Lithium ions against depression: Is the internal clock involved in endogenous depression? Experiments in Spitsbergen

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Acknowledgements see page 135

Dedicated to Anders Johnsson at the occasion of his 70th birthday,
and in memory of Burkhard Pflug, who died on March 4, 2009

Die Naturwissenschaft braucht der Mensch zum Erkennen, den Glauben zum Handeln

Max Planck

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Preface

This book describes an experiment to solve a scientific problem. A very specific problem caught our attention and fantasy but it could well be that the outcome will be of interest from an applied point of view. It struck me that the way we used to solve the problem meant that we encountered methods and problems that are often described in detective novels. Therefore, a short comment on detective work:

For many people science is a closed book. They believe, a scientist is specialized in a particular field, uses eccentric methods and complicated devices, and as a laymen one does not understand anyway, what he or she is doing. However, it is often quite exciting, what a scientist is doing: He tries to solve one of the numerous riddles nature is posing.

In doing it he proceeds in a similar way, a detective tries to clear up a case. He or she will study the findings very carefully, interrogate the people involved, sift the objects used in committing the crime. He will reflect on why the crime was done, and who might be worth considering. In using all these information and thought he will try to visualize the course of events of the crime. If the findings are not clear cut enough, he will consider other explanations. These ”hypotheses”, as a scientist would call it, have to be checked. Do they conform with the findings? Where are discrepancies? Are there facts, statements, hints, which are not in accordance with the hypotheses? Or do they even speak against them? A qualified detective will take into account especially those signs, which speak *against* the hypotheses, because such a negative sign can upset the hypothesis or even several of them. A positive finding, on the other hand, makes the hypothesis only somewhat more likely. Further clues have to be found, in order to verify the hypothesis. To disproof hypotheses is thus a faster and more efficient way of solving a case.

A scientist proceeds in a similar way. He deals with processes in the living and inanimate nature, observes, reads books and articles, listens to lectures of other scientists and talks to them. In this way he finds a problem, which he would like to solve. Like a detective he will first of all have a close look at the basis of the problem (the case). He will observe, study, measure, note down, ponder, check and take finally several solutions into account. As in the case of a detective, the actual work does now begin: How can he critically test the various hypotheses? How can he disproof them in such a way, that only a few of them remain, until finally perhaps a single explanation is the valid one?

Pure science can be important also for the everyday life.

Many people do not understand, why a scientist can engage oneself for a long time and intensively with just one topic. And often this is additionally very abstract and special. They might also ask them self, what comes out of the results of such a scientific study for them personally or for other people. This is especially true for studies in ”pure science”. In case of ”applied science” the advantage for mankind is obvious. If a new, more fertile variety of cereal has been bred, its useful for men. But when Heinrich Hertz studied electromagnetic waves, neither he nor anybody else anticipated, that nowadays in almost every house a radio would be found and that our society would be a completely different one without this invention.

Our studies aimed at the begin also to solve quite a special question. They lead, however, to results, which might become important for the treatment of certain diseases.

An introduction and overview

A short glimpse from my student time shall explain why I took an early interest in the phenomena of depressive states – a basic topic of this book. Many of us encounter influential teachers or relatives or unhappy/sick persons and such experiences can, consciously or subconsciously, affect decisions in our life, for example about studies or work.

It was summer 1960. I was working on my doctoral thesis at the Botany Department in Tübingen (see http://w210.ub.uni-tuebingen.de/volltexte/2009/3800/). In order to earn my living I had been working for professor Faber at the Research center for Bioacustics of the Max Planck Society in Tübingen to collect grasshoppers in various countries of Europe. Faber studied the song patterns of grasshoppers. He asked me, to travel to the Pyrenees and Andorra and search for grasshopper species of the genus *Chorthippus* which he was going to study.

Since I had to prepare myself for the doctoral examination, the urgent date did not fit my schedules at all. I proposed therefore, to ask my friend Enno M.. I got to know him during a recreation of the Lutheran student community in Tübingen together with the corresponding group of the University of Jena in the Thuringia woods. He went later to West Germany, continued his zoology studies in Tübingen and had started to work on his doctoral thesis.

Professor Faber agreed and Enno took a train to Andorra. From there Faber received a package with grasshoppers. But all of them where dead, because Enno had used potatoes as food instead of grass pieces. The grasshoppers were struck dead by the potatoes. Faber had furthermore received several telephone calls from Enno from Andorra, which worried him. He asked me to travel to Andorra and send Enno back to Tübingen.

I felt awkward since I had proposed Enno and since Professor Faber had spent a lot of money for getting the animals for his research work. I took therefore the train to Perpignan and from there a bus to Andorra (figure 0.1). I recall an adventurous journey over the Pass de la Case (more than 2000 m altitude) and a truck in front of us which was also heading for the city of Andorra. At the steering wheel stood a boy. He could not sit, since he was too short.

In the hotel of the city, in which Enno stayed overnight, I was told that he left in the morning for collecting grasshoppers. He had taken the bus to the Pass, which I had just passed. I took the next bus and walked from the pass in the mountain meadows. Soon I found Enno, running around stripped to the waist (it was dead cold!) catching insects indiscriminately with a butterfly net and cramming them in a jam glass. He did hardly notice me. One could scarcely restrain him from his drive for actions. Professor Faber had described the species of grasshoppers he needed before my departure. I was thus able to collect enough specimens and to pack them professionally.

We traveled afterward to Eyne situated between Saillagouse and Mont Louis and

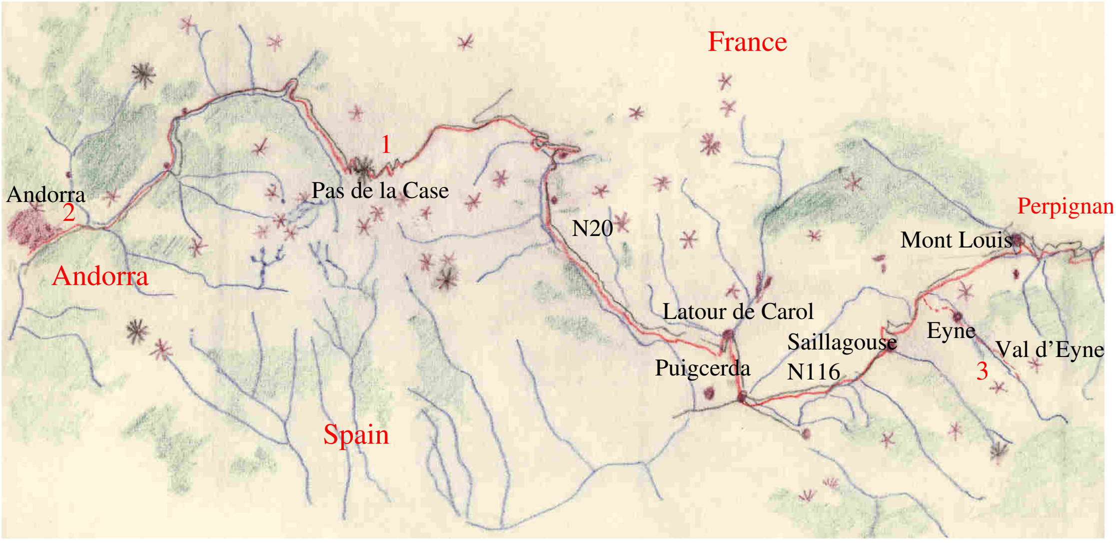


Figure 0.1: *Map of Andorra and parts of the Pyrenees. 1 Pass de la Case, 2 Andorra, 3 Val d'Eyne. Drawn from part of Carte Michelin No 86, Luchon-Perpignan 1:200 000 by the author*

walked from there to Val d'Eyne, a valley at the foots of Puigmal. There was a special grasshopper species we wanted to collect. Unfortunately the weather had changed and it had snown in the medial and upper part of the valley. The grasshoppers had crept away and we had to wait for warmer temperatures. Our food was soon eaten up. Water was plenty in the beak. For staying over night we found a haystack with hay. There was, however, no way of getting sleep: Enno was full of energy, was talking constantly and disputed philosophical questions. That was a challenge for me first, but with time it became an unbearable imposition, since Enno apparently did not need sleep. We waited two further days, but the weather did not change. Enno was finally at the end of his strength, and so was I. Since in addition we were quite hungry, I sent Enno down to the valley. There he should take the bus to Perpignan and the train back to Tübingen and deliver the animals we had collected already in Andorra. I stayed another two days until the weather cleared up and it became warmer, so that the grasshoppers showed up again and I could catch enough. I had to take care, that Professor Faber got his grasshoppers for his studies.

In Tübingen I got to know that Enno suffered under depression. It is the most common mental disorder and occurs in about 4 % of the population (the Department of Health estimates, that four million Germans are suffering from depression and that at least ten million people had had a depression until the age of 65, Brakemeier et al. (2008)). About twice as many women suffer under depression as compared to men. In childhood this disease is rare (in preschool children less than 1 %, in school children 2–3 %, in juveniles 7–13 %).

Enno went later with his doctor father to Würzburg. And from there I got one day from a colleague the message, that Enno had committed suicide. That was my first experience with a depression. But more about this disease later.

I have told this story, because I was very touched by it. Since then the riddle of this disease has been of much interest to me. Many scientist are influenced in their studies by deeply felt personal experiences.

1 Flower clock *Kalanchoe* and lithium ions

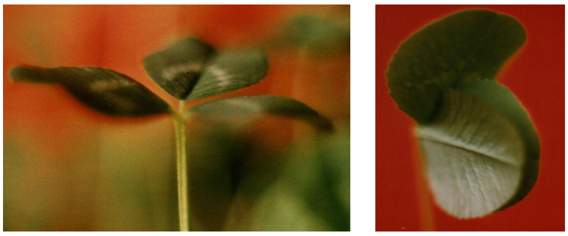


Figure 1.1: *White clover in day- (left) and night position (right). The two anterior leaflets fold together during the night and the third leaf is on top of it. From Mayer (1977)*

About daily rhythms, a flower clock and their connections with depression

Humans spend, like most of the higher animals, their days with being awake and sleeping. Sleep takes in adults about eight hours. Some people need more, others less sleep. Together with this change between rest and activity many other events change in the human and animal body.

Less well known is, that even plants possess daily rhythms. It can be easily observed in the pea subfamily: They move their leaves up and down during the course of a day. The best way to observe this is by looking at a clover plant in a meadow. Dig out a specimen with roots and soil, put it in a flower pot and keep it at the window. If you compare the leaf position during the day and the night, it looks like shown in figure 1.1. During the day the leaves are in a horizontal position. during the night folded up.

Petals are also able to move in a day-night rhythm. Around Christmas time

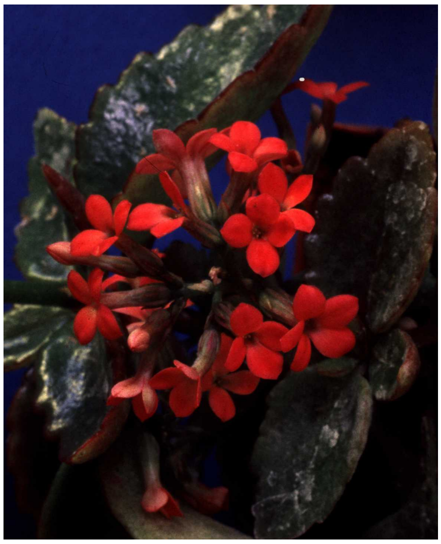


Figure 1.2: *Flaming Kate* (Kalanchoe blossfeldiana*) with numerous red flowers, which are open during the day and close at night (see figure 1.3)*

the Flaming Kate can be bought in flower shops. This plant originates from Madagascar and its scientific name is *Kalanchoe blossfeldiana*. It possesses many small red flowers (figure 1.2).

During the day the flowers are opened, during the night closed (figure 1.3). Even if individual flowers are cut off from the mother plant, they continue to move in a daily rhythm[1] if mounted suitably in a sugar solution. The sugar solution is used to provide energy for the flowers.

The flower consists of a calyx, a flower tube and four petal tips. A cross section

[1] http://w210.ub.uni-tuebingen.de/volltexte/2009/3800/

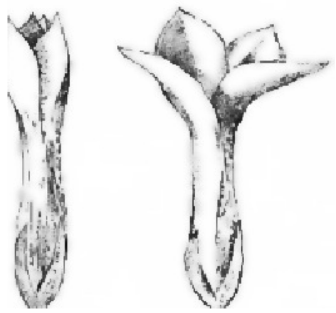


Figure 1.3: Kalanchoe-*flowers during the night (left) and during the day (right). During the night the tips of the petals are in an upward position, the flowers are thus closed. During the day the tips bend outward: The flower opens*

of a petal (see figure 1.4) shows about ten cell layers beyond each other. The uppermost consists of red colored papilla cells (upper epidermis). The lower most consists of tightly connected cells (lower epidermis). The cells in between contain large vacuoles. They are responsible for the movement of the flowers and are therefore called *motor* cells. During the day their vacuoles are extended like balloons and extend the cells longitudinally. As a result the flowers open. During the night the motor cells are shrunken, the vacuoles small, and the cells shortened. The petals close. The physiological basis of it is not yet fully understood.

So much for the mechanism of the petal movement. But how is the timing of the opening and closing of the flowers controlled? Is the extension of the cells somehow regulated by the light of the day? Perhaps the motor cells shrink and the flowers close, if light is absent. However, an experiment shows, that it is not as simple. If the flowers are kept for several days in darkness or in weak green light (which works

Figure 1.4: *A cross section of a petal consists of an upper layer of so called* epidermis cells*, which are papilla like. They are colored red. Below them are several layers* of so called parenchyma cell*s. The lower most cell layer* is a cobble epithelium*: The cells are mutually interlocked (can not be seen here see "How plants grow and move":* `http://tobias-lib.ub.uni-tuebingen.de/volltexte/2009/3777/`*)*

as darkness for the flowers), they still continue to move: They open and close in the same way they would in a light-dark cycle. It was thus not a direct reaction to light or darkness, which resulted in opening and closing of the flowers.

Perhaps something else in the environment is cycling in a 24 hour measure? For instance temperature differences between day and night? But we find the movement also at constant temperature. If one looks under constant conditions at the rhythm of the petals more carefully, it can be seen that the period of opening and closing is not 24 hours, but about two hours shorter (figure 1.5).

It is thus not an external factor which times the movement. The flower of *Kalanchoe* must possess an internal mechanism that regularly tell the flower when to open and to close. This mechanisms is called an internal clock, or biological clock. We can also denote it a flower clock, as in the name of this chapter.

Under normal day-night cycles the flower clock is tightly coupled to the 24 hour day, more or less controlled by the day-night changes. But under constant conditions the flower clock mechanism uses only its inherited rhythm when timing the flower movements. And this is about two hours shorter than our normal 24 h day. It is therefore called a *circadian* rhythm[2].

Many experiments with *Kalanchoe* flowers and other plants and animals have shown the properties of this daily clock. Under appropriate constant conditions this clock continues to run, but deviates slightly with its period from 24 hours. It can, however, be synchronized by time cues, so called "Zeitgeber", to the 24 hours of a day. The most important Zeitgeber is the Earth's light-dark cycle.

Much work has been done to understand the mechanisms of the biological clocks. This is not only interesting in itself, but has many important implications for organisms including humans, as will be shown also in this book. One finding is that the period of the clocks – in the *Kalanchoe* flowers about 22 hours – is usually very slightly, if at all, influenced by chemical compounds. This is one of the riddles of the mechanisms.

