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A New Science from a Historical Figure: Goethe as Holistic Scientist

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Abstract

Johann Wolfgang von Goethe's scientific approach countered both the prevailing vitalism and mechanistic ways of seeing the world which dominated the science of his time (1749–1832). His approach was of an informed holism that did not reject science but aimed to direct its path towards a more sensitive appreciation of the generative power of nature. He called this a 'delicate empiricism'. His work in botany and osteology is described to show how morphology and sense perception (Anschauung) can tune into the being of a phenomenon as 'in process' and understand something of nature herself through such human engagement. Goethe's approach could inform new ways of developing more sensitive approaches to engaging with the environment, such as through agroecology. This chapter explains the link between Goethe and Rudolf Steiner (the initiator of biodynamic agriculture) and phenomenology. Goethe's scientific approach uses human faculties such as imagination and intuition, once they have been carefully disciplined. It acknowledges that we are inevitably intertwined with nature, so rather than trying to ignore this, we should bring our human qualities into play. We can renew Goethe's approach by following his method, or we can chance upon it through dedication and a receptivity to nature. To demonstrate the latter, the chapter introduces the work of cytogeneticist Barbara McClintock (discoverer of the transposition of genes) who, it is suggested here, works in a Goethean way.

Introduction

It might seem odd, in a book about the cutting edge of agroecology, to look back to a historical figure. However, it is worth indulging this narrative because Goethe's scientific work sowed the seeds that may now be brought to fruition. In radically rethinking agriculture, we are rethinking our relationship with nature and with the world, and there are early indications of a holistic approach in Goethe's work that could guide us here. As an early objector to the mechanistic and dualistic direction that science was taking, he lived through a fulcrum period in Western history and created a different path, one that we could have followed and may still yet. To build a historical bridge between Goethe and the current discussion, I will also discuss Rudolf Steiner's research into Goethe and the example of Barbara McClintock's scientific work with maize.

Johann Wolfgang von Goethe's dates are 1749–1832, which place him chronologically at the watershed between the study of what was then called natural history and the new science of biology. His scientific approach countered both vitalism[1] and mechanistic ways of seeing the world which dominated the science of his time (Steiner, 1985: 92). Although most famous for his literary work, he believed his scientific endeavours were the most important (Seamon and Zajonc, 1998: 1), and there are many complete historical accounts of these contributions (e.g. Nisbet, 1972). The purpose here is not to repeat them but to contextualise key elements of his approach so that we can see why he might be relevant today.

Goethe's scientific work covers the areas of geology, meteorology, osteology and botany and the study of colour. He was also an early exponent of the history of science as a discipline in itself (Fink, 1991: 70). Working across a wide range of subjects seems strange to our ever-more specialised contemporary approach to science. Why would someone hop from one realm to another and risk being labelled a dilettante? Even in the late eighteenth century,

1 Vitalism has different versions, both ancient and modern, but in Goethe's time, it was characterised by belief that organic entities were infused by a mystical/imperceptible life force or spirit. It gained popularity and adherents as a bulwark against purely mechanistic views.

this would have seemed to be spreading oneself too thinly to make any progress in any field of science. To understand this and to make sense of Goethe's scientific writings and discoveries, we have to understand him as embracing a form of holism, of seeing nature as one, and investigating sides of that whole in order to see it in its fullness.

In order to present a picture of his approach, I will focus on three aspects of Goethe's science: the rejection of an over-reliance on theory; the grasping of nature as being in flux; and the role of human faculties in understanding nature. In all of these aspects, he was neither representative of his own time nor foreshadowing the direction that science was to follow. Furthermore, although he did have an early fascination with alchemy, and draws on it in his literary work (Gray, 1952), what he was doing here was something new.

