

On morphological thinking¹

Morphological Polarity, an alternative to the concept of the essential organs (Grundorgane)

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The science of plant morphology was founded some 200 years ago by *Johann Wolfgang Goethe*. His scientific publication «Versuch, die Metamorphose der Pflanze zu erklären» reflects only one special methodological aspect of his way of thinking. The scientific estate left by Goethe contains interesting reflections on morphological thinking, and can give new impulses to plant morphology.² The way of comparing forms practised by *Goethe* in his publication on the metamorphosis of the plant can be described as a mental act of varying the proportions of an organ in a quantitative way, resulting in the form of another organ.

If one organ can be transformed by this act into another one, then both organs belong to the same type.³ *Wilhelm Troll* has accepted only this special aspect of Goethean morphology. According to *Troll*, the main purpose of morphology is to understand the great variety of forms, groups, organisms or organs as quantitative variations of a type as the constituting principle.

The theory of the essential organs, an important part of the foundation of modern morphological thinking, is the result of reducing various ways of comparing forms to only one. The theory of the essential organs states – it is a statement, not a law – that no morphological relationships exist between root, shoot axis and leaf. They do not exist, because it is impossible to transform one of these organs by the way of varying proportions into one of the others. The essential organs cannot be compared to each other in a morphological sense.

Starting point of modern morphology is a description of the different organs of the seedling (or germ). In contrast, the starting point should be a reflection of the cyclic life of the plant. This reflection provides the base for a more adequate view on the organs of the seedling. Plant life is a cyclic process of germination, sprouting, flowering, fertilisation, embryogenesis, fructification, dissemination and again germination. Morphological thinking should reflect this cyclic process of the living plant. In

reality, morphological thinking is restricted to special parts of this cycle. I will try to show some limits of modern morphological thinking and how these limits can be overcome.

It can be clearly demonstrated that the enormous and fascinating variability of forms of the vegetative plant can be accurately described and the manifold parts and organs can be related to each other with the help of the principle of varying proportions, together with the concept of the essential organ. We need both concepts to establish homologies or analogies. In this respect, we have learned a lot from *Wilhelm Troll*.

These concepts have their limitations. The germ is one morphological stage in the life cycle of the plant. The preceding stage is the zygote. What is going on in a morphological sense during embryogenesis? Growth and differentiation of the developing embryo are well known processes. We have sufficient anatomical and histological knowledge to describe precisely the structure of the embryo in every moment of embryogenesis. In spite of this fact, we do not have a clear morphological concept of what is going on. Here we can learn from *Goethe*, not from *Troll*.

In the fourth chapter of his scientific estate, «Versuche zur Methode der Botanik»⁴ (On methodology in botanical science), entitled «Organic disunion», *Goethe* introduces the concept of organic disunion: I quote:

«Before, (in the preceding chapter) we looked at the plant as a unity. We can see the empirical unity with our eyes. It arises by the association of many different parts of the greatest variety as an apparent individual. A one year old completed plant torn out. Ideal unity: when these different parts are thought to have arisen from an ideal body, and have developed sequentially. From the very beginning we have to consider this ideal body as simple as possible, and to look at it as disunited, for without the process of disuniting of an entity, a third one cannot develop.»⁵

The process of organic disunion becomes visible in the polarity of the root and the shoot. This polarity is at first a spatial one. Is it a structural one, as well? The second step after establishing the polarity of root and shoot is the differentiation of the shoot in shoot axis and leaf, and of the root in root axis and what I have called root organ.⁶ So far, plant morphologists have considered the root to be one organ, not a complex of different organs. From a logical morphological point of view it is inconsistent to distinguish two shoot organs, stem and leaf, and to look at the root as not being differentiated into two organs. The meristem of the root tip gives rise to different kinds of tissues. Forwards, the meristem gives rise to the root cap, the rhizoderm with the root hairs and the hypoderm. The hypoderm is the next cellular layer adjacent to the rhizoderm; after the decay to the rhizoderm the hypoderm is in direct contact with the substrate. Backwards the meristem gives rise to the elements of the root axis: cortex and central cylinder. I have called the root cap the rhizoderm with root hairs and the hypoderm root organ. The root organ must be compared to the leaf. The cortex and the central cylinder can be called root axis. The root axis must be compared to the stem.

The polarity of root and shoot are revealed in the following characteristics: 1) the central configuration of the vascular strands in the root axis, and their radial and pe-

ripheral configuration in the stem; 2) the root organ arises in a process of continuous construction and destruction. It is of cylindrical shape and not clearly detached from the root axis. Several leaves grow, spatially separated, the leaves are clearly detached from the shoot axis. The tissue layers of the root organ become spatially separated, those of the leaf constitute a spatial unit.⁷

According to the theory of the essential organs, the shoot axis and the root axis are not comparable to each other. The root axis cannot be transformed in the shoot axis and conversely.⁸ This is true for the differentiated organs. On the other hand, this is incorrect, when we look at the hypocotyl. The hypocotyl is the visible falsification of the ground organ theory. We cannot understand the transitional region of the hypocotyl in terms of varying the proportions of root and shoot axis. But we can understand this region when we look at it as starting point and connective region of a polarity.