Another riddle concerns the influence of temperature on the clocks. Temperature cycles can synchronize the clocks, which was true for the light-dark cycles as we just saw. So temperature variations, for instance 12 hours temperature of 20° C and 12 hours of 25° C, results in a flower rhythm of 24 hours. In spite of this synchronization by temperature differences this clock is "temperature compensated", that is, it runs with about the same speed at higher (for instance continuous 25° C) and lower temperatures (for instance continuous 15° C, figure 1.5).

The daily flower clock can also adjust to light/darkness regimes. If we give the flowers a light-darkness cycle deviating from 24 hours (for instance by cycles of 11 h light and 11 h darkness), it will be entrained up to a certain range, until entrainment fails.

1.1 How to record the *Kalanchoe*-petal movement

I studied *Kalanchoe*-flowers already during my doctoral thesis. It would have been strenuous and time consuming, to observe the opening and closing of the flowers during day and night by eye and to note down the degree of opening. I therefore took camera pictures of the flowers for record-

[2]from circa, Latin about and dies, Latin, day

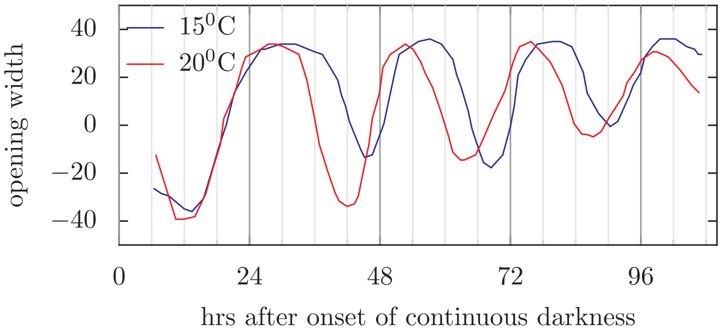


Figure 1.5: *The opening width of* Kalanchoe *flowers was recorded at a temperature of 15° C (blue curve) and 20° C (red curve) at different times. At both temperatures the flowers open (increasing values) and close (decreasing values) rhythmically. Although maximal opening at 20° C is somewhat earlier as compared to 15° C, this is also true for the maximal opening in the following days. The distances (called period lengths) between the time of maximal opening (*called maximum, *plural* maxima*) are, however, the same, namely 22 to 23 hours. The clock which controls the opening and closing of the flowers has thus the same speed at the different temperatures. After Oltmanns (1960)*

ing the movement of the tips of the flowers: Individual flowers were broken off the plant and mounted in holes of a plastic disk floating in a cuvette on a sugar solution. Every third hour pictures were taken from above. Since under white light the movement of the flowers would soon stop, the flowers were illuminated with green fluorescence tubes which were additionally wrapped with a green foil. Green light does not affect the movement of the flowers and can thus be used as safe light: It allows us to see the flowers and to focus the camera for taking pictures. The film was developed and the distances between the tips of the petals determined under the microscope. This method was still laborious, since pictures had to be taken at day and night every third hour.

Therefore I developed a new method, where the cuvette with the flowers was placed on top of a photoelement and illuminated from above with green light. The voltage of the photo cell increased with the amount of light. If the flowers were closed, the voltage would be higher than for open flowers. The voltage could be recorded with an electric recorder and the curves evaluated. Later the electric recorder was replaced by a data logger with punched tape and evaluated in the computing center of the university. The data were printed as curves. With the advent of the PCs we used them for recording and storing the data.

Today we use instead of photo cells a video camera, which is connected to a computer. The size of the flowers is determined by a special image analysis program (figure 1.6) and displayed as a curve (figure 1.5).

Using this automatic recording device we have studied not only the influence of light and temperature on the petal movement of *Kalanchoe*, but tested also chemical compounds. Since the flowers were cut off the plant, they were able to take up substances from the solution easily. If they affected the clock, the period length of the movement should change. Many substances had,

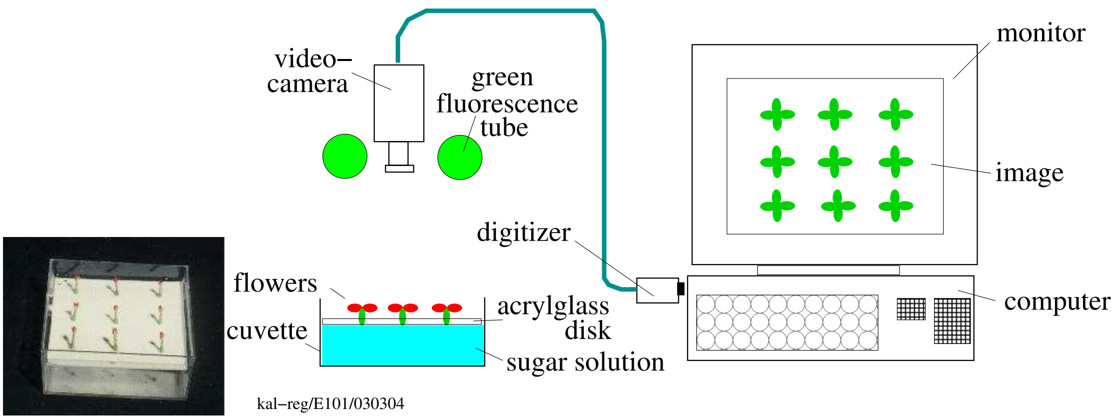


Figure 1.6: Kalanchoe-*flowers are broken off from a plant and mounted in holes of a plastic disk floating on a water filled cuvette (left). The flowers open during the days and close in the night in the same way as on the plant. Here the flowers are closed. They can be photographed by a camera for instance every hour from above (right). The digitized pictures are send to a computer, analyzed by an imaging program and the data of each individual flower graphically displayed (see for instance figure 1.7).*

however, no such an effect. It looked like the internal clock had sealed itself off from external influences.

1.2 Lithium ions slow the circadian clock

There were, however, some substances, which did influence the daily clock. Lithium ions (Li^+ in the following) belong to them. In nature $LiCO_3$ is often found in mineral waters and in stones. We added different amounts of LiCl to the sugar solution, on which the flowers swam. They slowed the rhythm of the petal movement. Instead of a period of 22.5 hours in the sugar solution it amounted to 24.5 h, if the concentration was 3 mM (figure 1.7) and 25 h at 5 mM (figure 1.9). Apparently Li^+ affect the clock mechanism and slow it. In doing so mainly the opening of the flowers is slowed, as shown in figure 1.8.

On the other hand Li^+ could affect also processes between clock and the observed petal movement. In this case the clock itself is not slowed down, but only the link between clock and petal movement, as figure 1.8 might indicate (only the closing is affected). Therefore a series of experiments was performed, in which the period length was deduced from the effect of light pulses (details in the legend of figure 11.4 in the Appendix). The experiments proved, that the oscillator was slowed, and not events between clock and hand of the clock.

I asked myself, whether this is true also in circadian rhythms of other plants. Indeed, daily leaf movement rhythms were slowed, as found for instance in shamrock by Anders (Johnsson et al. (1981), figure 1.10), or in bean plants by us (Engelmann (1987)), and in the conidiation rhythm of the bread mold *Neurospora crassa* (figure 1.11). Later we studied cockroaches, which

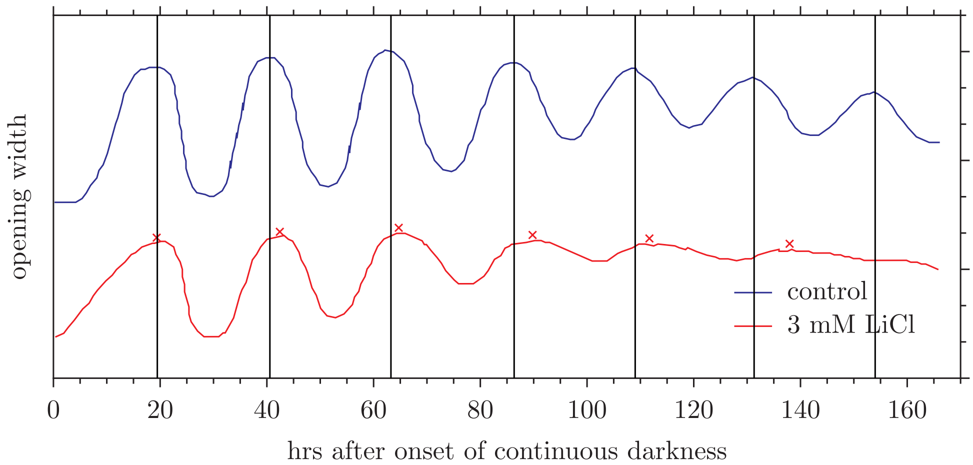


Figure 1.7: *LiCl, increases the period length of the* Kalanchoe *petal movement. Upper curve (blue) control, lower curve (red) with 3 mM LiCl added to the water, on which the flowers float. The vertical lines indicate the maxima of the controls, the red x's the maxima of the LiCl treated flowers. On the y-axis the opening width of the flowers are plotted. After Engelmann (1973)*

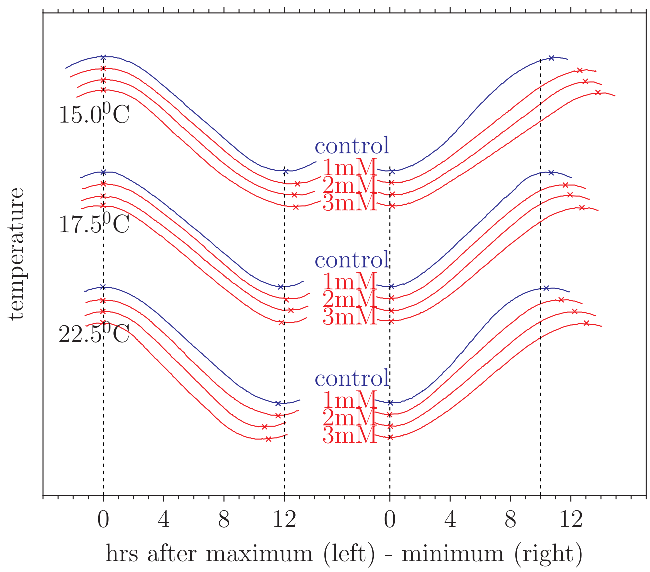


Figure 1.8: *The longer period under LiCl is mainly due to a retarded opening of the flowers (right part of groups of curves), whereas the time span for closing is about the same (left part). The experiments were carried out at different temperatures as indicated to the left, and with different concentrations of LiCl (red curves), as also indicated – controls did not get LiCl (blue curves). The positions of the closing movements in the left part of the figure differ only slightly, whereas the maxima of the openings in the right part of the figure are delayed with respect to the controls. After Engelmann et al. (1976)*

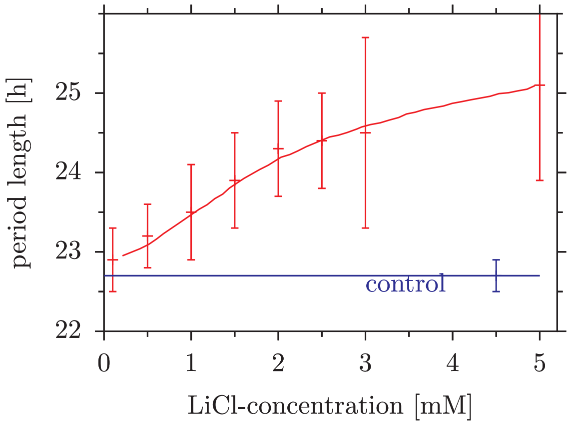


Figure 1.9: *Lengthening of period of the Kalanchoe petal movement by LiCl. Groups of five petals each were kept in cuvettes at eight different concentrations (x-axis) as shown in figure 1.6. The period lengths were determined from the curves (see figure 1.7), the mean values (red crosses) with standard errors (vertical lines) plotted and a curve fitted to the values (red). The period lengths of the 15 control flowers (horizontal blue line) is shown with standard error (vertical blue line). After Engelmann (1973)*

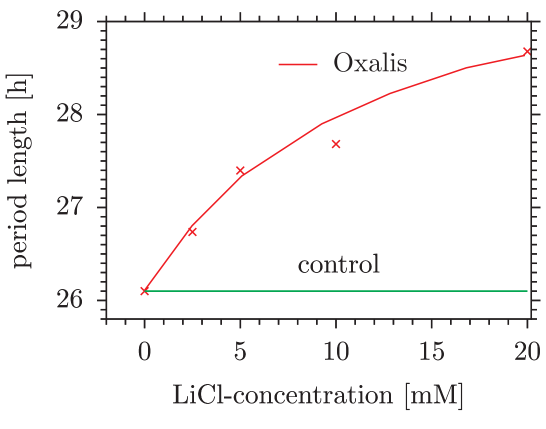


Figure 1.10: *Increase in period (y-axis) of* Oxalis regnellii *leaf movement rhythm by LiCl of various concentrations (x-axis)*

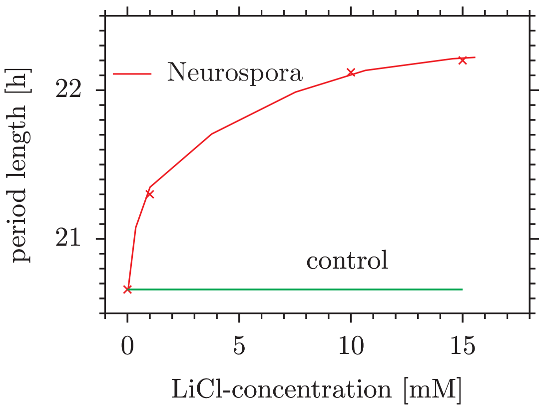


Figure 1.11: *Increase of period (y-axis) of* Neurospora crassa *conidiation by LiCl of various concentrations (x-axis). Unpublished data Engelmann*

obtained Li^+ in the drinking water. The animals had access to the liquid via wicks in bottles. Here too Li^+ increased the period of the daily rhythm. We measured the locomotor activity, that is the movement of the animal in the cage (Hofmann et al. (1978)). Only male animals were used and kept in running wheels[3]. The turning of the wheel activated (via small magnets glued to the wheel) a magnetic switch, and this signal was transferred to an event recorder which produced small strokes on a role of paper. Daily patterns pasted underneath each other are called an actogram and an example is shown in figure 1.12.

A further example for a period lengthening in animals is given in the Appendix (figure 11.5). There are, however, also examples, where Li^+ shortens the period such as in bats (Subbaraj (1981)) and in Syrian hamsters. Data are given in table 11.4 of the Appendix.

