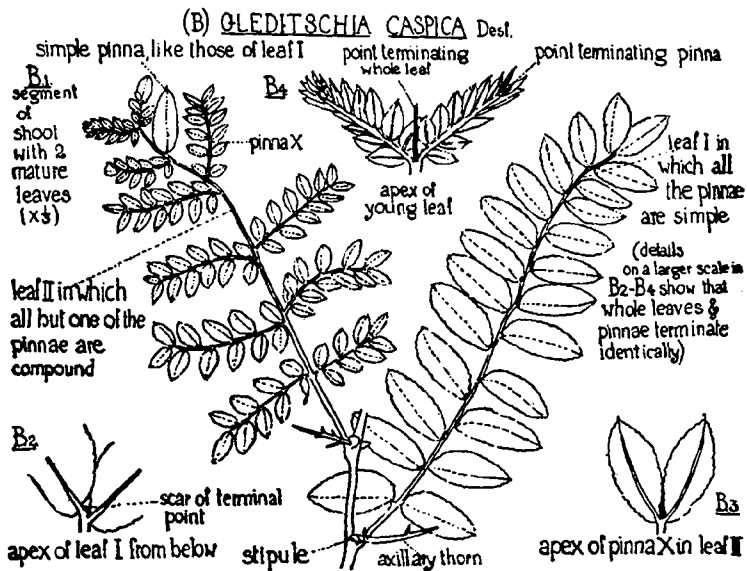
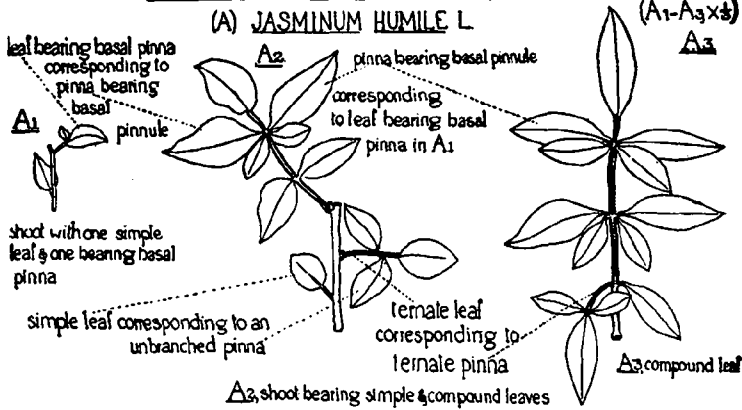
BY

AGNES ARBER

M.A., D.Sc., F.R.S., F.L.S.

CAMBRIDGE  
AT THE UNIVERSITY PRESS  
1950

## IDENTITY-IN-PARALLEL OF LEAVES & PINNAE



## PREFACE

**I**N the present study I have tried to express certain general ideas, which have gradually disengaged themselves in my mind, in the course of a lifetime's concern with the morphology of flowering plants, both as it is understood to-day, and in its historical development from the time of Aristotle onwards. I began by thinking of this subject quite simply as a branch of natural science, but I have come finally to feel that it reaches its fullest reality in the region of natural philosophy, where it converges upon metaphysics, to which it brings its own, distinctively visual, contribution. In this book I have made a tentative and provisional attempt to review the relations of parts in the flowering plants in the light of those more universal, and also more stringent, modes of thought, which are characteristic of philosophy rather than of biology. There are indications that, when morphology is subjected to this discipline, its content may be unified by the synthesis of various theories that are, from the standpoint of analytical science, irreconcilable. The thread running through the following pages is thus a belief in the vital necessity of a linkage between morphological and philosophic thought.

This small treatise is the upshot of so many years that a *catalogue raisonné* of those to whom I have owed practical help or intellectual stimulus would expand this preface into an autobiography; so I must content myself with recording how deeply beholden I am to the generous comradeship of fellow-workers, above all when this has taken the form<sup>1</sup> of enlightening criticism.

To my daughter, Muriel, I dedicate this book, in the consciousness of its having come into being on the background of our unending talks about "why things [are, and that sort of thing"]".

