# Science and Mathematics Group of the Anthroposophical Society in Great Britain Newsletter – Spring/Summer 2019

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### Reports

# The Mercury Relationships in Space and Time Notes from a presentation at the Sacred Mathematics and Seven Liberal Arts Festival 21st January 2019

Mercury, like Venus, alternates between being an evening and morning star. Near the sun and so present through most of each day, the planet only appears to our sight fleetingly at twilight, before sunrise or after sunset. As the sun culminates higher through Spring to Summer we can imagine the orbiting Mercury makes an ascending spiral as he passes infront and then behind the sun through his orbit. This spiralling ascent led to the image known as the staff of Mercury, and the Hermes Caduceus .



Fig.1 An Alchemical Drawing of the Staff of Mercury which reflects the spiralling ascent of Mercury at the Sun's midday position.

People of earlier times than our own clearly worked out this ascending and spiralling relationship of Mercury around the Sun. With the help of modern technology, and ephemirides calculated by NASA, we can construct a diagram of the Mercury positions over the course of one earth year that older generations must have imagined from their twilight observations.



Fig. 2 Mercury relative to the Sun over the course of one year as seen from the earth. The dynamic form is diffeent from year to yearbecause of the inclination of the Mercury orbit relative to our own. The morning star period is to the right of the sun, and the evening star period is to the left. The first of the month is indicated by the numbers. The width of the picuture is about  $20^{0}$  east and west: Sin<sup>-1</sup>(2/5).

The next drawing shows exactly the same movement, for the same year, as in the above but takes into account the ascending and descending of the sun-its changing declination- through the seasons, which is represented by the central lemniscate. It is worthwhile following in your imagination the spiralling motion before and behind the sun. A comparison of the two pictures reveals how astronomical representations always give a relative perspective by selecting the context of observation as well as the observer position, ignoring some movements while representing others. The first is a planetary observation from earth, whereas the second has geographical perspective as well : it could be accurately constructed by identifying the position of Mercury ( for example with a smartphone and an astronomy app!) at midday by clock time every day for a year. It is a most directly phenomenological view from our position on earth.



Fig. 3 This is taken for the year 1963 and copied from Miovement and Rhythmn of the Stars by Joachim Schultz. It is a rarely available perspective even though it would be a natural result of direct observations if the sun were not so bright. Every year has a uniquely different spiralling form.

The drawing to be attempted will also be earth-centred but it will be from a wider perspective which takes into account the directiion to the stars. Astronomy in the scientific age has concentrated on spatial distances and these will also be included in the drawing. The transitions between evening to morning star periods happens at so called inferior and superior conjunctions with the sun- these are closest and furthest points of Mercury to the earth. The ratio of distances from us to Mercury at these pivotal points are around 3:7. By sun centred reasoning this leads to the ratio 2:5 for Mercury and Earth orbital radii. These ratios are shown in the diagram which gives the proportions for the drawing and movement of the Mercury relationship.



Fig. 4 The Mercury-Earth-Sun Metrical Relationships. Distance to earth at inferior and superior conjunctions are in the ratio of 3:4. The ratio of earth's and mercury's orbital radii is 5:2. The markers represent a distance of 0.2 A.U

These ratios are reasonably accurate given the inherent variability in the distances. Especially in the case of Mercury, we are dealing with ellipses rather than circles, and there are also inclinations to the ecliptic plane for example, and rotating nodes of intersection. The whole number ratios are certainly accurate for the purposes of constructing the orbit on a piece of paper and still have some validity in Bode's law with its indisputable predictive capacity. The average semi major axis of the orbit of Mercury is 0.387 rather than 2/5 or 0.4 astronomical units.

Integer ratios are more natural when we look at ratios in time rather than space because our experience of time is of complete cycles: days, months or years for example. There are 3 complete "synodic" cycles of Mercury , each containing a morning and evening star period, in 1 earth year, and in 4 Mercury years. One of these numbers is perfectly integral, because it is a complete cycle. Any difference from integer values in the other two numbers will be measured in integer values of other cycles of astronomical time. Whenever one orbit or set of events completes, there is always an interlude before the completion of the other cycle. The interludes give expression to the progression in the repeating rhythms.

This sequence 3, 1, 4, is a natural arithmetic sequence : 3 plus 1 equals 4 and this summation is the key to all epi-

cyclical movements. With Venus, there are 5 synodic cycles in 8 earth years and 13 Venus years. The fact that in this latter case, 5,8,13, the numbers form part of the Fibonacci sequence, belongs to the particular harmonic form of the Venus –geocentric orbit. 3,1,4 also has its geometric elegance as we shall see.

Cassini was possibly the first to draw these movements of Venus and Mercury geocentrically: , although he may also have found similar by Kepler.



Fig. 5 Drawing from Cassini of the geocentric orbits of Venus and Mercury over a period of 8 Earth years for Venus and 7 Earth years for Mercury. Note the overlap of Mercury loops at the 8 o'clock position-letter B.

More precisely, in days rather than in years, a synodic cycle of Mercury is 116 days on average.( The range is from 104 to 132 days in individual cases) and a Mercury orbit around the sun takes 88 days.

3X 116 = 348 days and 4X88 = 352 days. Both fall just short of one earth year, and this difference brings about a movement in successive cycles, both in the calendar and against the background of the resting stars. 7 years brings about a complete form in the zodiac as seen in fig 5, and after 46 ( almost 7<sup>2</sup>) years all Mercury phenomena return with a delay of only about one day. This 46 year period was known by Hipparchus and Ptolemy and was used as a basis for medieval planetary ephemerides in the Alphonsine tables in Spain in 1252 AD. There is an impressive interlocking of Lunar rhythms with those of Mercury. 3 Months : 3X 29.5 = 88.5 days and 4 Months : 4X 29.5 = 118 days. A single evening or morning star period is 2 months; there are 3 months in a sidereal rotation of Mercury, and 4 months for a complete synodic cycle. This lunar synchronisation is certainly an aid to anticipating direct observation of this elusive planet.

It is possible to look at all these space and time interrelationships and put them alongside the forms and growth of flowering plants, especially the monocotyledons, many of which accomplish their growth and flowering within the first 4 months of the year. This presentation is concentrating only on the mathematical and geometric aspects.

The great Johannes Kepler brought together the ratios of both time and space. As space is three dimensional, and ancient traditions spoke of the harmony of the spheres, he cubed the space ratios of sun-planet distances:  $(2/5)^3$ = 8/125. Then he compared a Mercury year in Earth years with an Earth year in Mercury years- a genuinely mutual comparison of time cycles 4:1/4= 16. The product of these two ratios is approximately unity:

16X 8/125 = 1024/1000 = 1.024 and if we use the more accurate measurements, we get even closer to unity:  $0.387^3$  X  $(365/88)^2=0.997$ . A similar calculation Kepler was able to show was true for any pair of planets: it is a mathematical law governing the whole solar system. Kepler's Third Law, expressed simply above, was absorbed into Newtonian Mechanics and its nearly perfect accuracy is presumed today as part of the law of Universal Gravitation. I am of the opinion that its discovery by Kepler was through the thinking outlined above. Later work discovered that Mercury, among all the planets, shows the only significant deviation from Newtonian Mechanics. Einstein's idea to explain this deviation is that the framework of space and time (our metric Cartesian grid) is altered in the vicinity of the sun, and this gives extra fluidity, to the motion of the swift inner planet.

To draw the form of Mercury's orbit relative to the Earth and with the resting stars behind, we need to rotate a point on a circle 3 times while its centre moves once around a second circle drawn in the centre of the paper. As is clear in fig 4, the first circle-representing Mercury's orbit around the Sun- will be 2:3 in radius of the second centred on the Earth. ( 4cm and 6 cm radii for example) We accomplished the relative rotation rate by dividing the 4cm circle into  $12 \ 30^{\circ}$  sectors and cutting this out. The second circle, drawn on the page is divided into 36  $10^{\circ}$  sectors. Radiating the latter divisions out across the page gives us a simple framework for accomplishing the epicyclic rotation. Nowadays you can use computer drawing software but it is more artistic to do the sketching yourself. (With Venus the same process involves rotating an octagram around a pentagram.)

What are we doing when we draw the solar system on paper like this? We are showing a relationship in space which is true in terms of relative distance and direction to the zodiacal circumference. It is a scale drawing, and mathematicians know that form is preserved through any scale of enlargement so we can say that the form of the Mercury movements is expressed in our picture. It is easy to approximate the picture on the dance floor and to make the loops around the trigon. If you begin with a hexagram and extend alternate points appropriately, then one cycle curves from superior conjunction into the next adjacent point -inferior conjunction and then outward again. The loop is easy to step and its form seems to fit with the polite greeting you make with the person representing the Earth in the centre. Enthusiasts can put the sun into the dance, and then as the sun moves around the earth, ( i.e. through the Zodiac) Mercury accomplishes her elegant epicyclic curve around the earth while moving in an ordered circle around the sun. A ribbon of appropriate length will express the Sun's steady regulation of the orbit which is represented in Fig. 6 by the dashed line. The picture can easily be scaled up and would suit 7 dancers or 9 just as well as 2 or 3. There is a stimulating suggestion by Rudolf Steiner in the foundation course for teachers lecture X : "Now, as human beings, our purpose is to imitate, to absorb the movement of the world into ourselves through our limbs. What do we do then? We dance. This is true dancing. Other dancing is only fragmentary dancing. All true dancing has arisen from imitating in the limbs the movement carried out by the planets, by other planetary bodies or by the earth itself."