Li^+ influence also the flower reactions of plants. A critical day and night length is

[3] Female cockroaches run less and more irregularly

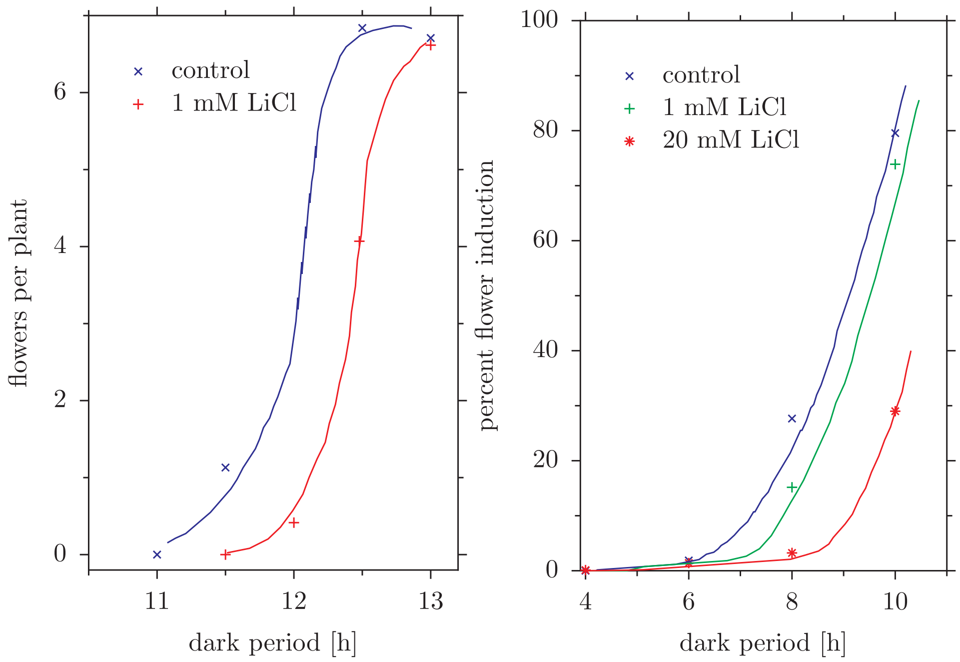


Figure 1.13: *Left: Shift of critical day length (x-axis) of flower induction of* Pharbitis nil *by 0.5 h due to a 1 mM LiCl nutrient solution (red curve, blue curve is control without LiCl). Right: Likewise in* Chenopodium rubrum *the critical night length (i.e. 50 % of the plants are induced to flower) is increased (from 9.25 in the controls to 9.75 in 1 and to 10.5 in 20 mM LiCl solution). If the length of the day is too long, the corresponding dark period will be too short and the plants will not produce flowers – they are denoted short-day plants. In both cases a single dark period is already sufficient for flower induction. After Engelmann et al. (1976) et al. (1976)*

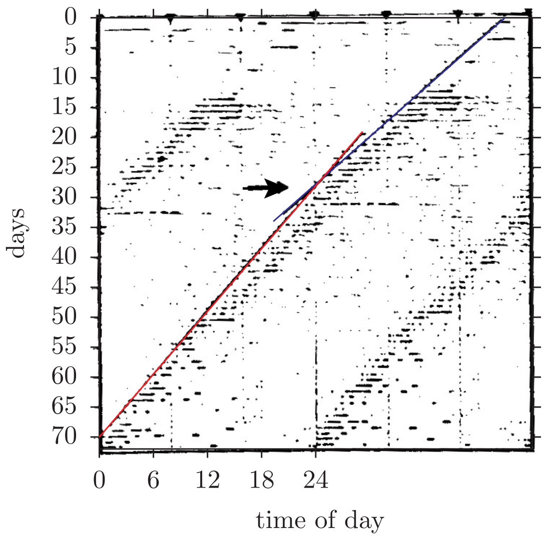


Figure 1.12: *Slowing of the locomotor activity rhythm of* Leucophaea maderae *by LiCl (10 mM), which was offered from the arrow onward. The straight line connects the onset of activity before (blue) and during (red) the* Li^+ *treatment. The actogram displays the daily activity in a double plot, which allows to recognize the course of activity during the entire recording period more easily. After Hofmann et al. (1978)*

necessary for flowering at a precise time of the year. This length is measured by the daily clocks of plants according to Bünning (1936) and, therefore, the flowering should be affected if Li^+ slows the clock. Short day plants require a minimum dark period to produce flowers and this is controlled by the clock. Therefore, a test can be carried out to see if Li^+ given such plants slows the clock and a longer dark period is necessary to produce flowers. This was indeed found in studies on the morning glory *Pharbitis nil* and on *Chenopodium rubrum* (figure 1.13 and Engelmann et al. (1976)).

2 Endogenous depression and their causes

We will first look at endogenous depression and their possible causes and show in the following section, how to test, whether Li^+ slows also the daily clock of humans.

A relatively large number of people suffer under endogenous depression. This mental disease was called melancholia in earlier times.

Reactive depression are caused by an external reason: A close relative has died, a severe disease begins, goods and chattels are destroyed. An *endogenous* depression, however, does not begin with a direct, external cause, but unanticipated. It has the following symptoms[1]:

- mental-somatic inhibition or agitation (depressive stupor or agitative depression)
- sleep disturbances, early awakening and anxiety for the coming day
- low spirit in the morning; improvement in the evening
- hypochondric delusional ideas
- massive feeling of guilt, self blaming, self destructive behavior
- loss of interest
- sexual disinterest
- mental loosing, disturbances of memorizing- and concentrations, emptiness in the head
- feebleness with collapse of performance
- often loss in weight
- hereditary imposition

Figure 2.1: *Depressive! After a drawing of a depressed, made by the author (slide Pflug)*

The mood is best illustrated by the drawing of a depressed person (figure 2.1).

Endogenous depression occur in two forms, the unipolar and the bipolar one. Under an unipolar endogenous depression the affected person is very depressive, but becomes normal again in due time (figure 2.2). After some time a new depressive period occurs.

[1] http://www.psychosoziale-gesundheit.net/seele/endogenedepression.html

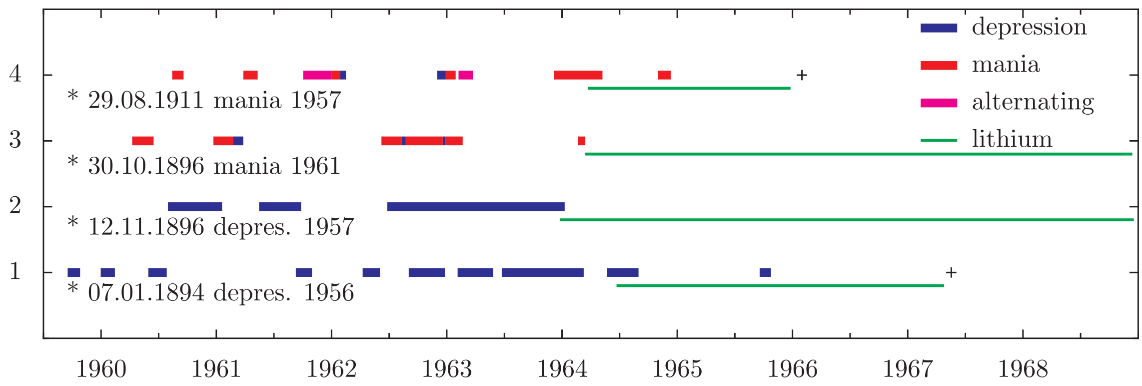


Figure 2.2: *Monopolar (depression only, blue, patient 1 and 2) and bipolar (depression and mania, red, patient 3 and 4) endogenous depression. *birthday, + died, magenta: rapid change of mania and depression, green: Li^+ treatment. Data from Schou (1971)*

In the bipolar form a depressive phase alternates with a so called manic phase. During mania the affected person exhibits an extremely high zest for action, is full of energy but uncontrolled. This was Enno's condition when I met him at the pass and which lasted until the Val d'Eyne excursion. I realized also, how careless it was to let him travel back all by himself, because the onset of a depressive phase could easily have led to problems. During a depressive state such a sick person might even commit suicide. About 3–4 % of all depressives die by suicide (Wolfersdorf (2008)).

This kind of endogenous depression with mood alterations between high and low phases is found in quite a number of artists and writers, but also politicians. During a manic phase they are very creative. Händel composed his Messiah in just six weeks, Rossini needed only 13 days for the "Barber of Seville". Robert Schumann, Honore de Balsac, van Gogh, Ernest Hemingway, Abraham Lincoln, Theodore Roosevelt and Churchill were manic-depressive. More details can be found in Fieve (1977).

The causes of endogenous depression are still not well understood. The disease must be anchored in the genetic makeup, since it occurs more frequently in certain families. Today it is treated with certain psychopharmaca.

It turned out, that Li^+ has also a therapeutic effect (Fieve (1977)). It was an accidental observation. John F. Cade, a psychiatrist at a hospital in Australia believed, that urea was causing the manic state in endogenous depression. He wanted to test this hypothesis by injecting urea in guinea pigs. In order to solve the urea he used lithium urea. The animals became, however, apathetic instead of agitated as is the case in mania. Since Li^+ carbonate showed the same sedative effect, Li^+ had to be responsible and not the urea. He tried therefore in ten patients with endogenous depression to calm them with Li^+ during the manic phase. The results were astonishing. The mood of his patients normalized even in "hopeless" cases. They could be dismissed from the hospital. After his report in 1949 (Cade (1949)) this treatment became soon accepted.

Later some casualties were reported. The cause was kidney failure. It was recognized, that the dose for the treatment had to be exactly and individually determined. If done correctly, there were no problems with the kidney. This therapy is still used today. If, however, it is noticed that the kidneys are strained, the Li^+ treatment is stopped and other pharmaceuticals are used.

When we did our experiments with *Kalanchoe*-flowers, a paper of Pflug and Tölle on sleep deprivation and depression had just been published (Pflug and Tölle (1971), Pflug (1972)). It was shown, that sleep deprivation was an effective remedy in endogenous depression. It was assumed, that prevention of sleep affected the daily rhythm of the depressed person favorably, so that he/she felt well again.

In Tübingen a teacher, who suffered under endogenous depression, had told his doctor in the psychiatry, that during his mania he would take his bicycle and move throughout the night through the woods in the Schönbuch, a beautiful forest area close to the city. In this way he could better control the manic attack. The treating doctor took over this method and tried it out systematically. It showed indeed a therapeutic effect. The crucial point was not the physical exercise, but the sleep deprivation. It was later found, that one has to prevent sleep at the time around which the daily rhythms have their midnight point – the body temperature has its lowest value at this time. For many people this is between 3 and 5 o'clock in the night.

These results and other findings, according to which the circadian system is altered in endogenous depression, was interpreted by some researchers and medical doctors in such a way, that perhaps the depression was caused by a disturbed circadian system (see page 122 and figure 10.2).

An example of how the daily body temperature can be disturbed during depressed periods in a patient is shown in figure 2.3.

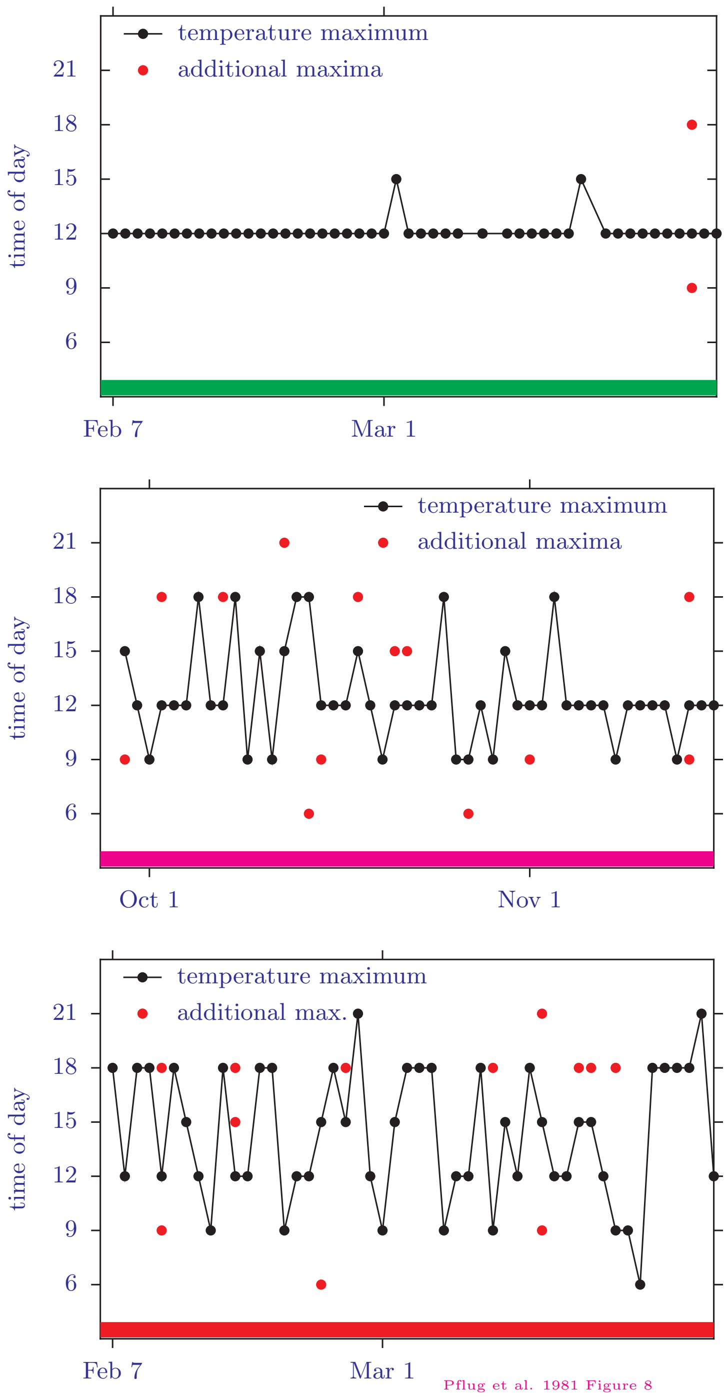


Figure 2.3: Example of the daily temperature maxima of a patient during the time of feeling well (top, green bar), during the time of improvement (middle, magenta) and during the depressed period (bottom, red). Date: x-axis, time of day: y-axis. Temperature maxima: dots (red, if more than one per day). During depressed period maxima at quite different times of day, during period of feeling well at same time of day. Intermediate pattern during time of improvement. After Pflug et al. (1981)

3 Testing a hypothesis: Do lithium ions slow the daily clock of humans?

Here I describe our results of studies on the Kalanchoe *clock in Tübingen, which could be simulated with a feedback model. This clock and the one of other plants and animals are slowed by Li^+. Since Li^+ is effective therapeutically in endogenous depression and since in this disease the circadian system is disturbed, we wanted to test, whether Li^+ slows the daily clock also in humans.*

In 1969 a group of students from Lund in Southern Sweden came to Tübingen. They were on a journey through Germany, in order to visit several institutes. Professor Helmut Hertz (see figure 3.1, the father of whom was a nephew of the well known Heinrich Hertz), who had found the radio waves, led the group. He was chairman of the Department of electrical measurements at Lund University, and had (among other achievements) developed the ultrasound echo technique for heart diagnosis together with Inge Edler. His assistant was Anders Johnsson, who studied at that time together with Hage Karlsson the gravitropic pendulum movements of sunflower seedlings. They had proposed a feedback model, which described the oscillations occurring during the pendulum movement of *Helianthus annuus* (Johnsson and Karlsson (1972), Karlsson and Johnsson (1972)). It is shown and explained in figure 3.2.