The theory of the essential organs is, in German, a theory «des Gewordenen» and not a theory «des Werdens», it is a theory of generated forms and not of generating forms. The principle of varying proportions is applicable on forms of a type we have already distinguished. We can understand the variability of stamens, carpels and fruits as quantitative variations of a type as the constituting principle. But every where, where the plant generates new forms during its life cycle, morphology in the sense of *Troll* reaches its limit. We cannot understand the metamorphosis from the vegetative into the generative plant in a quantitative sense, only. Here too, we have the same methodological problem I have outlined before.⁹ *Goethe's* approach is still valid today.

Discussion

Since real discussion was not possible after the presentation of this paper, I just would like to focus on the most important objection. It was stated that *Wilhelm Troll* had not interpreted the theory of the essential organs in such a rigid way as I have done it. *Troll's* point of view does not diverge or at least does not do much from the concept of fuzzy morphology¹⁰ presented by Dr. *Rolf Rutishauser*.

The concept of fuzzy morphology takes into consideration the fact that there are organs which show intermediate characters between shoot and leaves or between root and shoots. On the basis of their position or on the basis of their characteristics, they cannot be classified unequivocally. Thus there are transitional stages between the essential organs.

I have no problem in accepting the concept of fuzzy morphology, but *the concept of fuzzy morphology does not affect the essential point of my critique on morphological thinking*. The seedling stage of the vegetative plant will always exhibit a differentiation in several organs. It is possible that roots do not appear (for example in certain species of the Utriculariaceae), and that one, two or even more cotyledons appear within the Dicotyledons, but cotyledons will never be replaced by root caps. Root caps, root hairs and hypoderm are so differentiated that they will not generate leaves. The concept of fuzzy morphology criticises a too rigid classification of organs. The concept of organic disunion or morphological polarity, however, criticises

the atomistic character of the theory of the essential organs. The type of the vegetative plant by which the concept of organic disunion is developed, starts with the first undifferentiated meristem (in most cases the zygote) and ends with the seedling. The concept of fuzzy morphology starts with the appearing seedling, the concept of organic disunion ends with the appearance of the seedling.

This paper is dedicated to Dr. Jochen Bockemühl. Bockemühl emphasises and shows in his work another aspect of Goethean morphology; it is the identification of the scientist with the inner nature of the plant, providing an ethical approach for human actions.¹¹

Anmerkungen

- 1 This paper has been presented at the 13th Symposium «Morphologie, Anatomie und Systematik» in Leuven in April 1997.
- 2 In u.a.: Goethe, J.W. (1964): Die Schriften zur Naturwissenschaft, Leopoldina Ausgabe, erste Abt.Bd. 10. Weimar 1964.
- 3 A second way of comparing is only tipped at, when Goethe compares the bud of the vegetative plant with the seed of the generative plant.
- 4 In: Goethe, J.W. (1964): Die Schriften zur Naturwissenschaft, Leopoldina Ausgabe, erste Abt. Bd. 10, Weimar, p. 133 ff.
- 5 «Organische Entzweiung. Vorher ward die Pflanze als Einheit betrachtet. Die empirische Einheit können wir mit den Augen sehen. Sie entsteht aus der Verbindung vieler verschiedenen Teile von der grössten Mannigfaltigkeit zu einem scheinbaren Individuum. Eine einjährige vollendete Pflanze ausgerauft.
Ideale Einheit: Wenn diese verschiedenen Teile aus einem idealen Urkörper entsprungen und nach und nach in verschiedenen Stufen ausgebildet gedacht werden. Diesen idealen Urkörper, mögen wir ihn in unsern Gedanken so einfach konzipieren als möglich, müssen wir schon in seinem Innern entzweit denken, denn ohne vorher gedachte Entzweiung des einen lässt sich kein drittes Entstehendes denken.»
- 6 P. Schilperoord-Jarke (1997): The concept of morphological polarity and its implication on the concept of the essential organs and on the concept of the organisation type of the dicotyledonous plant. *Acta Biotheoretica*, 45, p. 51-63.
- 7 A more detailed description of the polarity is given in the above cited literature, note 6.
- 8 In very special cases the root can be transformed in a shoot. The transitional stage is a stage of undifferentiated meristematic growth. See Wilhelm Troll. *Vergleichende Morphologie der höheren Pflanzen*. Erster Band, dritter Teil. Otto Koeltz, Koenigstein-Taunus, 1967.
- 9 See note 6.
- 10 Sattler, R. (1996): Classical Morphology and Continuum Morphology: Opposition and Continuum. *Annals of Botany* 78, p. 577-581.
- 11 Bockemühl, J. (1994): Die Fruchtbarkeit von Goethes Wissenschaftsansatz in der Gegenwart. *Elemente d. N.* 61.

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