I The Bodily Foundation of Thinking
II The Bodily Foundation of Feeling
III The Bodily Foundation of the Human Will
IV Man's Connection with the whole Universe

1944 Nutrition
I The Transformation of Matter
II The Difference Between Vegetable and Animal Food
III The specific Effects of Various Foods on the Different Human Organs

1944 I Zoology for Evetbody
II Birds

1945 Geology
I Review of Various Geological Theories
II The Ice Age – The Existence of an Atlantean Continent

Translated by David Heaf from the original German article which appeared in Beitraege zu einer Erweiterung der Heilkunst 31. Jahrgang, heft 2, March-April 1978, pp37-55. The editor would like to thank Uwe Werner and Peter Braithwaite of the Goetheanum Archives, Dornach for help with obtaining a republishable copy of the sunflower experiment image and Pat Cheney for correcting the English text.

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The Fourth Dimension

Rudolf Steiner

Berlin 24th March 1905

Translator's note: this lecture by Rudolf Steiner is the first lecture from the volume: *Die Vierte Dimension. Mathematik und Wirklichkeit* (Rudolf Steiner Verlag, Dornach, Switzerland, 1995; GA 324a in the collected works in German). The volume was edited by Dr. Renatus Ziegler and Ulla Trapp. All the editor's additions are enclosed in square brackets […]. The detailed end-notes below originate from Dr. Ziegler, and we are extremely grateful for his kind permission in both allowing us to make use of them, and his reading through of the present translation. *David Wood*.

Before you become disappointed with what you are about to hear, let me first of all say that today I will discuss very elementary things [about the fourth dimension]. Whoever desires to penetrate more deeply into this problem must be thoroughly acquainted with the higher concepts of mathematics. I would like to give you a few very elementary and general concepts. We must distinguish between the possibility of thinking in four-dimensional space and the reality itself. Whoever is capable of making observations there has to do with a reality extending far beyond what we know as sense-reality. One must undertake thought transformations when entering this domain. You must allow the things to play a little into the realm of mathematics, and acquaint yourself with the manner of thinking of a mathematician.

We have to realise that a mathematician does not undertake a single step without providing a justification for the results of his inferences. However, we must also become aware when occupying ourselves with mathematics that even the mathematician himself cannot press forward a single step [into reality], that he is unable to draw any inferences [extending out beyond what is possible in thought]. Initially we will be dealing with quite simple things that will soon become more complicated if we wish to arrive at the concept of the fourth dimension. We must become clear as to what we understand by dimensions. This is best done by analysing the various configurations of space according to their dimensionality. This leads to studies that were first tackled in the 19th century by great mathematicians such as Bolyai, Gauß and Riemann.[1]

The simplest magnitude of space is the point. It has no extension at all; it has to be thought. It is the fixing of an extension in space. It has no dimension. The first dimension is the line. The straight line has one dimension, length. If we move or rotate the line itself – which has no thickness – we pass out of one dimension and the line becomes a plane. This has two dimensions, length and breadth. If the plane is moved about we pass out of these two dimensions and get the solid. It has three dimensions: height, breadth, depth (Fig 1).

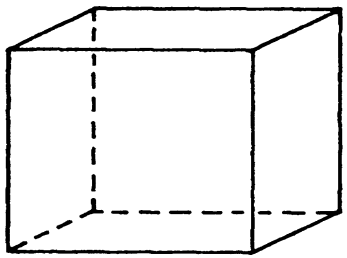
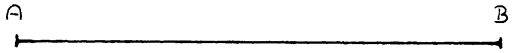


Figure 1

However, if you move the solid itself about, [for example] if you move a cube around in space, you will still only get a solid. You cannot move [three-dimensional] space anymore out of itself. We shall have to apply a few other concepts. If we look at a straight line, it has two boundaries, two endpoints *A* and *B* (figure 2).

Figure 2



Now let us imagine that *A* and *B* have to come into contact with one another. If we want them to make contact we shall have to bend the straight line. What happens? It is impossible for you to remain in the [one-dimensional] straight line if you want *A* and *B* to coincide. To join the points *A* and *B* we have to pass out of the straight line, that is, we have to move out of the first dimension and pass into the second dimension, the plane. In this manner [a closed curve, i.e. in the simplest case] a circle arises from the straight line, due to the fact we have made its endpoints coincide (figure 3).

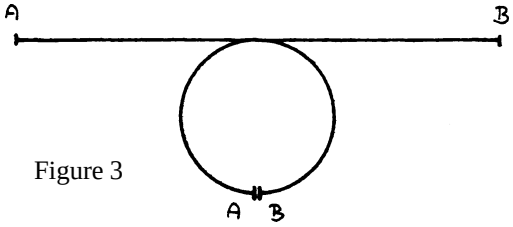
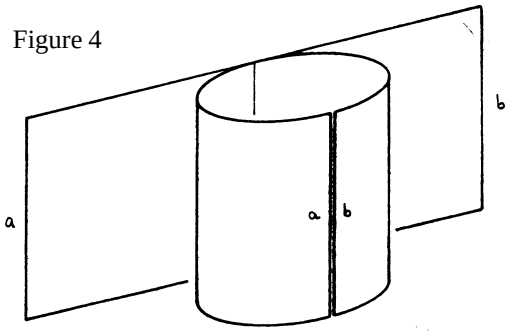


Figure 3

Thus it is necessary to pass out of the first dimension, we cannot remain in it. The circle only arises in this manner. You can carry out the same operation with a [bounded rectangular] plane. This is only possible if we do not remain in two dimensions. We must pass into the third dimension, thus obtaining a tube or a cylinder from out of the plane. This operation takes place in precisely the same way as before when we brought the two endpoints into coincidence, and thereby passed out of the first dimension. Here [with the plane], we have to move into the third dimension in order to bring the two ends of the plane together (figure 4).

Figure 4



Is it conceivable that a similar operation could be carried out with a spatial configuration already possessing three dimensions? If you have two congruent cubes, you can shift the one cube over into the other. [Now imagine two congruent cubes as the boundaries of a three-dimensional prismatic solid.] If you attempt to bring one of the cubes, which is coloured red on one side [and blue on the other opposite side], into coincidence with the other cube, which is in all other respects [geometrically] the same – apart from the fact its blue and red colours are interchanged – then you cannot bring them into coincidence in any other way except by rotating the cube (figure 5).

1926 Aus dem biologischen Institut am Goetheanum, Gäa Sophie Bd. I, Dornach 1926
1926 Vom Mysterium der Materie: Natura, heft i, Juli 1926. August 1926
1927 Vom Mysterium der Materie: Natura, März 1927. April/Mai 1927
1927 Sternenwirken in Erdenstoffen I (Saturn-Sonnenkonjunktion)
1927 Steinenwirkcn in Erdenstoffen II (Sonnenfinsternis 29. 6. 1927) (Orient-Occident-Verlag, Stuttgart, Den Haag, London)
1929 Sternenwirken in Erdstoffen III. Das Silber und der Mond (mit zwei mehrfarbigen und 150 einfarbigen Tafeln) Orient-Occident-Verlag, Stuttgart, Den Haag, London
1928 Workings of the Stars in Earthly Substances with 15 plates
1928 The Solar Eclipse, 29th June 1927, with 3 multicoloured and 20 single colour plates
1932 Mitteilungen des Biologischen Instituts am Goetheanuin Nr. 1 (med. Sektion am Goetheanum, Dornach/Schweiz)
Physiologischer Nachweis der Wirksamkeit kleinster Entitäten
1932 Der Jupiter und das Zinn
Sternenwirken in Erdenstoffen (IV) (mathemat. -astronom. Sektion am Goetheanum, Dornach/Schweiz)
1932 Jupiter and Tin
Working of the Stars in Earthly Substances, 30 plates amongst which are 4 coloured reproductions
1933 Der Mond und das Pflanzenwachstum (Stuttgart, Mitteilungen des Biologischen Instituts am Goetheanum, Dornach)
1934 Mitteilungen des Biologischen Instituts am Goetheanum Nr. 1 (Stuttgart, Orient-Occident-Verlag, hrsg. Med. Sektion am Goetheanum, Dornach/Schweiz)
1934 Mitteilungen Nt. 2
1935 Mitteilungen Nr. 3
1935 Mitteilungen Nr. 4
1936 Mitteilungen Nr. 5 (Sonnenfinsternis 19. 11. 1936 in Brussa, Turkey)
Kristall-Gestaltungskräfte I
Crystal-forming process, 12 postcards in folder
1936 The Moon and the Growth of Plants
1936 Gold and the Sun Total Eclipse of the Sun 19th June 1936, 43 illustrations
1943 Capillary Dynamolysis (Advance Print)
1945 Agriculture of Tomorrow, 426 pages with 299 illustrations 4 coloured plates (Kolisko-Archive)
1947 Gold and the Sun-Total Eclipse 20th May 1947, 44 illustrations
1947 Agriculture of Tomorrow, Preparations (Kolisko-Archive)
1948 Spirit in Matter, 76 illustrations, 8 diagrams
1952 Sternenwirken in Erdenstoffen (V.). Saturn und Blei, mit 325 Bildern (self-published)
1957 Die Landwirtschaft der Zukunft (Kolisko-Archive)
1959 Physiologischer und physikahischer Nachweis der Wirksamkeit kleinster Entitäten bei: Gesellschaft AnthroposophiseherÄrzte, Trossinger Straße 53, 7000 Stuttgart 75 (still available [1978, *Tr.*])
1961 Die totale Sonnenfinsternis vom 15. 2. 1961, L. Kolisko, A. Stifter, R. Steiner — im Experiment als Erlebnis und ihr Wesen (Arbeitsgemeinschaft Anthroposophischer Ärzte, English trans. available)
1961 Eugen Kolisko — ein Lebensbild (self-published), translated into English and published by Lili Kolisko (Kolisko-Archive) by E. Kolisko
1943 Fundamental Problems of the Anthroposophical Knowledge of Man

‘The road is long –
Time stretches to eternity
But never let up with your inner growing.’

These lines succinctly encapsulate her biography. She came a long way; she found the eternal light in the Earth’s being, because she continued to grow. And if we allow the memory pictures of this individuality to pass before our minds we can sense how even now they continue to grow for new impulses on the altar of scientific endeavour.

Notes

1. See *Der Lehrerkreis um Rudolf Steiner,* Stuttgart, 1977
2. Note added by the translator: after Rudolf Steiner’s death in 1925 the Anthroposophical Society experienced a number of internal difficulties which eventually led to the break up of its *Vorstand* (Executive Committee) originally chosen by Steiner and even to the splitting up of the Society, including the expulsion en bloc of the membership in Great Britain. Eugen Kolisko was caught up in these difficult times and in 1935 he was eventually expelled from the Society, an act which is now generally acknowledged to have been illegitimate (Podak, C. Towards a history and a sociology of anthroposophical research institutes in the 1920s. *Archetype* **5**, 48-60, 1999).
3. Dr E. Kolisko: *Ein neuer Weg zur Heilung der Hunde-Staupe*, Stuttgart (1923). The injections were subcutaneous; also supplemented *per os.*
4. Note added by the translator: ‘GA’ refers to Rudolf Steiner’s *Gesamtausgabe* each volume of which bears a GA number assigned by the publishers. For a complete catalogue, contact Rudolf Steiner Verlag, Haus Duldeck, Postfach 135, CH-4143 Dornach 1, Switzerland. The contents of a particular GA volume are not necessarily reproduced in full in individual publications of Rudolf Steiner’s work in English.
5. Werner Kaelin (1965) wrote: ‘L. Kolisko developed the method published by F. F. Runge in 1855. He let metal salt solutions spread out on horizontal filter papers. Paper chromatography then developed from this. Lili Kolisko made no reference to it. However she referred in 1923 to *Über Kapillaranalyse* by Hugo Platz (1922), Pharmacist and manager at the firm of Dr W. Schwabe. Platz attributed his method to Goppelsroeder: Paper strips hang from racks in small cylindrical glass containers and dip into plant juice which rises up them. The resulting differences in colour enabled Platz to distinguish, for example, adulteration of *Rhizoma imperatoriae* with *Radix gentianae*. He studied many plant juices as well as bread, flour, urine and drinks. Lili Kolisko rolled up the paper strips into cylinders which fitted into the glass cylinders dipping into the plant juice. Metal salts were added to the juices.

Bibliography

1921 Milzfunktion und Plättchenfrage (Kommender Tag AG Stuttgart und
1922 Philos.-Anthroposophisdier-Verlag, Dornach)
1923 Physiologischer und physikalischer Nachweis der Wirksamkeit kleinster Entitäten (Kommender Tag AG Stuttgart und Philos.-Anrhroposophischer-Verlag, Dornach)
1926 Physiologischer Nachweis der Wirksamkeit kleinster Entitäten bei 7 Metallen. Wirkung von Licht und Finsternis auf das Pflanzenwachstum (Philos.-Anthroposophischer-Verlag, Dornach)

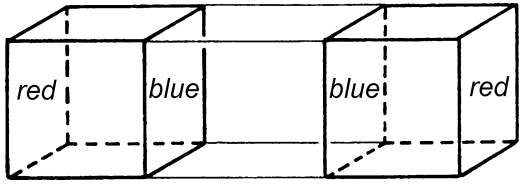


Figure 5

Let us consider another spatial configuration. If you take a left-hand glove, it is impossible to put this left-hand glove on to the right hand. However, if you view both [mirror-symmetrical] gloves as a single entity, like the straight line with its endpoints *A* and *B*, then we now have something that is related or belongs together. We are now dealing with a single configuration that has a boundary [i.e. a mirror-plane] along the middle. This is somewhat similar to the two symmetrical halves of the surface of our skin.[2]

Yet how can two [mirror] symmetrical three-dimensional forms be made to coincide? This is only possible if we pass out of the third dimension, just as we did earlier with the first and second dimensions. We can also transform the left or right-hand glove on to the right or left hand respectively, if we pass through four-dimensional space.[3]

[With the construction of the third dimension (dimension of depth) of visual space] we bring the image of the right eye into coincidence with that of the left eye, we transform it, as it were, on to the other one.[4]

Let us now consider an example from Zöllner.[5] Here we have a circle, and outside of it is a point *P* (figure 6). How can we bring the point *P* into the circle without breaking through it? It is impossible if we remain in the plane. Just as one has to move out of the second dimension and into the third in the transition from the square to the cube, so here too we must move out of the second dimension. Likewise, there exists no possibility of passing into the [inside of a] sphere except by [penetrating through its surface, or] going out of the third dimension.[6]

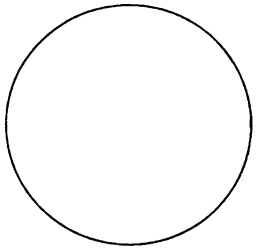


Figure 6

These are thought possibilities having a practical significance for the theory of knowledge [in particular for the problem of the objectivity of the content of perception]. Once we have attained clarity concerning how it is we actually perceive, we shall arrive at the following view. Let us first ask ourselves: how do we acquire knowledge of objects through the senses? We see a colour. Without eyes we wouldn’t be able to perceive it. The physicist then says: what we call colour is not out there in space, but merely spatial forms of motion; these penetrate into our eye, are then caught by the optic nerve and sent on to the brain, to come into existence, for example, as red. One can now ask: is the colour red also present when there is no sensation?

Without the eye, red cannot be perceived. Without the ear, the pealing of bells cannot be heard. All our sensations depend on the fact that forms of motion become transformed through our psycho-physical apparatus. The matter becomes even more complicated if we ask: where does this red exist in reality, this particular quality? Is it on the object? Is it a vibrational occurrence? Externally, there is a motion that is continued on into the eye,

and then up into the brain itself. Everywhere we discover vibrational [and nerve] processes, but nowhere is there red. Even if you examine the eye itself you would never find red. Externally it isn't there, and it is also not in the brain. For red only arises if we place ourselves as subjects before these vibrational processes. Thus, is it really possible for us to discuss how the colour red affects the eye, or how c-sharp affects the ear?

