Chemistry

Reader

An Orientation to Developing Chemistry Instruction In Waldorf Schools

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Chemistry Reader

Contents

Dirk Rohde, Marburg Waldorf School, Christmas 2013

Introduction to the Waldorf Chemistry Reader

I General Notes

Chemistry is a very exciting and interesting science that is highly relevant to each one of us. In health and illness, in medicine and nutrition, in all sorts of technological aspects, in global climate issues, in space travel – almost everywhere we look, we encounter not only the many possible positive applications of various directions in chemistry but also the risks they entail, which must not be overlooked. Chemistry, therefore, is included in all school curriculums today as a matter of course. By exposing young people to multiple points of contact with this important science and introducing them to its very fluid reasoning, Waldorf schools aim to empower their students to deal with the subject of chemistry as self-reliant, discriminating personalities.

To this end, Waldorf education has developed its own specific approach that has proved at least somewhat fruitful. For example, the 2006 PISA study ascertained that students in German and Austrian Waldorf schools demonstrated not only as much factual knowledge as students in public schools but also significantly greater interested in scientific subjects. Furthermore, there were obvious gender-specific differences (to the disadvantage of girls) in the public schools but not in the Waldorf schools involved in the study. Not surprisingly, a study by Heiner Barz and Dirk Randoll revealed that scientific professions were the second most popular career choice among Waldorf school graduates. (1, 2; see the end of this introductory chapter for these and subsequent footnotes).

These findings are anything but self-explanatory. Many of our contemporaries seem to have difficulty developing a connection to the natural sciences in general and to chemistry in particular. There are only relatively few chemists, and they tend to have a reputation for specializing in a questionable minor discipline rather representing a generally acknowledged and valued field. Intensive interdisciplinary exchange is all the more important for them, and especially for the few Waldorf chemistry teachers, due to the challenges of their specific instructional model.

At a continuing education conference on chemistry for Waldorf teachers in Moscow in the spring of 2010, we heard a request to make basic written information available to the international Waldorf school movement for purposes of preparation and review. This request is all the more understandable when we consider how difficult it is – especially because of the geographical distances involved – for many of our colleagues to share ideas with other Waldorf chemistry teachers outside of these occasional continuing education events.

Another problem is that the German professional literature on teaching chemistry in the Waldorf schools has become so extensive over the decades that it would be almost impossible to translate all of it into all the languages in international use. Even if the staff and the funding were available, it would take much too long. In addition, beginners would probably be overwhelmed by this large body of work and daunted at the prospect of having to make meaningful selections to meet their needs in a hurry.
That is why I proposed to take up this issue myself. I have been teaching chemistry in the

Marburg (Germany) Waldorf School since 1988 and have also been involved in teacher training and continuing education for many years. My offer to compile an electronic Chemistry Reader for beginners was received positively, and so work began on it in the autumn of 2010.

It must be emphasized that this reader is intended specifically for *beginners* – as a handbook to help them develop chemistry instruction in Waldorf schools or assume responsibility for chemistry classes in situations when little outside help is available. It is also meant to provide suggestions on preparing for continuing education events and the mutual sharing there, which will then aid in the further development of their courses.

For this reason, this reader will *not* include many of the interesting points raised for further exploration at conferences by teachers with many years of experience, including (for example) the anthroposophically developed imaging techniques that are so important to me personally. Beginners, however, need secure foundations before venturing further. I have also not dealt with anything directly related to governmental requirements regarding curriculums, graduation standards, etc., which vary too much from one country to the next. Solutions to dealing with these will often need to be found locally.

Another exclusion criterion was the text lengths of the individual articles available. Translating a page into another language requires considerable effort on multiple levels. For that reason (as well as regard to the intended usage), it was clear from the beginning that the Chemistry Reader's total length should be limited to approximately 100 double-sided pages. Because Waldorf chemistry instruction involves all the grades from seven through twelve (in Germany) and must therefore touch on a whole series of different subjects, longer articles were eliminated from the very beginning.

Additional considerations included my desire to provide a platform for many different authors spanning the entire development of the Waldorf school movement – that is, from 1919 to the present – and to present the very individual impacts of their chemistry classes on our schools. I hope that in spite of any difficulties in translation, these riches will be preserved at least to an extent that allows "newcomers" to hear many different voices in their own words, the voices of teachers with very different approaches and temperaments and thus with many different inspirations to offer. My sense is that these voices form a harmonious "choir" in which the individual authors complement each other well, since they are not competing with each other but share a common starting point for their interpretations, namely, the curriculum specified by Rudolf Steiner. At the same time, however, we can also see that these interpretations have conquered ever new realms of thought and extended the scope of their subject over the decades.