Movement is generally acknowledged to be the secret of all the therapeutic arts. What Mercury teaches us is the gift of flexible movement: movement in thinking, feeling , and willing, movement in movement itself. In every situation we can be aware of the capacity to move with the situation, creatively even when in accord with lawfulness, flexibly even when time and space, past and present, seem determinedly fixed.

#### Alexander Murrell

# Universal Forces in Mechanics: The work of George Adams

Report from the Seminar held February 22nd to 24th at Wynstones School

This seminar was well prepared by Charles Gunn with extra input from Gordon Woollard and Pat Toms.

I will not try to recap the content which would not be easy or very digestible in the end I suspect, but I would like to say how well the process seemed to work. The lectures by Rudolf Steiner which George Adams had



Fig. 6 A sketch of the geocentric orbit of Mercury over one earth year. Notice the fourth loop falls just short of the first loop in the Trigon, corresponding to the 18 days short of one whole year. By using rounded off ratios the closed form can be obtained, although closed forms do not exist in our dynamic solar system. The dashed line represents the sun's rotation through the zodiac.

drawn on were suggested as preparation material and we also spent a good amount of time working with these in the seminar. This was very stimulating when we approached the realm of statics and imagined approaching bridge design for instance. We played a lot with strings and with our group dynamics, all in good humour!! The collaborative endeavour after individual preparation really seemed very fruitful.

We were a small group but I believe we all felt we progressed together in grasping the fundamental aspects of these things in a fresh way. I do hope we can build on this in future meetings.

Simon Charter

### Courses

### **Forming and Fluidity**

How can flowing water help us develop a more dynamic way of thinking.

A **Workshop** / **Symposium** working with the archetypal forms of flow by means of simple yet profound experiments with water .

# June 7<sup>th</sup>-9<sup>th</sup> 2019 at The Field Centre Nailsworth GL6 0QE

We are interested to explore how interactive experiences of fluidity and fluid formative processes work with us as experimenters in our thinking, feeling and will. The guided sessions will be collaborative, and include the harvesting of participants' experiences. In this way, we would like the event to lead on to further educational work in the future, aiming to improve ways of displaying and engaging participants with fluidity. We have in mind possible future public exhibitions and workshops, and we hope that participants of this workshop may consider joining such an enterprise. We see the work as growing out of Goethe's approach to morphology, applied to forms arising through flow, as was studied and illustrated by Theodor Schwenk in the 1960s (ref Sensitive Chaos published Rudolf Steiner Press). However there are also opportunities to link in to 2 other fields: firstly to the path curves revealed in projective geometry which can also help develop imagination and other faculties in the thinking (ref Vortex of Life, Lawrence Edwards, pub Floris books), and secondly to the art of creating vessels for flowing fluids especially Flowform sculptures which are often designed in a conversation with flowing water and where, through engaging feeling and will, one can become more attuned to the flow (ref Flowforms by John Wilkes pub Floris Books).

For the co-ordinating group Simon Charter MEd, (Flow design, flow research and education) Natural Science Group UK , Dr. Philip Kilner MD, PhD (Heart flow research and morphology), Emerson College UK,

Eva Wohleben (Art and morphology), Institute of Flow Sciences, Herrischried Germany

Nigel Wells ( lowform design, water education) Virbela Atelje, Jaerna, Sweden ,

Dr. David Auerbach, (Biophysics, Fluid dynamics, meditation workshops) Lecturing at Weingarten University, Germany.

The event will run from

Friday 7th June 9am to Sunday 9th lunchtime

The interactive research approach for the weekend will be introduced and then our programme has been woven together to include

:- **Dropping into vortices**-Hands on experiments in various vessels with guidance for active participation, :- **Modeling and meanders**- working with flowing water in a clay channel which can be shaped collaboratively to explore a variety of flow possibilities

:- **Moving revelations**, demonstrations of flow phenomena on smaller and larger scales

:- "Deeds of the flow: Understanding, Responsibility, Stewardship of the organism Earth" - A presentation on some aspects of our relationship to water in the world.

Later we will practice more focused **contemplative engagement** with the various phenomena which we have met experimentally.

- **experimenting with the flow** to explore the full range of possible flow phenomena with the equipment.

- **breathing out** with some playful activities

-Conversations in search of new insights and common understanding in the phenomena we have been observing. Explorations of the transformative potential of flow in educational work.

**-The collecting of ideas and initiatives** to develop this work into the future.

#### Costs

Full cost is £ 175 (concessionary rates can be considered if required: please ask) Booking deposit £50

The event is organized by the Mathematics and Science Group of the Anthroposophical society in Great BritainMore information please contact Simon Charter Telephone 01453 836060, evenings 01453 882114. mobile 07814 786682 Email: simon.charter@live.co.uk



# Geometry and Mathematics meeting February 2020:

Next year's Geometry and Maths meeting will take place at Field Centre February 20-24th 2020. Please contact Simon Charter with initiatives or interests you wish to pursue.

Email: simon.charter@live.co.uk, 01453 882114.

### Grants

### Science and Mathematics Group Funding: Call for Applications

We are pleased to announce that small grants are available to members of the Science and Mathematics Group. We can contribute to projects and travel costs (e.g. to conferences). Please contact the treasurer Simon Charter, with a brief proposal outline and a breakdown of costs. simon.charter@live.co.uk, 01453 882114.

### **Publications**

The following are summaries of three articles by *J. Duncan Keppie*, 2367 Ridge Road, Wolfville, Nova Scotia, B4P 2R3, Canada. johnduncankeppie@gmail.com Full versions are available at https://www.anthroposophy.ca/en/research/

# The Rock Cycle: the rocks are alive: if only we could "hear" them, what have they to tell us?

### Summary

This article attempts to elucidate what rocks are telling us, amongst which are:

(i) they are alive;

(ii) they strive for balance between opposites (polarity), an important factor in physical creation;

(iii) they strive for perfection culminating in a single DNA-like helix, i.e. intensification;

(iv) their evolution progresses towards increasing complexity and diversity, more sharing, cooperation, accomodation, and flexibility, and overcoming higher repulsion creates stronger bonds;

(v) warmth/love creates an environment for creativity. The Rock Cycle exhibits: (a) directionality, (b) Spirit Beholding and Spirit Recollection, and (c) Heredity following the First Karmic Law.

Each reader is encouraged to elucidate what the rocks are saying.

### The Body, Soul and Spirit of the Earth

#### Summary

The Goethean method involves discovering the dynamic processes (metamorphosis, transformation) involved in various cycles (e.g. plant, animal and rock cycles) that are hidden beneath successive layers (or veils), the outer one identified by the senses. In this context, a comparison of Steiners' threefold subdivision of the Earth and current natural science subdivisions reveals the following (terms: <u>Steiner underlined</u>, natural science in **bold**, *italicized introduced here*):

(1) <u>FIRST VEIL: MINERAL</u> = surface rocks, soil, water = *beauty*;

(2) <u>SECOND VEIL: BODY: World of Nature Spirits</u> that produces the Forces of Nature = **solid litho**-

sphere+plastic asthenosphere = wonder: these use the etheric, natural, life forces to produce archetypal processes, such as weathering, crystallization, plate tectonics, metamorphism, and melting that produce the various stages in the rock cycle, e.g. magma, igneous, sedimentary and metamorphic rocks;

(3) <u>THIRD VEIL: SOUL: Spirits of the Rotation of</u> <u>Time, which orchestrate the Laws of Nature emanating</u> <u>from the astral, soul forces</u> = **viscoelastic mesosphere** = *renewal*: this is created by additional archetypal processes (rhythmical mantle convection and plumes, and ring vortices that involve heat, radioactivity, and boson transfer);

(4) <u>SPIRIT: Planetary Spirit (Ego) from which arise the</u> <u>Meaning of Nature</u> = **liquid and solid core** = *love:* wherein lie archetypal processes, such as gravity and magnetic energy fields involving the exchange of elementary particles, gravitons and photons, respectively gravity drives convection, plate tectonics and holds the planet and its' atmosphere together, whereas magnetism provides a balance between earth and solar energy/radiation.

Lovelocks' Gaia hypothesis posits that the biosphere regulates the Earths' atmosphere, however with advent of the Anthropocene Era the balance is being upset by humans, who are rapidly changing the atmosphere, hydrosphere, biosphere and lithosphere producing massive extinctions – can humans curb this trend? This will require re-awakening knowledge and love of the Earth, the only living planet in our galaxy. Possible green solutions include primal energy sources, which include deep geothermal energy and artificial photosynthesis using cyanobacteria, the latter used as a natural fertilizer and food supplement.