Hence the question is: what is this inner [representation, or mental picture: Vorstellung], where does it come into being? You will find this question running through the whole philosophical literature of the nineteenth century. Above all Schopenhauer[7] put forward the following definition: the world is our representation. – What remains over then for external objects? [Just as a representation of colour can be 'generated' by means of motion, so] motion can also arise within us as a result of something that isn't in principle moving. In this connection let us consider 12 photographs of a horse [in motion], placed onto the [inside] surface [of a cylinder. In addition, there are 12 fine slits in the intervening spaces. If we look side-ways at the spinning cylinder] we can have the impression that there is only one horse, and that its legs are really in motion.[8] Thus [the impression of] motion may also arise through our [bodily organisation] even if the object is not [in reality] moving. In this way what we call motion dissolves completely.

But what is matter then? If you subtract from matter the lustre of colour, motion, [form and so on, i.e. those things mediated through sense perception], then nothing remains over. If we have to seek within ourselves those sensations [that are called forth into individual consciousness by the processes of the outer world, i.e. secondary sensations – colour, sound, warmth, taste and smell – those we call 'subjective'], then we must furthermore place into our inner life [primary sensations, those which are called 'objective' – form and motion], with the result that the outer world completely disappears. This presents major difficulties [for the theory of knowledge].[9]

Let us assume that everything is external to us. How do the qualities of external objects penetrate into us? Thus, where is the point [at which the outer passes over into the inner]? If we subtract all [sensory content], the external world ceases to exist. In this manner the theory of knowledge is placed in the position of Münchhausen, who wished to lift himself up into the air by his own hair.[10] Only when we assume that the world external to us really exists, can we arrive at [an explanation of] the sensations within. How then, can something external to us come into our inner being, to appear as our representation?

We must pose the question somewhat differently. Let us first of all consider a few analogies. We haven't any possibility at all of finding a relation [between the outer world and our inner sensations] unless we can grasp the following. Let us return once more to our study of the straight line with its endpoints *A* and *B*. We had to go out of the first dimension, and bend the straight line in order to make its endpoints coincide (figure 7).

Now imagine that the left endpoint *A* [of this straight line], is brought together with the right endpoint *B* in such a manner that they meet below it, thus allowing us to return [via the coincidental endpoints], back to our starting point. Now, if the length of the line is small, then the corresponding circle will also be small. However, if I make the [given] line into a circle, and continue to make the ever larger lines also into circles, then the point at which the endpoints meet continues to move ever further away from the [origi-

Rudolf Steiner (Vol. 2, Dornach 1952, published by A. Strakosh).

The death vigil and loneliness

At the last meeting with Rudolf Steiner his corpse lay in the studio before the statue of Christ. Ita Wegman, Count Keyserlingk and Lili Kolisko held a vigil through the night. They spoke of the 'living majestic image' of his face, 'so much alive, that it was if he was starting to breathe again'. 'Now we alone shall have to take full responsibility for all work.' Many difficult hours passed.

'When something gets too difficult, why don't you turn to the Spirit of the Institute; indeed, without it, it would not have its name.' These were the consoling words he had given them. Lili Kolisko remembered how she asked Steiner at 4 am. on the night of the destruction of the Goetheanum by fire prior to her lecture the following day: 'Do I have to speak today?' Steiner answered only, 'I'm speaking too.' Thus he for his part had learnt to bear the burden.

The researcher, famous and admired in the Anthroposophical Society, was finally alone in Stuttgart. When she emigrated to England in 1936 there were two people on the railway platform to say goodbye to her: Martin Borchart and his wife Elisabeth, priests of the Christian Community.

In England, unerring Saturn had in store hard times for her leaving a bitter residue at the end of her life. First, in 1939, came the sudden death of Eugen Kolisko just as they both intended to begin new work together. She then translated many of his lectures into English and published them through Kolisko Archive Publications. She supported herself by working from home making bags.

She continued the capillary dynamolysis experiments. When I visited Miss Gladys Knapp, her closest supporter, in December 1970 she said, 'Experiments in the morning, experiments in the evening, experiments at night, two hours sleep, this was her life'. As I parted from Mrs Kolisko at her garden gate (19 December 1970) she said, 'This will probably be the last time that we shall meet'. The myriad of lines on her face creased into a smile.

Lili Kolisko was alone. From 1970 onwards her bodily sufferings began to tell. Her spirit was unbowed, only its instrument was out of tune. We can re-encounter the being of Lili Kolisko free from all discordance in the class lessons of the School of Spiritual Science. In 1924 she was the first to be asked by Steiner to read them in the Stuttgart college of teachers. She continued to read them in Stuttgart between 1950 and 1969. During these lessons she seemed to grow in stature; at that time she had a powerful voice and yet she could speak quite intimately. Emil Leinhas was deeply moved and, not concealing it, said, 'That's exactly how Rudolf Steiner spoke to us in these lectures'.

Lili Kolisko began her life in dark, oppressive circumstances; she found the light of spiritual science; helped by Steiner she enhanced it with new scientific discoveries. Nothing like it had been done before. And finally under the eye of Michael she pointed out the way of the spirit that seeks the light in the darkness of the senses. Norbert Glas, who looked after her for many years, included at the end of his book *Lichtvolles Alter* dedicated to Lili Kolisko, the poem *Saturn-Chronos* which she included as a postscript to her book *Saturn und Blei* (Saturn and Lead). Its last lines read:

in question was called, according to the 1921 assignment, the 'Epidemic Department', later, when as foot and mouth disease receded, the 'Biology Department'.

When the Anthroposophical Society received its new impetus in 1923, Steiner changed the name into the Goetheanum Biological Institute. He discussed it with Ita Wegman, Eugen and Lili Kolisko in his Dornach studio. Steiner: 'You would like to be fully connected with the Goetheanum in Dornach?' He had always regarded Mrs Kolisko as 'belonging to the Goetheanum'. Ita Wegman suggested moving the Institute to Dornach. But on account of Eugen Kolisko's job as teacher and school doctor at the Waldorf school in Stuttgart, Steiner said that unfortunately this was not possible. There were to be laboratories in the second Goetheanum in Dornach where certain preparative work could be done for further development in Stuttgart. In The Hague the idea was to 'go even further' (see above). The discussion appears very significant because it shows that Steiner had planned further work with Lili Kolisko. She later confirmed this view word for word: 'The Biological Institute arose in a healthy way. It grew out of the work. Full rooms for which we had to find people were not there at the outset, but the work was there and we had to start working and then out of the work itself the thing grew more and more. The Biological Institute had a healthy start and *will be able to flourish again*'.

The death of Rudolf Steiner came as a heavy blow to all his closest colleagues. Nevertheless, the main threads of the work were already laid out and tried and tested. Without doubt he would have given further indications for experiments. Two will be mentioned here. On 11 September 1923 (*Rhythmen im Kosmos und im Menschenwesen*) Steiner addressed the Dornach building workers: 'Now we have founded our Institute in Stuttgart, one of our first tasks is to demonstrate that where there is a star there is nothing; that nothing is shining there. Because round it there is something, we can see a kind of light where there is really nothing'. Is not this one of the many research topics which at that time were not taken up? But who has any idea of how to investigate this? Anyway Steiner was accustomed to confirm experimentally in the sense world what he had discovered by spiritual science (clairvoyantly) about the composition of the stars and Sun. Discoveries arise from that form of science which can help people to deal with the destructive destiny of their time. Lili Kolisko was clear about this when she said in a lecture on 30 October 1949 that the disintegration of earthly substance and its effects has a positive counter-image in potentisation effects.

Establishing new topics for research of this kind one needs the greatest impartiality. Externally, this is exemplified by the empty room. Steiner recommended a drastic remedy: 'an empty room with a match box'. It came from that time. And in 1925 Ehrenfried Pfeiffer started Weleda in a garret in Arlesheim.

Another research topic concerned the fact that human proteins behaved differently in the day time compared with the night. At night they are subject to the working of the whole cosmos but during the day they are influenced by the consciousness. A chemist wanting to investigate this would need an understanding of spiritual as well as terrestrial chemistry (GA 219). Here we again see the concept of rhythm and how the experimental approach is developed out of the whole human being.

A. Strakosch reported on the continued work of the research institute in *Lebenswege mit*

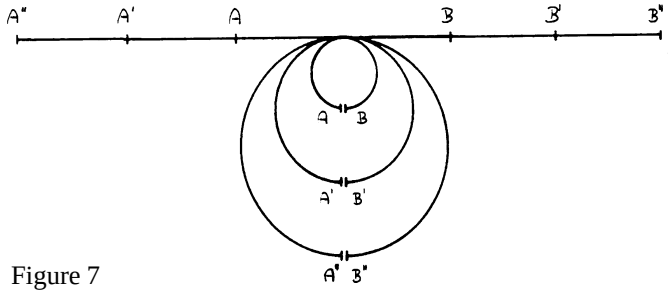


Figure 7

nal] line, and on into the infinite distance. It is only in the infinite distance that the [ever larger] lines of the circle have their endpoint. Thus the curvature of the circle becomes gradually less, until eventually we are unable to distinguish with the naked eye between the line of the circle and the straight line itself (figure 8).

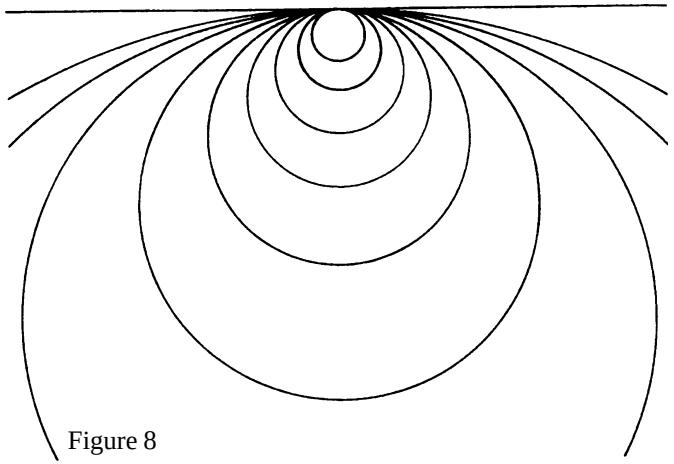


Figure 8

In a similar manner the earth appears to us as an even [flat] surface when we travel over it, despite the fact it is round. If we imagine the two halves of the straight line are extended into infinity, then the circle really becomes coincident with the straight line.[11] Hence it is possible to think of the straight line as a circle whose diameter is infinite. Moreover, it is also possible to imagine that if we [journey along the straight line] – continually remaining on it – we can return [again] from the other side, coming out of infinity itself. Therefore to carry this out we must pass through infinity.

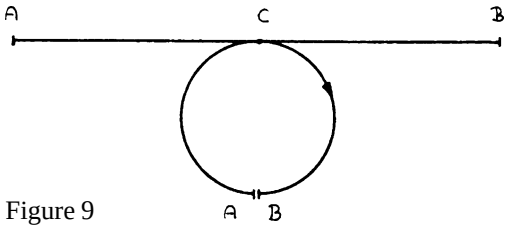


Figure 9

Now instead of a [geometrical] line, think of a reality, of something that connects us with reality. Let us imagine that as the point *C* advances [along the periphery of the circle], a cooling process comes into effect. That is, the point becomes cooler the further it moves away [from its starting point] (figure 9). The point travels along the line of the circle, becoming gradually cooler until it reaches the lower boundary *A, B.* The temperature increases once again as it returns from the other

side. Thus on its return journey the opposite condition occurs to the one prevailing at the outset. The heating-up process increases until we once again reach the temperature *C*, at which we started. However expanded the circle may be, the identical process always occurs: a reduction in heat is followed by an increase in heat. Let us imagine the same thing with respect to the [infinitely extended straight] line: as far as the temperature decreases [on the one side] it is able to increase on the other. Thus, here we have to do with a condition that decreases on the one side, yet increases again on the other.

We therefore bring life and movement into the world, and approach that which may be called in a higher sense, an "understanding of the world." Here we have two conditions affecting one another, which are dependent upon one another. However, concerning everything we can perceive [with the senses], the first process – let us say the one proceeding toward the right – has nothing whatsoever to do with the one returning again from the left. And yet, these two processes reciprocally condition one another.[12]

Let us now compare an object of the outer world to the cooling-off process, and in contrast compare our inner sensations to the heating-up process. [And although the outer world and our inner sensations do not directly have anything sense-perceptible in common] they stand in a relation to one other, they mutually condition one another [just as in an analogous way the processes described above condition one another]. This gives rise to a relationship between the outer world [and our inner world], which we may augment with a picture: [the relation between] a seal and sealing wax. The seal leaves an exact imprint, an exact reproduction of the signet in the sealing wax, without the seal itself having to remain in the sealing wax [and without something material of the seal having to pass over into the wax]. The seal, therefore, leaves a true reproduction of itself behind in the sealing wax. The relationship between the outer world and our inner sensations is entirely similar. Only what is essential [is transmitted]. The one state conditions the other, however nothing [material] is passed over.[13]

If we picture to ourselves that [the relationship between the] outer world and our inner impressions is indeed like this, then we arrive at the following. [Geometrical] mirror-images in space relate to one another like the gloves of the left and right hands. [To place these in a direct and continuous relation with one another] we have to call a new dimension of space to our aid. [Now, the outer world and our inner impressions relate to one another in a manner analogous to geometrical mirror-images, and consequently can only be brought into direct connection with one another through a further dimension.] To bring about a relation between the outer world and our inner impressions we must therefore pass through a fourth dimension, we must enter into a third element. Only here can we find what is common [to both the outer world and our inner impressions], only here are we one [with them]. [We can picture these mirror-images as] swimming in an ocean, within which we are able to make the mirror-images coincide. In this way we obtain [at first only in thought] something extending beyond three-dimensional space, but is still, nonetheless, a reality. We must therefore enliven and animate our conceptions of space.

Oskar Simony[14] attempted to represent these enlivened spatial configurations in models. [As we have already seen,] starting from the study of what is zero dimensional, one can [gradually] arrive at the possibility of visualizing four-dimensional space. [The easiest

ousness in every deed. At Easter 1934 she wrote while on a short holiday in Wengen to the first lab assistant Wilhelm Kaiser: 'Here it is very beautiful, – today it is even snowing. You'll be amazed how we (Eugen Kolisko was there) look when we return, fatter with red and brown faces! But I do have a bad conscience about the missed work…We shall probably not return until the end of this week. Don't let anyone into the lab during my absence. Best wishes, L. Kolisko'.

She wrote from Brussa in Turkey where in 1936 a solar eclipse was about to be followed experimentally: '…my room has a balcony facing due east so I can watch the sunrise. I hope everything works.'

It was the stars mirrored in substance that the conscience of Lili Kolisko the researcher was responding to. She became a model for present day and future generations of researchers; a figure of warning with a powerful conscience while she directed her research, to save the Earth and the life on it. *The lingering effects of the dark age and its science saw in Lili Kolisko a spiritual sunrise on the horizon.*

If we cast our saturnine memories back then we see that both methods she used are signs. The seed germination experiments seem permeated with the chthonic Eleusinian mysteries of substance. At that time were not the grains of the ears the great sign at sunrise? The pictures painted by the cosmic planetary forces seem like reawakened memories of Ephesus. At that time people saw by inner vision the statue of Artemis transported into the ether. Did Steiner indicate this when she met him the second time? He had known her a long time. And she accepted his assignment and devoted herself to it, making it her duty.

The effects of her work spread first of all to the doctors and pharmacists; thereafter to the farmers and to the cancer researchers (mistletoe). It was tested and confirmed by H. Junker, Th. Schwenk, W. Pelikan and Basold. Currently (1978), Christa Krüger is using the germination technique. Thus new discoveries must always be verified under different conditions and modified. The spirituality in matter has lit a way into the future like a bright light. Following the way is a duty which we owe to both it and its originators. At the same time it would enliven anthroposophy which, as a spiritual science, is dependent upon vigorous research.

The Goetheanum Biological Institute

At the end of Steiner's second lecture cycle on science (GA 321) the 'Kommenden Tag AG' was founded. It combined economic and cultural enterprises and included a laboratory. In the lecture cycle, Steiner gave indications for research topics. He took the initiative of a research institute: '…our research institutes will have to be founded on such things…' in order to add to the conventional instruments 'new ones by which we shall be able to show that certain processes going on in the earth, particularly the gaseous and fluid earth, *happen differently by night than by day*'. The way is from the daily cycle to the cycle of the year.