Figure 3.1: *Helmut Hertz (*1920; †1990, son of Gustav Ludwig Hertz, *1887 in Hamburg; †1975, physicist and Nobel laureate) was physicist and taught at the university of Lund in Sweden. Anders Johnsson was promoted under his guidance. Picture kindly supplied by Anders Johnsson, Trondheim (see also Lindström (1991))*

They had read our publication on the petal movements of the *Kalanchoe* flowers and used their model successfully for this

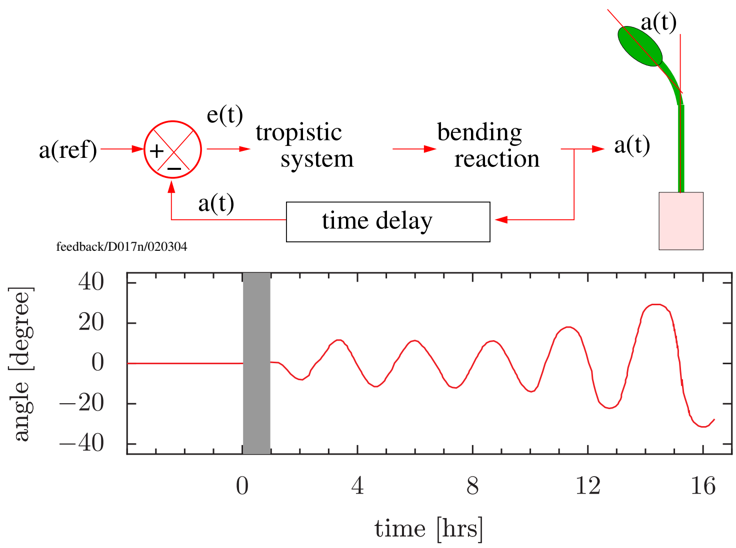


Figure 3.2: *Top: Feedback model of the gravitropic pendulum. A reference value ("grow vertically" α_{ref}) is compared with the actual value $\alpha(t)$. If the values differ from each other, an error signal $e(t)$ is produced. It is amplified by a tropistic system and weighted and time delayed compared again with the reference value. Oscillations occur (bottom), which are similar to the one, a sunflower hypocotyl (top right) would show, if for instance stimulated for one hour by gravity (the pot with the seedling is turned by 90°). At the right the actual angle $\alpha(t)$ is explained as the deviation from the plumb line. After Johnsson (1977)*

rhythm (Karlsson and Johnsson (1972)). The model explained also, how light acted on the petal movement and compared the results with those of our experiments (Engelmann et al. (1973)). With Anders Johnsson I had from then on an intensive scientific cooperation and a lifelong friendship.

We had also talked about the Li^+ effects in *Kalanchoe*. Since Li^+ is effective therapeutically in endogenous depression and used in medicine, it was suggestive, that the circadian clock of humans is slowed, as we had found not only in the *Kalanchoe* clock, but also in other plants and animals.

Our hypothesis was: In a person, who suffers under endogenous depression, a part of the circadian system runs too fast or too slow. It can, therefore, not longer be properly coupled to the normal 24 hour day or, to put it in other words, synchronization to the normal day/night variations fails. It runs instead at least partly "free" from the external day (during the depression). This would result, for example, in time intervals with the internal clock (or one of the internal clocks) at night state when it is normal day time or at day state when it is normal night time. This could be the cause of the depression (see Engelmann (1987)). Most people who had to rise occasionally during the night for a particular reason feel depressed and battered.

Anders proposed, to test this hypothesis in Spitsbergen during summer time when constant light and temperature conditions prevail. This would be a suitable natural laboratory to study the behavior of the 'free' daily rhythms in humans. We had originally thought of having the experiments done in a subterranean apartment in Erling-Andechs south of Munich. They were, however, booked out already for years with other experiments. They offered me at least, to do a pre-experiment. It would last for 4 weeks.

3.1 Pre-experiment in a Zeitgeber-free room in Erling-Andechs

The studies of rhythms on humans under constant, Zeitgeber-free conditions at the Max Planck Institut für Verhaltensphysiologie in Andechs began in 1967. At that time it was the first and only institute, in which the technical requirements for longer recordings on humans under Zeitgeber-free conditions were met. The various experimental questions and the results of the studies are compiled by Wever in a book (Wever (1979)). All experiments had to be done under complete isolation from the outside world, to warrant that not a single Zeitgeber of the normal day could be perceived by the experimental subjects.

At the begin it was feared, that these conditions are hard to bear by the subjects. It turned, however, out, that all of them liked to participate in the experiments. One reason for it was surely, that the two underground apartments provided a pleasant and comfortable atmosphere. Furthermore only a few, specially selected variables were recorded such as body temperature, locomotor activity and urine measurements. The participants had thus relatively much time for own activities and hobbies. Students took often advantage of this situation and used it for preparing themselves for examinations. In order to get suitable test persons, handouts were sent to various universities and posted there at appropriate places (see appendix subsection 11.5.1).

The location of the subterranean apartments and the ground plan are shown in figure 3.3. Each unit was isolated under

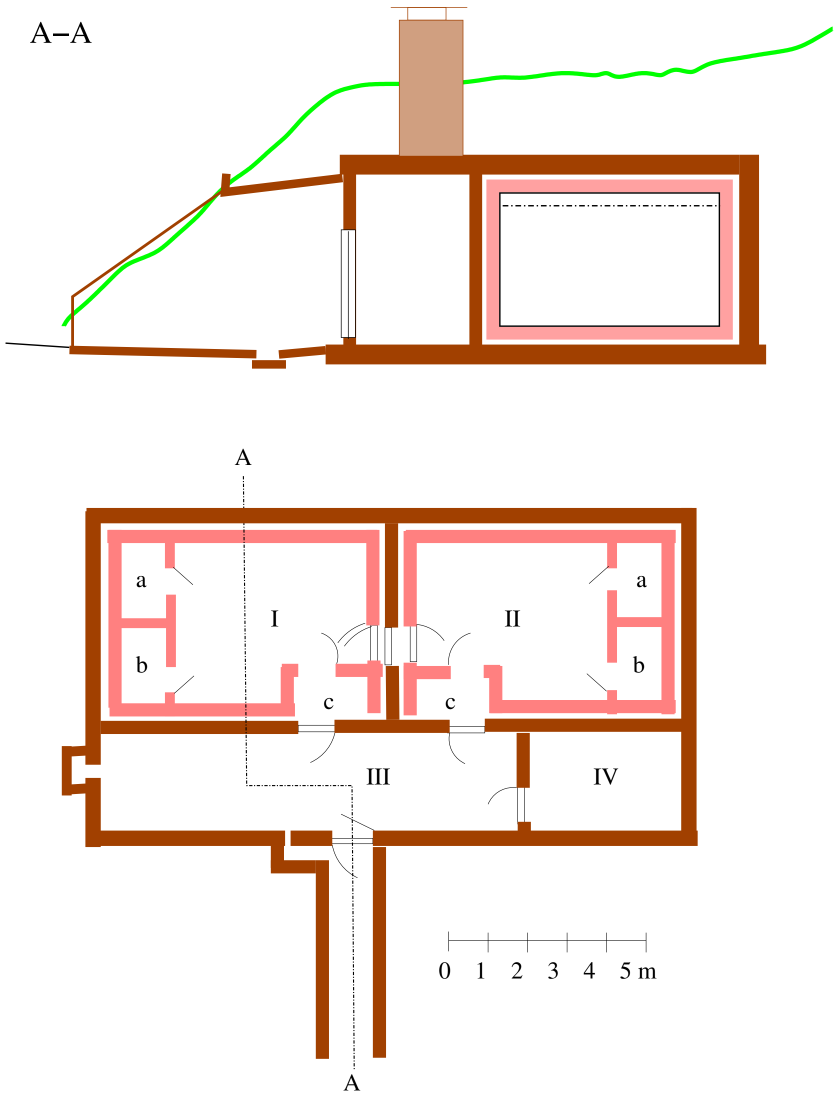


Figure 3.3: *Top: Lateral view (section: A–A). Bottom: Top view. Brown: Re-forced concrete. Pink: Brick walls. I and II units with kitchen (a), WC and shower (b), lock(c). III control room, IV special experimental room. After Wever (1979)*

the floor, above the ceiling and behind the walls with glass wool and was floating suspended in the outer construction. Noise below 130 dB (pain threshold!) from outside or from the neighbor unit could not be perceived. One of the units was additionally shielded against electrical and magnetic fields. It was, however, possible to produce such fields artificially. The other unit was not shielded.

The interior of one of the two (mirror imaged) units is shown in figure 3.4. It consists of a living room, kitchen and a lavatory. In the living room was also a bed. The units could be entered or left only via a lock, but were not locked up. The room could thus be left if wanted or in case of emergency. Several hundred experiments were performed in these two rooms during the years.

I was offered to participate for four weeks in a pre-experiment in one of the units. It was September 15, 1975, four weeks before the term started. I had taken the train to Munich and the commuter railway system to Herrsching. From there I walked to Erling through a beautiful landscape in the fall (I remember a letter of a friend, in which he wrote, oh, Wolfgang, this is the most beautiful fall which I ever experienced, and you are sitting in the bunker...). I had at least a nice large bunch of twigs from trees for the first days in my apartment, until the leaves had dropped. I had taken along literature, books and paper, for preparing a new kind of self directed basic course for biology students. Furthermore I took along my water colors and carbon rods for painting and a flute with notes. After spreading out in the room and getting acquainted with the local conditions, I bought in the local grocery shop food for the first days for my physical well-being. Then I said good by for four weeks from the outside world by taking a long walk in the surrounding of Erling and Andechs (with monastery).

In front of the two subterranean apartments is a long floor with the recording gadgets. Body temperature was recorded with a thermo probe, which was inserted in the rectum. It is connected by a long cable to a plug in the ceiling, allowing to move freely also to the kitchen and the toilet. During dancing one had to take care, however, not to turn only in one direction. Movements were recorded by contacts beneath the carpets. Contacts at the bed allowed to record sleeping time. Furthermore the urine had to be collected in bottles and marked, before storing them in a refrigerator in the lock. From there it was collected by the staff. The amount and concentration of the electrolytes (Na^+, K^+, Cl^- and so on) and other substances could be determined in the laboratory and the time course plotted (figure 3.5 shows the body temperature curves). *The period of my body clock was longer during the Li^+* period.

3.2 Data logging

Reliable instruments are important prerequisites for experiments. Sometimes they can not be purchased if needed for special purposes. Either they are not yet available, or they are too expensive. In our case both was true. Although one could buy instruments for recording the body temperature in hospitals[1], but they were not suited for our project and/or were too expensive. Therefore we decided to build the

[1] for instance Solicorder of Ambulatory Monitoring Inc. Ardsley, New York; costs Solicorder 16 1585.-$, temperature probe 85.- $, battery unit 100.- $, charger 15.- $, computer-interface for reading the data 575.- $, that is 2360.- $ per unit

Figure 3.4: *Living room (left) and kitchen (center) and shower (right) in Erling-Andechs. Distorted by the wide-angle-lens*

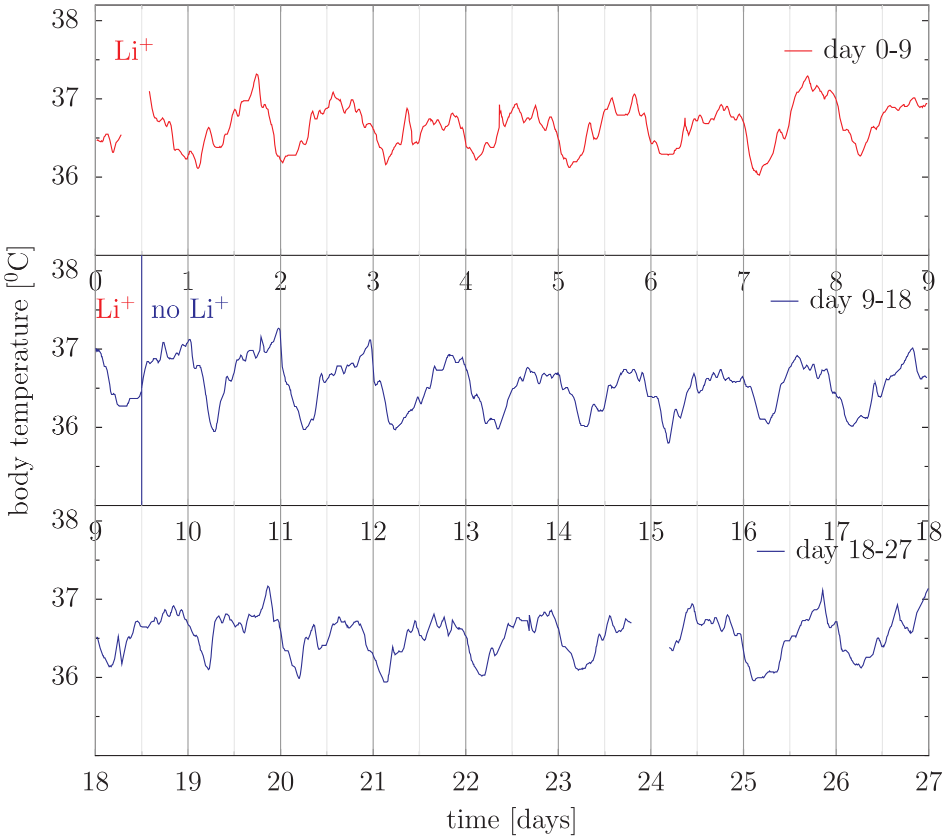


Figure 3.5: *In a subterranean apartment free of Zeitgeber in Andechs (south of Munich) the daily rhythm of the rectal temperature of Wolfgang Engelmann was recorded with a probe between September 15, 1975 and October 13, 1975. During the first time each day Li^+ tablets were swallowed by him. After 10 days, on September 24, Li^+ application stopped. The period of the temperature rhythm during the* intake of *Li^+ amounted to 24.6 hours as determined from the distances between the temperature minima. Without Li^+ the period length was only 23.97 hours. Thus Li^+ seems to lengthen the rhythm*

instruments our self. To collect data under the conditions of Spitsbergen continuously and reliable, special requirements had to be met:

- The instrument should work throughout the planned recording time of four to five weeks completely maintenance-free.
- The recorded data had to be stored reliably.
- The instrument should be insensitive against high humidity and temperatures close to zero degrees. If carried continuously on the body, it had to withstand occasionally heavy impacts.
- The stored data should be readable directly without auxiliary means for the staff and analyzable, since they had to control the values and decide accordingly for further course of the experiments.

At an electronic fair in Munich Waldemar found a thermo printer of the Kontron company (installation-printer type 5010[2]), which fitted our instrument. The digitized data were stored on paper rolls. The numbers were printed on metalized paper and clearly visible. The print mechanic was completely maintenance-free. The entire unit worked independent of its position. One set of batteries lasted for non-stop operation for more then 4 weeks. However, the recording unit had the size of a small photo bag. Furthermore, the data of the paper stripe had to be transferred manually to a computer, before they could be further analyzed. We could at least plot the data already in Spitsbergen manually on millimeter paper and in this way check the curves on spot and recognize any failures quickly.

During the construction of the instruments Waldemar had support from his brother in law, Reimar Lenz, who was well acquainted with electronics.

The temperature was recorded with a rectal probe. The monolithic temperature transducer LX 5700 AH of the National Semiconductor Company was used. It was molded in a small plastic capsule. This integrated circuit allowed to measure the temperature very precisely and in a simple way (circuitry and function in figure 11.8 on page 162).

The locomotor activity of the body was recorded with an actometer. It was a mercury switch in a plastic capsule and could be worn at the wrist like a watch (further details on page 161).

A print line on the paper consist of a four digit number, the numerator as the time information, a one digit number as a measure of the locomotor activity during the last recording interval and a three digit number as an information of the current body temperature (see figure 3.6).

An example for a shorter recording sequence is shown in figure 3.7.

The recorder for the body temperature and the arm movement (DE 101) was placed in a box of polystyrene (figure 3.8). In the box was furthermore a latex protection and toilet paper, powder, Vaseline and zinc ointment for the temperature probe. It contained furthermore an additional paper roll, four 6 V-replacement batteries and a 9 V-replacement battery. The equipment was completed with a pencil, a diary for notes of the times of urine collection, PVC snap-lid tube for urine probes, marker and filmoplast.

[2]thermo printer NIP18 of the Olivetti Co.