AGNES ARBER

CAMBRIDGE

19 December 1949

## ACKNOWLEDGEMENTS

I AM indebted to the Editor of *Biological Reviews* for permission to incorporate in this book parts of two articles of mine, which appeared in his journal. I have also to express my gratitude to the following publishers and editors, who have allowed me to quote from translations from the classics, for which they are responsible: the Clarendon Press, for certain passages from D'Arcy W. Thompson, *Historia animalium*, and W. Ogle, *De partibus animalium*—both in the Oxford translation of the Works of Aristotle; the Editors of the Loeb Classical Library, and Messrs W. Heinemann Ltd., for citations from W. S. Hett, *Aristotle on the Soul*, and A. Hort, *Theophrastus, Enquiry into Plants*; and Messrs Longmans Green and Co. Ltd., for an extract from W. Ogle, *Aristotle on Youth and Old Age*. In addition, I wish to thank Dr Robert E. Dengler, Professor of Classics, the Pennsylvania State College, for his kindness in letting me cite his version of the *De Causis Plantarum* of Theophrastus.

I desire also to acknowledge with gratitude the expert guidance and the invariable patience of the staff of the Cambridge University Press.

A. A.

# CONTENTS

<i>List of Illustrations</i>	<i>page</i> xiii
<b>Chapter I</b> The Meaning and Content of Plant Morphology	<b>1</b>
<b>II</b> The Plant Morphology of the Aristotelian School	<b>9</b>
<b>III</b> The Plant Morphology of Albertus Magnus and Andrea Cesalpino	<b>24</b>
<b>IV</b> Plant Morphology from Joachim Jung to Goethe and de Candolle	<b>33</b>
<b>V</b> The Concept of the Organisation Type	<b>59</b>
<b>VI</b> The Partial-shoot Theory of the Leaf	<b>70</b>
<b>VII</b> The Urge to Whole-shoot-hood in the Leaf	<b>93</b>
<b>VIII</b> The Bearing of the Partial-shoot Theory of the Leaf on other Morphological Problems	<b>124</b>
<b>IX</b> Repetitive Branching and the <i>Gestalt</i> Type, with special Reference to Parallelism	<b>136</b>
<b>X</b> The Mechanism of Plant Morphology	<b>162</b>
<b>XI</b> The Interpretation of Plant Morphology	<b>199</b>
<i>List of Books and Memoirs cited</i>	<b>212</b>
<i>Index</i>	<b>230</b>

# LIST OF ILLUSTRATIONS

Identity-in-parallel of leaves and pinnae	<i>Frontispiece</i>
1. Vegetative features in the floral shoot	<i>page</i> 49
2. Parallelism between flower and vegetative shoot	52
3. Transitional features in the parts of the flower	53
4. Transitions between vegetative and reproductive members in the flower	54
5. Foliar characters in stamen anatomy	57
6. Comparison of seed-leaves and stipules; persistent petiole; foliaceous calyx	81
7. Dorsiventrality in shoots	88
8. Comparison between a compound-pinnate leaf and a branch system	90
9. Predominance of laterals over the parent axis in leaves and shoots	96
10. Predominance of lateral over median region in leaves and leaflets	98
11. Stipular laminae and rachis tendrils	100
12. Relative importance of median and lateral veins	101
13. Predominance of lateral over median region in phyllomes, and of corona over its parent perianth	103
14. Individual bundles adopting stelar characters; leaf- branching; budding from leaves; abnormal leaf- peltation	106
15. Funnel-shaped (ascidial) phyllomes, and leaves with shoot-like or ascidial outgrowths	110
16. Peltation in compound leaves	112
17. Peltation in compound leaves, and the comparison with shoots	113
18. Relation of lamina and rachis in compound leaves; and leaf-budding	115
19. Shoot-like pinnate leaves; and the origin of more complex forms from ternation	117