In this time period, however, chemistry has also made tremendous progress outside of the anthroposophical movement. As a result, all of the articles required careful reading and, in some instances, corrections and omissions. Much information had become scientifically outdated, and (at least in Germany) certain topics can no longer be presented in the classroom due to safety issues. In addition, some of the articles included contents that the Reader does not cover and so the passages in question had to be deleted. I hope that all users of this material will feel bound to investigate further on their own: The science of chemistry continues to evolve, so all of these contents will require repeated checking to see if they are in need of updating.

II The Waldorf School Curriculum

In 1919, the first Independent Waldorf School was started in Stuttgart (Germany) and included grades one through eight. Its curriculum was developed in a series of conferences Rudolf Steiner held with the faculty from 1919 to 1924. Steiner's curricular suggestions on the occasion of the school's establishment included the topics in chemistry to be covered in those first seventh and eighth grade classes. The conferences continued until 1924, emphasizing indications for each newly added grade – that is, for grade nine in 1920 and so on. Chemistry, like many of the other subjects, reveals one of the most important instructional principles in Waldorf education, namely, the historical approach. Each successive grade studies examples of individual discoveries and insights in the order in which they appeared in the history of chemistry itself.

It is also important to note that each grade was intended to have only one chemistry block, as is often still the case today. During those blocks, chemistry was – and often still is – taught in daily lessons of approximately two hours each for three to four weeks, for a total of 30 to 50 hours in the course of a whole school year.

After Rudolf Steiner's death in 1925, his concrete indications (in chemistry as in all other subjects), which had been aimed at specific grades in one specific school at one specific time, were taken as suggestions and starting points for all other grades and schools that have since been added to the international Waldorf school movement. This Reader is also intended in that sense: It is not suitable for use as a "recipe," nor is it designed to be implemented word-for-word. Rather, it is a compendium of suggestions intended to support faculty members in their efforts to ensure the optimal development of each single student. Individual teachers, therefore, immediately assume responsibility for weighing these suggestions against the requirements of their specific instructional situations and for applying them to the development of their own instructional model.

In 1920, Eugen Kolisko, then 27 years old, joined the faculty of the first Waldorf School. His father was a distinguished physician in Vienna. Kolisko himself had also studied medicine, but beyond that he was very intelligent, highly gifted, and had enjoyed a well-rounded education. He was also an intimate pupil of Rudolf Steiner's and a very active anthroposophist. Kolisko became the first school physician in the Waldorf school movement and left a deep initial imprint on that new profession. In addition, he was a subject teacher for science blocks and devoted himself especially to developing a specifically Waldorf approach to teaching chemistry. These efforts were so successful that from then on, Rudolf Steiner called the specific procedures of the anthroposophical approach to chemistry "Kolisko's chemistry." (4) Kolisko's 1929 essay offers a very pertinent description of the unique aims and concerns of science instruction in the Waldorf School. Here it precedes and introduces the more specific essays on topics in chemistry. (3)

II.1 Grade 7

Rudolf Steiner's indication for grade seven reads: "Take a process such as combustion as your starting point. From this everyday process, you should then attempt to find the transition to simple chemical principles." (4) Kolisko developed this suggestion into a procedural method for the introductory chemistry block that is still used today by many, if not all, Waldorf schools as one of the central guidelines for teaching chemistry. For this reason, I have included Kolisko's significant 1932 essay "First Lessons in Chemistry" as the basis for grade seven in this Reader. (3)

II.2: Grade 8

Steiner says about this grade: “Continue presenting simple concepts in chemistry, but now in such a way that the children also learn the relationship between chemistry and industrial processes. In connection with chemical concepts and terms, you attempt to develop what needs to be said about the substances that make up organic bodies: starches, sugars, proteins, fats.” (4)

It is worth noting that Steiner’s indications include all three groups of essential organic substances that nourish us: proteins, fats, and carbohydrates. In a 1923 lecture to workers at the Goetheanum, the center of the anthroposophical movement, Steiner described how these three groups of substances relate to the makeup of the human being (in which anthroposophy distinguishes the so-called constitutional members of the physical, etheric, and astral bodies and the I). The relevant portion of this lecture was therefore selected for inclusion here. (5)