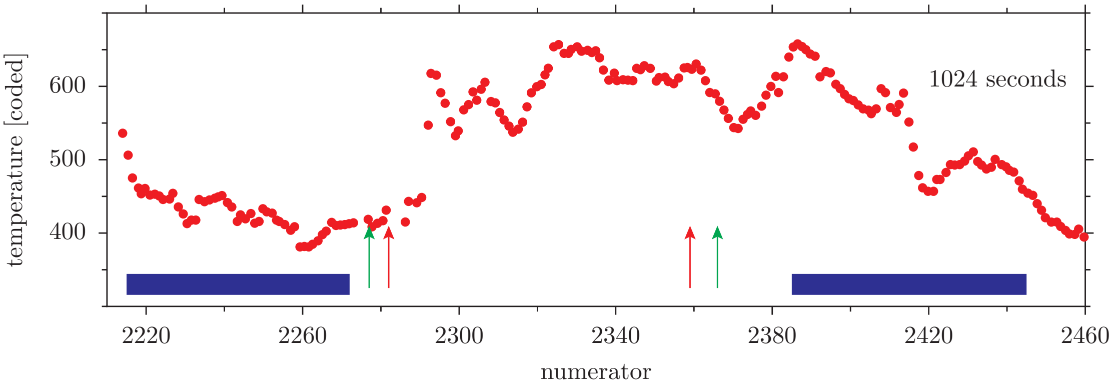


Figure 3.7: *Example for a rectal temperature recording with recorder DE101. Coded temperature on y-axis. On x-axis time coded as a numerator. The chosen preset interval was 512 sec. The interval between the first two numbers on the time-axis (2220 and 2260) is 5.69 h, between the first and last one (2220 and 2460) 34.135 h. Green arrows meals, red arrows physical activity, blue bars sleep periods*

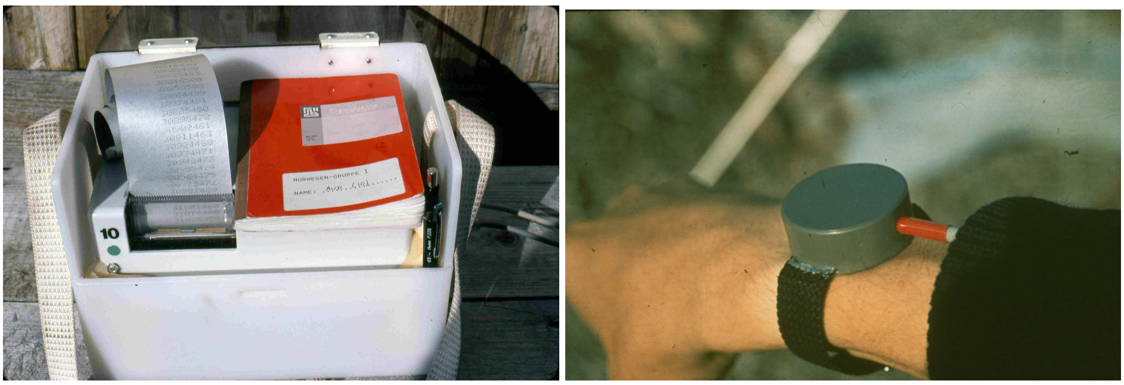


Figure 3.8: *Recorder for the course of body temperature and arm movement. A cable connects the temperature probe (carried in the rectum) with the recorder. Another cable transmits the data from the actometer (at the wrist – figure to the right). The recorder device is carried in a polystyrene box with a translucent plastic lid. Printer with print paper visible in the notch of the instrument; note also red book for the diary notations.*

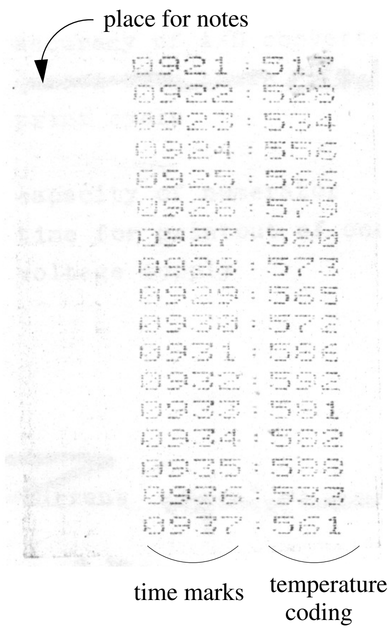


Figure 3.6: *Printout of the recorder DE101. Every 512 sec a new line is printed on the thermo paper. The first four numbers serve as a progressional time information (every 512 sec a value), the next digit codes for activity and the last three digits for the rectal temperature (value* $\times$ *0.05 + 35 = temperature °C).*

A short description for handling by the participants is found in the appendix (subsection 11.5.2).

With the pH-meter the pH of the urine was determined. The pH electrodes were kept in a protective tube with 3M KCl. There was furthermore a sprinkle bottle with distilled water, a drip bottle with 3M KCl, a drip bottle with a calibration solution for pH 4 and a further one for pH 7, a measuring cylinder 500 ml, a thermometer, a snap lid tube for 3M KCl, for pH 4, for pH 7 and another one for the actual measurement of the pH.

4 Planing of the experiments with humans

The experiments for testing the effect of Li^+ on daily rhythms of humans were planned to be done in the continuous light of the arctic summer in Spitsbergen. The difficulties to obtain funding is described. Not before a pre-experiment was executed the referees could be convinced, that in Spitsbergen the internal clock is not synchronized to the 24-hour day, but runs free.

The idea to test, whether the daily clock is slowed by Li^+ also in humans, occupied our thoughts. Anders Johnsson proposed, to do the experiments in Spitsbergen. During the summer light prevails during day and night, because this country lies beyond the polar circle, just about 1000 km away from the north pole (see figure 4.1, more on Svalbard see Stange (2008)).

During the winter term 1976/1977 I in Tübingen and Anders in Trondheim offered a seminar, in which we discussed this idea with students. We reflected, what one should think about, in order to run the experiment. In a "brain-storming session" we collected first all ideas and thoughts of the participants and what they considered important. The topics were divided in four parts:

1. scientific part
2. medical part
3. methodological part
4. Preparation and realization of the journey (logistics)

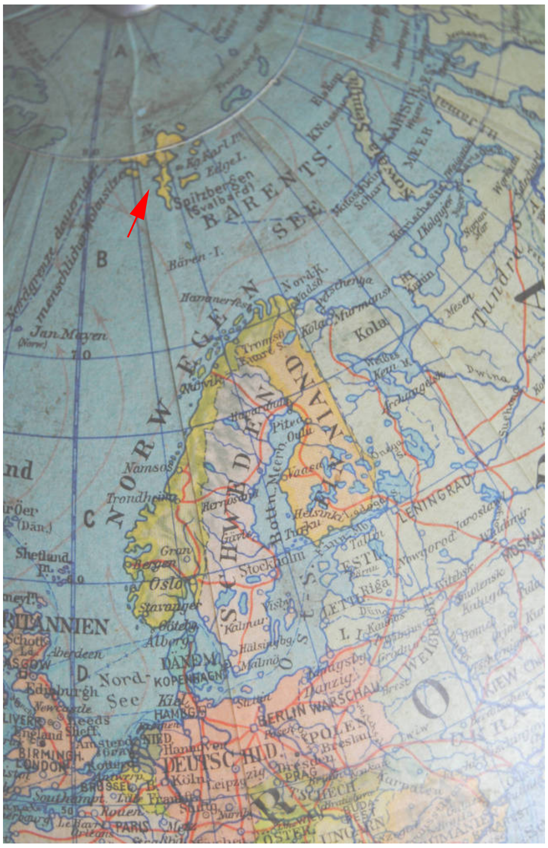


Figure 4.1: *Position of Spitsbergen (arrow)*

We planned the experiment originally for the summer 1978.

In the scientific part the experiments were planned. What kind of circadian rhythms are suited for recording? And how should they be measured? What is the best number of experimental subjects? Should they live in groups or single? Should the subjects take Li^+ during a part of the time and afterward or before "placebos"[1]? Should they thus be their own control? Or should groups be used which would take continuously the same - either Li^+ or placebo - throughout the experiment? Should the staff have information about whether the groups took Li^+ or not at a certain time, or should a double blind experiment be performed, in which neither the participants nor the staff know, who became what?

In the medical part we discussed mainly safety measures. Are there unwanted side effects of the Li^+ and could they be avoided? What are the hypothesis concerning the effect of Li^+ in depression? The participants of the seminar read a number of scientific reports on this topic and discussed it in respect to the planned studies.

During the methodological part we thought about the rhythms which could be measured to begin with and how it is done in the best way. Which conditions had to be taken into account? We decided to record the body temperature. It shows a distinct daily rhythm. Furthermore it had been used already before in numerous studies as a hand of the internal clock. Fortunately Waldemar Klemke was one of the participants of the seminar. As a biologist he had enough insight and understanding for the biological side of the task, and as an electronics amateur and handicraft enthusiast he could master the technical part. He proposed first a telemetric data transfer. However, after obtaining offers from various companies, we did not pursue this idea further for financial reasons. The sender and receiver would cost more then 100 000 DM. With mountains between the whereabouts and the receiver station, expensive additional stations would be necessary. Digital storage devices turned out to be a favorite alternative. The instruments that Waldemar finally developed and constructed are described in subsection 3.2.

We cared also about things which would be needed for the journey. Offers of travel bureaus for different alternatives and combination of cars, railways, air planes and ship were asked for. We wondered how the participants could be housed, in tents or huts. What kind of equipment is adequate, what kind of food.

At the end of the seminar we made an excursion to the Max Planck Institute for Behavior Physiology in Erling-Andechs (see section 3.1). We talked about our plans and got useful informations and proposals for the planned experiment experiment.

The main question was the funding of the project. We had hoped, that the pharmaceutical industry would offer money. But Li^+ tablets are too cheap. Our inquiries were without success. Only the placebos and Li^+ tablets would be provided without charge (Smith Kline company, Dauelsberg GmbH & Co, Göttingen).

We applied therefore on November 30, 1976 at the German Research Association (Deutsche Forschungsgemeinschaft, DFG) in Bad Godesberg for a grant. The DFG is the central self administrated institution of German science and supports research at universities and publicly financed

[1] tablets, which look alike and are packed in the same way as the medication, but do not contain the effective substance

research institutions. It finances research projects and supports the cooperation of researchers. To get a project financed by the DFG, one has to propose an application, for which certain rules apply (guide for application of a grant). The application is sent by the DFG to referees, who assess it. If they recommend it, it is forwarded to the senate of the DFG. This panel decides according to the financial situation of the DFG, whether the planned project should be supported by the DFG.

In such an application the applicants present themselves under general references and name the topic and the duration of the planned project. Then the research project is presented and the goals listed. The present state of research, own preliminary work on the topic and the work program are presented. Next we had to describe, what was needed for the studies: The composition of the research group, the cooperating scientists, the instruments and material which are available already. Finally the amount of means asked for at the DFG are listed. It consists of money for the coworkers and assistants (often students), for instruments and expendable items, for traveling and for orders to third parties (for instance analyzes in special laboratories, photographic work).

According to our calculations we had to ask for the 14 experimental subjects (students) and three staff members 52900.- DM. 29600.- DM out of it were needed for travel costs, 14400.- DM for the construction of eight digital data recorders, 3870.- DM for expendable items and 1530.- DM for further expenditures. Furthermore 3500.- DM were necessary for analyzing the data.

After having sent the application, the following postscript was mailed to the DFG:

Dr. Johnsson told me today by phone, that he had talked today to Prof. Rønning in detail about our Spitsbergen plans. He considers the area around Ny Ålesund to be more suited as compared to the Longyearbyen surrounding. There are housings for the staff. Instead of living in tents, he proposed to have the experimental groups live in huts. There are several of them in the surrounding which are far enough from each other. He considers danger by polar bears to be extremely unlikely. The accident during the current year was caused by very unfavorable weather conditions in the spring. A boat of the Polar Institute in Ny Ålesund for accommodation and surveillance of the participants is available. The best way of transport from Longyearbyen to Ny Ålesund would be by helicopter.
Dr. Johnsson would apply a grant for four of the twelve experimental subjects at the Polar Institute. If granted, 15367.- DM could be dropped (four data recorders 6400.-, expendable items 1287.-, travel costs 3728.-, living costs 1344.-, equipment 2608.-).

Since we had not gotten any answer about our application from the DFG, we asked and were told, the referees had not yet answered. We sent therefore a letter to the DFG on the 4th of November, 1977 requesting to forward it to the referees.

On November 24, 1977 the DFG answered, that the refereeing has not been finished. They did, however, tell us the hesitations of one of the referees (see in the appendix on page 140), which we responded to in a letter (see appendix page 141).

4.1 A pre-experiment 1978

Anders contacted from Norway the Sysselman in Svalbard, the director of the research station in Ny Ålesund, and scientists in Trondheim, who had been already in Svalbard. The preparations of such an experiment are usually much more time consuming than anticipated. To give an impression, I list a few examples of what has to be considered (see my letter to the Norwegian embassy in Bonn and their answer on page 144).

To convince the DFG, that the hesitations of the referees did not honestly speak against the experiment, we planed a pre-experiment for 1978. Two students, Helmut Ellinger and Fritz Mörgenthaler, were prepared to participate.

Shortly before they left, our application was granted by the DFG, but again some hesitations mentioned.

Anders Johnsson did inform the two participants of the Lithium-pre-experiment 1978 by sending them a list of points to remember (see appendix page 144). They should test the equipment, use huts, try out the way of living, food, clothing, pack sacks and so on. The two drove with their own VW-bus from Tübingen to Oslo. From there they flew via Tromsø to Longyearbyen. Until the departure of the ship they camped in their tent close to Longyearbyen. Then they took the *Hurtigruten* to Ny Ålesund (see figure 4.2).

An Englishman brought both of them with a boat to the Blomstrand-peninsula on the other side of the Kongsfjord (figure 4.3). There they stayed in the London hut (figure 4.4). To avoid disturbances by visitors, they fixed notes in different languages to the door of the hut (see figure 4.5).

They began the recordings on the 9th of July, 1978. Although we had asked them not to undertake exceptionally long hikes and to stick together, F.M. had done this on the 15th and 22nd of July. This showed up in the course of his body temperature, the sleep-wake rhythm (figures 4.7 and 4.8) and in the locomotor activity. But the two had a good time, they spent the days with preparing their food, cutting wood and other work around the hut, with hikes, observing birds, taking pictures (see figure 4.6).

We were afraid that the direction of the sun or activities of people in Ny Ålesund could act as Zeitgeber and prevent free run according to the internal clock. That was, however, not the case, as shown by the analysis of the data (figure 4.7 and 4.8).

On the 27th of July the two were brought back to Ny Ålesund. From their they took the ship to Longyearbyen and the airplane via Tromsø to Trondheim, where they visited Anders. From there they flew to Oslo, from where they drove back with their VW bus to Germany.

The results of the periodogram analysis of the body temperature-rhythm of Helmut Ellinger and Fritz Mörgenthaler during their stay in the London hut are compiled in table 4.1. Main periods found in the analysis were 25.5 and 30.3 hours (these numbers just above the 95 % confidence limit), also 27.8 and 22.8 components were present. Other periods that might be present in the data (revealed when the main rhythms are subtracted) are shown in the column called "residues".[2]

On August 5, 1978 we sent a report of the pre-experiment to the DFG, which can be found in the appendix on page 142.