The shareholders [of Kommenden Tag] also supported Mrs Kolisko's work financially. 'It was a lucky gift not to find myself in an already full room.' The research questions took precedence, not ready-made apparatus, not to mention a whole building. The room

The *Mitteilungen des biologischen Institutes am Goetheanum* (1-5) were published every year. These reported results for the crystal formative forces and observations with capillary dynamolysis through four eclipses of the Sun.

Crystallisations were carried out during the daily and annual cycle of several years at 17 levels from that of the laboratory down to 16 metres below the Earth's surface. At night, crystallisation happened earlier. In February there was a maximum in the monthly weight of crystals, also at night, and in August there was a minimum.

In Stuttgart, Steiner set the task of showing through crystallisation with plant poisons 'the transition from mineral to plant formative force'. Lili Kolisko carried out these experiments too. Hans Krüger has seen unpublished pictures of these (see also GA 321 and 327).

Amongst all the capillary dynamolysis experiments the one of 9 October 1933, during a meteor shower, is particularly notable. 'By chance' Lili Kolisko had prepared more silver nitrate pictures than necessary. 'I just had the feeling that they might be needed for something today. At 8 p.m. we were again on the way to the laboratory and looked up at the starry heavens. A beautiful meteor came down, drawing a broad arc of light behind it.' Then it rained, causing quite a stir. She hurried to the lab and applied metal solutions to the already prepared experiments, particularly iron sulphate prepared from meteoric iron. The cylinders were orientated to the north, south, east and west. A *rise in the iron forces* was observed experimentally during this unusual performance in the heavens. The effect also showed with other metals. This work was published in 1935 in issue number four of the *Mitteilungen*. It was as if heavens had lent a hand in advance so as to help its language be expressed experimentally. Where else in the whole world can we find such pictures and such a destiny? The Spirits of the Elements became laboratory assistants!

Monographs were published under the titles *Das Silber und der Mond*, *Der Jupiter und das Zinn* and finally *Saturn und Blei* (1952). This last major work completed a circle and resulted in the publication of a book. An attempt was made to make an overview of the chemistry, astronomy and physiology (with a contribution from Eugen Kolisko). And this work too meant a pioneering deed in its own way. In the postscript thanks are directed to Dr A. Leroi; other helpers with the publication of potential interest being R. Abecassis, Hans and Martha Kleemann, who had always been of loyal assistance both at the beginning and later, likewise Julietta Leroi and M. Muller of Ascona and W. Rollvink, Dr P. von Siemens and Dr H. C. H. Voith of Heidenheim.

Life and work are one

This work meant a lot to Lili Kolisko. On 9 December 1956 she told me, when I asked for her personal assessment of it, 'If you go from the spleen function (1922) to lead (1952) then you have my autobiography'. The cause is more important than the person. The planet with its 30-year orbit became the symbol for the life and work of Lili Kolisko. The work of her star shaped her life's work on Earth. She meant that she had begun with the Saturn organ and finished with its corresponding metal. From Saturn she drew her constancy and perseverance, her strong will in an otherwise delicate body; from it too came the supra-personal conduct of her life with its devotion to the work and to the deep seri-

way] of initially attaining knowledge about this space is [by studying mirror-symmetrical objects, i.e. with the help of] symmetry relationships. [Another method of investigating the relation between the peculiarities of empirical three-dimensional space and that of four-dimensional space, is afforded by the study of knots in ribbons and string.] What do we mean by symmetry relationships? Certain complications arise if we intertwine spatial configurations around one another. [These complications are due to the peculiarities of three-dimensional space; they do not arise in four-dimensional space.][15]

Let us carry out a few practical thought exercises. If we cut a circular ribbon down the middle, we end up with two identical rings. Yet if we cut a ribbon and rotate one of its ends by 180°, and then join the ends back together again, we end up with a single twisted ring that doesn't fall apart. If we rotate the ends of the ribbon by 360° before joining them back together, the result after cutting will be two intertwined rings. And finally, if we rotate the ends of the ribbon by 720°, then by following the same process a knot will result.[16]

Whoever reflects upon natural processes knows that such twists and knots may also occur in Nature; for [in the real world] intertwined spatial configurations of this kind are connected with certain forces. Consider, for instance, the orbit of the earth around the sun, and then the orbit of the moon about the earth. We say the moon describes a circle around the earth, which is really, [if one examines it a little more closely], a line that furthermore twists and intertwines itself [around the orbital path of the earth]. That is to say, it marks out a spiral path around that of the circular path. Next we have the sun, which speeds so rapidly through cosmic space that the moon must [also] follow a spiral orbit around it. Accordingly, there exist extremely complicated lines of force extending throughout space. We must realize we are dealing with highly complex spatial conceptions, which we are only able to grasp if we do not think of them in a rigid or immobile manner. Instead, we have to bring movement into our conceptions of space.

Let us recall once again what we have just discussed: the point is zero-dimensional, the line is one-dimensional, the plane is two-dimensional, and the solid is three-dimensional. How do these conceptions of space relate to one another?

Well, imagine you are a being who is only able to move length-wise along a straight line. What sort of conception of space would such a being have if it is only one-dimensional? It would only be able to perceive points and not its own one dimensionality. For in the straight line – if we wish to illustrate anything at all in it – there are only points. A two-dimensional being could only encounter lines, that is to say, it could only discern one-dimensional beings. A three-dimensional being, a cube for example, would perceive two-dimensional beings. The human being, however, can perceive three dimensions. If we are to infer correctly, we have to say: just as a one-dimensional being can only perceive points, a two-dimensional being only one dimension, and a three-dimensional being only two dimensions – so a being that is able to perceive three dimensions must itself be four-dimensional. Hence, because a human being can distinguish external beings of three dimensions, and [move about] in spaces of three dimensions, he must himself be four-dimensional.[17] And just as a cube is only able to perceive two dimensions but not its own three dimensionality, so it is true that man cannot perceive the fourth dimension in which

he lives.

Notes

1. *János Bolyai* (1802-1860), Hungarian mathematician. Worked on the so-called parallel problem (whether or not parallel lines converge) and belongs with *Carl Friedrich Gauß* and the Russian mathematician *Nikolai Ivanovich Lobachevsky* (1792-1856) among the discovers of hyperbolic non-Euclidean geometry. His only work – and sole publication – relating to this subject appeared in 1832 as an "appendix" to a textbook (*Tentatum*) on mathematics by his father *Farkas (Wolfgang) Bolyai* (1775-1856).

Carl Friedrich Gauß (1777-1855), German mathematician and physicist in Göttingen. Occupied himself very early with the parallel problem and came to the conclusion that there must exist such a thing as non-Euclidean geometry. However, he published nothing on this during his lifetime.

Bernhard Riemann (1826-1866), German mathematician in Göttingen. First to discover elliptical non-Euclidean geometry. His 'Habilitation' lecture "On the Hypotheses which lie at the Foundations of Geometry" (given 1854, first published 1867), contains among others the foundations for an extension of differential geometry for other than Euclidean metrics, as well as for the theory of *n*-dimensional spaces (manifolds), and dramatically influenced initial studies into higher-dimensional spaces. Riemann was the first to distinguish between the *unboundedness* of space, and the *infinitude* of space. The first is the expression of relations of extension, i.e. of the general geometrical structure (topology) of space, the latter is a result of metrical relations. This distinction led to the clear separation of differential geometry and topology.

2. *Immanuel Kant* drew attention to this in his *Prolegomena* (1783), § 13: "What can be more similar in every respect to my hand and to my ear, or in every part more alike, than their images in a mirror? And yet I cannot put such a hand as seen in the glass in the place of its original; for if this is a right hand, that in the glass is a left hand, and the image or reflection of the right ear is a left one that can never take the place of the other. Here there are no internal differences which any understanding could perceive by thought alone; and yet the differences are internal as far as the senses teach, for the left hand cannot be enclosed in the same bounds as the right, notwithstanding the complete equality and similarity of both (they are not congruent); the glove of the one hand cannot be used for the other." (In: *Kant's Critical Philosophy*, translated by J. Bernard and J. Mahaffy, London: Macmillan and Co., 1889, p. 39). Also see Kant, *Thoughts on the True Estimation of Living Forces* (1746) §§ 9-11 and *Concerning the Ultimate Foundation of the Differentiation of Regions in Space* (1768). For Kant this fact was proof that man could only apprehend sensible intuitions, i.e. the *appearances* of things, but not the things in themselves. – For an analysis of the Kantian conception of space in relation to the problem of dimensions, see Zöllner *Wirkungen in die Ferne* (On Actions at a Distance, 1878 – cf. note 5), pp. 220-227.

3. Figures reflected about an axis in the plane can be transformed into one another in a continuous manner by spatial rotations about the axis of symmetry. If *F* is a figure in the plane and *F'* the figure reflected about the axis *a*, then *F* merges into *F'* via a spatial rotation about the axis *a*. Figure 10 shows a few stages of this rotation in a normal projection in the plane. If it is interpreted as a *plane* figure, then this transformation is an orthogonal affinity with the axis *a*. (In the sense of projective geometry, axis *a* and centre *A* are perspective to the line at infinity of the plane).

reported his request that she 'study the formative forces' – using the pictures formed in this way. In the *Mitteilungen des biologischen Instituts* No. 1934 it says 'Let the extract *rise in a filter paper strip, according to the customary method of capillary analysis*, then the various plants (earlier, for the drop method, Steiner mentioned several by name) will be clearly differentiated from one another'. Thus they abandoned the drop method because it 'was unable clearly to differentiate the different plants'. Metal salts (iron and copper sulphate, gold chloride etc) 'enable forms to be developed' (Mitteilungen 1, 1934). The experimenter was now satisfied that she could see formative forces. With this a method was evolved which enabled cosmic formative forces for the various constellations to be made visible. The cosmic *rhythms* of the potentisation curves were now extended to *pictures* by the constellations.[5]

In 1966 Theodor Schwenk adopted the drop method in a modified form. 'Dropping was retained but the filter paper surface was replaced by an elastic medium, namely water.' The flow forms of water which arose in this way were made visible optically (*Bewegungsformen des Wassers*, 1967, p.16). In this way the quality of water could be assessed. Agnes Fyfe published her results of capillary dynamolysis research as *Die Signatur des Mondes im Pflanzenreich* ('The signature of the Moon in the plant kingdom' published in English as 'Moon and Plant', Stuttgart, (2nd ed. 1975)). Magda Engquist published her work on the capillary dynamolysis method as an indicator for life processes in plants in *Die Steigbildmethode, ein Indikator für Lebensprocesse in der Pflanze* (Klostermann Verlag, 1977). Breda and E. v. Wistinghausen used the capillary dynamolysis method to carry out quality testing in agriculture.

Workings of the stars in earthly substances

Lili Kolisko published an article with the above title and its foreword is dated 30.3.1927. In the same year the series of articles appeared in *Natura* with the title 'The Mystery of Matter'. The two are intimately connected. Lili Kolisko took as her starting point Steiner's indication, 'While a substance is in the solid condition it is subject to the forces of the earth. But as soon as a substance enters the fluid state, planetary forces have an effect on it…' She had rock solid faith! After a few preliminary daytime and night time experiments with various solutions of metal salts, on 21 November 1926 at 6 p.m. during a Sun-Saturn conjunction she allowed silver, iron and lead salts to rise in filter papers. She was amazed to discover that the usual forms in the pictures disappeared. 'An invisible hand had blotted out the working of the lead in my solution. (…) The Sun had stood before the planet Saturn and here below on Earth the lead could not manifest its activity. When the Stars speak man must stand still in silent awe.'

That was the foundation stone of a metallic bridge whose further development with various metals and planets was pursued through decades of work between Earth and cosmos. As the Moon reveals its movements on Earth in water, there arose the fundamental work on the Moon and plant growth with many varieties of wheat (1926-1932 and subsequently). The annual cycles with various Moon phases, the experiments with animal substances (e.g. urine) and the planet studies all went on in parallel in her laboratory – a busy schedule!

realise the full significance of this! So it's no wonder then that when the Anthroposophical Society began to take no notice of what we were doing, this had repercussions outside the Society. In fact we are working not only without the involvement of the public but also without the interest of the Anthroposophical Society!' (GA 218, p.81).

This warning was unsuccessful because after Steiner's death in 1925, Lili Kolisko was unable to publish his suggested plan for an appeal to the members for financial support of the Goetheanum Research Institute.

Steiner's report at The Hague ended with the comment, 'But after this, we must go even further'. In 1920 Steiner's ideas regarding experimentation were obviously underpinned by rhythms within the human being and in the cosmos. Modern chronobiology has uncovered the inner Sun-rhythm as a circadian cycle in many processes. But it has not yet arrived at the idea of there being rhythmical systems in both cosmos and man.

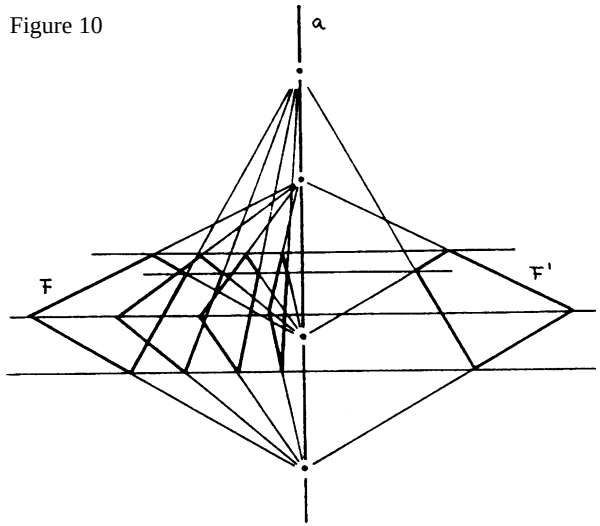
On 22.4.1812 Goethe was in Döbereiner's lab where metal oxides and pure silver were on show. They spoke of 'the modern day dynamic view' – the origins of the periodic system of the elements. In the afternoon Döbereiner visited again and they discussed the chemistry of plants. Goethe noted in his diary: 'Symbolic expression of the higher organisation used by the lower. It will eventually happen that the atomistic and mechanical way of thinking will be completely banished from good minds and all phenomena will appear dynamic and chemical, evermore confirming the spiritual life of nature.' In that the primal causes speak out of the rhythmical curves it is the spiritual life of nature. In that cosmic rhythms reveal themselves in matter it is the higher organisation manifesting itself in the lower.

Capillary dynamolysis

Lili Kolisko has written in several publications about the origins of capillary dynamolysis. In the first issue of *Natura* (July 1926) we read: 'I was able to present the pictures during a visit by Dr Steiner to the Biological Institute. He studied them thoroughly and was satisfied with the method'. She wanted to know 'whether this method had potential for studying the shaking process' (1959). She had published the germination experiment, presented before the capillary dynamolysis experiments, but did not go into the method itself there. But with the first pictures the question arose as to the method used, i.e. the chromatograms (cf. the first edition of *Entitäten* 1923, p.44, with its reference to Friedrich Goppelsroder 1904: *Kapillaranalyse* etc.). Steiner 'was satisfied with the method, but considered the shaking to be still insufficient' (1959, p.10). 'You must shake them until you get a horizontal line (on the rising extract), then the substance is homogenous' (Natura 1926, Issue 1). (From the differences in how far the rising progressed in the pictures according to different shaking times and from looking for a horizontal line, she ascertained the optimal time for the shaking process.) From Lili Kolisko's writings it is clear that Steiner had a different attitude to the germination experiments than to those with capillary dynamolysis.

As reports differ from one another we cannot exactly discover the circumstances that led Steiner in 1923 to suggest, by means of a sketch, that the plant saps should be extracted and drops of the extract placed on filter paper. Lili Kolisko verbally and in writing

Figure 10



In the projection onto the plane the figure which is rotated in space about the axis *a* seems to pass through *a*; thus in this transitional state it appears to lose a dimension the moment the figure is parallel to the direction of projection. We have to take into account that the edges of *F* and *F'* can only be transformed into one another through a rotational operation *within* the plane (i.e. rotations about points in the plane), if they are decomposed into sections that can be rotated about the corresponding points along the axis *a*.