#### Found? The lost continents of Atlantis and Lemuria

### Summary

During the late 1800's and early 1900's following Plato original ideas, the lost continents of Atlantis and Lemuria were envisaged by Steiner and Scott-Elliot to have lain in the Atlantic and Indian oceans, respectively. These lost continents appear to be substantiated by modern geological research: (i) the Atlantic Ocean was formed by Mesozoic and Cenozoic motion of the plates away from a central ridge, the mid-Atlantic Ridge, which dispersed fragments of the super-continent, Pangea ( $\equiv$  Atlantis): and (ii) a slab, the southeast Indian Slab ( $\equiv$  Lemuria) that lies in the mantle beneath the Indian Ocean, was

### The Seat of the Soul: Rudolf Steiner's Seven Planetary Seals by *Yvan Rioux*

How are the internal and external forms of the human organism shaped? How does human consciousness emerge? These are questions to which conventional science has no answers. In The Seat of the Soul, Yvan Rioux invites us to consider new concepts that can explain these phenomena. His exposition is based on the existence of external 'formative forces' – or morphic fields – which, he argues, create the human body or organism in conjunction with forces that resonate within us from the living solar system. The psyche – or soul – emerges progressively as an inner world of faculties that in time learns to apprehend and understand the outer world.

In his previous book The Mystery of Emerging Form, Rioux explored the formative forces of the twelve zodiacal constellations. In this absorbing sequel, he investigates how such activity from the planetary spheres works within us, as 'life stages' or metabolic processes. Through seven chapters, he explores the impact of each of these planetary spheres on our complex organic makeup and psychic activity. The link between organs and tissues, he says, produces five specific 'inner landscapes' in relation to the external rhythmic environment. Rioux also gives a description of Rudolf Steiner's seven 'planetary seals' from a biological perspective. According to Steiner, these seals are: '...occult scripts, meaning that, as hidden signatures, they show their ongoing etheric impacts on the seven stages of our metabolism'.

Between Steiner's indications concerning human physiology and the ancient Chinese view on the subject, there is a convergence of ideas – as synthesized here – that breaks through the boundaries of modern reductionist science, offering exciting perspectives for understanding the human being.

YVAN RIOUX was already a keen naturalist as a boy, taught by Christian Brothers and Franciscans. He studied biology at Montreal University, but it left him cold as it didn't touch anything that was alive. Working for ten years as a biodynamic farmer in Quebec, however, he encountered living ecosystems. Later, in Montreal, he taught on the relationship between human physiology and nature. In 1992 he moved to England with his two boys and joined a family of two girls and their mother, Gabriel Millar, who became his muse. Retiring ten years ago, he decided to write about his knowledge gained from 25 years' of teaching experience, culminating in his previous publication, The Mystery of Emerging Form.

Available from booksellers or direct from: Booksource, 50 Cambuslang Road, Glasgow, G32 8NB. Tel 0141 643 3961. Email: orders@booksource.net

# Membership

# Note from the Treasurer and Membership Secre-

**tary**. The subscription for membership of the Science Group (including receipt of Newsletter) stands at  $\pm 10$  per year. If you have not already done so, please update your standing orders and let me know when this is done. I can still accept cheques but the local bank has closed so paying cheques in is more difficult. Standing orders or direct payment are preferable.

Our account is "The Science Group" Sort code: 20-23-97 Account No. 90800007 with Barclays.

Membership subscription is £10 (UK), £12 (Europe) or £14 (elsewhere). For all membership and subscription queries please contact Simon Charter, simon.charter@live.co.uk, 01453 882114.

### **Next Issue**

This newsletter is issued to members twice each year. There is no set date for the next newsletter. Please set copy to Dr. Judyth Sassoon, School of Earth Sciences, University of Bristol, Queen's Road, Bristol, BS8 1RJ. Tel: 00 44 7811 323658 Email: js7892@bristol.ac.uk

Science Group web site: http://www.sciencegroup.org.uk

## Articles

# Rudolf Steiner, the Ice Age, and the Year 1250Rudolf Steiner's Occult History

# (Please note Figures 2 and 3 may be found at the end of this article)

There are several occasions when Steiner relates the most recent Ice Age to the disappearance of Atlantis, and links these two events to the precession of the equinoxes. In lecture 5 of the cycle "Occult History" for example, [GA 126, lecture given in Stuttgart on 31/12/1910.] Rudolf Steiner said the following:

Between the old influences in the Atlantean epoch and those in the Post-Atlantean, there was a boundary-period filled by the Atlantean catastrophe — by those events whereby <u>the face of the earth was totally changed in</u> <u>regard to the distribution of water and land</u>. (die das Antlitz unserer Erde in bezug auf Verteilung von Wasser und Land total verändert haben) Such periods and changes consequent upon them are connected with <u>mighty</u> <u>processes in the constellation, position and movement of</u> <u>the cosmic bodies connected with the sun</u> (großen Vorgängen in der Konstellation, in der Lage und Bewegung der mit der Sonne zusammenhängenden Weltenkörpe). In fact, such periods in the earth's evolution are determined and directed from macrocosmic space. It would

lead too far if I were to attempt to describe to you how these successive periods are directed and regulated by what is called in modern astronomy the precession of the equinoxes. This is connected with the position of the earth's axis in relation to the axis of the ecliptic, with mighty processes in the constellation of neighbouring celestial bodies (großen Vorgängen in der Konstellation unserer benachbarten Weltenkörper); and there are definite times when, on account of the particular position of the earth's axis in relation to these other bodies of the cosmic system, the distribution of warmth and cold on our earth is radically changed. (eine ganz andere Verteilung von Hitze und Kälte auf unserer Erde vorhanden ist als sonst) This position of the earth's axis in relation to the neighbouring stars causes the climatic conditions to change. In the course of something over 25,000 years, the axis of the earth describes a kind of conical or spherical movement, so that conditions undergone by the earth at a certain time are undergone again, in a different form and indeed at a higher stage, after 25,000 to 26,000 years . . . .

And here, because it is of essential significance in the whole historical development of earthly humanity, we may point particularly to the fact that in the seventh millennium before Christ there was an especially important astronomical epoch - important because, on account of the constellation brought about by the relative position of the earth's axis to the neighbouring stars, the climatic conditions on earth culminated in the Atlantean cataclysm. This happened six to eight thousand years before our era, and the effects of it continued for long ages.

During this period the macrocosmic conditions worked into the physical in such a way as to bring about the mighty physical upheavals of the Atlantean cataclysm, which completely changed the face of the earth. This was the greatest physical transformation of all, the most drastic action of the macrocosm upon the physical earth.

As there is no geological evidence for 'mighty physical upheavals completely changing the face of the earth' at the end of the most recent Ice Age, nor for a global change 'in regard to the distribution of water and land' during this time, a question which may be asked is how Rudolf Steiner came to make these startling assertions. If the phenomena he describes took place in the physical world as recently as he said, geologists would certainly have uncovered traces of these events.

There are well documented cases of <u>local</u> catastrophes as the Ice Age glaciers slowly melted about 10000 years ago; for example, the Missoula Floods which occurred in the Columbia River basin in North America. These were the result of the breaching of an enormous ice dam more than 600 metres high. It was created by the retreating glaciers of the North American ice sheet, but repeatedly gave way, thereby again and again draining the huge glacial lake behind it. The immense floods scoured the Columbia Plateau as the water roared toward the Pacific Ocean, resulting in the so-called channelled Scablands in Washington State.

Analysis of ocean floor sediments have shown that the largest glacial lake in North America, Lake Agassiz, more voluminous than the Great Lakes combined, emptied catastrophically about 12000 years ago. A torrent of fresh water rushed into the Atlantic Ocean in an unimaginable cascade, creating a fresh water cap on the surface which noticeably slowed down the Gulf Stream. Temperatures in the Northern hemisphere dropped sufficiently to bring back Arctic conditions for about 1000 years [Known to climatologists as the Younger Dryas cooling event.].



### Figure 1

A recent example of such local cataclysms occurred in the Val de Bagnes in the Swiss Alps in June 1818. A lake more than a mile long had filled the valley behind an ice barrier formed by the Gietroz glacier. See Figure 1. Attempts were made to drain the lake by digging a trench through the ice, but the ice dam gave way before the work could be completed, and 18 million cubic metres of flood waters cascaded into the valley below. Fortunately, the local people downstream had been aware of the danger because a similar torrent had destroyed their village in 1595. Many were able to evacuate, but the flood waters still claimed 47 lives. The disaster motivated the engineer who had been in charge of the attempted diversion, Ignace Venetz (1788 – 1859), to make a careful study of local glaciers. His work would eventually lead to new ideas about the recent history of the earth. [Jamie Woodward (2014) The Ice Age, A very short Introduction, Oxford University Press, p.41.].

### Precession

A second question which may be asked is how precession of the equinoxes, and the 'mighty processes in the constellation of neighbouring celestial bodies are related to the global catastrophes described.

The equinoxes mark two special days, March 20 and September 22, on the earth's annual journey round the sun, when there are exactly 12 hours between sunrise and sunset all over the earth (equi-nox = equal night and day). The term 'precession of the equinoxes' is used by astronomers to describe the gradual year-on-year change in the position of the earth relative to the fixed stars of the zodiac on the day of the spring equinox. The equinoxes precess (from precede = to go before) because as the earth orbits round the sun, the 20<sup>th</sup> of March arrives at a slightly earlier position each year, a phenomenon as old as the solar system itself. The full cycle is completed after 25920 years, the so-called Platonic, or Cosmic, Year. The equinoxes (and indeed all the planets in their orbits round the sun) have been continually precessing since the solar system took on its present form, and its not clear how precession by itself could have altered the <u>'face of the earth' and the 'distribution of warmth and</u> cold' at the end of the Atlantean epoch.