It is followed by an essay by Frits H. Julius. (6) From the 1930s to the 1960s, Julius was a science teacher at the Waldorf School in The Hague (Netherlands) and also a researcher and one of the most important Goetheanists the anthroposophical movement has produced. He was distinguished by an exceptional talent for observation as well as by the great spiritual depth and inwardness that are also apparent in his essays. He wrote extensively about his rich experiences and trains of thought. His articles on teaching chemistry in grades eight and ten seemed especially suited for inclusion in the Reader because in addition to offering concise summaries of many of the essentials for these grades, they are also deeply imbued with Waldorf pedagogy.

II.3: Grade 9

“The topics we assigned to grade eight – namely, introductory aspects of organic chemistry (with the word ‘organic’ being used only for the sake of brevity) – should now be continued in grade 9 with discussions of what an alcohol or an ether is, for example” (4). That is all Steiner has to say about teaching chemistry in this grade. As teachers, therefore, we are handed the difficult assignment of developing a conceptual plan for an entire three to four-week block and adapting it to our immediate needs on the scant basis of this single sentence. Manfred von Mackensen is a master well suited to this task. Until recently, he taught science at the Kassel (Germany) Waldorf School, but his field of activity was much broader. Among other initiatives, he founded a center for educational research and in that context researched and described many materials and sample lesson plans for teaching science in the Waldorf schools. Much of this material has been published, so this extensive documentation – distinguished by comprehensive, up-to-the-minute knowledge, profound thinking, and outstanding practical relevance – is now available to the international Waldorf school movement. Mackensen’s significance in this connection cannot be overestimated.

For reasons mentioned above, this Reader can include only a few passages from Mackensen’s extensive work, passages that can also be seen as stimulating representative glimpses into his other writings. A short text on the ninth grade chemistry block is reproduced here as an example of how one of Steiner’s suggestions can serve as a starting point for designing a lesson plan steeped in profound understanding (7).

As I interpret Steiner's indication for grade nine, the carbon cycle is a very appropriate central theme for this block. Over the years, I have thoroughly researched and tested this interpretation and written it up in a dissertation. The brief excerpt in the Reader is intended to give a quick first impression of this work. (8)

II.4: Grade 10

Here Steiner's indications are somewhat more extensive. The block is meant to give the class "a clear picture of the overall significance of salts, acids, and bases," first through "systematic observation of alkaline, acidic, and saline substances," then by "talking about how alkalis and acids react" and finally "drawing connections to physiological processes." (4) In just a few pages, another essay by Julius presents this topic both in depth and – by introducing several important sub-topics – in its full scope and variety. Because it also covers certain aspects of electrochemistry, it also offers a preview of the transition to grade eleven. For these reasons, I again chose one of Julius' articles as the main text for this block (9).

II.5: Grade 11

In spite of their brevity, Steiner's statements about this grade touch on many very important issues that remain highly relevant today, so his remarks are reproduced here in their entirety: "In chemistry, the key concepts of acid, salt, and base must be developed as completely as possible as a basis for understanding what an alcohol is and what an aldehyde is. We will pay less attention to traditional issues such as the division between organic and inorganic chemistry. – This seems to me to be where an overview of the substances can be inserted. It would not seem right to me to begin by deriving chemistry from a study of substances. It is better to gain an understanding of the *processes* first and only then to insert substances and metals. Your instruction should leave the students with the sense that the substances we are dealing with are simply processes held fast. When we look at a chunk of sulfur, we confront an arrested process. If rain is pouring down where I am standing, that is a *process* in which I am involved, but if I look at the cloud from a distance, it appears to me as an *object*. Observing certain processes is like standing in the rain. When I observe that chunk of sulfur, it is like observing the cloud from afar. Substances are processes that appear to be congealed or arrested." (4)

As we notice immediately, topics from grades nine and ten reappear here, the distinction between inorganic and organic is dealt with anew, the concept of matter is approached in a very specific way, and the "overview of substances" could also be taken to mean the periodic table of the elements. Although sulfur was named only as an example, it is a very important substance and also a chemical element. Accordingly, it plays a major role in chemistry instruction in the Waldorf schools. Because these topics touch on many different aspects of chemistry, the essays related to them are given more space in the Reader.