The Rejection of Over-Reliance on Theory

At the time that Goethe was writing, mechanistic, reductionist ways of thinking were becoming prevalent in society and science, and these were leading to impressive discoveries and inventions. However, for Goethe, these discoveries were often misunderstandings and science itself was being driven up a blind alley. One aspect of the practice of science on which Goethe writes extensively is the movement towards an over-reliance on theory. What happens is that we no longer see the phenomenon we seek to understand; we see only our own construct. As Goethe argued:

> Someday someone will write a pathology of experimental physics and bring to light all those swindles which subvert our reason, beguile our judgement and, what is worse, stand in the way of any practical progress. The phenomena must be freed once and for all from their grim torture chamber of empiricism, mechanism, and dogmatism; they must be brought before the jury of man's common sense.
>
> von Goethe (1995: 309)

Goethe is not saying that theory or hypothesis has no role in scientific investigation; he does, however, want to rein it in and sees it as a tool that needs very careful handling. Goethe rejects both the over-reliance on theory to determine what to look for and the habits of mind that

construct phenomena in the way suggested by the preconceived theory. A strong example of this criticism can be seen in the following quotation:

> To rid the human mind of an hypothesis that has unduly restricted it, forcing it to observe erroneously and to combine falsely, to muse instead of seeing, to sophisticate instead of judging, is already to render it an inestimable service. Henceforth it sees the phenomena with greater openness of mind, in other relations and interconnections, orders them after its own manner, and once more gets the chance to err after its own manner, a chance that is invaluable if it soon succeeds in perceiving its error.
>
> Goethe, Naturwissenschaftliche Schriften Vol 4, Part 2, cited in Heinemann, (1934: 68)

The method by which one is to 'rid the mind' of constricting hypotheses is to approach the phenomenon from all directions. One of these directions will be prior hypotheses, but that is only one direction amongst many diverse approaches. Apart from the importance of a full investigation of the phenomenon as experienced by the scientist, there is also, as the latter part of the quotation reveals, the conscious attention to the action of theory, hypotheses and opinion on perception itself. Thus, the scientist has to investigate his/her own mind as well as nature to ensure that the necessary openness is maintained and to let the mental faculties be guided by nature.

Out of the many scientific works by Goethe across a range of fields, he finds certain principles that are evident in nature and these, for him, help to explain its endless creativity (Tantillo, 2002). Rather than having strict laws circumscribing what is possible, these four principles are better seen as ways of capturing the way nature does what it does. They are as follows:

Polarity: Goethe's term for the way nature is creative through the juxtaposing of opposites; it remains in flux by breaking apart and rejoining.

Intensification (*Steigerung*): Goethe's term for the way all of nature seems to be striving or overcoming itself through increasing complexity.

Compensation: This recognises that nature creates within limits; forms can develop and change, but they are always sacrificing something to develop something else; for example, adaptability is sacrificed for specialisation.

Generativity: This is the principle Goethe recognises to explain the way an organism's parts can work together or even compete, in some sense, to grow. For example, a plant can produce more of itself vegetatively or sexually and these two impulses are both working generatively and express an inner vitality in the plant. Goethe considers that an abundance of generativity suggests a radical freedom at work, as opposed to a hierarchy where certain parts direct development.

These principles operate for Goethe in the way that a theory or hypothesis operates, although they are, he maintains, found in nature, not created by scientists for their convenience nor to constrain or shape what we are seeing. If we approach nature as a machine, we will find machine-like aspects, not because nature is like a machine but because that is the lens we look through. These principles are for Goethe a means to capture something of nature for the human mind to grasp, but they are, like nature itself, ever malleable and undergoing change. One way to understand these principles is as guides for reasonable ways of adding the non-physical meaning aspects of a phenomenon, through contemplation of the phenomenon in the light of these principles.

All in Flux: Time and a Sense of Mobility

An aspect of Goethe's science that seems unusual for the time he was writing was his appreciation of nature as continuously in flux. The project of biology in the eighteenth and early nineteenth centuries was to catalogue and order nature. Nature was understood as created by God, and the human task was to know what was there and to order its objects into static tables. Taxonomy: Putting things in the right boxes was the order of the day. Goethe, as we see from the principles above, is more interested in nature as a whole and how it generates itself.

Indeed, his first published scientific discovery in 1786 of the intermaxillary bone in humans upsets one of the most fundamental divisions: that between humans and other animals. This bone in humans is fused with the maxillary bone, whereas in other animals (even apes) it is freer. Goethe can see this fusing, as opposed to seeing one discrete bone, because his scientific question is not 'which box does it fit into?' but rather, how does dynamic nature shape bones? He was seeing the hard material of bones more fluidly without preconceptions

driven by a theory that must separate humans. This fluidity was so new as a concept that Goethe needs to introduce a new term for it, and in 1796, he used the term 'morphology' for the study of the transformation of organisms (Jensen, 2019).