### The Spirits of Form

What Steiner does explain is how during this time approximately 10000 years ago, certain spiritual forces (the Spirits of Form) were able to work most strongly on the changing physical (climatic) conditions on earth, thereby bringing about the Atlantic cataclysms. Their effect on the development of human consciousness was at a minimum, so that other, lesser, spiritual forces were able to exert their influence, and the human spirit had to partially withdraw from the earth for a time. It seems reasonable to conclude from this that the precession of the equinoxes somehow support the spiritual forces in the achievement of their goals.

Hence the influence from the macrocosm upon the spirit of man at that time was at its lowest; this epoch therefore provided an opportunity for Hierarchical Beings less powerful (than the Spirits of Form) to begin to exercise on man a potent influence, which then ebbed gradually away.

Steiner follows this with a suggestion that it is possible to imagine a time when the opposite situation comes about:

... when those who are cognisant of such a matter experience the reverse of these conditions - namely, the least influence upon the physical and the greatest influence, precisely of the Spirits of Form, upon the human spirit. Hypothetically you can conceive that there may be a point in history where the reverse of the great Atlantean catastrophe applies. Of course, it will not be so easily noticeable, for the Atlantean catastrophe, when parts of the very earth were blotted out, is bound to be a very striking event for people of our Post-Atlantean epoch, with their strong leanings to the physical. When the Spirits of Form are exercising a powerful influence on the human personality and have only a little influence upon what is taking place in the external world, the impression will be less vivid. The point of time when this condition - in the nature of things, less perceptible to men - set in, was the year A.D. 1250. The year 1250 is of momentous importance in history (ein außerordentliches, historisch wichtiges Jahr).

Steiner then presents historical evidence illustrating just how important the Middle Ages, and the year 1250, were:

That was a point of time especially adapted for conveying to mankind the mysteries which come to direct expression in the connection of the Spiritual with the working of Nature. Hence we see that this year 1250 was the starting-point of great and detailed elaborations of what was formerly only believed, only divined: it was the starting-point of Scholasticism, which is greatly undervalued to-day. It was also the starting-point of revelations which found expression in spirits such as Agrippa of Nettesheim (1486 - 1535), and which took effect most deeply in Rosicrucianism. This shows that if we want to search for the deeper forces of historical development, we must take into account conditions quite other than those outwardly in evidence. In point of fact, behind the things of which I have just been speaking there are also hidden the forces working, for example, in the waves and subsequent ebbing of the Crusades. The whole of European history, especially the flow of happenings between East and West is attributable solely to the fact that forces are at work behind the events, as I have now elucidated."

What had been perceived during earlier times as "spiritual reality behind the manifestations of Nature was forgotten, and attention began to be paid only to the manifestations of Nature. That is the modern mentality. Tycho Brahe (1546 - 1601) is one of the last of those who still grasped the reality of the Spiritual behind the data constituting the sciences of external Nature. Tycho Brahe was a truly wonderful personality, because with his supreme mastery of external astronomy he discovered thousands of stars, and at the same time he had such deep inner knowledge of the sway of the spiritual Powers that he could astonish all Europe by boldly predicting the death of the Sultan Soliman. We see how out of the spiritual nature-knowledge, which begins to appear in 1250 and is exemplified in Spirits such as Agrippa of Nettesheim, there gradually emerges what later on amounts merely to perception of the manifestations of external Nature; while the inner, the Spiritual, remains in that mysterious stream known to us as Rosicrucianism. Then the two streams flow on.

### The Medieval Renaissance

The late Middle Ages of European history have often been characterised as the Medieval Renaissance. Politically (the founding of free cities), economically (the establishment of craft and merchant guilds), and intellectually (the growth of free universities), the development of Western Europe during this time prepared the way for the later achievements of the Italian Renaissance, and the 17<sup>th</sup> Century age of scientific discovery. Contact with the Islamic and the Byzantine empires during the Middle Ages gave scholars access to the work of Greek and Islamic philosophers and scientists, especially the works of Aristotle (384-322 BCE), and later of his teacher Plato (428-348 BCE). Learning moved out of the monasteries and into newly established universities such as Bologna, Paris, Oxford, Padua, Vienna and Heidelberg, to name but a few. These provided the infrastructure on which the intellectual progress of Europe would be based.

**The climate too was different.** The research of climatologists has shown that Northern Europe and the North Atlantic experienced a small but significant increase in average temperatures between the 9<sup>th</sup> and the 14<sup>th</sup> centuries, a period known as the Medieval Warm Period. Reductions in both sea ice and land ice in the Arctic allowed the Vikings to travel further north than had been possible during earlier times. Greenland was settled by the Vikings in the 10<sup>th</sup> century, beginning with the voyage of Erik the Red from Iceland in 985. Ancient tax records show that grapes were grown in Britain in the 11th century.

The Middle Ages marked the beginning of an important development in the evolution of human consciousness, and it took place in a somewhat milder climate (at least in Northern Europe), contrasting with the Ice Age 'six to eight thousand years before our era', and the 'Little Ice Age' which followed the Medieval Age [A deterioration in the climate after the Medieval Warm Period led to the years between 1645 and 1715 being referred to as the Little Ice Age.].

This raises a third question: How can the year 1250 be understood as the 'point in history where the reverse of the great Atlantean catastrophe applies'? Taking this literally, it means that from this year on the Spirits of Form were able to redirect their attention from changes in global climate to the evolution of human consciousness.

Steiner is making the point that precession of the equinoxes, the 'mighty processes in the constellation of neighbouring celestial bodies', the global changes in the 'distribution of water and land' and the 'distribution of warmth and cold on our earth', are all related to the most recent Ice Age and the end of Atlantis. To emphasize the importance Steiner attached to these processes, here are two more passages from his lectures describing cosmic processes relating to Atlantis, the Ice Age and the year 1250 in the Middle Ages.

# Changes in Human Consciousness during the Middle Ages

In Lecture 6 of the Astronomy Course [GA 323, on 6 January, 1921] Steiner explains the "connection between what is going on in the life of mankind and the phenomena in the Heavens beyond the Earth"; specifically, how the "inner experiences which man on Earth was undergoing at that time, (i.e during the 13th Century) connected with the evolution of the Earth-planet altogether".

During the Middle Ages significant changes were taking place in human thought processes, a deeply "moving and stirring of humanity" was taking place. Moreover, these changes lay "in the very midst between two end-points in the scale of time". In Europe these end-points represent times during which human life was (and presumably will be) barely possible at all. For if we go back 10,000 years, and forward 10,000 years from the Middle Ages (at A, on Steiner's sketch) we reach the "maximum development of the Ice Ages" in Europe.



"Surveying therefore the evolution of these European regions we find an Ice Age — a laying-waste of civilization (Verödung der Kultur) — 10,000 years before the Christian era, and we should find the same again 10,000 years after this time. The deep stirring of human life, of which we have been speaking, happened midway between two such barren epochs."

Steiner then describes the precession of the spring equinox through the ecliptic in the course of a Cosmic Year.

"At the time we spoke of, when there was that deep stirring of the spiritual life in mankind, the spring equinox was entering the sign of Pisces. In the Graeco-Latin Age it had been in the sign of Aries, previous to that in Taurus, and so on. We get back to Leo or Virgo, more or less, during the time when glacial conditions prevailed over the greater part of Europe and in America too. Looking into the future, there will be another Ice Age in these regions when the vernal point reaches the sign of Scorpio. This rhythm is contained within what takes its course in 25,920 years. Although admittedly of vast extent, it is a true rhythm none the less.

### **Clairvoyance and Initiation**

Secondly, an extract from Lecture II of Steiner's book "The Spiritual Guidance of Man" [GA15, based on lectures given in 1911.). Here details of a more esoteric nature relating to the year 1250 are revealed. After 1250 it is no longer sufficient to be merely clairvoyant. In order for a clairvoyant person to draw correct conclusions from their spiritual experiences they must be initiated. Only initiation enables such a person to distinguish between the various kinds of super-sensible beings and events.

"In modern times the powers guiding humanity are faced by the special task of bringing about a balance between the two principles of clairvoyance and initiation. Leaders

of spiritual training had necessarily to pay attention to this at the beginning of the modern era. Therefore the esoteric spiritual movement which is adapted to present conditions, always makes a point of maintaining the right proportion between clairvoyance and initiation. This became necessary at the time when mankind was passing through a crisis with regard to its higher knowledge. That time was the thirteenth century. About the year 1250 was the point of time when mankind felt itself most shut out from the spiritual world. A clairvoyant looking back upon that period sees the following: The most eminent minds of that time who were striving after some kind of higher knowledge could only say to themselves: 'What our reason, our intellect, our spiritual knowledge is able to find out is limited to the physical world around us. With all our human endeavour and power of perception, we cannot reach a spiritual world. We only know of it by accepting the information concerning it which our forefathers bequeathed us.' This was the time when direct view of the higher worlds was obscured. That this can be said of the era in which scholasticism flourished, is not without significance.

About the year 1250 was the time when men were compelled to fix a boundary between what they were able to apprehend for themselves, and what they had to believe from the impression made upon them by the traditions which had been handed down. What they could find out for themselves then became limited to the physical world of sense. Afterwards, however, came the time when there was more and more possibility of again winning a view of the spiritual world. But the new clairvoyance was of a different kind from the old, which virtually became extinct just about the year 1250. In the new form of clairvoyance, western esotericism was obliged strictly to uphold the principle that initiation must be the guide of spiritual sight and hearing. This was the special task assigned to an esoteric current which then entered the stream of European civilization. As the year 1250 drew near there arose a new kind of guidance into the supersensible worlds.