In terms of the history of science, the transition from grade ten to grade eleven topics can also be seen as the transition to modern chemistry that took place around 1800. It began with attempts to define chemical elements anew, which also led to the discovery of a number of new elements. As the nineteenth century continued, another new discovery – electricity – was increasingly put to use, especially in electrolysis. In grade eleven in the

Waldorf schools, therefore, electrochemistry is the focus of the chemistry block.

Rudolf Steiner goes into the subject of electrolysis in detail and in depth, although briefly, in a lecture to physicians, relating electrolysis to bases, acids, and salts on the one hand and on the other to the metals lead, tin, and iron with their radiating effects and connections to the I, astral body, and ether body. In my opinion, familiarity with Steiner's indications on this subject is indispensable to preparing to teach chemistry in grade eleven, and so in the Reader they come first in the list of materials for this grade. (10)

Günther Heuschkel is a chemist from Hamburg, an outstanding experimental researcher, and a very active anthroposophist. He spent his professional career in the chemical industry, but in retirement he took up Steiner's explanations of metals (both those cited here and others), researching them very thoroughly from a variety of perspectives before publishing many of his findings. With regard to teaching chemistry, it occurred to both Heuschkel and myself that Steiner's statements on electrolysis could be incorporated into this block not only by focusing the discussion on electrolysis but also by conducting experiments with the typical radial patterns of lead, tin, and iron that appear at the cathode as the result of reduction. An excerpt from Heuschkel's comprehensive book "Metal Processes" is included in the Reader and describes the requisite techniques. (11)

The next article is by Gerhard Ott, one of Kolisko's most dedicated students, who also became an enthusiastic Waldorf teacher after completing his education. He taught first at the Hannover Waldorf School, moved to the Waldorf School in Dresden during World War II, and later returned to the school in Hannover. Among other writings, he authored a two-volume work on a phenomenological approach to chemistry. To my way of thinking, the section on how electricity intervenes in the sphere of chemistry is exceptionally clear; beginning teachers will find much of value in these passages with regard to experiments to conduct in grade eleven. (12)

In chemistry, any involvement with the elements leads consistently to the issue of the relationships among these elements and thus to the periodic table. The thinking that went into it and the debates about different ways of depicting it are much more diverse than most of our contemporaries realize. A very good introduction to this subject, followed by coverage of a number of grade twelve topics, is provided by Wolfgang Schad, professor emeritus at the University of Witten and one of the most prominent anthroposophical scientists. Schad's field of activity is broad and his publication list impressively comprehensive. Because he also taught at the Pforzheim Waldorf School and trained teachers at the Waldorf Teachers' Seminar in Stuttgart, he is intimately familiar with all questions related to Waldorf education. The essay included in the Reader, an excerpt from his book "Chemistry in the Waldorf Schools," is directed specifically at Waldorf Chemistry teachers. (13) Schad himself revised this text specifically for the Reader.

The discussion of the periodic table of the elements is rounded out by a graphic representation of the table as proposed by Friedrich A. Kipp and reproduced in the above-mentioned book by Ott (12). Kipp was an excellent anthroposophical scientist with significant accomplishments, especially in biology. – A recently published, groundbreaking article by Peter Brodersen, a colleague from Flensburg, can only be mentioned here. Taking mathematical reasoning as his starting point, Brodersen establishes a well-founded connection between the chemical elements and the planets, which he then expresses in a new representation of the periodic system. (14)

The writing of chemical formulas, as a further aspect of dealing with the chemical elements, must be discussed and introduced in this grade (at the latest). Mackensen's essay in the Reader describes a well-founded and time-tested way of dealing with this challenge from the perspective of Waldorf education. (15)

In the third lecture of his course on agriculture (CW 327), Rudolf Steiner describes certain individual elements from the perspective of spiritual science, an approach that is also essential to instruction in the Waldorf Schools. The relevant excerpt, which includes these outstanding examples and also serves as the transition to protein chemistry in grade 12, has been included in the Reader at this point. (16)

II.6: Grade 12

An overarching theme encompasses all of the subjects in each grade in the Waldorf School. In grade nine this theme could be called "revolution and upheaval," in grade ten "polarity and potentization," in grade eleven "the individual and his/her connection to the whole, to the world," and in grade twelve, "overview and conclusion." (The Waldorf School ends with grade twelve, although in some cases a thirteenth grade is added to meet national graduation requirements.)