Morphology also suggests the need for a kind of lively apprehending, not only to see the whole form, but to understand it as a whole. The organic, for Goethe, has no fixed form (von Goethe, 1995: 64). Thus, the organism seen in everyday consciousness is not the organism as a living thing to see this, we need to bring to it the sense of flux that it is engaging in.

With plants, the picture is even clearer. Unlike his contemporaries, Goethe does not stick to studying plants as dry preserved specimens in herbarium samples. As he discovers, particularly on his extensive and life-transforming trip to Italy (von Goethe, 1989), the way a plant grows reflects aspects of its environment such that there can be no stable sample of a plant – its size and development are shaped by where it grows. In *The Metamorphosis of Plants,* Goethe sets out his insight that the plant develops by transforming its material through time by shaping and reshaping itself. It does not unfold to a strictly determined plan, but it does express a vitality and a drive to develop and reach a point of fruition, when circumstances allow. His cryptic statement 'all is leaf' means that the plant substance, which might now be expressed as leaf, undergoes a transformation (akin to reproduction) to become the other plant parts: sepal, petal, carpal, stamen, etc. Nature's creative process is visible to us once we shift our attention from static form to fluid process. This insight he attributes to encountering the discontinuous metamorphosis in the shape of leaves, which he first noticed with the dwarf palm (*Chamaerops humilis L.*) in the botanical gardens in Padua in 1786 (Arber, 1950: 42).

The Role of the Human Being

The third aspect of Goethe's approach to science that needs some explication is the role the human being plays in scientific investigation. As Goethe says, to understand the whole as a metamorphosing possibility we need to 'remain as quick and flexible as nature and follow the example she gives' (von Goethe, 1995: 64). What does he mean by this exactly? The bridge that Goethe uses to make the sequential connection from one instance to another, from one leaf to another, from one plant to another, etc., is that of the human imagination. Rather than seeing

human faculties such as imagination, or indeed intuition, as impairing scientific objectivity, Goethe sees these human faculties as the means to really understand nature. By allowing nature to work with the human faculties, he thought we can begin to see with the mind's eye and thus make connections and reveal the workings of nature that are not initially or easily apparent. For Goethe, the supersensible dimension would be that which we can see once we know how to look and bring that looking into our thinking, to contemplate and use the mind's eye (Stephenson, 1995: 13). He is resistant to the notion of a free-floating idea or concept that is not tied to, or indeed given by, the sense perceptible to the human mind through what seems like a shared contemplation (Stephenson, 1995). The observation and identification of key aspects of nature and an open contemplation of them helps to reveal nature as a whole, and this activity, in Goethe's view, is crucial for the progress of science. His use of the term *Anschauung* captures this well although it is not directly translatable. Agnes Arber,[2] commenting on Goethe's work, renders it as 'intuitive knowledge gained directly through contemplation of the visible aspect' (Arber, 1954: 122).

Goethe's lively discussion of philosophical problems with the activity of scientific investigation helps to fill out the picture of how he worked and what he thought was possible. Accounts of Goethe's own perceptual abilities abound (Amrine et al., 1987: 379), and he acknowledges that he was naturally very perceptive, but also believes in the development of one's faculties. It is clear that he thought the human sensorium was capable of improvement when he discusses the idea of scientific work opening 'new organs of perception'. 'The human being knows himself only insofar as he knows the world; he perceives the world only in himself, and himself only in the world. Every new object clearly seen, opens up a new organ of perception in us' (von Goethe, 1995: 39). The means to improvement was the exercise of looking at nature. He seems to invoke a cycle of looking at nature, examining oneself, looking at nature again and so on. The procedure then becomes a spiral of enhancing capabilities through

[2]Agnes Arber was a twentieth-century botanist and philosopher/historian of biology who was an insightful interpreter of Goethe's scientific work.

experience and closer and closer relationship with the aspect of nature studied. For Goethe, this is the activity of science, he says: 'Insofar as he makes use of his healthy senses, man himself is the most exact scientific instrument possible' (von Goethe, 1995: 331). That sense of having to live into, to merge with, the thing studied comes through in his writing.