## LIST OF ILLUSTRATIONS

20.	Transition from simple to compound-pinnate leaves	<i>page</i> 119
21.	Pedation and pinnation	121
22.	Midrib- and rachis-leaves	122
23.	Shoot production from a root	133
24.	Transition from simple leaves to leaves with ternation of the first, second, third, and fourth order	137
25.	Ternation in a whole lamina, and in its pinnae	138
26.	Transition from pinnae to hairs	140
27.	Pseudanthia	146
28.	Shoot, bearing two generations of umbels, replacing an umbellule	150
29.	Marginal corolla-like development in inflorescences	152
30.	Inflorescences developed from floral axes	154
31.	Corresponding developments located in different floral whorls	156
32.	Numerical variation in floral whorls and in phyllotaxis	163
33.	Numerical variation in floral whorls	165
34.	Colour variation in sectors of a shoot or leaf	167
35.	Results of differential growth in flowers and fruits	169
36.	The effect of pressure on vegetative and reproductive phyllomes	172
37.	Crowding as a factor in ovule development	175
38.	Fusion of bracteole and inflorescence axis	176
39.	Replacement of flowers by inflorescences	179
40.	Hypertrophy of basal or terminal flowers, or inflorescences	181
41.	Peculiarities of the terminal umbellule in an individual umbel	183
42.	Peculiarities of the terminal umbel of a whole plant	186
43.	Peloric flowers in the terminal region of an inflorescence	188
44.	Lateral and terminal peloric flowers	189
45.	Corolla differences associated with sex differences	192
46.	Changes in inflorescences associated with a permanent or temporary sterile phase	194



## CHAPTER I

# THE MEANING AND CONTENT OF PLANT MORPHOLOGY

**I**N these days of specialised study, the different branches of biology cannot but lead existences which are, to a great extent, isolated from one another. The aims which they pursue, and the highly technical methods by which these aims are achieved, differ so widely that one reminds oneself, with something of a shock, that all the branches are concerned with the same living world, and that their disjunction arises, not out of differences of content, but out of the divergent treatment which the mind accords to the same phenomena, when seen from various standpoints—"thinking makes it so". The different branches should not, indeed, be regarded as so many fragments which, pieced together, make up a mosaic called biology, but as so many microcosms, each of which, in its own individual way, reflects the macrocosm of the whole subject. The flowering plant, which in the present book will be our focal centre, offers innumerable 'microcosmic' aspects, varying according to the lines upon which it is considered; but we shall confine ourselves here to one chosen approach—that of morphology. This may seem a narrow road, but, rightly conceived, it should, like other biological paths, lead us towards infinite issues. By morphology we shall understand the study of *form*, giving this word, however, the wider connotation which it has, in general, lost; in modern speech it has become restricted, until it relates only to characters of superficial shape, while the adjective, 'formal', is reduced to mere triviality. A slight indication of the extent to which the word 'formal' has suffered degradation in the last few centuries is given by the phrase, "To make of him a formal man again";<sup>1</sup> for no one would now use this expression, as Shakespeare does, to include all the implications of a return to sanity. Some hint of

<sup>1</sup> *Comedy of Errors*, Act v, Sc. i. Moreover, in seventeenth-century philosophy, 'formal' may mean "that which has actuality or form"; cf. White, W. Hale, and Stirling, A. H. (1899), p. x.

## I. MEANING AND CONTENT OF MORPHOLOGY

the fuller meaning of 'form' is retained to-day in such colloquialisms as "on the top of his form". In morphology our usage needs to be enlarged again until it can be brought into relation with that of Aristotle, to whom the scope of 'form' was wide enough to cover the whole of the intrinsic nature of which any given individual was a manifestation.

The term 'morphology' itself is also liable to be mulcted of its full measure of significance; in this connexion it is worth while to consider its etymology. The Greek *μορφή* as a rule means form, but Plato uses it in a more generalised fashion to denote a sensible character or quality.<sup>1</sup> Like the Latin *forma*, and like *makdome*, the corresponding old Scottish word, *morphe* sometimes carries the implication of elegance; that is to say, it conveys a certain suggestion of the harmony which is characteristic of the organisation of living things, and which St Augustine, who saw it in "the hearbes flower" and "the trees leafe", called "the peacefull concord of composition".<sup>2</sup> In analysing the term 'morphology', we have, furthermore, to consider the meaning of its termination, as well as of *μορφή*. We ought not to dismiss *λόγος* as equivalent merely to 'word'; it may stand for 'definition', 'explanation', 'that which is thought', and even for 'rational law',<sup>3</sup> or 'the formula giving the essence of a substance'. We may, indeed, understand morphology as involving the description and interpretation of the entire external and internal organisation of the plant, from the beginning to the end of its life-history, this organisation being viewed *sub specie formae*<sup>4</sup>—under the aspect of *form*—the fulness of content, with which Aristotle endowed it, being restored to this word. It is hence the business of morphology to connect into one coherent whole all that may be held to belong to the intrinsic nature of a living being. Such a process clearly must transcend preoccupation with outward shape alone. There is indeed no justification for limiting morphology to external features; as well as the outward form seen by the artist and systematist, it should invoke the analytic detail of anatomical and nuclear structure seen by the microscopist. Moreover, among