These themes are also evident in Steiner's indications with regard to teaching chemistry in Grades nine, ten, and eleven. In grade twelve, finding an overarching theme becomes significantly more difficult. By the end of grade eleven, the students have still learned relatively little about organic chemistry (in the conventional sense) and have barely encountered structural formulas and the chemistry of modern technological processes. In addition to reviewing and summarizing the contents of earlier grades, therefore, a number of new topics must also be tackled.

Steiner's indications with regard to grade twelve are relatively extensive, which also has to do with the fact that in his time (as is also the case still today) the need to prepare for graduation exams had to be taken into account. Even today, the following excerpts are frequently taken as the starting point for twelfth grade chemistry instruction: "For the present, you must attempt to bring chemistry to some kind of conclusion …. An overview of geological formations (types of stone, fossils) up to the Ice Age … the nature of organic toxins, alkaloids, and some concept of cyanogen compounds in contrast to hydrocarbons. Here we need the qualitative connections. It can all be understood entirely on the basis of qualitative connections." "If we were to use three-dimensional formulas, then at least it would make sense. Usually, formulas are written in two dimensions and are meaningless." "Let us consider chemistry in intimate connection with the human being…That would mean going all the way up to processes that are found not only in animals but also in human beings. We would need to talk about ptyalin, pepsin, the formation of pancreatin, and so forth. – We must approach the metal processes in the human body as further developments of the basic metallic principles, but we must show that all substances and processes are completely transformed inside the human body. For example, we must identify a "lead process" in the human body so that [the young people] understand it. With regard to pepsin production, we must begin again with the production of acid as the lifeless manifestation and then consider pepsin formation as something that can happen only within the ether body – and in fact, even the astral body must play into it. In other words, the process must be completely laid bare and then built up again. We must start over again with lifeless hydrochloric acid, whether obtained from table salt or through synthesis, and discuss its properties. Then we attempt to evoke a sense of how it differs from what can happen only in the living, organic body. These considerations must then culminate in the differences among plant, animal, and human proteins – in other words, in a concept of ascending types of protein grounded in the differing structures of the ether body. Human protein is something different from animal protein. … Chemistry would actually need to include inorganic chemistry, organic chemistry, animal chemistry, and human chemistry. … [And as a further example:] “The formic acid/oxalic acid metamorphosis." “We would need to begin with the rhythm of worlds, to explain the periodic system on the basis of cosmic rhythm. … For example, the relationship of hydrogen to oxygen is something like an octave, but that would lead us too far afield.” And a separate Technology block in grade twelve is to cover the chemical processes of in greater depth and in connection with the most important factors in the global economy. [All from (4)]

The grade twelve topics, therefore, are very demanding and multi-faceted, and they repeatedly pose great challenges even to Waldorf teachers with years of experience. As yet, no one has come up with a time-tested written proposal for the entire grade twelve chemistry block such as we have available for grades seven through ten. Nor do the materials included in the Reader produce a coherent picture of both a multi-faceted approach and a unified thrust, as was the case for grade eleven. For grade twelve, there are essays available on some of the above-mentioned topics and, just recently published, a very broad approach by Ulrich Wunderlin (17). In my experience, experiments involving the formic acid/oxalic acid metamorphoses are especially important and informative with regard to Steiner’s call to make a distinction between plant and animal chemistry, which is why Mackensen’s concise and practical description (18) as well as the considerations of Frisch (19) have been included in the Reader. I must emphasize that the booklet of Mackensen (18) from which these few pages were excerpted also include additional essential material on this topic as well as on the lead process mentioned by Steiner.