This guidance was prepared by the spirits then guiding outer historical events, who centuries before had prepared for the kind of esoteric training which would become necessary by the conditions prevailing in 1250. If the term "modern esotericism" be not misused, it may be applied to the spiritual work of those very highly evolved personalities. External history knows nothing of them, but what they did is apparent in every form of civilization which has developed since the thirteenth century."

There can be no doubt that Steiner considered 1250 as a year of crucial importance for the evolution of human consciousness. It turns out that there was indeed an astronomical event round about the year 1250 CE, an event which provides answers to the three questions raised above. This event is described in an essay written by one of Steiner's high school teachers in 1879.

In the second chapter of his autobiography Rudolf Steiner mentioned an essay written by his geography and history teacher Professor Franz Kofler, entitled The Ice Age during the Diluvial Period and its Causes. [Die Eiszeit während der Diluvialperiode und ihre Ursachen by Dr. Franz Kofler, published in the Vierzehnter Jahres-Bericht der Nied.-Österr. Landes-Oberrealschule, Wiener Neustadt, 1879; reprinted privately by C. S. Picht, Stuttgart in 1927.]. He wrote that he had read the essay eagerly and 'had retained a living interest in the problem of the Ice Age'. [Rudolf Steiner An Autobiography (1977) p. 50, Rudolf Steiner Publications, Blauvelt, New York.].

The Ice Age problem was a relative newcomer to 19<sup>th</sup> Century natural philosophy and to the 'savants' (scientists) studying the natural world. Goethe had been one of the first to speculate on the origin of the huge blocks of Scandinavian granite (so-called erratics) dotted about on the North German plain, suggesting that they might have been carried there by large sheets of floating ice. He followed the ideas of Venetz and other Swiss glaciologists with great interest, and devoted a chapter [Book 2, Chapter 9.] to a discussion of the possibility of an ice age in his novel Wilhelm Meisters Wanderjahre, published in 1829.

[See for example Dorothy Cameron (1964) Goethe -Discoverer of the Ice Age,

https://www.igsoc.org/journal/5/41/igs\_journal\_vol05\_is sue041\_pg751-754.pdf

and W. Engelhardt (1999) Did Goethe discover the Ice Age?

https://www.researchgate.net/publication/291794935\_Did\_ Goethe\_discover\_the\_ice\_age]

The term Ice Age (Eiszeit) [I use "Ice Age" to refer to the most recent period of widespread glaciation, and "ice age" to refer to any prior periods of extensive glaciation.] was introduced in the course of a ground-breaking lecture by the palaeontologist Louis Agassiz (1807-1873) in 1837. The members of the Swiss Academy of the Natural Sciences had come to their annual symposium in Neuchâtel in July of that year prepared to hear a lecture on fossil fish, a subject on which Agassiz was a recognised expert. They were more than a bit surprised to hear him enthuse about a vast ice-sheet which had once covered most of Europe.

Although Agassiz gave credit to Goethe ["Goethe alone unified all the indications into a definite theory." W. Engelhardt (1999) Did Goethe discover the Ice Age? Ibid.], and in spite of a hastily organised field trip into the nearby Jura hills to see the evidence first hand, he was unable to overcome their scepticism. Later in the year a letter from his mentor, the renowned German naturalist Alexander von Humboldt (1769 -1859) strongly advised him to return to his research on fossil fish. But Agassiz would not be dissuaded, and became one of the leading proponents of the Ice Age during the 19<sup>th</sup> Century. He closed his Neuchâtel lecture with the

### Professor Franz Kofler and the Ice Age

words:

'I conclude, that at a certain epoch the whole of Europe was covered with ice . . . Death enveloped nature in its burial shroud, a remarkable premonition of Steiner's description of the desolation 10000 years ago.

# **Steiner's Interest in Geology**

Kofler's essay was written in 1879 when Rudolf Steiner was 18 years old. That same year he enrolled at the Vienna Institute of Technology (Technische Hochschule), where he studied both philosophy and the natural sciences for four years. One of his teachers was Karl Julius Schröer, who was working on a new edition of Goethe's dramas for Joseph Kürschner, publisher of a new collection of German National Literature. On Schröer's recommendation Steiner was employed by Kürschner as editor of Goethe's scientific writings between 1883 and 1897. During this time, he wrote a series of four articles on geology for Pierer's Konversations-Lexikon, a household encyclopaedia also published by Kürschner. One of these was entitled Ice Age (Eiszeit), written in 1889 [The others were entitled Alluvium (1888), Basalt (1889), and Geologic Formations (1890).]. Ice Age is a standard reference article outlining what was known about the Ice Age towards the end of the 19th Century. It presents the evidence for an extended period of glaciation covering all of Europe North of the Alps (in particular the erratics) and considers the two most likely causes under discussion at the time:

- periodic changes in the inclination of earth's axis of rotation and
- changes in the distribution of continents and oceans.

Both of these had first been suggested by the French mathematician Adhémar in 1842, and are described in detail in Kofler's essay. Steiner did not cite Kofler in his encyclopaedia article, using instead more scholarly sources. Many years later he did say that his contribution to Pierer's Konversations-Lexikon would probably have been edited.

## **Professor Kofler's Essay**

Kofler's essay is made up of three sections. The first summarises the evidence indicating that vast ice sheets had covered Northern Europe and North America in the not too distant past [For example, erratics, U-shaped valleys, terminal moraines, and striations.]. During the 19<sup>th</sup> Century it was commonly believed that the earth's crust had gradually cooled from a molten state to its present condition. The indisputable evidence of vast ice sheets covering Europe and North America in the recent past contradicted this belief, for some unknown factor must have warmed the earth's surface again, causing the ice to melt. The second section looks to the cosmos for possible answers, and the third lends support to the conclusions of the second by examining a theory current during the 19<sup>th</sup> Century, namely the global redistribution of land and sea.

Many theories had been advanced to explain the onset of the Ice Age, and the subsequent anomalous warming; a decrease in the strength of the sun's radiation (insolation), an increase in interstellar dust in that part of the universe through which our solar system was passing at the time, or a decrease in atmospheric carbon dioxide, or enormous volcanic eruptions blocking the sun's energy. Charles Lyell (1797 – 1875) considered by many (in England) to be the father of geology, even considered the possibility of the Northern continents uplifting to a higher altitude, thereby causing temperatures to drop. But none of these theories stood up to closer scrutiny. And so, Kofler tells us, geologists began to consider 'cosmic laws' (kosmische Gesetze) to explain the Ice Age.

Based on the observations of Tycho Brahe (1546-1601), Kepler (1571-1630) had shown that the earth's orbit round the sun is an ellipse, with the sun at one of the foci. (In his Principia Mathematica published in 1687, Newton used his universal law of gravitation to prove this mathematically.) As the earth travels along its orbit it is sometimes closer and sometimes further away from the sun. It reaches its closest point to the sun (146 million km) on January 3 during the Northern winter. This is called the perihelion point. The earth is furthest away from the sun (151 million km) on about 4 July, the point of aphelion. The difference of 5 million km, or about 3.4%, may not seem like much, but turns out to be significant, as we shall see. Perihelion and aphelion are called the apsidal points of the elliptical orbit, and the line joining them across earth's orbit is called the apsidal line. See Figure 2 on page 18.

What follows is an outline of the second section of Professor Kofler's essay in which he explains what he believed to be the cause of the Ice Age. I have included in this outline the names of the astronomer-mathematicians who did the necessary calculations and made the extraordinary discoveries which form the backdrop to Kofler's essay, and deserve a mention in the story. We are as indebted to them for explaining the physical laws

From 22 September to 21 December days.	er = 8 + 31 + 30 + 21 = 90	
From 21 December to 20 March = days.	10 + 31 + 28 + 20 = 89	
Total = 179 days.		
From 20 March to 21 June = $11 + 30 + 31 + 21 = 93$ days.		
From 21 June to 22 September = $9 + 31 + 31 + 22 = 93$ days.		
Total = 186 days.	Difference = 7 days.	

of our universe, as we are to Rudolf Steiner for explaining its spiritual laws.

The first proposal for an astronomical, or cosmic, theory to explain the Ice Age was made in 1842 with the publication of 'Revolutions of the Sea' (Révolutions de la mer) written by the French mathematician Joseph Alphonse Adhémar (1797-1862). He believed that the Southern hemisphere is currently experiencing an ice age, and that ice ages occurred alternatively in each hemisphere with a cycle of 21000 years. He reasoned as follows:

### **Solstices and Equinoxes**

The rotation of the earth about its axis gives rise to day and night. The axis of the earth's rotation is tilted at an angle of 23.4° to a line drawn vertically to the plane of the orbit. The tilt of the axis (the obliquity) gives rise to our annual seasons. The Northern hemisphere experiences summer when the North Pole is inclined towards the sun, and winter when the North Pole is inclined away from the sun. In the Southern hemisphere the situation is reversed. (The obliquity varies very slowly between 22.1° and 24.5°, over a period of 41000 years, but this will not concern us here.)