<sup>1</sup> Cornford, F. M. (1937), pp. 188, 199.

<sup>2</sup> Healey, J. (1610), *St Augustine, of the Citie of God*, bk v, chap. xi, p. 213; for a modern version of edition 2, see Healey, J. and Tasker, R. V. G. (1945), vol. 1, p. 156.

<sup>3</sup> Whittaker, T. (1918), footnote, p. 36.

<sup>4</sup> See Arber, A. (1937a), p. 158.

## FORM AND FUNCTION

plants, form may be held to include something corresponding to behaviour in the zoological field.<sup>1</sup> The animal can *do* things without inducing any essential change in its bodily structure. When a bird uses its beak to pick up food, the beak remains unchanged, but for most, though not for all plants, the only available forms of *action* are either growth, or discarding of parts, both of which involve a change in the size and form of the organism. Consider the growth phases of a bulbous plant. In the autumn it is a dormant bulb; in the spring and summer it puts forth roots, leaves and flowers, passes through a period of sex activity, and produces seeds; in the succeeding autumn, it loses its roots and the parts above ground, and returns to the bulb condition, sometimes accompanied or replaced by offspring bulbs. This sequence of growth stages, entailing shape transformations, corresponds to a whole series of motor acts<sup>2</sup> in an animal, and also to such directive activities as those concerned in sexual reproduction; assembling a store of food; and going into hibernation for the dead season. An example of this kind suggests that the contrast, which generally is assumed to exist between *form* and *function*,<sup>3</sup> has no reality when the word 'form' is given its full content. The treatment of the two conceptions as antithetic has, no doubt, been fostered by the neat alliteration of the phrase, but their assumed opposition is, in the main, traceable to the analogy, mistaken for something approaching an identity, between the works of man, and living beings themselves. In artificial constructions, the object which a man is making is first shaped, often in separate parts, and finally, when all is completed and fitted together, and some source of energy is supplied, the mechanism becomes capable of fulfilling the purpose for which its maker destined it. It is possible here to think of form and function as disjoined; but in living creatures there can be no such separation, for form (in the narrower sense), and function, are merely two aspects of the same unity. The word form, in its wider meaning, must be held to synthesise form in the more obvious sense, which is static, and function—the dynamic—which is the reverse side of the

<sup>1</sup> Russell, E. S. (1934), p. 89; the same idea seems to be hinted at in Crow, W. B. (1929), p. 30.

<sup>2</sup> For an account of a 'motor act' see Sherrington, C. (1940), pp. 205 *et seq.*

<sup>3</sup> The conceptions of form and function in zoology are treated on an historical basis in Russell, E. S. (1916).

## I. MEANING AND CONTENT OF MORPHOLOGY

same shield; in other words, form, as understood in morphology, should comprehend and fuse both static and dynamic elements.

The word 'form', as applied to plants, has indeed so far-reaching a connotation that it may induce a sense of hopelessness about the possibility of getting to grips with so extensive a notion. This is, however, a difficulty which resolves itself, since form, in its whole breadth of significance, finds a focus and expression in that aspect which is perceptible to our sight, supplemented by the sense of touch; for, in the "Figures, Fashions, and Shapes" of plants—to use Lyte's sixteenth-century wording<sup>1</sup>—all the elements belonging to form in its wider sense are made manifest, and brought into relation with our minds. Goethe long ago noticed that there was a tendency for scientific men to consider the external, visible, and tangible parts of living things as indications of their internal parts;<sup>2</sup> and modern work confirms the idea that form in the narrower sense often serves as an index to more recondite characters. It is well recognised, for instance, that the classificatory position assigned to a flowering plant, exclusively on the evidence of such outer morphological features as can be detected in herbarium material, frequently survives the test of subsequent detailed knowledge of the anatomy, life-history, chemistry, and ecology of the plant in question.<sup>3</sup>