Entirely analogously, two three-dimensional geometrical bodies *F* and *F'*, which are mirror-symmetrical with respect to a plane α, can be continuously transformed into one another through a (three-dimensional) spatial orthogonal affinity with the affinity plane α (figure 11). This transformation can be interpreted as an orthogonal projection of a four-dimensional Euclidean rotation about the plane α in three-dimensional space. In this projection the three-dimensional object *F* passes through the two-dimensional plane α, and it seems as if *F* loses a dimension in the transitional state.

If one breaks down the surface of *F* into its planar sections, then these parts can be rotated about the corresponding axes in α such that the surface of the figure *F'* arises.

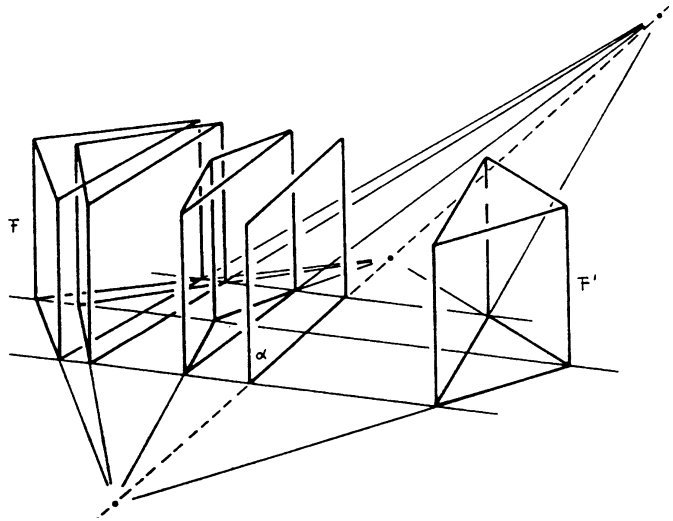


Figure 11

On the basis of this analogy between planar and spatial reflections, *August Ferdinand Möbius* (1790-1868) appears to have been the first mathematician to conceive of the possibility of a four-dimensional space in which three-dimensional mirror-symmetrical bodies could be brought into coincidence via a continuous transformation. (See Möbius, *Der barycentrischer Calcul* [1827, Leipzig. In: *Gesammelte Werke*, Vol. I. Leipzig: Hirzel 1885, pp. 1-388], § 140 footnote). However, he rejected this idea as being "unthinkable" and did not pursue it any further.

4. The presence of two eyes allows the perception of depth; see Rudolf Steiner's answer to the question of 11th March 1920 (raised by A. Strakosch), contained in this volume (i.e. GA 324a). On the significance of one's own activity for the perception of the dimension of depth see the answer to the question of 7th April 1921 (GA 76); cf. also note 17.

5. *(Johann Karl) Friedrich Zöllner* (1834-1882), astrophysicist in Leipzig. Considered to be one of the founding fathers of astrophysics; made fundamental experimental and theoretical contributions to photometry and spectroscopy. His theories on the structure of comets set the tone for all future experiments. His book *Über die Natur der Cometen; Beiträge zur Geschichte und Theorie der Erkenntnis* (On the Nature of Comets: Contributions to the History and Theory of Knowledge) [1886, Gera: Griesbach, 3rd edition] contains – as do nearly all of his writings – not only thought-provoking expositions of a philosophical and historical nature, but also critical and polemical reflections on contemporary epistemological endeavours.

In connection with his studies contained in the volumes: *Principien einer electrodynamischen Theorie der Materie* (Principles of an Electro-Dynamic Theory of Matter) [1876, Leipzig: Engelmann], *Über Wirkungen in die Ferne* (On Actions at a Distance) [1878. In: *Wissenschaftliche Abhandlungen*, Vol. I, pp. 16-288] and *Über die Natur der Cometen* [1886], Zöllner explored modern investigations into non-Euclidean and multi-dimensional geometry. Already as early as the beginning of the 1870s he conjectured that for an understanding of certain physical phenomena we must enlist the help of curved space or space of a fourth dimension. Around 1875 Zöllner also began to investigate spiritualism, spurred on by the researches of the chemist and physicist *William Crookes* (1832-1919). Zöllner developed the view that the existence of spiritualistic phenomena can be explained by the assumption of four-dimensional space, since as he thought, the former prove the actuality (and not merely the conceptual possibility) of the latter (see Zöllner, 1878: *Über Wirkungen in die Ferne*, p. 273ff.). Shortly thereafter Zöllner commenced his own investigations into spiritualistic phenomena (cf. "Thomson's Dämonen und die Schatten Plato's" (1878) in: *Wissenschaftliche Abhandlungen*, Vol. I, pp. 710-732, particularly p. 725ff.; "Über die metaphysische Deduction der Naturgesetze" in: *Wissenschaftliche Abhandlungen*, Vol. II, 1878, pp. 181-433, especially p. 330ff.; and above all the treatise "Zur Metaphysik des Raumes" (1978) in: *Wissenschaftliche Abhandlungen*, Vol. II.2, pp. 892-941 & pp. 1173-1192).

For a small taste of Zöllner's work that is available in English, see the essay: "On Space of Four Dimensions." In: *The Quarterly Journal of Science and Annals of Mining* (London), April 1878, pp. 227-237. In the paper "Friedrich Zöllner, der Spiritismus und der vierdimensionale Raum," (*Zeitschrift für Parapsychologie und Grenzgebiete de Psychologie*, vol. 19, 1977, issue 4, pp. 195-214), Franz Luttenberger has provided an overview of Zöllner's spiritualistic experiments; while for a contemporary analysis of Zöllner see Simony's *Über spiritistische Manifestationen vom naturwissenschaftlichen Standpunkte* (1884, Vienna/Pest/Leipzig: Hartleben). And concerning spiritualism in general, see Eduard von Hartmann: *Die Geisterhypothese des Spiritismus und seine Phantome* (1891, Leipzig: Friedrich) and *Der Spiritismus* (1898, Leipzig: Haacke); for Steiner's thoughts on the history of spiritualism see the lectures 1st Feb. and 30th May 1904 (GA 52), as well as the lectures from 10th – 25th Oct. 1915 in *The Occult Movement in the 19th Century* (GA 254).

London and The Hague. Perhaps the most precise picture was published in his initiation knowledge lecture cycle at Penmaenmawr. He described the experiments as finding the spiritual in the physical. By diluting in a ratio of one to one trillion, the 'functions' of substances were made effective. Substances 'crossed over into the spiritual'. What was just mere belief in homeopathy was 'raised to the level of a science' by the experiments. Now we know when we must use allopathy and when homeopathy.

At Penmaenmawr, several paragraphs dealt in depth with medicine, taking the experiments as the starting point. 'If the results of this research are estimated rightly (inter alia as a boundary stone between allopathy and homeopathy), the laws of nature in future will no longer be sought only in the present atomistic way, by measuring and weighing; it will be recognised how in all material things there is a rhythm, and how in the rhythm of events in nature the rhythm of the cosmos is expressed. Thus, as with human beings we can turn from the metabolic system to the rhythmic system, 'it is possible in nature, also, to find in a quite exact, scientific way its rhythmic system' (Steiner, R., Penmaenmawr, 30.8.23, GA 227. Published in English as 'The Evolution of Consciousness', Rudolf Steiner Press, 1991).

He presented the same results to the builders in Dornach on 31 October 1923. After thoroughly explaining the dilution method and the wheat grains growing in the dilutions he presented the results of the experiments: 'The effect of the smallest amounts of substance is rhythmic'. Certain dilutions are stronger, further dilutions are weaker and further dilutions again give stronger growth in the plants.

As early as his first medical lecture cycle in March 1920 Steiner presented his pre-experimental intuitive finding about the properties of substances arising from the rhythmic nature of matter with its 'zero points' and 'oppositions', as later illustrated in the minima and maxima of the potentisation curves.

If we put beside this just one of many of Steiner's comments made 15 years previously when he said 'We need the will to get to the primal causes … *rhythm is implanted in matter by the spirit* …' (Lecture on 21.12.08, GA 117), then we can sense how satisfying it must have been for him that the experiments were successful. They were suggested by him and Lili Kolisko had now penetrated to the primal causes.

In contrast to this, the work on the spleen is like a brief, microcosmic prelude. Steiner had long since prepared the question. In The Hague lectures there is a comment pointing to Steiner's self criticism in these experiments and what he had in mind. We know that the rhythmic function of the spleen had already been thoroughly dealt with in the Prague lectures on occult physiology in 1911. 'The irregularity that must necessarily arise through food intake is corrected by the balancing effect of the spleen. *That is what I realised at that time.* But now in our Biological Institute the experiments on spleen function have fully confirmed this using methods which are just as precise as clinical methods in general are today, even if in some of the details there are justifiable criticisms.' These results of work in a normal clinic have made a big impression, but that they 'have arisen in an anthroposophical context still remains largely unknown' (GA 319).

'But the beginnings of this, which people do not talk about, were made in our Anthroposophical Society. I would not like to bet on how many of our members really

appear as matter, spirit has to be metamorphosed. In the experiments, the descending metamorphosis is itself metamorphosed into one which is ascending to the spirit. As the autobiography was being written, Lili Kolisko's key text was being published (1923).

How can we picture the two metamorphoses of downwards and upwards? The original spirit of matter *condensed*; this condensation is like a *densification*, in the densest state the hitherto supersensible matter is at the limit of visibility; if it takes on physical substance it is *fixed* as earthly substance and cannot, apart from in the realm of the living, return to the spiritual. The three stages of condensation, densification and fixation have corresponding opposites. To fixation there is *dissolving*, to densification *shaking* and to condensation *dispersal* in the medium giving rise to a change in its structure. At this point the medium contains the spiritual formative force of the substance that it had before its condensation.

Here I should like to draw attention to a fundamental epistemological attitude to experimentation that we can deduce from the foregoing. The questions asked in the experimentation arose from the intuitive knowledge which was poured into the work. That way it was also possible to arrive at a satisfactory answer: experimentation has to be balanced by the quest for knowledge of the spirit (Anthroposophy and Science: Observation; Experiment; Mathematics, 8 lectures, GA 324, 1921. Mercury Press, NY, 1991). 'But unless a person has spiritual intuition to put aside their dead experiments and instead draw from living nature its real essence so as to pour it into their experiments, they will be unable to gain anything that is at all valid for living nature.'

After it has become largely detached from the human being, the experiment has to be reconnected to the totality of knowledge. In this respect too we can learn something crucial from the research institute, namely that one half of the work is first examining the questions from all angles and the other is the answer found in the experiment.

It is wrong to think that things become so much simpler when a clairvoyant is involved. A clairvoyant is necessary neither for the questions nor can they dispense with experience. This is absolutely clear.

Both Goethe and Steiner regarded thinking and experience as necessary for scientific knowledge. 'Performing experiments in manifold ways is thus the prime duty of every researcher' (Goethe). 'By making a number of observations we discover amongst them something objective that stands above them and becomes for us a higher observation (primal phenomenon) amongst our observations…If we can manage to place side by side a series of experiments, we then only need to recreate the interconnection and the natural law will once again express itself.' (Steiner)

We can be sure that work at the Goetheanum Research Institute was carried out in the spirit of Goethe. A primal phenomenon is revealed in the rhythm of the potentisation curves. Indeed, Goethe's spirit clears the way to the future of medicine! The rhythmic primal phenomenon is an example of this (Steiner 1920, GA[4] 314).

Rudolf Steiner's reports

Steiner spoke in many lectures about the results at the research laboratory (1923), not only in Dornach, where he dealt with the Christmas Imagination, but also in Penmaenmawr,

Zöllner conceived the Kantian "things in themselves" as real four-dimensional objects that project themselves into our perceptual world as three-dimensional bodies. He found evidence for this view in the existence of three-dimensional mirror-symmetrical bodies, which are indeed mathematically congruent, but cannot be continuously transformed into one another (cf. note 3). "In reality, the space in which the visible world ought to explain things in a manner *free of all contradictions*, *has to* possess at least four dimensions, since *without* this property the actual existence of symmetrical bodies could never be derived from a *law*. […]" (Zöllner, 1878: *Über Wirkungen in die Ferne*, p. 246). Zöllner could include Kant as a precursor to his conceptions (see note 2).

In the last mentioned essay, Zöllner describes some of the peculiarities in the transition from the third to the fourth dimension which underlie both his theoretical contemplations and spiritualistic experiments. He begins with a discussion of knots in three-dimensional space and draws attention to the fact that they may only be disentangled if "for beings of three dimensions, the parts of the string *temporarily* vanish out of three-dimensional space. [cf. note 15] This would be the same as if a solid body in a totally enclosed three-dimensional space were to become transported outside of this enclosed material space by means of a motion executed in the fourth dimension. Accordingly, the law of the so-called impenetrability of matter in three-dimensional space would then be suspended; and moreover in a manner completely analogous to how a body transposed into the *plane* and enclosed by a *closed* planar curve may be transported over the boundary of this curve without coming into contact with it." (Zöllner, 1878: *Über Wirkungen in die Ferne*, p. 276). Also see note 6.

6. A perpendicular can be drawn through every point on a two-dimensional surface. If a point *P* moves perpendicularly outward from the surface, then it distances itself from all the points on the surface, without anything changing with regard to its perpendicular projection *M* onto the surface. If this point is the centre *M* of a circle, then the point *P*, which moves outward from the surface, has the same continuously expanding distance to every point in the periphery of the circle. If we were to allow the point *P* to move so far perpendicularly that its distance from the centre *M* of the circle becomes greater than the radius of the circle, with the perpendicular furthermore rotated into the plane of the circle, then in this manner the point *P* would have continuously moved out of the circle without intersecting the circle's periphery.

In an entirely analogous fashion a point *P*, which is inside a ball, may continuously move out of the inside of the ball without breaking through its surface, once we call four-dimensional space to our assistance. For one can virtually pass from every point of three-dimensional space onto a straight line in four-dimensional space without intersecting any of the points of the former space. If one then similarly moves the centre *M* of a ball in three-dimensional space out of this space, then the point is equidistant to every point on the surface of the ball, i.e. it has the same distance from every point. As soon as the distance from the starting point *M* becomes greater than the radius of the ball, the point is then outside the ball; this may be rendered visible by rotating the corresponding straight line in three-dimensional space.

7. *Arthur Schopenhauer* (1788-1869): "The world is my representation: – this is a truth that is valid for every living and thinking being." *The World as Will and Representation* I, § 1 [1894].

8. Rudolf Steiner also mentions this example in his book *The Philosophy of Freedom* (GA 4), Chapter 6, "The Human Individuality." Cf. also the lecture of 14th January 1921 (GA 323, p. 252).

9. Rudolf Steiner examines these problems more closely in his book *The Philosophy of Freedom* (GA 4), Chapter IV, "The World as Perception," as well as in *Goethean Science* (GA 1) Chapter IX "Goethe's Theory of Knowledge" and Chapter XVI.2 "The Archetypal Phenomena".

10. Rudolf Steiner also uses this comparison in a lecture held on 8th November 1908 (GA 108).

There the relationship between sensation, perception, representation and concept is considered in more detail.

11. Strictly speaking, this is only valid for the transition of the circle into the straight line within the realm of Euclidean geometry. In projective geometry the circle coincides in the extreme case with the fixed tangent *and simultaneously* with the line at infinity. Only with the addition of the line at infinity of the projective plane to the Euclidean plane is the passage through infinity possible. (Also see Renatus Ziegler: *Mathematik und Geisteswissenschaft. Mathematische Einführung in die Philosophie als Geisteswissenschaft* (Mathematics and Spiritual Science. Mathematical Introduction to Philosophy as Spiritual Science) 2nd edition, 2000, Dornach: Philosophisch-Anthroposophischer Verlag am Goetheanum, chapter III.