Thus, we have a scientist very alive to the problem of presuppositions and human tendencies to shape the world to themselves and yet endorsing faculties such as imagination and intuition to arrive at insights about the workings (or rather the being) of nature. To highlight that seeming conundrum, he talks of the kind of approach that is needed as a 'delicate empiricism'. He says, 'There is a delicate empiricism which makes itself utterly identical with the object, thereby becoming true theory. But this enhancement of our mental powers belongs to a highly evolved age' (von Goethe, 1995: 307). This delicate empiricism is *Anschauung:* where contemplation leads to intuitive insights by allowing nature to speak because we have placed our faculties at her disposal. Such an enhancement would perhaps allow us to become, for a moment, that which we study, for example, to experience vegetative growth or even photosynthesis. Moreover, it allows us to bring the wider picture of relationships and forces in nature to bear on our perception.

To build a bridge between Goethe's time and our own, I will look at two separate developments. One is the connection between Goethe and Rudolf Steiner (whose work was the impulse behind biodynamic agriculture). The other is a twentieth-century scientist, Barbara McClintock, whose work highlights both attending to nature as in flux and the feeling capacities that the human being can bring to the scientific endeavour.

Goethe, Steiner and Biodynamic Agriculture

Biodynamics, as a cosmologically informed farming method, is discussed elsewhere in this book; the purpose of this section is to look at how Goethe informed Steiner's work. Rudolf Steiner claimed to have been, from childhood, able to perceive the supersensible world. As he grew up, he was able to discriminate between those perceptions that he could share with others and those that would draw blank looks. As a student in Vienna, the problems of equating the scientific theories he was being taught, such as the wave theory of light, with his own way

of perceiving, became a problem; what he was expected to learn was in direct contradiction to his own perception. Starting from a firm belief that an unprejudiced examination of phenomena would yield the truth and thus solve these contradictions, Steiner began a detailed study of light and colour. Professor Karl Julius Schröer, who had already shared his enthusiasm for Goethe's poetry with Steiner, was able to see that the ideas this student was developing were close to those in Goethe's *Theory of Colours,* so he drew Steiner's attention to this text. Thus began Steiner's lifelong interest and interpretation of Goethe's scientific work, which led to him being asked to edit Goethe's scientific writings for the *Deutsche National-Literatur* (Steiner, 1978). At that time, Steiner was also reading Schiller and drawing from him the idea of different stages of consciousness. Together, these ideas suggested to Steiner that the 'impassable limits' of science were only impassable in an ordinary state of consciousness. If other states could be actively schooled and used with the same rigour, as he believed to be foundational to science, then a science of nature that included the supersensible could be developed. For Steiner, Goethe was someone who showed how it would be possible to perceive something of this supersensible realm, not from natural clairvoyance, but by developing one's own faculties to understand the nature of physical phenomena. This would mean that the way was open for others to share in his way of seeing, and indeed by working through Goethe's method, Steiner was able to ground his own supersensible perceptions as part of his development.

It is, of course, valid to ask if Goethe saw glimpses of the same world. Some historians, such as Karl Fink, see in Steiner's work on Goethe a one-sided or overemphasised view which does not equate with the bulk of Goethe's scientific work (Fink, 1991). Steiner's work certainly developed Goethe's scientific insights, yet there were already features such as a living richness and a clear divergence from the mechanistic/reductionistic orthodoxy, plus a new working method. Steiner's interpretative work of the scientific works of Goethe is a key inspiration for contemporary Goethean scientists, such as Craig Holdrege (2013), Jochen Bockemühl (1985) and Arthur Zajonc (1998). Goethe's science, in particular his way of approaching phenomena with the human faculties operating in a disciplined 'objective' way – a form of schooled subjectivity – is emphasised repeatedly in the various fields developed out of Steiner's spiritual

science, which he called anthroposophy, including Waldorf education, anthroposophical medicine and, of course, most relevant here, biodynamic agriculture.