Brigitte Hirth, a former student of mine, wrote an article about this experiment in the Schwäbisches Tagblatt (see subsection 156 in the appendix), which was later also

[2] The data of Mörgenthaler were analyzed between July 15 and 25, since the lack of data on the 15th were not interpolated. The long periods during the analyzed time are caused by long lasting hikes on July 20 and 21

Figure 4.2: *Ny Ålesund seen from a plane, Kongsfjorden*

Table 4.1: *Results of periodogram analysis of body temperature values of Helmut Ellinger and Fritz Mörgenthaler during their stay in the London hut near Ny Ålesund, Spitsbergen. Period lengths in parenthesis: just above the 95 % confidence limit. All period lengths of the residues of Mörgenthaler, except the 37.0 hour component, just above the 95 % confidence limit.*

Analyzed period	Period length	Signal energy	Residues (h)
Ellinger 12-27 July	25.5 (27.8)	40.8 %	20.0, 22.0. 27.6, 29.8
Mörgenthaler 15-25 July	(22.8) 30.3	32.4 %	13.5, 22.5 37.0

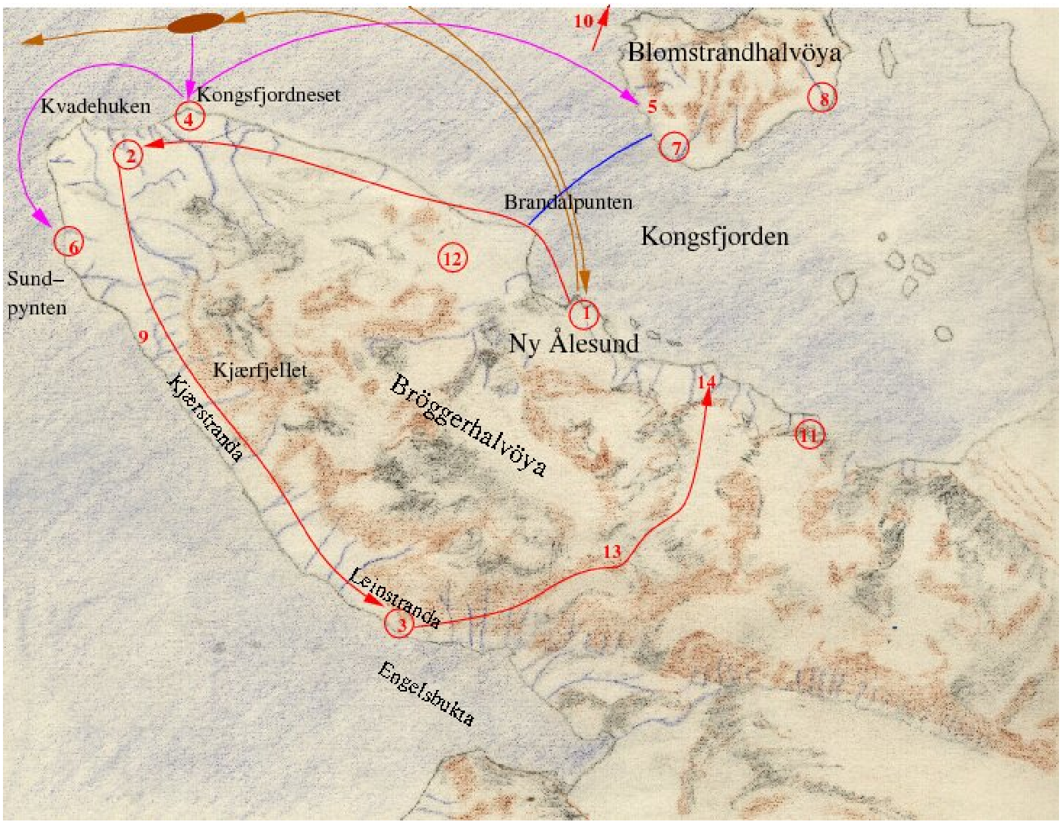
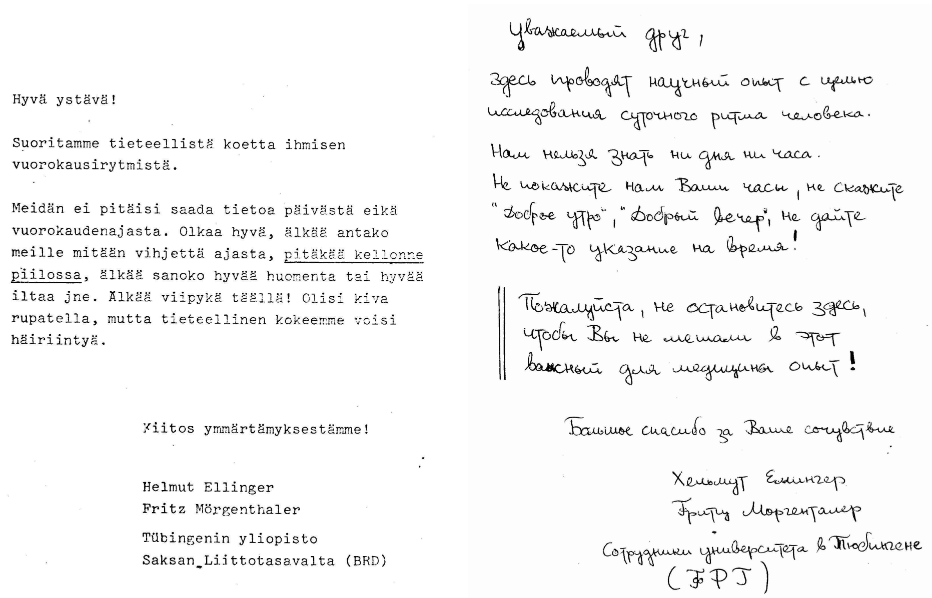


Figure 4.3: *Map of Ny Ålesund and surrounding with travel routes and huts. During the pre-experiment Fritz Mörgenthaler and Helmut Ellinger lived in the London hut (red circle with 7) opposite of Ny Ålesund (1).*
For the main experiment Aud and Olav stayed in Geopol (2) and Inga and Lars-Erik in Stenehytta (3). The red arrows show the hikes to the huts and a later crossing of the mountains by Anders and myself (13,14). The groups of the German participants had their quarters in Londonhytta (7), Gorillaheimen (8), Ragnahytta (10, outside of map), Tyskerhytta (11) and Nilsebu (12). Furthermore the journey of the Polarstar to Ny Ålesund and its way back is shown by a brown arrow, with a blue line indicating the begin of the closed ice field in the Kongsfjord. Magenta arrows indicate some of the boat trips: From the Polarstar to Kongsfjordneset (4), from there with the rubber boat to the Blomstrand-peninsula (5) and to the survival camp (6). Kjærsviken (9) was originally planned as a hut for the siblings Rudolph. Drawn by the author after a part of the topographic map of Svalbard, Sheet A7 Kongsfjorden 1:100 000 of the Norsk Polarinstitutt

Figure 4.4: *Helmut Ellinger and Fritz Mörgenthaler were housed in the London hut. View towards Ny Ålesund*



Hyvä ystävä!

Suoritamme tieteellistä koetta ihmisen vuorokausirytmistä.

Meidän ei pitäisi saada tietoa päivästä eikä vuorokaudenajasta. Olkaa hyvä, älkää antako meille mitään vihjettä ajasta, pitäkää kellonne piilossa, älkää sanoko hyvää huomenta tai hyvää iltaa jne. Älkää viipykä täällä! Olisi kiva rupatella, mutta tieteellinen kokeemme voisi häiriintyä.

Kiitos ymmärtämyksestämme!

Helmut Ellinger
Fritz Mörgenthaler

Tübingenin yliopisto
Saksan Liittotasavalta (BRD)

Уважаемый друг,

здесь проводят научный опыт с целью исследования суточного ритма человека.

Нам нельзя знать ни дня ни часа.
Не покажите нам Ваши часы, не скажите "доброе утро", "добрый вечер", не дайте какое-то указание на время!

Пожалуйста, не остановитесь здесь, чтобы Вы не мешали в этот важный для медицины опыт!

Большое спасибо за Ваше сочувствие

Хельмут Еллингер
Фритц Моргенталер

Сотрудники университета в Тюбингене
(ФРГ)

Figure 4.5: *Information on the door of the London hut in English (not shown), Norwegian (not shown), Finnish and Russian for visitors, to avoid disturbances*

Figure 4.6: *Fritz Mörgenthaler and Helmut Ellinger on a hike near London hytta. For safety reasons (polar bear) they had to take a gun along. This picture appeared in "Schwäbisches Tagblatt", September 22, 1978 and was kindly provided by the newspaper. It was the only picture left, since all the others were distroyed by a fire*

published in "Die Zeit". She received a prize for it.

On August 18, 1978 our application En42/20 was finally granted. From 1975 onward the mode of administrating and accounting of the DFG-resources had changed. Whereas before this had to be done by the applicant, this task had to be taken over now by the administration of the universities. For our project an administrative location was created at the University register in Tübingen. We had to contact also the administration of the university, if personal was hired.

On September 26, 1978 I received the following letter of the DFG:

On the basis of the pilot study sent to us in the letter of September 14, 1978 and after another questioning of one of the referees the granted means of our decision of August 14, 1978 can now be released. We have informed our Department Inspection and Accounting correspondingly.

4.2 Preparing for the main experiment in 1979

After the application was granted we looked for interested students who could participate in the planned Spitsbergen experiment. We had to find participants that were healthy and willing to accept and follow all the requirements imposed on the experiments. We must, therefore, meet and have a pre-study of the interested student participants. We posted an information and "recruitment" sheet (see poster below) and hoped for suitable 'applications'.

In Trondheim, Anders also looked for interested students and found them.

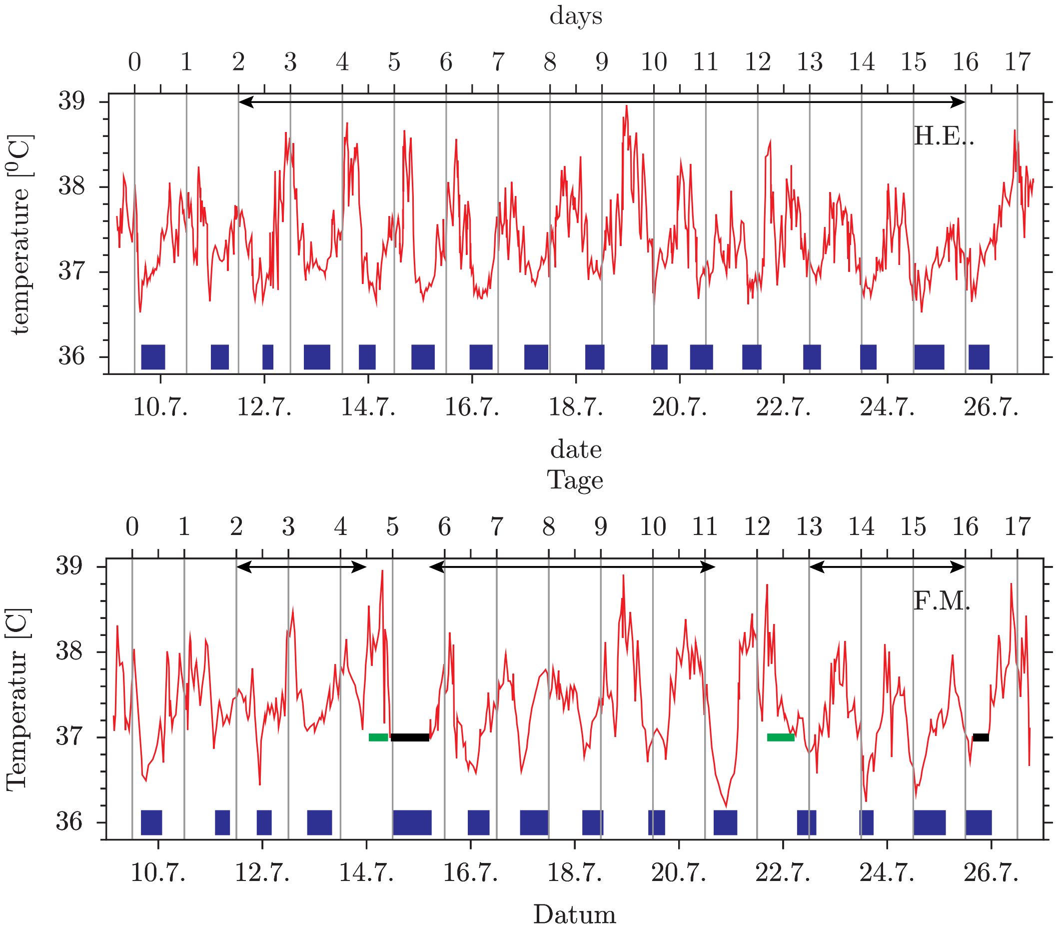


Figure 4.7: *Body temperature rhythm (red) and sleep times (blue) of Helmut Ellinger (H.E., top) and Fritz Mörgenthaler (F.M., bottom) during the time of July 9 to 27, 1978. Arrows show the analyzed periods of time, in the case of F.M. three periods, since he took two long hikes (green), preventing the analysis in these intervals. Missing data of F.M. marked black*

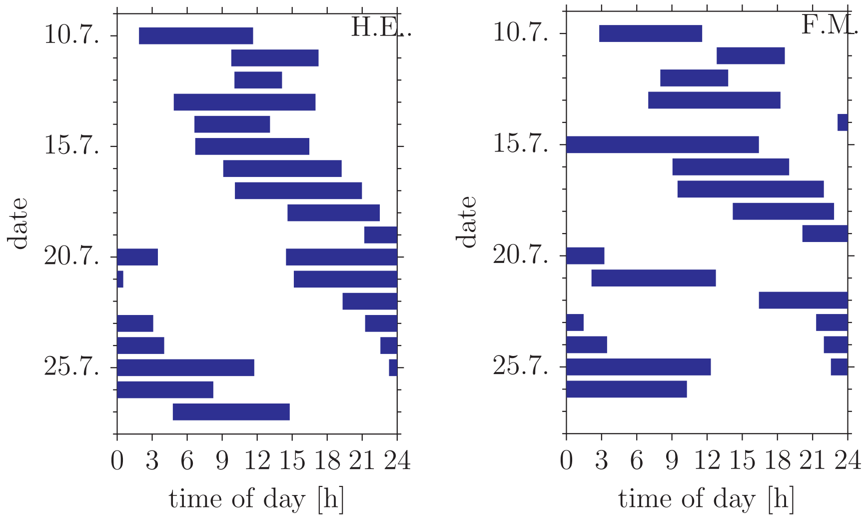


Figure 4.8: *Sleep-wake rhythm (blue: Sleep) of Helmut Ellinger (H.E.) and Fritz Mörgenthaler (F.M.) during the period July 10 to 27, 1978*

Posting

We are looking for participants of a research journey to Spitsbergen (15th of June until 30th of July 1978).

It is a study within the framework of medical-biological basic research. The problem is defined by the prophylactic effect of Li^+ *preparations on phasic dispositions in humans, which is so far not understood. On the basis of studies in plants and animals a substantiated working hypothesis assumes, that* Li^+ *influences the daily rhythm. If this effect shows up also in humans, a substantial insight in the treatment of episodically recurring mood disorders would be obtained.*

The studies are done in Spitsbergen, because conditions of continuous light in the arctic are necessary for the recordings. Engagement and particular readiness for action should be present, since the conditions in this area are quite inhospitable requiring a certain endurance. It is planned to live in groups of two for 6 weeks without time information in simple huts. During the whole time various body functions are recorded, which underlie a rhythmic variation (continuous measurement of temperature with a probe worn in the rectum and a small portable recorder, simultaneous recording of movements, collection of urine samples for later analysis of the ions, filling in of questionnaires concerning mood). From time to time blood samples are taken by a medical doctor. A diary should be kept with free entries.