12. This is directly connected with the geometrical fact: that the passage through infinity is only possible when one forsakes the realm of Euclidean geometry (see note 11). In other words, the *sensibly conceived* point on the one side *doesn't* merge into the sensibly conceived point on the other side. What joins these sensibly conceived areas of the straight line beyond infinity is their conceptual structure that can only be grasped in thinking; what separates them, is the visual representation of the points.

13. The example of the seal, sealing wax and the impression left behind in the sealing wax, was often used by Rudolf Steiner to illustrate the different epistemological factors coming into play in the relationship between the objective outer world and the individual consciousness of the cognizing subject. With this example it is crucial to bear in mind that even in the physical-sensible realm the transference of a form is not dependent upon the transferral of any kind of matter. Also see the essays *Philosophy and Anthroposophy*, and *The Psychological Foundations and Epistemological Position of Anthroposophy* (in: *Esoteric Development*…) [Bibliographic details in English??].

14. *Oskar Simony* (1852-1915), mathematician and natural scientist in Vienna. Son of the alpine explorer and geographer *Friedrich Simony* (1812-1896). Professor at the Vienna College of Agriculture from 1880-1913. His mathematical work is mostly concerned with number theory and the empirical-experimental topology of knots and of two-dimensional planar sections in three-dimensional space. The models Steiner mentions are partly printed in Simony's papers. It was this early topological work of Simony that led him to examine Zöllner's spiritualistic experiments (cf. note 5). This occasioned him to study the theory of space brought about by the discovery of both non-Euclidean and multi-dimensional geometry. His investigations even extended as far as physiological and epistemological considerations (cf. Simony's writings: "Über eine Reihe neuer mathematischen Erfahrungsätze." *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, Vienna, Mathematisch-Naturwissenschaftliche Klasse, 1883, section II, volume 88, pp. 937-974; *Über spiritistische Manifestationen vom naturwissenschaftlichen Standpunkte.* 1884, Vienna/Pest/Leipzig: Hartleben; and *Über die empirische Natur unserer Raumvorstellungen* – lecture from 17th February 1886. Vienna: Verein zur Verbreitung naturwissenschaftlicher Kenntnisse, 1886). He believed that empirical and idealised-mathematical space shouldn't be confused with one other. As a mathematician he had no trouble in conceiving a four-dimensional space. However he couldn't agree with Zöllner's thesis that all objects in three-dimensional space were projections of (non-sensible) four-dimensional objects. He didn't seek to reject out of hand the actuality of spiritualistic phenomena, but like Zöllner, advocated an exact scientific investigation of these phenomena. He tried to explain how the spiritualistic phenomena as reported by Zöllner could be justified using the traditional tools of physics and physiology, or at the very least, how they could be reconciled with them in a non-contradictory manner (cf. Simony, *Über spiritistische Manifestationen vom naturwissenschaftlichen Standpunkte.* 1884.) It was important for him to demonstrate

she knew nothing about agriculture, he said, 'But then the farmers do not have your skilful hands'. Mrs Kolisko devoted herself to this assignment too (see Bibliography).

In 1927 Eugen Kolisko went to a major Homeopathy Conference in London and gave a lecture on his wife's potentisation experiments. In the published English proceedings of this conference the incredible amount of work, the tremendous selflessness and the unsurpassable exactitude of the experimentation was emphasised. It was considered that the work would 'gain the support of other schools of medicine for homeopathy when they see how carefully and scientifically such work is carried out and how its exactitude is beyond reproach.' (Goetheanum 8 (1), 1.1.28)

In 1938 Mrs Kolisko was invited to a conference of Indian homeopaths. Dr Munkacy said in his address that it was a great moment to be able to welcome a pupil of Rudolf Steiner, a man whom he would have chosen as his guru. In Madras she spoke about the Moon and her audience was very enthusiastic.

Eugen Kolisko's report from the London homeopathy conference (1927) was republished in *Beiträge zu ein Erweiterung der Heilkunst* 1977, 2. This reprinting was appropriate because the doctors of the anthroposophical and homeopathic schools had in 1976 renewed exchange of their experiences and ideas.

Leading homeopaths today know the value of the Kolisko experiments. 'The other school of medicine,' i.e. the allopathic one has gone in directions which makes it look improbable that it will ever find its way out of the labyrinth. Medical science's claim to be scientific is based on nothing other than certain indispensable models which are postulated as already understood (gravitation, magnetic fields etc.) which, as we know, is not true. In this context Steiner makes higher demands and calls for a more precise attitude to science. Under Steiner's direction it was possible for Lili Kolisko to reveal experimentally the supersensible workings of the spirits immanent in matter. The point at which ordinary science comes up against a boundary is the point where the boundary is crossed. This is the boundary of the influence of matter, which, as in seeds, is taken over by the activity of the vitalisation process or the etheric.

The new experiments and the development of anthroposophy

If we look at Steiner's development of anthroposophy we can see that it was just at that time in 1920 when Mrs Kolisko began her work in Stuttgart that he was giving the lectures in Dornach on Thomas Aquinas. And just as Thomas saw himself placed with his thinking between the higher intelligence of the cosmos and the lower intelligence of earth's creation, the experiments in Stuttgart began to reveal precisely the same constellation of spiritual and material. A 'transformation of Thomism into science' took place (Steiner 1920). It was accomplished by none other than Rudolf Steiner! And Lili Kolisko was predestined for this. She worked through her experiments at a historic moment: science was once again being imbued with spirit. Her experiments led the transformation that meant science could now deal with the working of spirit in matter. Thus a threshold was crossed. She fulfilled the expectation of her teacher to establish new scientific facts.

Steiner writes in his autobiography that materialism 'looks at matter but is unaware that it is really spirit that it is looking at, only it is appearing in material form' (Chapter 23). To

cal. Initially she thought that the maxima and minima should always be in the same place. 'Your wife is so sceptical,' said Steiner to Eugen Kolisko, 'but even so she has very nice curves.'

It is easy to see the significance of the demonstration of the effect of potentised substances, especially for anthroposophical medicine and homeopathy. It is well known that Hahnemann worked with potentised medicines. He spoke of 'power developments' and 'potencies'. Other doctors can now stand behind their colleagues who adopt this new concept of matter as becoming rather than being. In discussions or through occasional failures, it cannot be snatched from their hands again. It can now withstand the dogma of science. Belief in the effect of potentisation, which accords with clinical experience, is now also verifiable by precise scientific experimentation. And research in this direction fulfils a historical need, more so today that at that time.

Mrs Kolisko discovered that plant substances were most effective if each stage of dilution was shaken for 2-2.5 minutes. Mineral substances needed 4 minutes. These indications were instructive for the pharmacists.

Spleen function and the platelet issue – an open challenge

In parallel with the aforementioned researches, Mrs Kolisko conducted studies on blood. She had worked as a bacteriologist with Bauer in Vienna. She had hoped to find in the blood of diseased cows a causative agent. She managed to get Steiner to examine these preparations too. After he had said 'nothing' in relation to several preparations, he stopped short and described certain pictures which were linked to spleen function during which the expression 'spleen hormone' cropped up. It should be observable in healthy people when food consumption occurs arhythmically. The experiments resulting from this which were carried out mainly on Waldorf teachers comprised the first work published by Mrs Kolisko (1921) under the title *Milzfunktion und Plättchenfrage* (Splenic function and the platelet question).

Intellect, the matchmaker, immediately made its appearance, thinking itself superior.. A mongst the doctors of the Klinisch-therapeutischen Institut in Stuttgart (1921) there was criticism, even resistance. Whether Steiner himself was affected by this is unclear. He intervened, he sharply criticised, he defended. Mrs Kolisko: 'From then on there was always a certain opposition to my work'.

What Mrs Kolisko saw in her blood smears and described as 'regulators' were also known to clinical haematologists. They were described as forms of thrombocytes. Heinrich Zeller, cited by Kolisko (Deutsch med. Wochenschr. No.18, 5.5.21), also described the ring form of thrombocytes. But the connection with the rhythm of nourishment was discovered by Lili Kolisko. Finally the time was ripe to test and clarify these sidelined issues in a clinic. This was a fruitful thus pleasant task, quite apart from the fact that the necessary outlay in time and expense was not great. Looking back, one can see that that was the beginnings of practical chronobiological research. Today it forms its own broad field of science but at that time in the Biological Institute it was just beginning.

When Steiner spoke at Whitsun 1924 at Koberwitz of the new preparations for agriculture he also gave Lili Kolisko an assignment connected with them. To the objection that

that one didn't have to forsake three-dimensional empirical space in order to explain these phenomena. He showed that Zöllner's hypothesis concerning the existence of a four-dimensional space contradicted our everyday experience of space. For if this hypothesis was correct, the bodies of everyday three-dimensional physical space would then be shadowy forms (i.e. projections), upon which we could carry out any number of changes without having direct access to the archetypal form (cf. Simony: *Gemeinfassliche, leicht controlirbar Lösung der Aufgabe: "In ein ringförmig geschlossenes Band einen Knoten zu machen" und verwandter merkwürkiger Probleme.* Vienna: Gerold 1881, 3rd edition, chapter §6; and *Über spiritistische Manifestationen vom naturwissenschaftlichen Standpunkte,* 1884, p. 20f.). Yet as can be seen in the above example in the projection of a three-dimensional object onto a plane, that is, in constructing its shadow, it isn't possible to effect a change in the shadow without direct access to the object casting the shadow.

With his topological experiments, Simony wished to study the nature of three-dimensional *empirical* space, in contrast to curved space or some other kind of idealised-mathematical space: "[…] because the phenomena under investigation here belong to the *space of our senses*, they [can] only be understood within an *empirical* geometry […], without entering into any kind of relation with the theory of so-called higher manifolds. Moreover, the course of development chosen by me clearly highlights the reasons why I have neither made use of analytic geometry nor infinitesimal calculus when examining the 1st and 2nd different types of sections in order to remain independent of every conceivable hypothesis concerning the nature of the space of our senses." (Cf. Simony: "Über eine Reihe neuer mathematischen Erfahrungsätze," 1883, p. 963f.).

What was of especial mathematical interest to Simony was the origin of knots in twisted, circular or also closed cruciform, yet un-knotted planar surfaces; he showed that surfaces of this kind could be cut in such a way that they remained closed on the one hand, while on the other a knot arose under the appropriate conditions (Simony: "Über jene Flächen, welche aus ringförmig geschlossenen, knotenfreien Bändern durch in sich selbst zurückkehrende Längsschnitte entstehen. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, Vienna, Mathematisch-Naturwissenschaftliche Klasse, 1881, section II, volume 82, pp. 691-697; "Über jene Gebilde, welche aus kreuzförmigen Flächen durch paarweise Vereinigung ihrer Enden und gewisse in sich selbst zurückkehrende Schnitte entstehen." *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, Vienna, Mathematisch-Naturwissenschaftliche Klasse, 1881, section II, volume 84, pp. 237-257; and *Gemeinfassliche, leicht controlirbar Lösung der Aufgabe: "In ein ringförmig geschlossenes Band einen Knoten zu machen" und verwandter merkwürkiger Probleme.* Vienna: Gerold 1881, 3rd edition). The most famous and simplest example of this kind – the closed circular ribbon twisted 720° – is mentioned by Rudolf Steiner in the lecture.

15. Knots do not occur in four-dimensional space; that is, every knot in a closed piece of string or a closed ribbon may be disentangled through a mere distortion without cutting the string or ribbon.

It was *Felix Klein* (1848-1925), who in the 70s of the 19th century appears to have been the first mathematician to have drawn attention to this fact. According to a report by Zöllner (*Über Wirkungen in die Ferne* [On Actions at a Distance] 1878. In: *Wissenschaftliche Abhandlungen*, Vol. I, p. 276), he discussed this problem with Klein during a scientific conference shortly before the latter wrote on this topic in a paper published in 1876. (See Klein: "Über den Zusammenhang der Flächen" in *Mathematische Annalen*, Vol. 9, 1876, pp. 476-483). Klein also describes this meeting and is of the opinion that it was he himself who suggested to Zöllner this thesis about the existence of four-dimensional space and its significance for the

understanding of spiritualistic phenomena. (See Klein: *Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert*, Part 1, Berlin: Springer, 1926, Grundlehren der Mathematischen Wissenschaften, volume 24, p. 169f.).

While Klein's 1876 essay ("Über den Zusammenhang der Flächen" p. 478) mentioned above merely draws attention to general facts, Reinhold Hoppe's 1879 article "Gleichung der Curve eines Bande mit unauflösbarem Knoten nebst Auflösung in vierter Dimension" (*Archiv der Mathematik und Physik*, volume 64, p. 224) concretely presents the solution for disentangling a simple three-dimensional knot in four-dimensional space using an analytically conceived example (also cf. Heinrich Durège: "Über die Hoppe'sche Knotencurve." *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften*, Vienna, Mathematisch-Naturwissenschaftliche Klasse, 1880, section II, volume 82, pp. 135-146; and Reinhold Hoppe: "Bemerkungen betreffend die Auflösung eines Knotens in vierter Dimension." *Archiv der Mathematik und Physik*, 1880, volume 65, pp. 423-426.)

In *Wirkungen in die Ferne*, pp. 272-274 (cf. note 5), Zöllner argues with the help of an analogy in order to demonstrate the disentangling of knots in four-dimensional space. He initially examines the disentangling of a two-dimensional knot within a closed curve (figure 12): a curve with a crossing point cannot be disentangled without cutting it apart. However, the disentangling of the crossed part of the curved line can be achieved without cutting if we rotate a piece of the curve about a straight line in the plane through three-dimensional space.

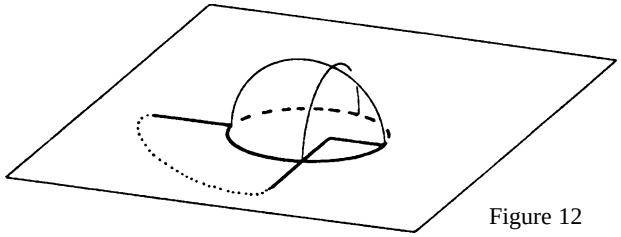


Figure 12

"Analogously, if we apply these considerations to a knot in a space of *three*-dimensions, then it is easy to see how not only the entangling but also the disentangling of such a knot can only be carried out using operations in which the elements of the string have to describe a curve of *double* curvature." This knot cannot be disentangled in three-dimensional space without cutting. "If there existed beings among us who were able to precipitate through their will four-dimensional motions of material bodies, then they would be able to much more quickly both entangle and disentangle knots of this kind, and indeed via an operation entirely analogous to the one described above for a two-dimensional knot. […] I myself was led to these aforementioned studies on the intertwining of a pliable string in different spaces after conversations with Dr. Felix Klein, professor of mathematics in Munich. It is clear that in the operations in question those parts of the string have to *temporarily* vanish from three-dimensional space for beings of the same dimension." (Zöllner, *Wirkungen in die Ferne*, pp. 273-276)

Actually, the disentangling of a knot in three-dimensional space can always be carried-out if one allows either the curve to cross over itself or the addition of four-dimensional space. For with the help of the latter the end-result of crossing over can be achieved without actually making any crossings (cf. Herbert Seifert/ William Threlfall *Lehrbuch der Topology*, Leipzig: Teubner, 1934, pp. 3 & 315). One only

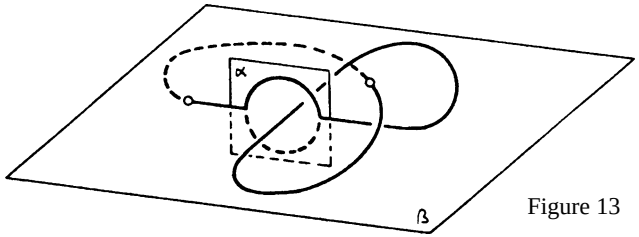


Figure 13

entities of L. Kolisko). 'Entities' was Steiner's expression for what is more generally referred to as high dilutions or potencies.

'From becoming to being,' said Plato. But here, being, matter, was now made to become, or, was translated into an existence whence the becoming of matter originates, namely the etheric.