Thus, there is a clear lineage between Goethe and biodynamics through the work of Steiner, but a lineage should not be necessary. If Goethe is right that the best method of working is drawn from the phenomena themselves, it should be possible to stumble upon this way of working simply by trying to work with whole plants and one's full human faculties. In this last section, I want to examine just such an example.

Barbara McClintock's Understanding of Organisms

Barbara McClintock's work on maize in the 1940s–1950s, as presented in Evelyn Fox Keller's 1983 biography *A Feeling for the Organism*, shares many features of a Goethean approach. Both the way she went about her work and her concept of the task of science could be described as Goethean. The key similarity, which she so clearly exemplified, was her aim and her ability to 'get to know' the organism with which she worked. It is this aspect of her approach that I will primarily focus on.

Barbara McClintock's career spans many changes in the field of genetics. When she began her life in science, the maize plant was the preferred plant for looking into the action of genes. The colours of the kernels on a cob of maize display genetic traits very clearly. Thus, a yearly crop of this higher plant was seen as the obvious choice for study in an older style of biological research that still focused on the whole organism. Although the study of genetics then moved on to the examination of simpler organisms, with more rigid theoretical models about the behaviour of genes, McClintock continued to study maize. Her determination to stick to a complex organism and older styles of research (1983: 101) was finally vindicated when her work became widely acknowledged as a 20-year precursor of where genetics had reached by the late 1970s. In 1983, she was awarded the Nobel Prize for her work on gene transposition. As an examination of the pressures at play in the world of science, McClintock's story is an interesting one. However, here her story is used as an example of someone working with a plant for decades and coming to know it. Fox Keller asks the question 'What enabled

McClintock to see further and deeper into the mysteries of genetics than her colleagues?' She answers that question with the following:

> Her answer is simple. Over and over again, she tells us one must have the time to look, the patience to "hear what the material has to say to you", the openness to "let it come to you". Above all one must have "a feeling for the organism".
>
> Fox Keller (1983: 198)

McClintock's work involved the microscopic examination of chromosomes, but her trips to the field to gather the cobs to be tested allowed her the opportunity to 'guess' what their later examination would show. She became adept at 'seeing' in the plant what a microscopic examination would later reveal. The kind of seeing she recounts was not fully conscious:

> It is done with complete confidence, complete understanding. I understood every plant. Without being able to know what it was I was integrating, I understood the phenotype.
>
> Fox Keller (1983: 103)

It could be suggested that she was, through her engagement with the plant, 'developing new organs of perception'. McClintock's experiences with maize demonstrate the ideal of really engaging with the phenomenon: engaging not just with the end product on the bench, but with the living organism in its context through its whole cycle, many, many times.

Her ability with this one plant could also be seen as a training of her observation powers in general. Once she knew she could trust the intuitive flashes of insight, she could apply her abilities to a new problem. In 1944, she helped a colleague by working for a time on a mould (*Neurospora*) with chromosomes so small that they had not been individually identifiable. Once in her stride with this new organism, McClintock was able to work with it, and her account, reported by Fox Keller is revealing in terms of living into the organism. She said:

> I found the more I worked with them the bigger and bigger [they] got, and when I was really working with them I wasn't outside I was down there. I was part of the system. I was right down there with them, and everything got big. I even was able to see the internal parts of the chromosomes—actually everything was there. It surprised me because I actually felt as if I were right down there and these were my friends.
>
> Fox Keller (1983: 117)

Once connected to the new organism in this way, she could recognise and follow the development of chromosomes through the meiotic cycle.

However, McClintock's credentials as a scientist, whilst eventually vindicated by her results being corroborated by others, were sometimes doubted. She was working against the flow of developments in genetics and was seen as personally eccentric. If we examine her outlook on science in general, it is possible to find other resonances with Goethe's approach. I shall briefly outline five points that demonstrate a concurrence in their approaches to science which could explain why McClintock's 'feeling for the organism' sounds 'Goethean'. These are as follows:

1. *The Recognition of Models as Models*: McClintock was resistant to what she saw as the dogmas in genetics. Examples of these would be the following: the integrity of genes; the usefulness of bacteriophage because it is simple and one can apply the laws revealed to complex organisms; and the inability of the environment to affect the genome. She had a deep mistrust of theoretical models when they are used as more than, as Goethe would say, the temporary scaffolding. As Fox Keller explains:

   > For McClintock it was what she calls "tacit assumptions"—*an* explicit adherence to models that prevents people from looking at data with a fresh mind. These tacit assumptions impose unconscious boundaries between what is thinkable and what is not. Even glaring lapses in logic become invisible: "They didn't know they were bound to a model and you couldn't show them". Fox Keller (1983: 178)

2. *An Openness of Approach*: Not only was McClintock open to the organism as a part of her practice, but she also advocated a more open approach to other ideas as necessary for science. This is particularly clear from her criticism of her colleagues' dismissal of a presentation on extrasensory perception. She said, 'If they were as ignorant of the subject as I was, they had no reason to complain' (1983: 202).
3. *Dealing with Whole Organisms*: The holism of her approach can be seen in the way she professed to a strong sense of the oneness of all nature. On a practical level in her work with the whole cycle of the plant, the sense of engagement with a continuous process comes through. She felt that it was an important aspect of science that one had the wider picture. 'Basically everything is one. There is no way in which you draw a line between

things. What we [normally] do is to make these subdivisions, but they're not real' (1983: 204).

4. *Using an Emotional Engagement with Phenomena*: Part of the openness to the organism which she cultivated was dependent on an emotional engagement with the object of study, but also a distancing of self. The exacting rigour of her work seems to come from a respect for the organism studied rather than an idealised distancing of the 'less objective' aspects of the scientist. Of the creative points in her life, the intuitive flashes, she says that they come about with an emotional intensity and a losing of one's self. It is as if, as she says, 'I am not there'. An account of the experience which Fox Keller cites is as follows:

> Beneath these trees she found a bench where she could sit and think. She sat for half an hour. "Suddenly I jumped up, I couldn't wait to get back to the laboratory. I knew I was going to solve it"… She doesn't quite know what she did as she sat under those trees. She remembers she "let the tears roll a little", but mainly, "I must have done this very intense subconscious thinking. And suddenly I knew everything was going to be just fine".
>
> Fox Keller (1983: 115)

5. *Putting Process into Observations of a Static System*: Her understanding of the maize plant was aided by her approach to it as a whole, developing, growing organism. Seeing things in process rather than as static results perhaps contributed to her ability to see genetic processes as dynamic, as life in the process of living, rather than as mechanism. Fox Keller provides an account of her watching the meiotic cycle of the Neurospora. Her description of what she had seen 35 years earlier still today holds a vivid narrative quality. It is easy to forget that she had to reconstruct the process from separate slides, that she did not see it unfolding in 'live action' (1983: 115).

These five interlocking points demonstrate the extent to which McClintock's approach to science and the way she explores phenomena share something of the Goethean approach without, as far as is known, any direct lineage. She was simply trying to understand the organism and not following trends in science that, to her, seemed to be getting in the way.

Conclusion

We have seen from the preceding sections that Goethe was able to bring together careful observation of the sense-perceptible aspects of a phenomenon with the supersensible aspects as revealed by a schooled use of the imaginative and intuitive faculties that are themselves informed by the sense-perceptible phenomenon. Historically speaking, this is important as it avoided the errors of two conflicting approaches that were informing the science of his time: vitalism and the mechanistic approach. For Goethe, vitalism gives away the self-generative power of organisms and of nature herself to a vague mystical idea of some free-floating force and is thus a kind of obfuscating mystery mongering, whereas the mechanistic approach ignores the complexity of the intertwined relationships in nature and denies the generative power of organisms in their full majesty. Science, as it developed from the eighteenth and into the nineteenth centuries, rejected vitalism and embraced mechanism with gusto. This ignored the possibility that other options were available.

To address the problems we face in the twenty-first century, we need a way of working with nature, one that does not destroy it or replace it with some limited imaginings. The approach of Goethe and of those who continued developing his insights and carrying out his suggested method of working could have much to offer. In a later chapter, I set out what that method is and how one might examine a phenomenon to develop 'new organs of perception' such that we could have 'delicate empiricism' as a practical approach to researching a more holistic variant of agroecology.

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