In conclusion, I will attempt a brief summary of my own approach to the twelfth grade block. Because I also teach biology and chemical technology and because the state guidelines for secondary school graduation in Germany require considerable knowledge of both biochemistry and genetics, I combine my subjects in an attempt to take advantage of synergies resulting from the increased number of class hours. For example, I can then take Steiner’s indications on protein as guidelines for a combined approach to both chemistry and biology. I use protein digestion experiments to deal with the topics of hydrochloric acid, ptyalin, pepsin, and pancreatin (trypsin). At the end of this digestive sequence, we arrive at the amino acids. Similarly, I have the class conduct experiments using restriction enzymes and gel electrophosphoresis to break down DNA. Amino acids and DNA form the starting point for a discussion of protein biosynthesis. We then move from peptide bonds to different protein structures (primary, secondary, tertiary, and quaternary structures). The spatial consequences for protein structures offer a starting point for the step from written structural formulas to the more realistic spatial conceptions Steiner calls for (see above). The specificity of individual proteins (in the context of the immune system, for example) offers opportunities to identify distinctions between human and animal proteins. In contrast, I deal with the topic of plant protein in conjunction with the Papilionaceae (legumes), which in many respects represent one of the few – and one of the most important – means by which inorganic nitrogen from the air gains access to the biosphere. This example, which I like to introduce using Goethean exercises in plant metamorphosis, not only illustrates the specific biochemical potentials of plants but also delineates them from animal potentials, especially with regard to different proteins but also in relationship to other substances. At this point it is helpful to heavily emphasize the difference between active, process-related proteins (enzymes) and structural proteins (including storage proteins). – For more details on this sketchy outline, you are welcome to contact me at the e-mail address listed below.

II.7 Conclusion

In my view, a short lecture by Rudolf Steiner, given at Eugen Kolisko's request in a faculty meeting of the Waldorf teachers of that time, makes it very clear what Steiner expected of Waldorf teachers in terms of their knowledge of chemistry in relationship to their job as educators. Because this lecture touches briefly on all the topics covered in teaching chemistry in the Waldorf schools and provides an immediate practical context relevant to all of us as Waldorf teachers, it seemed very suited to rounding out and concluding the material presented in this Reader. (20)

III Thanks

This Reader could not have come about without the financial support of the Software AG Foundation (for the German, Russian and English version) and the Mahle Foundation (for the Spanish version), to whom the international Waldorf School movement is greatly indebted; let me herewith offer sincere thanks on behalf of us all. I am also extremely grateful to the Freunde der Erziehungskunst ["Friends of the Art of Education"] for offering crucial assistance in carrying out the project. My very personal thanks go to Professor Dr. Dirk Randoll, to Alexander Lerch and to Eleonore Jungheim, my project advisers at the Software AG Foundation, the Mahle Foundation and Friends of the Art of Education, respectively, without whose competent support I would not have been able to compile this Reader.

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IV Acknowledgements

<u>The Russian translations were undertaken by:</u>

Maria Babkina, Moscow, Russia: Kolisko, "Developing and Shaping Science Instruction in the Waldorf School" (3); Steiner lecture of September 22, 1923 (5); Heuschkel on electrolysis (11); Mackensen on chemical formulas (15).

Oleh Faliy, Dnepropetrovsk, Ukraine: this introduction to the Reader; Kolisko, "First Lessons in Chemistry" (3); Julius on grade eight (6); Mackensen on grade nine (7); Rohde on grade nine (8); Julius on grade ten (9); Ott on electrolysis (12); Schad (13); the periodic system as cited by Kipp (from 12); Mackensen on formic and oxalic acid (18).

All of these translations except 10, 16 and 20 were cross-read by Ksenia Kudrenko, Dnepropetrovsk, Ukraine.

Russian translations of three out of four Rudolf Steiner's lectures (texts 10, 16 and 20) were already available:

- The lecture of April 18, 1921 was translated by Olga Vartazaryan. It is reproduced here with the kind permission of the publisher of volume 313 of Steiner's complete works in Russian; the agreement was facilitated by Sergey Ivashkin, Samara, Russia.

- The course on agriculture (CW 327), translated into Russian by Maria Zhemtschuzhnikova and Alexandr Demidov, was published in 1997 by Nikolay Banzeliouk, Kaluga, who kindly permitted the inclusion of the third lecture into this reader.

- The lecture of February 6, 1923 was translated by Michael Sluch. It is reproduced here with the kind permission of the publisher of volume 300b of Steiner's complete works in Russian; the agreement was facilitated by Sergey Ivashkin, Samara, Russia.

<u>The English translations were undertaken by:</u>

Catherine Creeger, Ithaca, New York, USA: the introduction to this reader; both Kolisko essays (3); Rohde on grade 9 (8); Heuschkel on electrolysis (11); Ott on electrolysis (12); the Schad-article (13); the periodic system as cited by Kipp (from 12). Peter Glasby †, Wights Mountain / Brisbane, Queensland, Australia, assisted Catherine Creeger's translations.