The conditions, which one has to deal with in Spitsbergen around this time of the year are continuous light, about 5 - 10° environmental temperature, tundra without trees with bare vegetation, fjords, stony landscape. Eventual risks might arise from the consistence of the terrain, getting lost in fog, meeting polar bears. The landscape is boring and without recreational opportunities.

A modest living throughout the experiment is necessary. As a partner couples or friends of longer times are worth considering, since living together without con-

tact with other people are demanding. From time to time people of the staff will contact the groups. There is furthermore the possibility to contact the staff by radio telephony. The participants are besides the required tests free in choosing their leisure occupations.

The final selection of the participants occurs after a detailed medical checkup. Maximally only 12 persons can participate. The checkup will be in January/February/March and includes among others a transient adjustment to the Li^+ *tablets, in order to check the tolerance (the medication is used already since more then 10 years therapeutically).*

Journey: Tübingen-Tromsø (Norway) by train. Tromsø-Longyearbyen in Spitsbergen air flight. Longyearbyen-Ny Ålesund helicopter.

Staff: Dr. W. Engelmann, Institute of Biology I, Tübingen (experimental procedure and organization), Dr. B. Pflug, Psychiatry Tübingen (medical care), Diplomabiologist W. Klemke (technical organization), Prof. A. Johnsson, Biophysics Trondheim (Norway) (overall organization, safety, transport).

If interested, please contact Dr. Pflug (telephone Tübingen (07071) 296527 or Dr. Engelmann (telephone Tübingen (07071) 296162.

More students were interested than we needed for the experiment. But since Burkhard had planned a study for finding out the effect of Li^+ on physiological and psychological attributes, we did not mind.

5 The participants

In Tübingen and Trondheim measurements of daily rhythms were performed within the framework of seminars in students and participants selected for the planned experiments in Spitsbergen.

Before the experiments in Spitsbergen started, we had invited students within the framework of a seminar in Tübingen, and Anders similarly in Trondheim, to measure their body temperature and the locomotor activity under the influence of Li^+. After four weeks the recordings were continued with placebo tablets. Beforehand all the participants were medically examined, either in Tübingen or in Trondheim, and the number of tablets determined, which were needed to reach the correct Li^+ level. With questionnaires the chronobiological phase type was furthermore determined (so-called Östberg test, see sections 11.5.8) and psychological tests performed. The students were hold out the prospect of participating in our planned Spitsbergen expedition. The selection would be based on the measurements. Important was to clearly recognize variations in the body temperature, regular daily courses and to find not too extreme chronobiological types.

At the end of these studies for the two Norwegian groups Aud Tveito-Ekse with Olav Ytre-Arne (group NI) and Inga Strömme with Lars Erik Berg were selected (group NII, see figure 5.1). The German groups consisted of Albert Gorthner with Ulrich Schäfer, Peter Klein with Anna Schneider and the siblings Angelika and Bernd-Ulrich Rudolph (figure 5.2).

Figure 5.1: *Olav Ytre-Arne and Aud Tveito-Ekse (from left) formed the Norwegian group I, Inga Strömme and Lars Erik Berg the Norwegian group II. Here in Ny Ålesund*

Finally, the leaders and organizers have to be mentioned, Anders Johnsson from the Physics Department of the University of Trondheim, Burkhard Pflug from the Psychiatry Hospital, Waldemar Himer (former name Klemke) from the Plant Chemistry Institute and myself, Wolfgang Engelmann, from the Biology Department I of the University of Tübingen.

Figure 5.2: *Anna Schneider (front left) with Peter Klein (behind) formed the German group GI, Albrecht Gorthner (second from left, back) and Ulrich Schäfer (second from left, front) group GII and the siblings Angelika (second from right, back) and Bernd-Ulrich Rudolph (right, back) group GIII. Here photographed at the airport of Longyearbyen. Our medical doctor Burkhard Pflug at the front right*

6 Journey to Ny Ålesund, transport to the huts

Unexpected difficulties during the journey to Ny Ålesund. How the two Norwegian and the three German groups reached their huts and were supplied with food.

Towards the end of May we engaged the Hamburg Shipping Company to ship our luggage to Ny Ålesund. From Tübingen it was sent with a transport company to Hamburg, after dispatching it by the customs office in Tübingen. They proposed to fill out the allegedly necessary T2L-form, but they could not find it. The head of the office proposed therefore that we do not need a special form, since only personal things are involved. A list had to be made, the titles of the books of the participants, the number of rubber boots and so on. Since we had to check all this in the already packed chest, we had to open it, and afterward we had a hard time to get the lid closed again. On June 9 the chest should be transported with the ship Nord Norge to Ny Ålesund and arrive there on June 15. But Anders was later told in a telephone call from Trondheim with the Bergen Shipping Company, that the ship was not able to bring the load from Bergen to Longyearbyen because of the frozen sea in Spitsbergen and that they will try again in a second approach.

On Saturday, the 26th of June 1979 Waldemar and I travelled by train from Stuttgart via Copenhagen to Oslo. From there we flew to Trondheim. Anders picked us up at the airport and showed us the impressive dome. In the evening we met with the four Norwegian participants and talked about the journey and the difficult and unexpected situation due to the frozen shipping routes in Spitsbergen. We went asleep late.

With taxi and bus we reached the airport on Sunday, the 27th of June in the morning. The flight from Tromsø to Svalbard was two hours delayed because of fog. Above the Bering street was a dense cloud cover, which was especially high above Svalbard. It was still foggy. The pilot comforted us by telling us, there is enough kerosene for up to an hour to circle above Svalbard. Finally the airplane dived into the fog. In a swashbuckling flight we were penetrating the low laying clouds. Now the ice floes became visible on the sea. The closer we approached the land, the more coherent the ice cover became. The visibility improved.

At the airport of Longyearbyen Harald Celius picked us up. With a VW bus he brought Anders, Lars-Erik and Inga to the Vitenskapens hus, the rest stayed over night in the hut of the MAB[1] project 12 km outside. We drove through a bleak area of the coal mining industry with dirty roads, passing the water reservoir of Longyearbyen. In the hut we met Nick from Cambridge. He studies the behavior and the survival rate of the Spitsbergen reindeer. In the evening we met with the others in the Vitenskapens hus. On the way back to the hut of the MAB project the VW bus had a flat tire. Close to the hut some Ger-

[1] Man and Biosphere

mans camped and tippled with Inge, the Sami driver of the bus, through the night. Aud and Olav went to bed around 3:00. We experienced for the first time the continuous light of Spitsbergen and covered the windows with blinds.

On Monday, June 28th we rose at 7:00 o'clock. At 9:00 we woke up Aud and Olav, who were quite sleep deprived. Olav drove, since Inge, the driver, was not yet able to do it. Due to a change of a wheel we arrived too late at the airport. The first group had left already. We, that is Lars-Erik, Waldemar, and I had a wonderful flight above the Isfjord, at which Longyearbyen is situated, and over the mountains following the coast to Ny Ålesund.[2] The weather was much better as compared to yesterday. Clouds on the sky, ice floats on the water and much snow on the land. We land on a small airstrip above Ny Ålesund. Then we were welcomed by the chief of the Research station, Kristian Sneltvedt. He played an important role for us during the whole experiment. We also met Harald Bratback from the Botany Department in Trondheim, working within the Man and Biosphere project in close collaboration with professor Olaf Rønning.

We carried our luggage into one of the houses of the Research station, a fairly comfortable 'headquarter' for our team during the weeks to come. From this place we were also to provide supply and care for the various participating groups in their huts. And here we would also survey the experiment and analyze the printouts from the recorders to visualize the courses of the body temperature of the participants.

At this time we just barely started to understand and to contemplate the extent of our transport problems - with no ship being able to deliver our supplies, due to the heavy ice in Kongsfjorden, and with our inability to distribute supply to the huts via the frozen sea with our rubber boat.

On Tuesday, the 29th of June, begins the subjective day 1 for the four Norwegians with beautiful weather. We rise at 6:45, prepare the Li^+- and placebo tablets in envelops and have a breakfast at 7:30. Now we have to reach the huts. The first one, were Aud and Olav will stay, is Geopol, which was constructed by an oil company trying to find oil by drilling. It lies about 15 km west of Ny Ålesund (see figure 4.3) on Kvadehuken[3] in a stone dessert with a peculiar charm. Small ponds and stone

[2] Ny Ålesund is one of the most northern settlements of the earth. The first building was constructed in 1901 by a private black coal company. 1916 the settlement was founded. The extraction of coal was discontinued in 1929, being not worthwhile anymore. From 1945 it was started again under state directive, but closed down permanently after a mine disaster in 1963. The settlement should have been closed. However, the existing buildings were now used for a Polar Research Station, which opened in 1968 and now an international Research Center. During the winter about 30 persons stay here, during the summer about 120. The settlement is supplied either by air or during the ice free season by ship. Ny Ålesund has the most northern post office on earth. On mount Zeppelin is a station for atmosphere studies. From there one has a beautiful panorama view over the Kongsfjord.

The climate in Ny Ålesund is arctic. Due to the Golf stream it is, however, relatively mild in respect to its high latitude. The coldest time is February (-15,2° C average temperature), the warmest month is July (average +4,7° C). The precipitations are uniformly spread over the year (average 385 mm), only during May and June it is relatively dry. See http://de.wikipedia.org/wiki/Ny-Ålesund

[3] after the Dutch name Kwaade Hoek: Bad corner. Due to numerous flat rocks in front of the coast this headland is dangerous for ships

circles (see subsection 11.5.13 in the appendix) are found here.

The second hut is Stenehytta, which lies on the other side of the mountains south of Ny Ålesund (see figure 4.3). The hike to the huts is much more difficult then anticipated. Originally it was planned that Waldemar would bring the groups with their luggage to their lodgings with his rubber boat. Since the winter was staying so long and the Kongsfjord was still frozen, neither the chest from Tübingen nor the food boxes from Norway had arrived. The situation was difficult. But fortunately Kristian Sneltvedt and Anders could arrange for emergency supplies from the Research station and (wooden!) skis for all of us. We could also use a drawing sled to transport some heavy supplies and luggage over longer distances.

The students had bought in Trondheim photo equipment and had it sent to Ny Ålesund. In this way they did not need to pay tax. Besides the private belongings we carried gasoline and petrol for cooking.

At 13:15 the four students, Anders, Harald Celius and I started from Ny Ålesund. Waldemar was sick. He took penicillin and stayed in bed. First we crossed the frozen fjord and reached Brandalpunten, then we passed the rocks at Stenhallet and reached after a few hours Geopol. We all had some food. Celius instructs briefly the males of the groups how to use the guns. Afterward he walks back to Ny Ålesund.

The recorders of Aud and Olav are prepared, paper and batteries tested. At 23:30 they are started (Aud estimates the time to be 22:30, Olav 23:00, Inga 22:00 and Lars-Erik 23:00). I am also starting to record my body temperature with my own data logger. All of us stay over night in the hut. Before going to sleep I inspect the river close by. It has a very high level due to the melting snow.

Before our hike to Stenehytta we give some advises for the participants. They should deposit the data of the printer in envelops at the door and mark the subjective days, allowing us to pick them up even if they are asleep or happen to be under way. In this case they should note down in which direction they are planning to walk and how far. They should, however, not undertake strenuous hikes. They should also note the code number when drinking (and the amount of drinking), the code when eating, sleeping etc. Activities were also to be specified and the weather conditions to be written down. In case of emergency they should hoist a red flag on top of the roof and an SOS sign visible for planes.

On Wednesday, 30th of June (subjective day 2) Aud and Olav rise up at 8:30, we have breakfast at 9:30 (Aud estimates 6:30, Olav 9:00, Inga 8:30, and Lars-Erik 9:00). Anders and I slept quite disquietingly. Anders hip was hurting due to the unusual long skiing tour the day before, and by fetching water he brakes through the ice, shoes and trousers are getting wet. We both ate just a bit to save the supplies.

At 10:30 Anders, Inga, Lars-Erik and I start our tour. We have skiers and the sled. After about two hours we reach Kjaersviken, a small, beautifully situated and well equipped hut on the way to Stenehytta. There is, however, no heating material. We cook a soup and eat the content of two fish cans which we find in the hut. Sled and our pack sacks we deposit above the hut at the foot of the mountains for our way back. Up there the crossing of the creeks is easier; further to the sea they are deeply cut into the rocks. At 13:50 we continue our hike to Stenehytta. At 16:30 we rest at the big Traudalen, at 17:30 at the moraine river, and at 18:20 we finally reach Stenehytta. At 23:45 Inga and Lars Erik begin recording (Inga estimates the time to be 23:15, Lars Erik 22:00). Anders and I had originally planned to walk back to Kjaersviken on the same evening, but since we had gotten burning eyes because of the very sunny day, and since we needed sleep, we stayed overnight in Stenehytta.

On the next day (Thursday, 31st of June, subjective day 3) Anders and I rise at 6:30 quietly and begin without breakfast (since the emergency ratios for the groups are scarce) the way back at 6:45. We walk back further up, which is better as compared to the way to the hut. Unfortunately it is again very sunny and the rivers have much more water. We arrive at the place were we had deposited the sled and are now able to put our pack sacks and the gun on the sled. On our way we meet reindeer. They are smaller than the one from the mainland. Two years ago 15 were flown in from Longyearbyen and brought to this place. Because of an error in the telefax they got, however, after the transport not enough food (200 instead of 2000 g per day).

We felt like these reindeer after our almost five hour tour. We passed a few bird rocks, saw at snow free locations Saxifrage (*Saxifraga oppositifolia*). At 11:30 we reached Geopol, but could not come to the hut because of the high level of the river. We crossed it therefore higher up. Completely exhausted we arrived at 14:30 a tiny hut with just a small bench inside. We had nothing to eat for the whole day, were very hungry, had tummy rumbles and our head lacked blood. Fortunately we found a lump of old sugar in the hut. After a rest for half an hour we continued our way towards Ny Ålesund, were at the Knudsenhights Harald Celius came towards us like an angel. He took over the sled with our luggage and showed us the shortest way over the frozen fjord. Quite exhausted and hungry we finally arrived. We eat a lot, have a shower and sleep for half an hour very deeply. In the evening we eat again a lot.

On the 6th of July Anders has to participate in a meeting in Tromsø and flies to Longyearbyen. There he meets on the airport the German participants with Burkhard Pflug, our medical doctor (figure 5.2). They had arrived by plane from Tromsø. He explains them quickly, that the Hurtigruten[4], the passenger ship, which should have brought them from Longyearbyen to Ny Ålesund, can not go: The winter was long and hard and the Kongsfjord still frozen. Therefore three of them should go with the Polarstar to Ny Ålesund, the other four should fly with the same Cessna, with which Anders arrived. The pilot would be coming in 2 hours (or later). He himself had to take the plane to Tromsø.

In a letter to his parents Ulrich Schäfer describes the journey from South Germany to Longyearbyen:

Since in the next days we expect a visit of Herrn Pflug, who will take the mail along, I will begin with a detailed report, which will also be a diary and document for myself. You know already, that I reached the Intercity train in time[5]*. We all gathered in a compartment and had a good time talking. Herr Pflug was also in high spirits, talkative and companionable, in the meantime we have de facto started to say "Du" to each other. In Mannheim we had to change trains in a few minutes. The other Intercity was, however, on the same plat-*

[4] the Hurtigruten ships run along the Norwegian fjord coast and in former times also to Longyearbyen and Ny Ålesund on Spitsbergen

[5] Ulrich entered the train in Stuttgart

form, even the same reserved compartment was opposite to ours, so that the change went smoothly. The next change was in Hamburg. We had one and a half hours stop, which was long enough for a small evening meal and to buy a smear-resistant felt pen. Then we left for Copenhagen. Briefly before sunset the whole train was stowed on the ship "Deutschland" and we could for the first time smell sea air. After landing we experienced the last sunset for several weeks and the onset of a night.