Each of the four seasons begins at a specific point along the earth's orbit. These are called the cardinal points. In the Northern hemisphere December 21 marks the beginning of winter because on this day the Northern hemisphere is inclined furthest away from the sun, making it the shortest day of the year North of the equator. This point is called the winter solstice for the Northern hemisphere (and the summer solstice for the Southern hemisphere). Six months later, 21 June marks the beginning of summer. This is the summer solstice, the longest day of the Northern year, when the Northern hemisphere is most inclined towards the sun. See Figure 2.

On two days of the year both the Northern and Southern hemispheres are equally inclined towards the sun, on March 20 and on September 22. On these two days there are exactly 12 hours between sunrise and sunset everywhere on earth. These two points are therefore called the equinoxes. Equinoxes occur when a line joining the centre of the sun to the earth is perpendicular to the earth's axis.

The four cardinal points mark a cross intersecting at the sun. The short arm of the cross divides the orbit into two unequal parts. It can be seen from Fig. 2 that the distance travelled by the earth between the autumn and spring equinoxes is shorter than the distance travelled between the spring and autumn equinoxes. In addition, according to Kepler's second law, the earth travels faster during this time. There are in fact 7 fewer days in the Northern winter than in the Northern summer. In the Southern hemisphere the situation is reversed. There the winters are 7 days longer than the summers.

Adhémar reasoned that because there are more hours of darkness in the Antarctic region ( $7 \times 24 = 168$  hours) during the Southern winter, it must be cooling. He believed that the Antarctic ice sheet was evidence that the Southern hemisphere is currently experiencing an ice age.

Having established to his satisfaction that the Antarctic is currently experiencing an ice age, Adhémar went on to explain how the most recent Ice Age in the Northern Hemisphere came about, basing his theory on the precession of the equinoxes.

### Precession of the Equinoxes (Axial Precession)

We can follow earth's journey around the sun from the winter solstice on December 21, past the spring equinox on March 20, past the summer solstice on 21 June, then past the autumn equinox on September 22, and back again to the winter solstice, one full orbit later. But the winter solstice has occurred slightly (about 20 minutes) earlier in the orbit! When the earth has returned to the same apparent position relative to the zodiac, the point of maximum inclination away from the sun has been passed. In fact, each of the four cardinal points, including the equinoxes, is reached about 20 minutes earlier on each subsequent orbit. This is the phenomenon known as the precession of the equinoxes, or axial precession. Twenty minutes might seem a very small fraction of a year, but it turns out to be highly significant.

The phenomenon of precession was first noticed by the Greek astronomer and mathematician Hipparchus in about 120 BCE. By comparing his astronomical observations with those made by Timocharis 170 years earlier, as well as with even older observations made by the Babylonians, he noticed small but systematic variations in the direction in which the earth's axis pointed relative to a fixed star in the zodiac. He concluded that the direction moved (precessed) through the zodiac, with the result that the position of the earth in its orbit around the Sun at the equinoxes and solstices (or any other fixed calendar date), slowly changes, and that precession has the effect of rotating the cardinal points along earth's orbital path in a direction opposite to the (apparent) movement of the sun. See Figure 3 on page 19.

That is why the tropical year, which measures the seasonal cycle (for example, from spring equinox to spring equinox, or from winter solstice to winter solstice), is 20.29 minutes shorter than the sidereal year, which is measured by the sun's apparent position relative to the stars. After 25,920 years (the Platonic Year) the difference amounts to a full year, and the positions of the seasons relative to the orbit are back where they started.  $[20.29 \times 25920 \div (60 \times 24 \times 365.25) = 1]$ 

As a result, the apparent position of the Sun relative to a fixed point in the zodiac on some seasonally fixed day slowly precesses through all twelve constellations, at 1° every 72 years. Hipparchus calculated that the rate of precession was between 1 and 2 degrees per century.

The precession of the equinoxes is the third component of what Copernicus (1473 - 1543) referred to as the threefold movement of the earth, i.e.

- the rotation on its axis once per day,
- the revolution about the Sun once per year,
- and the precession cycle once per Platonic Year.

All plant and animal life is inextricably tied into the first two movements, but an awareness of the third is a key feature of human consciousness. Precession can only be discerned on the basis of observations made during the course of many generations.

The precession of earth's axis may also be imagined as the "wobble" of a spinning top with an extended earth axis tracing a cone in space. Today earth's axis points almost exactly to Polaris (the North star), but it will point to Vega in the constellation Lyra in about 13000 years. The rate of precession is not constant over time and various values are given. Using satellite technology and modern computers a value of 50.290966 arcseconds per year has been calculated for the present time (giving a Platonic Year of 25770 years) [An arcsecond is 1/3600<sup>th</sup> of a degree. A value of 50 arcseconds per year gives 25920 years for a complete cycle. Because the rate of precession is not perfectly constant, the length of a Platonic Year varies very slightly, depending on how it is calculated.].

Axial precession is caused by the gravitational pull of the sun and the moon on earth's equatorial bulge. The phenomenon was first explained in 1754 by the French mathematician Jean le Rond d'Alembert (1717 – 1783), who based his calculations on Newton's universal law of gravitation. Two other mathematicians were also busy calculating an accurate trajectory of earth's orbit. In 1784 the mathematician-astronomer Joseph-Louis Lagrange (1736 – 1813) discovered that earth's elliptical orbit itself rotates (apsidal precession, see below), and Adhémar was able to make good use of his results. The other is Urbain Le Verrier, who published his work one year after that of Adhémar.

Urbain Jean Joseph Le Verrier (1811 – 1877) spent much of his life developing equations for the planetary orbits. In 1843 he published a set of results showing how the shape of the earth's orbit had varied over the past 100,000 years. He based his calculations on the orbits and masses of the seven planets known at the time. This painstaking work enabled him to predict the existence of an unknown planet which was causing unexplained irregularities in the orbit of Uranus, which had been discovered by Sir William Herschel (1738 -1822) in 1781. The cause of these irregularities was the planet Neptune, discovered in 1846 within 1° of his calculated position. Even today, the discovery of Neptune is considered a triumph of Newtonian mechanics. [Le Verrier also discovered an irregularity in the apsidal precession of Mercury, and he spent much of the rest of his life trying to find the planet Vulcan, assumed to be responsible for this irregularity. Vulcan was never found, and Newtonian mechanics was (and still is) unable to account for the anomaly. In 1915 Einstein was finally able to solve the mystery using his general theory of relativity.]

## **Apsidal Precession**

Adhémar had studied the work of Lagrange, and so he

knew that earth's elliptical orbit rotates (together with the apsidal line) in the same direction as the (apparent) movement of the sun, a phenomenon known as apsidal precession. This rotation is primarily due to the gravitational effects on the earth of the giant planets Jupiter and Saturn on their orbits round the sun. It takes 112000 years for a complete rotation of earth's elliptical orbit relative to the fixed stars

[https://en.wikipedia.org/wiki/Milankovitch\_cycles#Apsi dal\_precession], equivalent to 11.571428 arcseconds per year [The observed value is 11.45 arcseconds, giving 113,188 years for a complete cycle.].

[http://farside.ph.utexas.edu/teaching/336k/Newtonhtml/ node115.html Table 2.] See Figure 3.

We therefore have two cycles of time, independent of each other, but both dependent on the force of gravity; axial precession with a period of 25920 years, and apsidal precession with a period of 112000 years. Because they occur in opposite directions, apsidal precession shortens the period of axial precession. Fig. 3 shows that perihelion is approaching the spring equinox at 50.290966 + 11.571428 = 61.862394 arcseconds per year.

The two cycles combine to shorten the time it takes for the spring equinox and perihelion to coincide to 21000 years.  $[360\times60\times60\div61.862394 = 20950$  i.e. approximately 21000 years.]. The result of this is that the date of perihelion slowly moves through the calendar, returning to the same date after 21000 years [Modern calculations give a long-term average of 23000 years, with values varying between 20800 and 29000 years.]. Currently perihelion falls on January 3.

Kofler used 11.8 arcseconds of apsidal precession in his calculations, which is close to the modern theoretical value of 11.87 arcseconds [Ibid, Table 2.]. His value implies an apsidal period of  $360 \times 60 \times 60 \div 11.8 = 109,830$  years.

Kofler then stated (without proof) that perihelion coincided with the winter solstice in 1248 CE., and that (in 1879, when perihelion fell on January 1<sup>st</sup>), they were 10.82° apart. Currently (2018) they are 13.2° apart. The date 1248 can easily be verified on the internet. One reliable source

[https://earthsky.org/astronomy-essentials/are-thedecember-solstice-and-the-january-perihelion-related] gives 1246 as the year when perihelion coincided with the winter solstice, another [http://adsbit.harvard.edu//full/1895PA.....2..219H/0000 219.000.html]

gives 1268, and also shows how to calculate it using standard trigonometry.

Today the Northern hemisphere winter solstice occurs when the earth is close to the sun near perihelion. In the Southern hemisphere the winter solstice occurs near aphelion, when the earth is further away from the sun. That's why Adhémar thought the Southern hemisphere is currently experiencing an ice age.

The situation was reversed 10,500 years ago. The Northern hemisphere winter solstice occurred when the earth was far from the sun near aphelion, and so Adhémar concluded that an ice age occurred in the Northern hemisphere 10,500 years ago. His prediction was that ice ages would occur every 21000 years, alternately in one hemisphere and then in the other. Placing the most recent Ice Age 10500 years ago turned out to be a remarkably prescient conclusion, because in 1842 geologists were unable to put even approximate dates on geologic and climatic events.