We may sum up these considerations by saying that, to arrive at the fullest understanding of any individual plant form, we have, first, to realise it accurately by means of sensuous perception; secondly, to get the completest possible picture of it with the mind's eye—a picture which receives sculptural solidity from the data gathered by touch, and internal concreteness from knowledge of anatomical structure; and, thirdly, to advance beyond this representation, so as to grasp its underlying and surrounding context of significance, and to see it in its living aspect, and in its relation to other forms.

In the present book, evidence from abnormalities will sometimes be used to illustrate and supplement conclusions derived

<sup>1</sup> Lyte, H. (1578), title-page.

<sup>2</sup> Troll, W. (1926), p. 115 [Goethe, J. W. von, *Zur Morphologie. Die Absicht eingeleitet*].

<sup>3</sup> Cf. Diver, C. (1940), p. 305.

## SIGNIFICANCE OF ABNORMALITIES

from the study of normal structures. This may seem to need justification, since evidence of this type is regarded by many botanists with distrust. It must be recalled that teratology can be viewed from two standpoints: firstly, as the study of abnormal forms, pursued for its own sake; and, secondly, as the same study pursued for the ulterior motive of discovering from it facts about ancestral history. This second aspect of teratology depends upon the assumption that clues to phylogeny are revealed in abnormal structures—an assumption which is both non-proven and improbable.<sup>1</sup> Biologists are thus rightly sceptical about the second aspect, but, unfortunately, this scepticism has often been allowed to extend to the first aspect, which, in justice, should not be placed under the same ban. Looking at the matter historically, we find that, before the Darwinian theory, with its phylogenetic corollaries, captured the imagination of botanists, the study of abnormalities was approached on much broader lines, as a help towards the understanding of normal forms. Early in the seventeenth century, Francis Bacon had written, concerning “the Errors of Nature, things strange and monstrous”, that “he who knows her deviations will describe her ways with the greater accuracy”.<sup>2</sup> Some two hundred years later, Goethe used the evidence of teratology to throw light upon normal processes,<sup>3</sup> while, early in the nineteenth century, Jäger<sup>4</sup> maintained that abnormalities in plants are subject to the same laws as those expressed in normal development. A little later de Candolle wrote of the regular order which lies hidden in abnormalities,<sup>5</sup> and Geoffroy Saint-Hilaire, in his book about monstrous forms, said that his main object in the study of teratology was to reach a deeper knowledge of the normal.<sup>6</sup> The attitude of these pre-Darwinian writers was determined by the truth—obvious but often overlooked—that macroscopic nature is never really anomalous, so that even the so-called ‘abnormalities’ are essentially law-abiding. This point was made explicit long ago by Montaigne, who recognised that nature could not be contravened—“rien n’est que selon elle, quel

<sup>1</sup> Cf. Arber, A. (1931 a), pp. 197–200.

<sup>2</sup> Bacon, F. (1620), lib. II, xxix, p. 241; translation in Kitchin, G. W. (1855), p. 184.

<sup>3</sup> Goethe, J. W. von (1790).

<sup>4</sup> Jäger, G. F. von (1814), p. 291.

<sup>5</sup> Candolle, A. P. de (1827), vol. II, p. 238.

<sup>6</sup> Geoffroy Saint-Hilaire, I. (1832–6), vol. I, p. 13.

## I. MEANING AND CONTENT OF MORPHOLOGY

qu'il soit";<sup>1</sup> while Sharrock, in the seventeenth century, in describing aberrant phyllotaxis, added, "Yet even in these irregularities themselves, there often seems to be a greater curiousness, and most proper order."<sup>2</sup> Examples of such orderliness in disorder are indeed frequent; we may recall the parallelism among abnormalities often seen within groups of related plants (e.g. the Gramineae).<sup>3</sup> The existence of a regularity underlying the abnormal makes it possible to apply scientific method to the study of teratology, and to use the results in the interpretation of normal form. Abnormalities, like other exceptional cases, at least show incontestably, what the plant *can* do; it is thus, in its revelation of potentialities not usually actualised, that teratology may throw light upon normal happenings.