In the curves were various maxima and minima. On page 204 of the book mentioned above is a photograph vividly portraying the results (see figure below). It is taken in the institute garden at right angles to a long row of sunflowers. Just a glance from a distance shows that the stems are shorter in four places. These correspond to the minima in the curves. In front of them is a row of much smaller and younger sunflowers already showing the signs of the result to come. The upper limits of the larger and smaller sunflowers show a clear wavy line corresponding to maxima and minima on the curves. (On this piece of land in 1977 the new building for the hall of the Waldorf school was opened.)

Sunflowers grown under the influence of tin chloride potentised in the range D1 to D60

The smaller plants in the foreground are a repetition of the experiment 4 weeks later.

This experiment was published in 1933. The sunflower seeds were first germinated in the various potentisations and then planted with a five-fold replication out in the open.

'After a few weeks you can see the potentisation curve of the sunflowers in the open air. The row starts on the right and runs along the fence. You can see clearly how the growth first increases, then decreases, reaches a minimum, then increases once again, reaching a third minimum, then increases before coming to a fourth minimum. The replicates in each position are one behind the other so that we can say that there is sufficient replication present. The variation between the plants was not great. In front of the obviously well advanced row of experimental plants is a *second* row, also potentised with zinc chloride, which was set up four weeks later. The course of the curves remains the same. (L. Kolisko, 1959)'

The work on the metal-planet relationships can only be mentioned briefly here. They produced characteristic curves. Many hundreds of substances from the mineral, plant and animal realms were investigated. Apart from decimal potencies, those following the centesimal rhythm were produced. Instead of 1:10, the dilution was 1:100. Others were done with the ratio of only 1:2. The curve types were the same. Mrs Kolisko was scepti-

calling Mrs Kolisko's institute in 1923 'The Biological Institute of the Goetheanum'. Rudolf Steiner had advised as a practical scientist and just as he objectively observed the supersensible in a new way, so too he sought in the realm of the senses a way to new experimental facts which would confirm the supersensible results. Both Steiner and Lili Kolisko were at a turning point in the sciences. Experiments were called for to answer the question of dosage!

As she presented the first plants in the dishes and the curves derived from them, the initial indication was substantially augmented: 'That's what I mean, only you will probably have to dilute them a lot more'. The potentisation experiments were born.

The potentisation curves

Diluting 1 g common salt in 10 cm^3 water gives a dilution of 1:10. This corresponds to the 1^{st} decimal potentisation. 1:100 = 2^{nd} and 1:1000 = 3^{rd}. Spectral analysis will detect small amounts of a substance to the 15^{th} potency, i.e. 1 g in a billion litres of water. This volume corresponds to a cube with 1 km edges.

Lili Kolisko: 'Picture it vividly' – that cube with 1 g salt dissolved in it – 'and you might think detecting it is totally impossible.' But the essential difference is that Mrs Kolisko did not simply dilute; she shook each stage of dilution. This enhanced the dispersal of the substance in the medium.

'It is a sudden hastening on and a being pushed back' … 'The potentisation thus arises through a gradual rhythmic (periodic) approach to a particular point whereas mere dilution happens abruptly (aperiodically).' Thus besides quantity arises a new quality of substance.

These substance qualities were used to treat the nutrient medium in which beans, peas and lentils were germinated. Up to 50 seeds for each potency with water controls of 300 - 500 seeds. Later only 30 seeds were used. Dinkel and wheat were tested and seed selection was used; for instance out of every 1000, only 20 were selected. This process alone took a week for each experiment. Lengths of roots and two leaves were measured and the values were plotted for each plant. The lines connecting the points gave the curves that Steiner referred to; the potentisation curves. The experiments were extended to the 30^{th}, 60^{th}, 400^{th}, 600^{th} and higher potencies. Variations were apparent but the curve types remained the same. The dishes containing the plants were photographed. For each of 30 plants in a dish, four measurements were needed, making 120 in all. In a 60-potency series this required 7200 measurements for one experiment. The list of experimental replicates alone makes it clear straight away what an immense amount of work was put into the potentisation curve experiments. Without colleagues this would have been unachievable. Lili Kolisko used to take two to three hours sleep. Even Steiner himself would come to the laboratory at 7 am. after he had been up until 2 am. with the college of teachers.

The Arbeitsgemeinschaft anthroposopischer Ärzte (Anthroposophical Medical Association) published a volume on the work which took place between 1923 and 1959 under the title *Physiologischer und physicalischer Nachweis der Wirksamkeit kleinster Entitäten von L. Kolisko* (Physiological and physical demonstration of the effects of the smallest

needs to rotate an appropriately formed curved piece in a plane α about a plane β through four-dimensional space (figure 13).

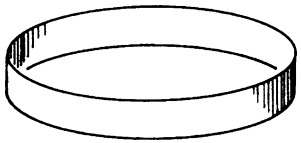


Figure 14

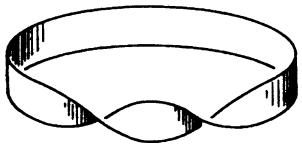


Figure 15

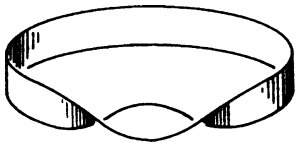


Figure 16

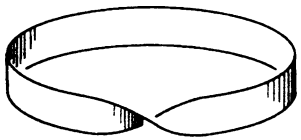


Figure 17

16. Twisting a cylindrical ribbon (figure 14) by 360º results in a surface (figure 15), which in four-dimensional space is equivalent to the first surface. In other words, twists of integer multiples of 360º may be unravelled in four-dimensional space. Simony was the first to recognise this fact, although he doesn't explicitly refer to it in his topological writings, which were mostly concerned with the peculiarities of empirical three-dimensional space.

An un-twisted cylindrical strip or ribbon is equivalent in four-dimensional space to a ribbon twisted 360º, since the ribbon can be characterized by two non-intersecting boundary curves. In the latter case the two are intertwined around one another, while in the first case they are not. This intertwining may be unravelled in four-dimensional space without cutting. Hence, a twisted ribbon gives rise to an un-twisted one (cf. the transition from figure 15 to 16).

However, it is worth bearing in mind that this is not possible with a cylindrically shaped ribbon that is twisted 180º, a so-called *Möbius strip* (figure 17). This surface only has *one* boundary curve, and can never be transformed continuously and without cutting (even in four-dimensional space) into an untwisted ribbon. (This is related to the one-sidedness or non-orientable nature of this surface; see Herbert Seifert/ William Threlfall *Lehrbuch der Topology*, Leipzig: Teubner, 1934, § 2). The Möbius strip was first described by August Ferdinand Möbius in *Der barycentrischer Calcul* (1865) § 11.

17. Considered geometrically, (static) vision in the plane or in space may be understood as the central projection of planar or spatial objects onto a line or plane respectively. To a being in three-dimensional space possessing a visual apparatus like this all objects then appear to be projections onto a plane. This being could only have a direct impression of the third dimension if it were capable of *dynamically* seeing; that is, if its visual apparatus possessed *two* projectional faculties together with the corresponding ability to accurately focus. On the other hand, it could certainly *deduce* the third dimension (just as the one-eyed beings are able to on the basis of their manifold sensations and abilities to compare), yet it couldn't *experience* it. The actuality of a dynamic three-dimensional vision in man is an indication of his 'four-dimensional nature', which he likewise cannot directly (sensibly) perceive, but is initially only able to deduce.

On the basis of geometrical and physical considerations, *Charles Howard Hinton* (1853-1907) also arrived at the view that man must be a four-dimensional or higher-dimensional being (cf. Hinton, *The Fourth Dimension*, London: 1904, Sonnenschein).

Acknowledgement: *Translated and published with permission of Rudolf Steiner Nachlassverwaltung.*

Large-scale Reservoir Projects – Examples of Faustian Work

Eduard Naudascher

Dams played an important part in my youthful aspirations to become a civil engineer. I could not imagine a better way of fighting poverty and hunger. So it seemed the obvious thing to immerse myself in the subject of hydraulic engineering and eventually to work in that field. With rising criticism of dam projects in the 80s, I suggested to my students that we take up this criticism and examine it carefully in a series of seminars. What I would like to present here are the results of a process of rethinking which was closely connected with many seminars of this kind.

It seems that we can only reach the kind of insights that change our outlook after having made mistakes and taken wrong turnings. At least, in hydraulic engineering we have started to put right a number of past mistakes. Only in relation to large reservoirs do we seem to have difficulty so far in questioning our cherished convictions about them. I would like to put this matter in a broader context and interpret it as the result of a certain blindness which is a tendency of not only engineers and scientists but all of us who have lived since our childhood in a modern society.

I should make it clear at the outset, especially in a country like Switzerland, that I do not want to criticise reservoir projects lock, stock and barrel. My focus is the large-scale reservoir projects, especially those in developing countries.

Negative consequences of large-scale reservoir projects for man and nature

We shall first of all consider the reservoir dam project in the way that most of our contemporaries do. Hasn't it become a real model for successful mastery of nature, the epitome of progress and development? It gives us electricity, drinking water, food from irrigated cultivation; it helps us to green the deserts and it protects us from flooding. As Figure 1 shows, there are today around 40,000 large reservoirs of which 90% were only built in

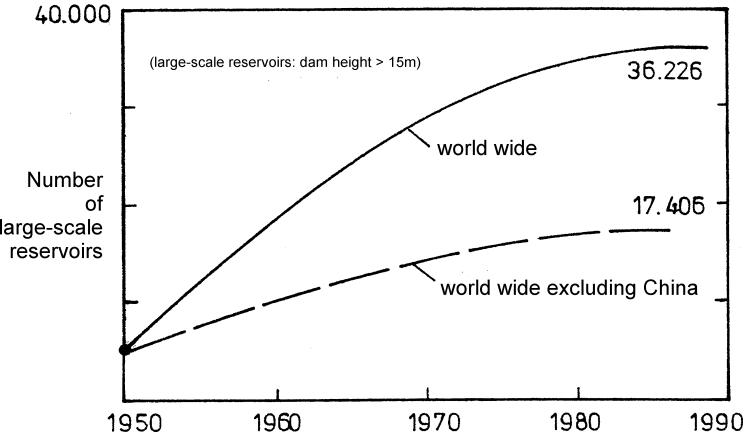


Figure 1. Graph showing the rise in the total number of large-scale reservoirs worldwide between 1950 and 1990 (Source: ICOLD, World Register of Dams, Paris 1988; McCully.)

speaks of how he learnt to spot a certain change in the eyes as an indication for the duration of the infusion. By using sectioning methods Eugen Kolisko demonstrated that in the dead animals there was damage to the heart muscle. When told about this Steiner said: 'When you take this illness…and infuse the medication.. then the illness is transferred to the head.' (Where it is normal and harmless.) 'Animals that are treated in this way should in fact have no damage to the heart.' But in the brain it will occur momentarily. One should be able to demonstrate centres of inflammation in the brain which later disappear again. It was an enviable and rare opportunity for Kolisko, who had worked at the Vienna Institute of Pathology, to work with Steiner and discuss pathology with him. Kolisko, together with the vet Dr J. Werr also very successfully treated dogs with distemper using the same medicament.[3]

It was also necessary to find the optimal roasting temperature for the coffee beans. Lili Kolisko had to look for a particular structural change in histological sections in the protoplasm of the roasted beans as an indicator of the optimal roasting temperature. This was not described more precisely by Steiner. This task was the first undertaken by the Goetheanum Biological Institute, initially just a small room which E. A. K. Stockmeyer provided in the administration building of the Waldorf school. In it was a stool and a table on which stood a microscope and a microtome built by Dr Rudolf Maier.

At the turning point in the sciences

Lili Kolisko prepared vital and stained preparations of the beans at different roasting temperatures. Members of the Anthroposophical Society thought it presumptuous to let an initiate look down a microscope. But they were wrong. Steiner examined numerous preparations and indicated in an unstained section the expected structure. Mrs Kolisko and others present could not see it. Steiner said: 'Yes, don't you see that some cells are completely clear but others have little star forms!' Then she thought she could see them too. He advised her to visit Prof. Römer in Leipzig to have them photographed and enlarged, then 'perhaps the camera will be able to see them better than your eyes'. With Römer she studied photomicrography and eventually saw the aforementioned structures in her own lab. These things are not yet published. Just before Mrs Kolisko went to Leipzig someone with her at her microscope asked in what strength (or dose) the preparation should be injected. (I suspect that it was Eugen Kolisko who put the question, because he was clearly the closest participant.) Of course, a lot depends on this and, turning to Lili Kolisko, Steiner said:

'Do some germination experiments with the substance and show the results in graphical form; then you will get the picture of the vitalisation process which the medicament brings about in the animal.' (Gaia Sophia 1926, p.116)

Those words sum up what became her life's task. It was the pointer that brought a new property of matter to light, opening the gateway to a new era of medicine and science. Anthroposophical doctors and scientists should familiarise themselves with this. It still contains a lot more than has yet been developed from it. Here too is the justification for

am prepared'.

She was introduced to Steiner when he gave a lecture in May 1915 to the Vienna branch. 'Ah yes,' he said, 'we've met before.' 'No,' she answered and stuck to her word even though Steiner repeated twice more that they knew each other until he finally helped her by saying: 'Yes, yes, from previously!'. We can imagine the effect of this on Eugen Kolisko who was standing next to them. He said to her, 'Don't you want to speak to Dr Steiner?' 'No,' she said again.

He advised her to write to Dr Steiner. This she did. 'But,' she said to me, laughing, 'I never got an answer'. She was 70 years old then. All this lay in the distant past yet she recalled her memories as if from a numbered ledger. Mrs Kolisko had an exceptional memory. Perhaps the general tenor of her life would have been more tolerable if she had been *able* to forget sometimes. Being at Eugen Kolisko's side, she had suffered the tragedy of his life with him and she had to endure everything that happened at that time as a participant in the events.[2] As a result of this there remained several bitter residues which could not be dissolved away and which left their mark on her in her final years.

At the next lecture Dr Steiner came up to her out of the crowd. 'You would like to speak to me.' – 'Yes, I should like a reply to my letter.' Steiner responded: 'You have lived through a lot of difficulties and you do not get much sleep'. To help her he advised her to imagine herself being at an abyss, allowing rose petals to fall into it and gathering them together again. Regarding the letter he continued, 'And you are asking about occult chemistry; you should first fill in the gaps and only then get involved with that!' And then he said to her aside: 'You can see the etheric'. This echoed in her ears like the words of a riddle.

Eugen and Lili Kolisko got married. In the meantime Eugen Kolisko was called to the Waldorf school at Stuttgart. (Their only child, Eugenie, became Mrs Clunies-Ross on her marriage in England.)

Pathological anatomy and the cow shed

In 1920-21 there was an outbreak of foot and mouth disease in the Neresheim region. Rudolf Steiner when asked for advice suggested treating it with a coffee preparation. He and Kolisko went into the cow shed. Kolisko had a syringe full of coffee extract and inserted it in a neck vein. Steiner stood in front of the animal. Kolisko continued the infusion until 'the astral body of the animal came out of its eyes'. Then Steiner signalled him to stop. In this way the two 'vets' administered their treatment to a cow. The animal suddenly fell down and then got up again. It was healed. In Kolisko's 1935 report, he said 'that is what Steiner called the collapse'. Not all animals got up again, some died. Incidentally it is worth noting here that the animal disease was the trigger for all the research that followed. From animal pathology the first steps were taken via spleen function studies to the groundbreaking experiments with plant germination and metals. From this came the new knowledge of substances and on the basis of this the way was open for an anthroposophical approach to medicines!

All this was squeezed into four years. Kolisko had a sabbatical for one year and with helpers he carried out the animal treatment, himself stationed at the animal's head. He

the last 50 years; almost half of those just in China!

Where is this leading to globally? Most of the world's great rivers have been transformed from *flowing* water to staircases of *stagnant* water. That we cannot do more violence to river and valley biotope hardly needs elaborating here.[1] The total volume of all reservoirs is 10,000 km^3 which corresponds to five times the total volume of water in rivers worldwide (Chao 1995). The mass of water that corresponds to this is so great that it can trigger earthquakes (Gupta 1992, Goldsmith/Hildyard 1984, p.114) and the resulting mass displacement of the earth's crust causes measurable deviations in the earth's speed of rotation, axial alignment and shape of rotational field (Chao 1995).