### The Changing Distribution of Water and Land

But Adhémar went further. He theorised about the thickness of the Antarctic ice sheet by comparing the depths of the Arctic and circum-Antarctic Oceans, and found the latter to be considerably larger and deeper. At the time it was not yet known that Antarctica was a continent, and the assumption was that the ice sheet either floated or rested on the floor of the ocean. In either case there was believed to be an enormous amount of ice in the Antarctic. Adhémar speculated that this vast amount of ice displaced the centre of gravity of the earth, and caused the water of the world's oceans to accumulate around the South Pole. This excess water would freeze and attract even more water. He suggested that the ice would eventually reach a thickness of 60 km. Then, as the Southern Ocean began to warm as the Southern hemisphere summers approached perihelion during the 21000-year cycle, it would gradually melt the base of the ice cap, leaving an enormous mushroom of ice, which would eventually collapse into the sea, creating a "tidal wave" that would sweep Northward, engulfing the Northern hemisphere, where the cycle of freezing would start again. Could this be the 'mighty physical upheaval of the Atlantean cataclysm' Steiner described in lecture 5 of "Occult History"?

Adhémar's contemporaries were quick to dismiss his oceanic revolutions as mere fancy, and the drastic changes in climate he proposed were also criticised. In 1852 Alexander von Humboldt pointed out that Adhémar's basic idea of one hemisphere warming up while the other cools down was wrong. Any decrease in solar energy (insolation) received by a hemisphere during an aphelion winter would be compensated by an increase during the perihelion summer. Total annual insolation does not vary, only its seasonal distribution. The British astronomer Sir John Herschel (1792 – 1871, son of Sir William) pointed out that any extra warmth the Northern hemisphere received during the longer aphelion summers we are currently experiencing in the Northern hemisphere, would be decreased by earth's greater distance from the sun.

Today the reasons why the Southern polar regions are colder than the Northern ones are well known. The Antarctic continent is isolated from the other continents by the Antarctic Circum-Polar Current, which prevents the moderating influence of warmer ocean currents, (like the Gulf Stream in the Northern hemisphere warming the Arctic Ocean). Secondly, the ice sheet itself prevents warming even during the summer by reflecting much of the sun's energy back into space.

Although Adhémar's theory turned out to be incorrect, his idea that astronomical phenomena such as the precession of the equinoxes might have a significant effect on earth's climate was more difficult to counter, and was taken up by the self-taught Scottish polymath James Croll (1821 – 1890). He was able to provide a crucial correction to Adhémar's theory by taking into account the fact that the eccentricity of earth's orbit gradually changes. Kofler refers to Croll's work several times in his essay, but only insofar as it supported Adhémar's catastrophic theories, thereby ignoring an important aspect of Croll's calculations.

### The Work of James Croll

James Croll grew up in a small village in Scotland. Although he had to leave school at the young age of 13 to help on the family farm, he managed to continue his studies at home. He became fascinated by the 'beauty and simplicity of the concepts of the physical sciences, which filled him with delight and astonishment'. His interest became a passion, and he later recalled:



#### Figure 4

'In order to understand a given law, I was generally obliged to make myself acquainted with the preceding law or condition on which it depended. I remember well that, before I could make headway in physical astronomy, I had to go back and study the laws of motion and the fundamental principles of mechanics. In like manner I studied pneumatics, hydrostatics, light, heat, electricity, and magnetism.' [Quoted in J. Imbrie and K. P. Imbrie (1979) Ice Ages, Solving the Mystery, The Macmillan Press Ltd., p. 77.] His family was unable to afford university, and he took a number of jobs before he found a position as janitor at the Andersonian College and Museum in Glasgow, where he had access to an excellent library.

Croll realised that Adhémar had been incorrect in concluding that that the difference between the lengths of winter and summer could cause an ice age, yet he was convinced that some astronomical mechanism, 'some great, fixed, and continuously operating cosmical law', must be responsible.

Croll was familiar with the work of Le Verrier who had demonstrated that the eccentricity of earth's elliptical orbit gradually changes, from as little as 0.005 to a maximum of 0.06. A full cycle takes approximately 100,000 years. Eccentricity is a measure of the roundness or flatness of an ellipse A perfectly round circle has an eccentricity of zero, whereas an ellipse only 1% longer than it is wide has an eccentricity of 0.14. At present the eccentricity of earth's orbit is 0.0167, i.e the ellipse is only 0.014% longer than it is wide. Even on a very large scale drawing such an ellipse would be indistinguishable from a circle.

Orbital eccentricity plays a key role in summer and winter temperatures because it determines earth's distance from the sun at perihelion and aphelion. An elongated orbit decreases the distance at perihelion and increases it at aphelion. As noted above even with earth's current very small eccentricity, the difference between perihelion and aphelion still amounts to 5 million km.

It occurred to Croll that the gradual change in orbital eccentricity might be responsible for climatic changes in the Northern and Southern hemispheres sufficient to bring about an ice age. His first published paper (in 1864) evoked a great deal of discussion, and he was encouraged to develop his ideas further ['On the Physical Cause of the Changes of Climate during Geological Epochs' published in the Philosophical Magazine in 1864]. He later wrote: '...as the path appeared to me a new and interesting one, I resolved to follow it out. But little did I suspect, at the time when I made this resolution, that it would become a path so entangled that fully twenty years would elapse before I could get out of it.' [Quoted in J. Imbrie and K. P. Imbrie (1979) Ice Ages, Solving the Mystery, The Macmillan Press Ltd., p. 80.

Using the formulas developed by Le Verrier, Croll calculated the orbital eccentricity for a selection of dates over the past three million years, and illustrated these on a graph. See Fig 4. [from J. Imbrie and K. P. Imbrie (1979) Ice Ages, Solving the Mystery, page 84.] From his astronomical calculations Croll came to conclusions very similar to those of Adhémar. If winter occurs when the earth is far from the sun, as it was in the Northern hemisphere 10500 years ago, temperatures drop. If winter occurs when the earth is close to the sun, as it is in the Northern hemisphere today, temperatures are higher than usual. However, a drop in winter temperatures does not automatically result in an ice age, as Adhémar had assumed. Glacial epochs only occur during periods of high eccentricity.

Croll showed that during periods of low eccentricity winters are not cold enough to induce an ice age. He called such periods interglacial epochs. During periods of high eccentricity, exceptionally mild winters result when the winter solstice occurs at perihelion, and exceptionally cold winters occur when the winter solstice occurs far from the sun at aphelion. See Fig 4. on which Adhémar's 21000-year cycles are clearly shown.

Croll also supported Adhémar's wilder speculations, namely that a vast ice cap on one side of the earth would 'so derange the earth's centre of gravity as to draw the ocean towards that pole, and cause the submergence of part of the land.' [Quoted in Fleming J.R. (1998) Charles Lyell and Climatic Change: Speculation and Certainty,

http://sp.lyellcollection.org/content/specpubgsl/143/1/16 1.full.pdf] In the third and final section of Kofler's essay this is discussed in detail.

Croll's pioneering approach to the Ice Age was decades ahead of his time. He was the first to recognise that small changes in insolation arising from orbital variations are amplified by positive feedback mechanisms in the climate system:

- Increased snow and ice cover would increase reflection of the sun's energy (albedo), thereby lowering temperatures even further.
- A temperature decrease in the Arctic would have the effect of displacing the Trade Winds and the North Atlantic Equatorial Current Southwards across the equator. These warm waters would be deflected further South by the East coast of Brazil, thereby decreasing the volume of the Gulf Stream and the North Atlantic Drift, and causing further cooling in the Arctic.

## Lyell's Reaction to Croll's Theory

By 1864 there was no longer any doubt that an Ice Age had existed across much of Europe and North America, but all theories attempting to explain it had proved wanting. Included were those of Charles Lyell, who held fast to the possibility of major continental upheavals, and the changing global distribution of land and sea. He described one possible scenario in the first edition of his classic work Principles of Geology, first published in 1830-32.

'When land is massed in equatorial and tropical latitudes, polar climates are mild. The land, heated to an excess under the equatorial sun, gives rise to warm currents of air that sweep North. On the other hand, land massed around the poles produces the reverse effect. There is no land at the equator to soak up heat, and no warm winds coming into polar regions.' [From the first 1830-32 edition of Principles of Geology, quoted in Fleming J.R. (1998) Charles Lyell and Climatic Change: Speculation and Certainty,

http://sp.lyellcollection.org/content/specpubgsl/143/1/16 1.full.pdf]

To illustrate his point, Lyell included two maps in all eleven editions of Principles of Geology published in his lifetime. One shows the seven continents we recognize today spread over the tropical latitudes, the other shows the same seven continents spread over the polar regions. He gives no indication of how the continents could have moved to the positions shown, but his maps are an uncanny premonition of Wegener's continental drift theory (today's plate tectonics). Could this have been the source of Steiner's (and Kofler's) claim that 'the face of the earth was totally changed in regard to the distribution of water and land'?

[Steiner was aware of Lyell's Principles of Geology. In Chapter XXII of his autobiography he writes: "On the other hand, despite the incomplete form in which they presented their ideas, I recognized in Lyell, Darwin and Haeckel a trend of thinking that could become fruitful when carried further.