The modern outlook upon abnormalities represents, in some ways, a return to pre-Darwinian views. It is thus a cogent instance of the need for a nexus of historical ideas as a background to morphology. It is true that the historical study of botany, if treated superficially, is apt to degenerate into pretty and trivial antiquarianism, but if pursued as an exacting discipline, it bears directly upon current thought. Botany, in so far as it claims to be a branch of natural philosophy, can neglect its own history only at great loss to itself. In philosophy in general, it is part of the recognised task of present-day thinkers to consider, criticise, appraise, and re-appraise, the work of philosophers of the past, remote as well as near; such studies are regarded, not as contributions to history merely, but as an intrinsic part of living philosophy. This should, by rights, be true also of biology, which, like philosophy, *is* its own history; and a study of the course, which biological science has taken, confirms the idea that repeated scrutiny of its embryonic phases is essential to its progress. In the history of research and discovery, the further work which arises out of that of each pioneer, is, as a rule, concentrated in some one direction. Eventually all that can be gathered by pursuing that path becomes exhausted; but by this time the originator himself has been more or less forgotten, and the trail which he blazed is deserted in favour of routes newly opened

<sup>1</sup> Montaigne, Michel de (1906, etc.), livre II, chap. xxx, p. 515. This sentence is o. Montaigne's manuscript additions to the 1588 text.

<sup>2</sup> Sharrock, R. (1660), p. 145.

<sup>3</sup> Arber, A. (1934), pp. 385-98.

## EARLY WORK IN MORPHOLOGY

elsewhere. If, however, at this stage the pioneer's work were again examined, it might be found to contain the germs of other developments, which could equally well have come to full fruition, but which have never had the chance, because one offshoot, which was more completely native to its period, achieved a monopoly from the first. For this reason it is well to return, even at long last, to such early work as is notably rich in content, to see whether it still offers suggestions, which formerly passed unheeded because the time was not ripe for them, but which the intellectual climate would now foster. Originality is so rare in the human mind, that we need to harvest it to the last gleanings. In plant morphology, the case for a return to the renewed study of the pioneers is particularly strong. For this there are two reasons, arising out of the nature of the subject itself. One of these reasons is that morphological research, though it can make full use of the utmost refinements of technique, is yet not debarred from proceeding vigorously without any such aids; for even when naked-eye observation was the only channel through which information could be gathered, sound conclusions were reached by those gifted with the seeing eye, bodily and mental. The earlier workers were thus at less disadvantage in the study of plant form than in other botanical fields. The second reason accentuating the value, even to-day, of long-ago work in morphology, is that, being free from any fixed scheme of evolutionary pre-conceptions, the writers of the past were at liberty to concentrate on form *in itself*. This single-mindedness enabled them to go far, since it meant that their thought was not inhibited by doctrinaire attempts to force it to fit hypothetical history. The whole attitude of many post-Darwinian botanists, on the other hand, has been distorted, through trying to compel the study of form to subserve phylogenetic ends. The work of the Greeks shows us how far morphology was capable of advancing in the absence of modern technique, and without the rigid mental framework imposed by evolutionary theory. It is, indeed, difficult to imagine how any biologist, even with to-day's massive heritage of factual detail at his command, could better the broadly holistic view of the general nature of morphological thought set forth by Aristotle. He pointed out that, when any part or structure is under consideration, "it must not be supposed that it is its material composition, to which

## I. MEANING AND CONTENT OF MORPHOLOGY

attention is being directed . . . but the relation of each part to the total form. Similarly, the true object of architecture is not bricks, mortar, or timber, but the house; and so the principal object of natural philosophy is not the material elements, but the composite thing, and the totality of the form, independently of which these elements have no existence.”<sup>1</sup> For the morphologist, Aristotle in truth remains, as for Dante long ago, “il maestro di color che sanno.”<sup>2</sup>

<sup>1</sup> Ogle, W. (1912), vol. v [*De part. anim.* 1. 5. 645a (Oxford trans.)], slightly modified after comparison with Peck, A. L. (1937).

<sup>2</sup> *Inferno*, canto iv, 131, “the Master of those that know.”