The 400,000 km^2 of land flooded globally by large-scale reservoir projects alone represents a huge loss (Shiklomanov 1993, p.14) because the flooded regions comprise the world's most fertile arable land or belong to the regions of greatest biodiversity. There are many reasons why they damage the environment but I will mention only some of them here:

- water flows below dams accord no longer with the ecosystem but with commercial considerations;
- the damaging properties of reservoir water resulting from rotting vegetation or lowered water temperature;
- the lowering of the water table downstream with the resulting depletion of flora and fauna;
- the drastically altered erosion and deposition in the river bed downstream;
- the retention of water-transported nutrients as well as the sediments and suspended solids in the reservoir;[2]
- the increased loss of water in the tropics through increased evaporation from reservoir surfaces and seepage from irrigation canals.

Most of us will be familiar with the shrinkage of the Aral Sea resulting from damming and usage of its feed-waters as an extreme example of the environmental damage under consideration here. What was once the largest body of freshwater on the earth is today restricted to three hyper-saline lakes which together comprise less than half the original water area (Kotlayakov 1991, Davoren 1992, Hinrichsen 1995).

The effects on people of dam construction have been and continue to be no less dramatic than the ecological impacts. According to conservative estimates, the number of compulsorily resettled people is about 30 million. A more realistic figure is around 60 million, i.e. about the entire UK population (McCully 1996, p.67). At least 1.3 million people will be compulsorily resettled as a result of the Three Gorges reservoir in China. Its flooded length of over 600 km would fill the entire Rhine valley between Basel and Düsseldorf (see Fig. 2). Imagine that one day you together with 1.3 million other affected people discover that the compulsory resettlement of your community has long been decided without your prior knowledge not to mention giving you the possibility of having a say in the matter.

There is hardly any information as to the fate of the resettled people in developing countries. What is clear is that only a few recover economically and psychologically from the trauma of it. Someone who was forced to leave the Narmada valley in India spoke

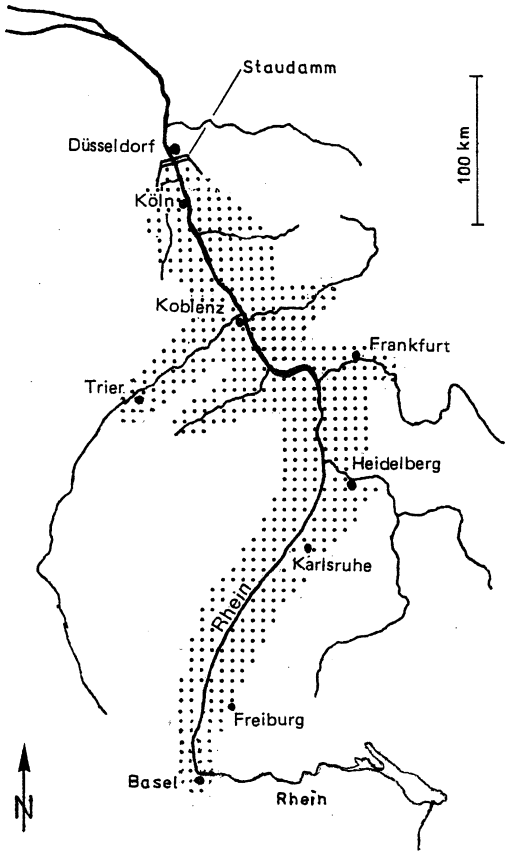


Figure 2. The Three Gorges Reservoir on the Yangtse would inundate the Rhine valley from Cologne to Basel.

about it as follows: 'Our society is not here. We're like dead people. What's the point of living like dead people?' (Morse/Berger 1992). As the following case study exemplifies, amongst the victims of reservoir projects in developing countries are also the countless victims who, whilst not actually being displaced, are robbed of either their whole basis of existence (Goldsmith/Hildyard 1984, p.49ff & 92ff) or their drinking water supply;[3] who suffer or die from project-induced new or re-emergent diseases such as haemorrhagic fever, malaria, bilharziosis etc. (Goldsmith/Hildyard 1984, p. 67ff.; Le Guenno 1995); or who are drowned by dam bursts or overflowing.

As McCully shows, 200 dam bursts outside China have claimed 13,500 lives. In China itself just one of innumerable bursts there caused 230,000 deaths. This was at Henan in 1975 (McCully 1996, p115ff.). In autumn 1998 we witnessed one of the biggest floods that China has ever had involving thousands of deaths and 240 million affected people alone on the Yangtse. How can this happen? If dams are meant to give protection from floods should not China with its 20,000 large dams have the best flood protection in the world? Clearly it is an illusion to think that dams and levees provide better flood protection. In fact it is rather the reverse. This is attributable inter alia to:

- reduced retention capacity of the soil through massive deforestation and modernisation of land use, the concomitants of dam construction;
- higher dykes constantly necessitated by the significantly raised river bed resulting from increased erosion from the former forest and land managed as large fields;
- loss of natural retention areas resulting from straightening and canalisation of the river, which normally accompanies dam construction, leading to higher flood peaks with larger velocities when the river is in spate;
- general prioritisation of higher storage targets for maximisation of power generation

Lili Kolisko – Her Life and Work 1889-1976

Gisbert Husemann

Lili Kolisko was born in Vienna on 1st September 1889 and died on 20th November 1976 in Gloucester, England. Her father was a typesetter. She had three step siblings. Apart from poverty, her home life was marked by her father's tendency to drown his troubles in drink. When he came home in the evening Lili's mother would send her to him to calm him down. Her only reading material in these gloomy circumstances was was provided by the texts on the the calendar pages which gave scant indication of a brighter existence.

A union of opposites

By comparison, the sophisticated surroundings and well cultivated family in which Eugen Kolisko grew up were a seemingly unbridgeable gulf.[1] But destiny closed that gulf. Eugen's father, already fatally ill, ultimately reconciled himself to it, though his mother never did. How was the web spun?

In 1914 Lili was a volunteer assistant in a field hospital where Eugen Kolisko was working as a medical student. He had a passionate interest in medicine and science. She learnt medical laboratory techniques: culturing bacteria, staining blood smears and identifying the cells by microscopy. The first encounter, so we are told, was as she helped carry a wounded soldier to the operating table at which Eugen was working as theatre assistant.

During this time Lili received two invitations to a lecture at the Society of Monists and she offered one to Eugen. Together they attended a lecture by Prof. Hatschek but were both disappointed with it. Afterwards Eugen said to her: 'May I give you a book to read?'. He gave her *Knowledge of the Higher Worlds and its Attainment* by Rudolf Steiner.

Mrs Kolisko, who told me all this, said she gobbled up the book in a night. It was her first contact with Steiner. Light shone in the darkness of her life and Lili Kolisko received it and deepened her understanding of it. When she returned the book to Eugen she asked him: 'Have you any more books by Rudolf Steiner?' He affirmed that he had. 'May I read them?' And thus she came to read several books on anthroposophy which were in Eugen Kolisko's library at that time.

First encounters with Rudolf Steiner

Lili Kolisko's independence of mind, so necessary to her in life, showed in the following initial encounters with Rudolf Steiner. Her will went totally into her work, she sacrificed herself to it. She was amongst the most selfless female researchers that the epoch has seen. Her will, from its working-class origins, led to a work output that is matched a few. Outwardly she appeared modest, speaking thoughtfully yet very resolutely. In her matriculation exam she chose Hebbel as her set author. The examiner, noting this, pointed out that he was not prepared for it, to which the examinee responded: 'It is sufficient if I

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and irrigation at the expense of permanent reserves of storage capacity for emergencies.

An important reason for flood damage being greater with flood protection measures is that the false sense of security they give increases settlement of the land below dams and behind levees. There are numerous examples of inundations that are caused not directly by floodwaters themselves but by over-hasty opening of floodgates of a reservoir in order to create room for an unexpected flood (McCully, p.146ff.).

Damage mitigation measures

Large-scale reservoir projects have their most catastrophic effect on the section of the population engaged in a subsistence economy (Ecologist 1992; Goldsmith/Hildyard 1984, pp.86 & 92, Dorcey 1997, ONIC et al. [year of publication unknown]) and in developing countries this means the *majority* of the inhabitants. As I hope to be able to demonstrate, this has less to do with a problem with the technology than a problem of modern economic life. Putting it another way: there is here, as I shall show, an alchemical process at work by which the many Philemons and Baucises who are not part of the monetary economy fall by the wayside.

How could it be otherwise? These people depend for their existence not, like us, on income and property, but on *unattested right of use* of a part of nature which is at the free disposal of an entire community.[4] But with the intrusion of technology and the monetary economy the water and the fertile ground are 'overnight' only to be had in exchange for money or capital (cf. Ecologist 1992). What this means for most of the people living in the region of a large-scale project cannot be expressed more poignantly than by the words of the Indian sociologist Agarwal:

> 'In a country like India with a high population density and high level of poverty, virtually every ecological niche is occupied by some occupational or cultural human group for its sustenance. Each time an ecological niche is degraded or its resources appropriated by the more powerful in society, the deprived weaker sections become further impoverished. For instance, the steady destruction of our natural forests, pasture lands and water bodies has not only meant increased economic poverty for millions of tribals, nomads and traditional fisherfolk, but also a slow cultural and social death: a dismal change from rugged self-sufficient human beings to abjectly dependent landless labourers and squalor-stricken urban migrants. Current development can in fact be described as the process by which the rich and the more powerful reallocate the nation's natural resources in their favour and modern technology is the tool that subserves this process.' (Agarwal 1982)

Self sufficient people become recipients of social security benefits, for whom, though, neither benefits nor even compensation for their lost land and water rights are usually factored into the cost-benefit analyses during project planning.

You may be interested to know that some years ago – in the UN designated 'International Year for the Eradication of Poverty' – I addressed a call to my colleagues in the International Association of Hydraulic Engineering and Research (IAHR) suggesting that they might like to collaborate in producing a list of criteria for avoiding such negative

consequences. The result of this was a list of 40 criteria which would have to be met during planning and execution of water-resources projects in order to avoid project-induced impairment of nature and impoverishment and possibly to secure a more equitable distribution of the benefits of such projects (Naudascher 1997). Here I should like to draw attention to only a few important points at the end of this criteria list. They specify for example that before any project planning there should be a rigorous investigation as to whether an alternative is not preferable to the particular technical solution: with respect to *power generation*, for instance, measures to increase efficiency, as suggested in the recent report to the Club of Rome by E. U. von Weizäcker et al. (1996); or with respect to *irrigation from reservoirs*: the reactivation and further development of one of the many traditional irrigation systems.[5]

Terraces, ditches and contour ploughing ensure that…..every drop of rain is caught.

Figure 3. Erosion prevention and reclamation of a catchment area in a famine and arid zone in India (Übelmesser 1998).

Figure 3 shows an example of such an alternative development where every drop of tropical rain is caught in the deforested or overgrazed (and therefore desertifying) ground and thereby at the same time preventing disastrous soil erosion. 'Community-Based Watershed Development' is the key phrase (Agarwal/Naraian 1989; Dying Wisdom 1997, Lamour 2000). In many places in India green oases spring up in the midst of man made deserts (e.g. in Raleghan Siddhi near Puna, Hazare 1998, p.127; Pangare/Pangare 1992). An essential component of such an alternative 'project' is the active participation of the local population as much as with its conception as with its execution and management. But here this means nothing other than that the process of transmuting nature into monetary cycles does not get under way and that – note well – the possibility of profiting by our companies, banks and engineering consultancies as well as by the elite in developing countries is removed or greatly reduced. So we should not wonder if for a long time there

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the Rhône was canalised in 1986.

2. For the World Bank Prof. Mahmood (publication year unknown, p.8) estimated that in 1986 the sediments deposited in the worlds biggest reservoirs comprise 1,100 km^3; this corresponds to a fifth of the storage capacity of these reservoirs which because of this can no longer be used. Each year some 50 km^3 of storage capacity is additionally lost.
3. An extreme example of this is given by India's Farakka dam a project serving the region round Calcutta which seriously impacted agriculture and water supplies of 40 million people in Bangladesh (Rahman 1986, p.267). It was also one of the many cases of conflict where large-scale reservoir projects can lead to armed fighting. Fifteen of the 19 largest rivers in the world flow through two or more countries. A time bomb of a special kind: the south-east Anatolia megaproject in Turkey (McCully 1996, p.242).
4. In Switzerland, common land is probably a relic of this form of economy.
5. To my great joy my last Ph.D. student had the courage to take up this topic for his work (Lamour 2000).
6. For example the impact on the water supply from springs and on the provision of firewood and game from the woods.
7. The suggestion came originally from Scudder (1980), but has so far not been realised for any tropical project although World Bank ecologists have since recommended the release of artificial floods for all tropical large reservoir projects (Goodland et al. 1992).
8. Our cost benefit assessment would look quite different if we – as suggested by Agarwal – judged it by means of a GNP-factor where 'GNP' means Gross *Natural* Product instead of Gross *National* Product!
9. For instance even with the suggestion outlined above for damage limitation through artificial flooding in the Senegal valley one aspect of the Faustian work remains untouched: *human beings* have now to decide about the time of inundation! As in modern medicine we have with a sort of God-complex assumed power to make decisions for which ultimately we are unable to take responsibility.
10. From 1990-1996 foreign debt in developing countries rose 47% to 2.17 billion US$ ('Debts…' 1998). The drastic effect debt from a dam project can have on a country is illustrated by the example of the Chixoy dam in Guatemala. In 1998 the credit taken on for this dam corresponded to almost 40% of the total foreign debt of Guatemala. What is usually overlooked is that credit and public revenue allocated to such projects makes it unavailable for more worthwhile and socially desirable projects (McCully 1996, p.273).
11. Faust (to the emperor): *The major bulk of treasure to be found / Throughout your lands, deep hidden in the ground, / Lies yet untouched. (…) And yet choice spirits, fit the depths to see, / Grasp infinite faith in an infinity.*
12. A claim, which basically hides in the smallest, hitherto seemingly harmless, legal claim to property.
13. Note inserted by the translator: this version is Philip Wayne's translation (Penguin Books, 1959), with two modifications to match word correspondences between the Goethe original and the German translation of Paul: 'master' is replaced with 'lord' (*Herr*) and 'people' with 'servants' (*Knechten*).
14. The value of money can only be maintained by a constant consuming. When money can no longer be equated to real goods drawn from the treasure chest of nature, it becomes worthless.
15. In chapter 11 (v.13 & 14) of the same letter Paul speaks of the 'deceitful workers transforming themselves into the apostles of Christ' and continues 'And no marvel; for Satan himself is transformed into an angel of the light'.

was little willingness amongst the addressees of the aforementioned criteria list to develop it further into an international code for planning guidelines.

In the meantime I have been invited to incorporate this list in the report by the World Commission on Dams (WCD) titled 'Dams and Development – A New Framework for Decision-Making' (WCD 2000). A thorough implementation of the guidelines contained in this report, however, will only happen when civil society as the third global power next to those of economy and politics, which Nicanor Perlas presents in 'Shaping Globalisation' (Perlas 2000) against a background of the modern globalisation phenomenon, has increased influence also in water resource planning.

Case study – the Senegal Valley Project

How can the damaging consequences of a pre-existing large-scale reservoir project be limited? I should like to illustrate this with the example of the 500 km^2 reservoir in Mali, which was formed through the completion in 1998 of the Manantali dam (Figure 4). This project is intended to supply power, irrigation and make the Senegal navigable (Mournier 1986, p.109ff.; Loimeier 1986; Pottinger 1997 & 1998; McCully 1996, p175ff.). Currently, negotiations continue over the way the project should be managed. As a basis for these negotiations, a report was published which had been prepared following a field study of several years by an interdisciplinary team from the Institute for Development Anthropology of the State University of New York (Horowitz 1991 & 1995).