For example, Lyell's principle, that those phenomena of the earth's evolution which are not accessible to sense observation – because they belong to the past – can be explained through ideas derived from observation of present phenomena, seemed fruitful to me when carried further in the direction indicated; and similarly to seek understanding of man's physical structure by deriving its form from animal forms, as Haeckel does in such a comprehensive way in his 'Anthropogenie', (Evolution of Man), appeared to me an excellent foundation for the further development of knowledge." Rudolf Steiner, an Autobiography, page 288.]

Lyell was eventually, but reluctantly, persuaded to grant recognition to Croll's work by the two highly regarded astronomers [Sir John Herschel and the Astronomer Royal Sir George Biddell Airy.] he had approached for advice on how Croll's theories might affect earth's climate. In 1866 he added a long chapter on the astronomical influences on climate to the tenth, and subsequent, editions of Principles of Geology, but insisted that these were subordinate to geographical causes such as 'the relative positions of land and sea'.

Charles Darwin was more impressed. He thanked Croll for sending him his papers, and wrote: 'I have never, I think, in my life, been so deeply interested in any geological discussion. I now first begin to see what a million means . . . I thank you cordially for clearing so much mist before my eyes.' [Letter from Darwin to Croll, 19 September 1868; quoted in James Croll in Context by James Rodger Fleming, http://www.meteohistory.org/2006historyofmeteorology 3/3fleming\_croll.pdf].

Croll wrote up the results of his meticulous research in Climate and Time in 1875. Unfortunately for his theory, the timing of his ice ages turned out to be wrong. His calculations implied that the most recent ice age ended 80000 years ago, rather than 10000 years ago (See Fig. 4). At the time it was not possible to test his theory because the ages of the glacial deposits had not yet been determined, and there was as yet no independent time scale against which his ideas could be tested. Nevertheless, Croll's painstaking work remains a milestone in our understanding of how interactions between astronomical and terrestrial factors such as albedo and ocean circulation, determine the climatic conditions of our planet.

### **Professor Kofler again**

In his essay Kofler explains the effects of the gradually changing eccentricity of earth's orbit, and quotes values of eccentricity from the 12<sup>th</sup> edition of Lyell's Principles of Geology. But does not explain how this modified Adhémar's theories, except that greater differences between summer and winter would undoubtedly increase the severity of the ice ages, which would continue with their 21000-year cycle. The greater the difference between the lengths of summer and winter, the more severe the ice age. But he does not mention Croll's discovery that eccentricity has to have a certain critical value before an ice age can occur.

Kofler also discusses the effect of earth's changing axial tilt (obliquity) on long term climate. He points out that the smaller the axial tilt the less the effect on our seasons. If the axial tilt was zero, we would have no seasons, the noonday sun would always be directly overhead at the equator, and continuously skim the horizon at the poles. The greater the axial tilt the greater the severity of an ice age, because winter snowfall and summer melting are determined by seasonal temperature changes.

The remaining 10 pages of Kofler's 25-page essay comprise a detailed discussion of the theories of Dr Heinrich Schmick, as described in his book 'Die Umsetzungen der

Eccentricity	Difference be-	How long	Difference
	tween perihelion	ago	in length
	and aphelion	-	of sum-
	-		mer and
			winter.
0.0167	5 million km	200 years	8 days
0.0458	13.6 million km	100000	23 days
		years	
0.0566	16.8 million km	200000	28 days
		years	

Meere, und die Eiszeiten der Halbkugeln der Erde, ihre Ursachen und Perioden' ['The Displacement of the Oceans, and the Ice Ages of Earth's Hemispheres, their Causes and Periodicity.' First published in 1869, the book has been republished (in German) in 2017, and is available on Amazon.].

Schmick attempted to support Adhémar's theory by finding an alternate explanation for the (supposed) presentday massing of the world oceans near the Antarctic. His explanation is based on the fact that the earth is closer to the sun during the 4 months (currently November to February) on either side of perihelion. According to Schmick the crest of the twice-daily tidal wave passing through the world ocean from East to West would therefore be slightly higher, and a small amount of this excess water would (for complicated reasons) be drawn to the South Pole, where it would freeze and accumulate over the many thousands of years remaining until perihelion coincides with the spring equinox (in 6500 CE approx.). In this way changing sea levels would gradually submerge the Southern and expose the Northern continents, leading to a redistribution of water and land as championed by Lyell. But the objections of von Humboldt and Herschel concerning the seasonal compensation of global temperatures are addressed by neither Kofler nor Schmick.

It seems reasonable to conclude therefore that Steiner's dating of the most recent and the next ice age (in the Astronomy Course) was based on the state of knowledge towards the end of the 19<sup>th</sup> Century, as presented by Kofler in his essay.

There can also be little doubt that, provided Steiner was referring to <u>physical</u>, astronomical processes, the 'mighty processes in the constellation of neighbouring celestial bodies' in 1250 CE refer to the alignment of the winter solstice with the apsidal line, i.e. the shortest day in the Northern hemisphere coincided with perihelion. On this assumption, the 'neighbouring celestial bodies' are the planets in our solar system, whose orbits and gravitational attractions to each other bring about the alignment. It is perhaps not too far-fetched to imagine that the Spirits of Form made use of the solar system's ever-changing gravitational field to bring about the alignment and the resulting changes in the global climate at the end of the Ice Age.

The previous such alignment would have occurred about 20000 BCE, at the very end of the Palaeolithic Age, and at the dawn of a human (Neolithic) consciousness we would probably recognise today, as demonstrated by the Magdalanian style of cave art at Lascaux in France and Altamira in Spain [The Magdalanian culture dates from about 17000 BCE, and is named after the overhanging rock shelter first excavated in the 1870's in Dordogne, France.]. That transition too was undoubtedly important from a spiritual point of view; perhaps this was a time 'when direct view of the higher worlds' first began to be obscured. [As quoted above from Lecture II of "The Spiritual Guidance of Man".]

10000 years from now perihelion will align with the summer solstice in the Northern Hemisphere. Summers will be warmer and shorter, winters colder and longer, but beyond that climatologists are hesitant to predict whether there will be another ice age as extensive as the one 10000 years ago. The consensus is that Ice Ages are initiated at the critical point when summer insolation reduces sufficiently so that it fails to melt back the previous winter's snow. Ice slowly accumulates, more of the sun's energy is reflected back into space (there is an increase in albedo), and the feedback loop ensures that the ice sheets continue to grow. But even today, the many variables (both astronomical and terrestrial) which determine this critical point are not yet fully understood.

The answers to the three questions posed above are to be found in the essay by Professor Franz Kofler. It gives an excellent overview of what was known of the most recent Ice Age at the time, discusses the astronomical theories of Joseph Adhémar and James Croll, as well as the terrestrial theories of Heinrich Schmick and Charles Lyell, all of which had sparked the interest of the young Rudolf Steiner. Although the terrestrial causes of the Ice Age advocated by Schmick and Lyell had been proved wrong by the time Steiner gave his lectures (1910, 1911, and 1921), he used them as graphic imaginations to support his case for a period of drastic upheavals in the spiritual evolution of humanity. Steiner uses the physical events which were believed to have taken place globally, and which did in fact occur locally, to describe what he sees in his spiritual vision; the storms and tempests experienced by human souls at a critical stage of their spiritual evolution.

### Postscript

Croll's astronomical theory was taken further by the Serbian civil engineer Milutin Milanković (1879 – 1958). By making various assumptions about the formation and retention of snow and ice, and for the first time including the effects of axial tilt into his calculations (a greater tilt makes the seasons more extreme), he produced graphs which appeared to correlate well with the 21000-year precessional cycle. He devoted most of his life to the Ice Age problem, and was the last climatologist to do all the necessary calculations by hand. His conclusions, like those of Croll before him, were questioned, and for many years believed to be inaccurate.

Questions which remained unanswered were for example, the problem of warm interglacial periods [Many climatologists believe that the earth is presently in such a warm interglacial period.]. There were still too may unknown terrestrial factors, such as the role played by carbon dioxide and water vapour in the atmosphere in determining global temperatures. To what extent precession, eccentricity and axial tilt influenced the onset of an ice age remained topics of lively discussions among geologists and climatologists. The breakthrough came 100 years after the publication of Croll's book. By the 1970's powerful computers were able to calculate planetary orbits with exquisite precision. International teams of geoscientists had learned to trace earth's changing atmospheric and oceanic temperatures by measuring the ratio of oxygen isotopes in air bubbles trapped in the Antarctic and Greenland ice sheets, as well as in deep ocean sediments. Complicated statistical methods had been devised to eliminate random errors in the measurements.

The results of all this work were put together in a ground-breaking paper published in the magazine Science in 1976. Entitled Variation in the Earth's Orbit, Pacemaker of the Ice Ages, it showed conclusively that the onset of an ice age is determined by the gradual variation in earth's orbit as it revolves around the sun [Hays, J.D., Imbrie J., and Shackleton N., (1976) Variation in the Earth's Orbit, Pacemaker of the Ice Ages, Science <u>194</u>, pp 1121-1132.]; changes which are in turn determined by the mutual gravitational attraction which the planets in our solar system exert upon each other; by the 'mighty processes in the constellation, position and movement of the cosmic bodies connected with the sun'.

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