Diederic Ruarus, Littelton, New Zealand, and Martyn Rawson, Elmshorn, Germany: Mackensen on chemical formulas (15); Martyn Rawson, alone: Mackensen on formic and oxalic acid (18); Dirk Rohde: Frisch on oxalic and formic acid (19).

English translations of the remaining seven articles were already available:

- The three Steiner lectures of September 22, 1923 (5), April 18, 1921 (10), and June 11, 1924 (16) have been published on the internet (wn.rsarchive.org/GA/GA0350, wn.rsarchive.org/GA/GA0313, and wn.rsarchive.org/GA/GA0327). They are being used for this Reader with the kind permission of Jim Stewart, e.Librarian.

- An English translation of the essay by Julius on grade 8 (6) was published years ago by the Steiner Schools Fellowship in Great Britain in the volume "The World of Matter and the Education of Man" (undated). The issue of copyright has not been definitively resolved. Thanks to Verlag Freies Geistesleben, Stuttgart, for the loan of the volume.

- Mackensen's contribution on grade 9 (7) was translated into English by Peter Glasby † and published in "Phenomenological Organic Chemistry" in 2009 by the Pedagogical Section of the Anthroposophical Society in Australia. Peter Glasby has generously made the translation available for inclusion in the Reader.

- The English translation of the essay by Julius on grade 10 (9) was published by the Association of Waldorf Schools of North America in the book "Fundamentals for a

Phenomenological Study of Chemistry" in 2000. It is reproduced in the reader with the kind permission of David Mitchell † of AWSNA Publications on the proviso that it be identified as copyrighted material made available by the publisher.

- The English translation of the Steiner lecture of February 6,1923 (20) was published by Anthroposophic Press, USA in 1998 in "Faculty Meetings with Rudolf Steiner, vol. 2." It is reproduced in the Reader with the kind permission of Gene Gollogly, Anthroposophic Press.

The Spanish translations were undertaken by:

Lia Tummer, Buenos Aires, Argentina: both of the Julius essays (6, 9), Rohde on grade 9 (8), Heuschkel on electrolysis (11).

Miguel Lopez-Manresa, Valparaiso, Chile: this introduction to the Reader, both Kolisko essays (3), all four Steiner texts (5, 10, 16, 20), all three Mackensen texts (7, 15, 18), Ott on electrolysis (12), Kipp's periodic table (from 12), and the Schad article (13).

Angel Chiok, Dornach, Schweiz: Frisch on oxalic and formic acid (19).

References:

(For practical purposes, these references are listed in the order of their appearance in the introduction to this Reader, rather than in alphabetical order.)

1: Cited in: Press release of 2009.03.24 by the Landesarbeitsgemeinschaft der Freien Waldorfschulen [State Consortium of Independent Waldorf Schools] in Hesse; business offices: Hügelstraße 67, D 60433 Frankfurt, Germany

2: Cited in: Press release of 2009.03.06 by the Bund der Freien Waldorfschulen [Association of Independent Waldorf Schools]; business offices: Wagenburgstraße 6, D 70184 Stuttgart, Germany

3: The Kolisko essays "The Development and Design of Science Instruction in the Waldorf School" and "First Lessons in Chemistry" have been taken from: "Auf der Suche nach neuen Wahrheiten", Philosophisch-Anthroposophischer Verlag am Goetheanum, Dornach 1989. They are reproduced here with the kind permission of the publisher. A new German edition of the book is in preparation and other works (in German) by Eugen Kolisko are also available from the same publisher.

4: All lesson plan indications are as cited in: E. A. Karl Stockmeyer, "Angaben Rudolf Steiners für den Waldorfschulunterricht" [Rudolf Steiner's Indications for Instruction in the Waldorf School], published by the pedagogical research center of the German Waldorf School Association, Stuttgart 1988

5: Rudolf Steiner, "On Nutrition," from "Cosmic Workings in Earth and Man" (CW 350), lecture of September 22, 1993. This translation is available online at www.rsarchive.org and is being used for this Reader with the kind permission of Jim Stewart, e.Librarian.

6: Frits H. Julius, “Grundlagen einer phänomenologischen Chemie. Teil 1: Zum Chemieunterricht der Mittelstufe” [Foundations of a Phenomenological Chemistry. Part 1: Teaching Chemistry in the Middle School] © 1960 Verlag Freies Geistesleben GmbH, Stuttgart. It is reproduced here with the publisher’s kind permission and preferred format for indication of source.

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