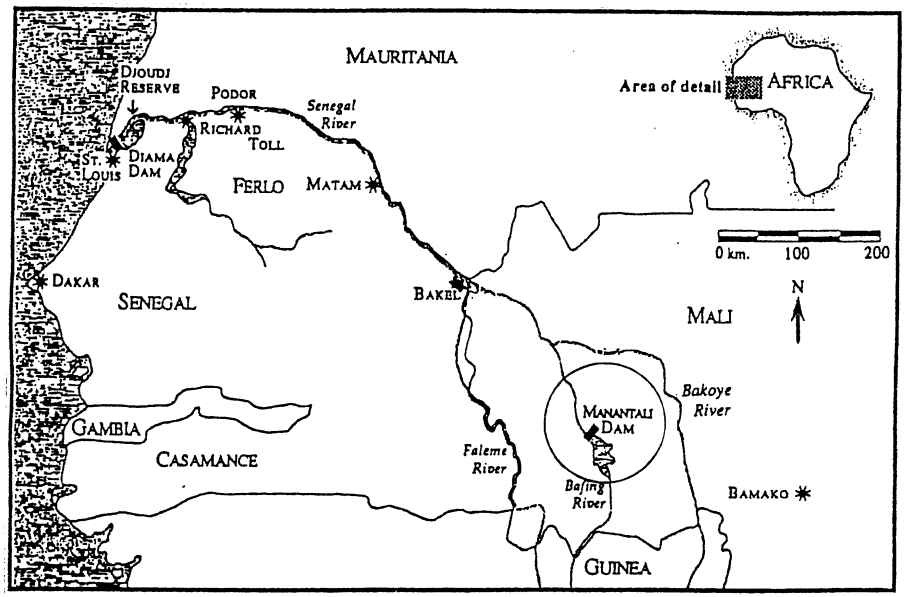

Figure 4. The Senegal catchment area showing the 500 km^2 Manantali reservoir (which corresponds in area to Lake Constance).

The result of this study is highly significant in several ways. It shows that in the Senegal valley below the Manantali dam a population of almost a million people comprising mainly farmers, herdsmen and fisherfolk have managed the river valley *truly sustainably* in peaceful coexistence, and indeed done this – as a report of the historian Al-Bakri from the 10th century shows (Levtzion & Hopkins, 1981) – for over a millennium! In addition the study shows that the yield of food from the totality of traditional ways of production which depend on the annual floods were significantly higher than the calculated yields from the proposed irrigation system, and this despite the fact that this comparison did not take into consideration the costs of the now essential artificial irrigation and provision of fertiliser as well as the several damaging impacts of the project-induced lowering water table[6] etc (documented in the appendix of Naudascher 1996). Of course it depends on *how* you calculate yields. In terms of yields per hectare they are higher with artificial irrigation and fertilisers. But based on units of invested capital and labour, which of course for those affected are the sole deciding factors, the traditional methods of production are many times more productive.

How is this possible? It can be explained primarily by the fact that the floodwaters have more useful functions than people generally thought possible (Bayley 1995; Anramovitz 1996, p.60). Here too it was the mistakes that helped us see the light. Thus for instance, only in 1996 the US Bureau of Reclamation arrived at correction measures for environmental damage in the Grand Canyon by releasing artificial floodwaters from the upstream reservoir ('Flushing…' 1996; 'Faking…' 1996). Experience shows that in the tropics the most important precondition for the fertility of river valleys and deltas are the floods. It is the floods which supply them periodically not only with freshwater but also mineral and nutrient rich fluvial mud which fertilises the soil and provides the basis of existence of many species of fish. They also provide the valley dwellers with drinking water from springs and with firewood and game from the wooded water-meadow land with its periodically enriched groundwater.

The superiority of the traditional methods of production in the Senegal valley in comparison to the modern one, however, results also from the fact that the *same* river valley is used in seasonal succession by farmers, nomads and fisherfolk (Horowitz 1991 & 1995) in several ways, of which the following are the most important:

1. for flood-recession cultivation in the 2 - 20 km wide flood basin of the Senegal,
2. for grazing in the same area after completion of harvesting by the farmers and
3. for river fishing.

As a result of these diverse usages, moreover, the food yield of the area is greatly improved by synergy. Thus, to cite just one example, the livestock of the Nomads graze on the gleanings of the farmers and at the same time manure the fields and enrich the water with nutrients for the fish. Once more to emphasise: the status of all sources of nutrition listeddepends on the annual floods, even the fish catches, because without the ponds that form after the flooding the fish would have no spawning ground.

An inscription in the valley of King Ramses (1200 - 1090 BC) reads: 'I never restrained the Nile. I never blocked the path of the waters. I never polluted the Nile.' Clearly this

For we preach not ourselves, but Christ Jesus the Lord; and ourselves your servants for Jesus' sake.
For God, who commanded the light to shine out of darkness, hath shined in our hearts, to give the light of the knowledge of the glory of God in the face of Jesus Christ.

This text refers to another blindness, the blindness to the light of the gospel. Faust is unquestionably blind in this sense too.

But now let us consider the key words presented in both texts. The key word '*light*' represents the fundamental difference between the two protagonists. On the one hand we have Faust: I, the modern man; I, who carry out my 'bold behest'; I, the *lord* (*Lord*) and creator of a 'better world', in which I command others, my *servants*; I, who with the *light* which 'within my mind shines still',[15] transform all I find to the 'noblest heights' thus creating money value for millions. On the other hand we have Paul: a man who through his Damascus experience underwent a transformation from a blindly raging and crusading Saul – a *homo faber* [man of action] not unlike Faust – into Paul, who describes himself and his people as *servants* of a higher power, namely the *Lord* and creator of all creation (including water!), and who reflect the *light* which comes from 'the knowledge of the glory of God'.

Using the noteworthy correspondences of these contrasting passages, expressed in the same words we can rest assured that here Goethe consciously wove in a hidden message against the day when a future generation will open its eyes to the connection between its economic-technical activities and their frightening results.

Perhaps we have finally reached the point of being able to receive this message.

Postscript

Our conference was – as a leitmotiv so to speak – planned from the Hymn to the Sun of St. Francis, the praise of God for *our sister water*. For several years I have occupied myself with some words of Paul which are also relevant in this context. They are from chapter 8 of his letter to the Romans (v. 19,21,22) and, according to the King James translation, go as follows:

For the earnest expectation of the creature waiteth for the manifestation of the sons of God.
Because the creature itself also shall be delivered from the bondage of corruption into the glorious liberty of the children of God.
For we know that the whole creation groaneth and travaileth in pain together until now.

Treating all creation – including water – with care and love will only happen when creation's 'earnest expectation' occurs: the manifestation of what we really are.

Notes

1. Only 70 km of the 2000 km length of the Columbia River in USA still flows unhindered by the 19 dams which transformed the river into a chain of reservoirs. The last free flowing stretch of

for possessions and lust for profit); Smite-all (naked power) and Keep-all (miserliness). In gratitude for his help in the war Faust receives from the emperor a parcel of land beside the sea. Here Faust brings his activities to a culmination in an ambitious project to reclaim land from the sea through which the third important aspect of our economics is presented to us: employing capital and technology to extract from the 'mines' of the earth only what is usable.

Goethe's most profound message to people nowadays is to be found in the words which Faust utters after his conversation with Care. The now blind Faust here says:

Deep falls the night, in gloom precipitate;
What then? Clear light within my mind shines still;
Only the lord's word gives action weight,
And what I framed in thought I will fulfil.
Ho, you my servants, quickly come from rest:
Let the world see the fruit of bold behest.

Man all the tools, spade, shovel, as is due,
The work marked out must straight be carried through.
Quick diligence, firm discipline,
With these the noblest heights we win.
To end the greatest work designed,
A thousand hands need but one mind.[13]

Faust was blind to the consequences of his activities. For him it was a case of not realising what he was doing. But does this also apply to the Faustian characters of our time? Do not the media already see to it that we can no longer shut our eyes to the destruction of nature and impoverishment around us? For the time being admittedly, the transmutation process of our economics still works for a minority of the earth's population; but we can certainly no longer ignore the fact that it is ruining the earth, without which the richest will go hungry too.[14]

This verse becomes exceptionally pertinent to our question as to the way out of the vicious circle when we – after Binswanger – compare it with the words of Paul in the second letter to the Corinthians. We can rest assured from the outset that the correspondences or contradictions between Faust's words and those of Paul are not accidental but are Goethe's consciously created contrasts with the Pauline text. How much this contrast mattered to Goethe and with it the reference to the Bible can be seen from the way he has Mephistopheles call out blasphemously at the death of Faust: *It is finished.*

The contrasting text of Paul can be found in the chapter 4 of his second letter to the Corinthians (v. 3-6):

But if our gospel be hid, it is hid to them that are lost:
In whom the god of this world hath blinded the minds of them which believe not, lest the light of the glorious gospel of Christ, who is the image of God, should shine unto them.

ancient culture had access to a wisdom that modern science must once again discover the hard way.

Returning to our case study: on the basis of its findings in the Senegal valley, the aforementioned scientific team suggested planning for the artificial release of floodwaters from the Manantali reservoir so that the river valley ecosystem – and with it the basis of existence of the local people – would not be excessively impaired. This revolutionising suggestion[7] is particularly noteworthy in that it can be applied to not only newly planned but also existing dams. Of course one had to reckon with objections from those behind the project. The hydrologists in the team therefore investigated the consequences of their recommendation and arrived at the conclusion that through artificial releases, even in the years of poor rainfall, only 5% less power would be generated (Horowitz 1991, p.177). In view of this small loss in comparison to the many disadvantages in the case of flow management according to the original plan – such as the threat of food shortage, massive migration from the land and the necessity of having to set aside scarce reserves from the exchequer for food imports – the Senegalese government initially agreed to the recommendation.

However, what was done since to prevent the slightest deviation from the planned maximal power generation in the three-country consortium, which includes Mali and Mauretania, and by the banks supplying the credit, would fill a paper on its own. I fear this shows that in a time in which daily 1.5 billion German Marks exchange hands worldwide in search of profitable investments, even economically less profitable large-scale projects in developing countries are pursued as keenly sought after opportunities to invest. Here a reduction in electricity production of only 5% might already signify an unacceptable risk to the return on the loan and its payback security.

The deeper causes of the damage to nature and impoverishment

In his book 'Money and Magic' with the subtitle 'A critique of the modern economy in the light of Goethe's Faust' the now retired economic scientist Hans Christoph Binswanger (1985) of the University of St. Gallen showed that in modern economy and technology a process of 'alchemy by another means' is set in motion – or, as I put it, a process of *transmuting natural cycles into monetary cycles.*

Let me illustrate this with an actual example, again using the case study just presented (Figure 5). The natural cycles in the Senegal valley provided *gratis* by means of the floods, firstly, natural irrigation; this is now to be replaced with an *artificial irrigation system*. Secondly it delivered equally free of charge, fertilisation of the soil with river mud; this must now be replaced with expensive *artificial fertiliser*. Thirdly by natural means the floods have so far prevented salination of the soil; for this now *drains* have to be installed. Fourthly the interchange of flooded and dry periods prevented pathogens from getting the upper hand. Without this interchange in areas kept moist for long periods bilharziosis inevitably develops and often malaria and hitherto unknown diseases too (Le Guenno 1995); for the treatment of these *medicaments and hospitals* are then required.

If, however, we judge this scenario with the aid of our usual economic standard, the Gross National Product (GNP), it produces a picture of magnificent economic develop-

ment. With each of these transmutations, an economy with a GNP of zero is turned into one with a meteoric rise in GNP. Yes, even the diseases caused by the irrigation system can be booked on the plus side because now pharmaceutical industries and hospitals move into the region, though they were hardly needed before.

Modern economy and technology set in motion a process of transmutation of natural cycles			→		**into monetary cycles**
Floods freely provide	•	irrigation	→	which is replaced by	• artificial irrigation
	•	fertilisation by mud	→		• artificial fertilisers
	•	and much more*	→		. . . . .
Floods prevent	•	salinisation	→	which is replaced by	• drainage systems
	•	disease agents from establishing	→		• hospitals and medicines

Fig. 5. The alchemical transmutation process set in motion by modern economy and technology, illustrated through the example of a large-scale reservoir project.

* e.g. maintenance of supplies of water from springs and of wood and game from the woodlands

The person of modern society who is integrated in and reaping the benefits of a monetary economy will most likely find this development fascinating – no less so than does the aged Faust in Goethe's prophetic work. And like Faust, our modern representative also seems blind to the accompanying damage, indeed destruction of nature, which – as the example case clearly shows – is the wealth of the as yet pre-monetary society living in harmony with nature (like Philemon and Baucis in Goethe's *Faust II*). Do we wonder then that this group of the earth's inhabitants is increasingly impoverished by the now globally operating and extensively deregulated alchemical transmutation process and that they register in the annual statistics as an increase in 'absolute poverty'? Should we wonder if only those who participate in this process profit from it? (At least so long as nature is not yet completely transmuted.)[8]

It is hard to understand that even the people most critical of progress in our society seem unable to grasp how immeasurably more important a correction of this alchemical process is compared with the improvement of any detail of whatever technological-scientific or political field is involved.[9] But whoever is on the winning side in this process can remain for a long time under the illusion that the damage to nature is really not so very dramatic. In Germany and Switzerland we have an exemplary environmental protection system, or so we frequently reassure ourselves. Is it not simply a matter of the developing countries also doing more in this respect, so we can supply them with know-how and credit? Let us not fool ourselves. The result would be little different from that arising

from our so called development aid for building dams! Most environmental protection measures with us are capital intensive. If we were to transfer these into developing countries too then their immense debts would grow even greater[10] – and with it the money flow from the losing to the winning side. Figure 6 shows just *one* of many examples of how modern economics and technology take effect. The more capital intensive a technology, the greater its contribution to the alchemical transmutation process!

Is there a way out of this vicious circle?

How can we escape from this vicious circle? A first necessary step would have to be to recognise that we are indeed stuck in a vicious circle. Hans Christoph Binswanger can help us greatly with this through his aforementioned book 'Money and Magic' (1985) in that he demonstrates the topicality and almost world historical significance of Goethe's 'Faust' for our theme. The apparent fulfilment of our dream of unlimited progress in increasing prosperity is here exposed for what it really is. Whoever cannot learn to see through and comprehend modern economics as an alchemical process according to Binswanger – such is the message of Goethe's *Faust* – cannot grasp its monstrous side and danger for the earth and its people.

Let me remind you of the relevant events of that drama for our theme. Faust makes a deal with the devil who appears in the form of Mephistopheles and who tries with the help of alchemy to lead Faust closer to the desired *highest moment* and thus bring about his downfall. Whereas *Faust I* is about preparing *Trinkgold*, the witch's brew for inducing virility and eternal youth, i.e. an equally topical theme in our time – *Faust II* is about the classical alchemy theme, the artificial production of gold. The first alchemical experiment goes wrong and ends tragically. But the second – at least considered superficially – leads to an almost overwhelming success. Here, finally Mephistopheles succeeds in making Faust see realised his vision of an 'infinite'[11] increase in wealth. In the premonition of his turning into a reality the happiness of millions of people, Faust calls out: *Foreknowledge comes, and fills me with such bliss, I take my joy, my highest moment this.*

The experiment begins – right at the beginning of *Faust II* in the imperial palace – significantly with the basis of our modern economy, printing paper money. But producing paper money alone is insufficient; it keeps its gold equivalence only if it is linked to profit or interest, if it materialises. We can understand what Faust is about here from Mephistopheles' question as to what his greatest desire is. Faust answers: *So realm [property] and rule [power] to me will fall.*

Property is what Faust is interested in; but not property in the sense of patrimony, that on the one hand is available for use but at the same time imposes the duty of looking after it for the benefit of future generations. No, for Faust it is more in the sense of dominion, something that confers the power of domination, something to use *and consume.* Here we come upon the most important component of capitalistic economy: the claim to ownership of land, i.e. ownership of nature.[12] Mephistopheles fulfils Faust's desire by standing by the emperor in battle and letting Faust appear the victorious commander. The three 'men of might' play a significant role not only here (Act IV,Sc.1) – together undoubtedly the personification of the modern economic mind set: Grab-all with Speedy Loot (greed