Around 23 o'clock we had reached Copenhagen, where we had to change trains again, now in a Norwegian, well equipped couchette. I was even able to sleep somewhat and did therefore notice almost nothing from a further shipping. The last landscape, we had seen in the evening, was Danish flat country, almost completely used by agriculture. Now in the morning we found our self in a smooth countryside of hills, lakes and fjords, woods, meadows, fields and picturesque settlements of typically Scandinavian character. We reached Oslo at beautiful weather, where we after a short discussion decided to take a taxi to the airport, which meant, that we did not see much of the city.

After Oslo the weather worsened below us, and when we landed, it was quite cloudy. Albrecht and I set in the rear of the plane, and when the back door was opened, we took our hand package and left. It was a small airport, and walking towards the airport building we were wondering why we could not see any name "Tromsø" written. In this moment somebody of our group whistled us back, since it was just a stopover at a military airport shortly before Tromsø. The next airport was Tromsø, the climate became arctic, the airport buildings smaller and improvised, and the passengers more hearty.

During the flight over the Polar Sea we saw the first pack ice fields, and the Bear island, which can only seldom be seen. Then Spitsbergen: an unforgettable view, partly still completely snow covered, giant glaciers, I hope my slides turn out well. (End of the letter).

In a further letter Ulrich describes the arrival in Longyearbyen and the flight to Ny Ålesund and the transport and ways to the huts. The report begins with Wednesday, the 6th of July, 1979:

We had a few hours time in Longyearbyen, and since the airport building was closed after the start of the plane (the next flight is in a week), we bustled in the surrounding. We did not want to walk to Longyearbyen, and since the weather was beautiful, we crossed the airport (via the runway) walking uphill. It was quite warm, we had a magnificent view over the Isfjord and saw besides the flora starting to flower also two reindeer, even quite close.

The pilot came finally, and we started in a five-seated Cessna towards Ny Ålesund. Again a glorious view, the ice in the fjord starting to brake up, the glaciers, the mountains. Unfortunately the sky became cloudy, and at the landing on an unpaved, stony airstrip full of puddles, surrounded by snow, it was completely covered.

The pilot had flown a round over Ny Ålesund, and immediately after the landing a VW lorry arrived with the Sysselman of Ny Ålesund, a kind of Burger Meister, as well as his daughter (together with her mother the whole womanhood of Ny Ålesund), who greeted us and drove us to the settlement.

We could now see our self, why the Hurtigruten could not run: The Kongsfjord was still completely frozen and there was a lot of -though thawing- snow. In the canteen (and the lounge of the scientists) we got some-

thing to eat, and the Herren Engelmann and Klemke reported about the difficulties they met because of the weather. Most of the huts which were planned as a stay for us were unreachable because of the snow and ice, and the other were reachable only by foot, partly through rapid rivers. It was not clear what will happen, for the time being we had to wait for the chest with the rubber boat and other things, and for the food. They were hoping that it would arrive on the following day with the icebreaker, with which the three missing persons of our expedition group would come.

Ny Ålesund consists of about 20-30 buildings and not more inhabitants. We four got one of the empty huts, which was in a fairly good condition. It was a funny feeling, to go to bed at bright light and to know, it is past midnight. Because of the unfamiliar sleeping conditions we soon woke up and Albrecht and I started to visit Ny Ålesund. We had finished it after not more then an hour: The buildings, a few sled dogs, the research station, two polar foxes in a cage, an Amundsen statue, the pole, from which he started with his Zeppelin to the north pole, a whale vertebra, an old steam locomotive from the times at which coal was still extracted, snow and melting water.

At the coast we saw that the icebreaker was making its way through the fjord, slowly and troublesome, in small parts, so that we could have our breakfast in the canteen, before it arrived. The arrival of the first ship of the year is of course an important event, and therefore the whole population of Ny Ålesund was standing on the gangplank, while the "Polarstar" anchored. In the following hours it became hectic several times, because it was not clear, how long the ship would stay, several messages came, whether the chest and the food boxes were on board or not. They were, and we had to sort and stack the food boxes on the gangplank before the ship left again, to open the chest and build up the rubber boat; and finally all nine of us together with the boat, luggage and food for the first days went on board of the ice breaker. It made its way to the outlet of the fjord, were the sea was ice free. There we were set to a small shingle beach. It was otherwise a steep coast, about 10 m high, on top a plateau. The shingle beach existed only during low tide, at high tide the water reached probably up to the snow, which started in breast height and extended to the top. Our luggage could of course not be left on the hardly 1 m broad beach. The luggage and the food boxes were therefore brought up to the top, while 4 of us including the luggage were brought in three goings with Klemkes rubber boat across the fjord, and where in the middle of the fjord (of course!) the motor - which was running for the first time this year - stopped and could be started again only after several trials.

Albrecht and I were the first to be transported with our pack sacks and we had agreed with Klemke, that while we would carry the pack sacks to the next, eventually also to our hut, he would bring over Peter and Anne, and that they should in any case wait, until he had brought in his third crossing the remaining luggage, and that we four, Anne, Peter, Albrecht and I would bring all of it to the huts. That somebody should wait at the place, where we arrived, was important for Klemke, because he could not tie the boat and unload it without a regular embarkation point.

Albrecht and I started to walk after landing and soon realized, that we would on this day at best reach the closer London hut. We brought our pack sacks to it and returned. According to our estimation Peter and Anne should have arrived already, *and the third arrival of Klemke would soon occur. To our surprise neither Peter nor Anne nor any luggage nor Klemke were there, which made us speculate in different directions, especially since there were tracks at the landing place which were not from us.*

After some time Peter and Anne arrived; they hiked also to the London hut, but failed us, and explained the situation. They had asked Klemke, to make his third crossing later, to give them time to bring a part of the luggage to the hut. This they did. We saw how Klemke approached the coast, but not quite in the correct direction, and since in the meantime a lot of flow ice had accumulated in front of the landing point, we were afraid, he would not find us. More out of curiosity than out of -not very serious- concern, what effect our signal pistols would have, we gave a shot, while Klemke disappeared with his boat behind a rocky protrusion; we were surprised about the deafening noise, but it was surely not widely hearable and visible. We have, however, also a longer burning and higher climbing signal rocket.

Klemke found us -even without signal rocket, we unloaded and walked four of us heavily packed (I myself carried already about 35 kg on my back) through snow fields and morass to the London hut. There we made a good fire (shoes and socks were completely wet), cooked and ate something and slept. On the next day we four walked together to the Gorilla hut, were Albrecht and I should stay, had lunch here, while shoes and socks were hanging on top of the stove for drying. In the afternoon we went unloaded back to the London hut, and Albrecht and I walked back under rain showers with the rest of the luggage and the food to the Gorilla hut.

That was the whole journey to our destination point. How the hut is looking like, its surrounding, the entire peninsula, all our doings here, about all this I will write later ...

The following is taken from a report of Waldemar Klemke, occasionally supplemented by myself respectively slightly changed (WE). It overlaps partly with the report of Ulrich:

Since the the biggest part of the fjord is still frozen (see the blue line on the map, figure 4.3 WE), members of the station perform blasting at various locations, in order to flaw the ice. In spite of it one can hear almost the whole night, how the Polarstar with its enforced hull makes its way through the ice to the landing stage of Ny Ålesund. It uses thereby the icebreaker way to gain momentum and drive a bit on the ice, to brake it by its mass, drive back and take a new run-up. In the early morning of the 7th of July Wolfgang and I are together with some people of the station on the landing stage and expect the rest of the participants of our expedition. For the station it is the first ship of the season.

After landing and welcome of the newcomers besides the supply for the station of Ny Ålesund our equipment and the food boxes for our expedition supplied by a Norwegian company[6] are unloaded. We had obtained gasoline from the research station for the rubber boat and petroleum for cooking on the huts. In a hurry we built up the rubber boat, equipped it and mounted the outboard motor.

It was originally planned to bring the participants with the rubber boat to the huts at the Kongsfjord and in the Engelsbukta. The unusually thick and compact

[6] luckily the rumor, the boxes are not on board, turned out to be wrong

ice in the Kongsfjord put a spoke in our wheel. The ship had to return soon, to avoid, that the laboriously broken route through the ice would not freeze again.

Our plan was to find a location at the coast, from were we could deliver the German participants with the rubber boat to their huts. We had furthermore also to bring the food boxes to the huts of the Norwegian participants, which had so far only emergency ratios of the station. After a short discussion with the crew of the Polarstar and members of the station we decided, to take all Germans together with the rubber boat, other equipment and a part of the food boxes on the ship, bring them back in the ice free part of the fjord and transport them from there with the rubber boat to the huts (see figure 4.3).

In a hurry Wolfgang and I decide to take out of the food supply boxes type A to D only the A type one, since we assumed they would contain the essential food. All the others we could deliver later, under better weather conditions, to the participants of the experiment (see figure 6.1).

The journey through the now open path in the ice is impressive. We enjoy the view across the ice to the snow covered mountains of the fjord and if it is getting too cold at the railing, one can even eat a snack in the warm cabin of the Polarstar.

Its getting hectic, however, when we reach the ice free water. The crew begins to unload the participants with the help of the dinghy of the Polarstar at the coast on a small stripe of gravel below a wall of ice and snow of several meters height. My rubber boat is also put on the davit and downed to the water. After all the participants and Wolfgang, Burkhard and the equipment is delivered to the coast, the Polarstar is bowing out and continues its way to Longyearbyen.

I can now start to bring the participants with the rubber boat to their huts. First the two groups Albrecht Gorthner/Ulrich Schäfer and Peter Klein/Anna Schneider are transported in two tours to the Blomstrand peninsula close to the London hut. Because of the ice shield it is not possible to bring them directly to the huts. The two groups have therefore to cover quite a distance heavily packed on land (see figure 6.2). Since the way to Gorillaheimen of Gorthner/Schäfer is quite a bit away, they stay for a night in the London hut and continue their hike to Gorillaheimen (red circle 10 in figure 4.3).

WE: In the meantime Burkhard and I try to bring two food boxes to Geopol. We deposit the boxes at the bank of the river and continue our way to the hut. The Norwegians are still asleep (they wake up briefly afterward, as turns out later). To avoid disturbing them, we pick up their letters from the box at the door, deposit a note with a sketch explaining the location of the food boxes, and that we would return tomorrow. Coming back to the coast Waldemar is just leaving with the Rudolph's to bring them to their hut.

WH: Surprisingly the rest of the expedition has disappeared when I return to the landing place. The shingle beach is also gone. The coming tide had forced them to move into safety by climbing a few meters higher via self-made steps in the snow and ice wall.

The Rudolph's had now to be brought around Kvadehuken ("devils nose") to the Kjaersviken hut (2 in figure 4.3) in the Engelsbukta. Since the boat is accredited for three persons only, two journeys are needed. Rapidly we reach the Engelsbukta – the boat reaches 35 to 40 $\frac{km}{h}$– but we have to stop long before the hut at the Syndpynten. The upcoming southeast wind

Figure 6.1: *At the Kongsfjordneset we, the luggage and Waldemars rubber boat were uploaded with the dinghy of the Polarstar (left). From there Waldemar brings the groups GI and GII to the Blomstrand peninsula (same location, top view, right)*

Figure 6.2: *The two groups Gorthner/Schäfer and Schneider/Klein had to walk through snow to the London hut. For Peter (mule) this was quite hard, since he had planed off a piece of a finger in Tübingen briefly before the journey and because the finger became again and again wet in spite of a good protection and a glove. Picture taken by Albrecht*

and the waves caused by it brakes the fjord ice up and drives it in large floes against us and onto the open sea. We land and the Rudolph start to hike to their hut, instructed with a rough description of the position of their hut.

The next boat tour brings Wolfgang and Burkhard in the Engelsbukta. However, the wind and the floating fjord ice forces us now to land even earlier. For some time I am trying to evade the large ice floes with the boat. But when almost no open water is left, we pull in a hurry the boat over the snow barrier caused by the waves onto the beach and observe a bit later, how the wind pushes huge ice floes to the coast, brakes them and piles them up in a large wall (see figure 6.3). It reaches such a height and the movement of ice floes on the sea is so strong, that we can not continue the journey with the boat.

The only way out is to walk by foot to the *Kiærviken hut* at the Engelsbukta. We take the most important items with us and also some of the food boxes type A and abandon the boat. The way is cumbersome, most of the swath at the coast covered with snow and it is especially unpleasant, if melting water has accumulated underneath the snow. Awkward are also the water- and wind tight sailing clothes, especially for Burkhard, who, being of a shorter stature, is fitted in a suit of size L. The crutch as well as the immersion of his legs are at the level of the knees of the suit. We leave one after the other heavy food boxes behind hoping to fetch them later.

After some time the Rudolph's come towards us. They had to return, because their way was blocked by the melting waters from the mountains; not deep, but with glassy ice ground and rapid current. Therefore we all returned to the boat, collecting up again the luggage left back. There is no indication of a fast change in the ice floe streaming and the weather conditions generally, and to make things worse it starts to rain at an air temperature between 3 and 7^0 C.

The Rudolph's start to construct a shelter at the beach out of the ice floes being available in masses (see figure 6.3 and also figure 7.22, taken by Lars-Erik at the Engelsbukta WE). The top is covered with driftwood and further ice floes on top of them. But when they turn on a fire in the interior of this shelter, it is hardly dryer as outside in the rain. Since we have to reckon with at least one overnight stay at this location, we put the boat on top of two drift logs above a trough in the soil. In the through under the boat Wolfgang and the Rudolph's find some protection against rain and wind, in the boat closely packed head to feet lie Burkhard and I, protected against humidity by rain proof covers for the sleeping bags.

For "dinner" we opened the transported food boxes and are after all quite surprised by the content. Instead of the expected basic food we find toilet paper, detergent, matches, a can with Tuttifrutti (much water and a few fruits), but also rice and onions. The full grain during bread is unfortunately molded. Wolfgang had forehanded taken along on the journey his tiny gasoline cooker, allowing us to produce magically a warm meal out of rice and onions by using the not quite appropriate gasoline-two stroke mix from the tank of the boat. As desert ice cold Tuttifrutti was served.

The next morning did not bring any change in the weather conditions. The ice floes at the beach are condensed by the wave attacks and now large ice blocks wobbling in the swell obstruct the way to the water. During the course of the day a he-

Figure 6.3: *Angelika and Bernd-Ulrich constructed a shelter in the ice floe piles (left). When a passenger ship passed by (at the horizon), we waved with a red flag as a SOS signal*

licopter announces itself long before it is visible by the noise of its motor. It is the Sysselman of Spitsbergen on his way to Ny Ålesund.

He probably wants to see on a side trip these strange Germans, who, in spite of most adverse weather and snow conditions try to get their experiment done. In contrast the Norwegian scientist working at the same time in the station in Ny Ålesund: They give way to the snow situation and spend the days in the station with good french red wine, which is warmed up on the radiators to drinking temperature before enjoying it. The helicopter turns a round above our camp in low altitude and I try to remember an emergency signal and wave my arms side wise and above the head up and down. The passengers of the helicopter wave and haul off. I am hoping the passengers are put down in Ny Ålesund, and that we are afterward taken up to rescue us from our difficult situation. Apparently my memory of the standard emergency signals were too weak, at least the helicopter does not return.

We have to realize, that we have to spend at least another night in our camp. Short exploratory walks at the coast of the Engelsbukta show us, that the situation has not changed essentially and that we are enclosed at this part of the bay on both sides by rivers of melting water. Thus a hike over the mountains or along the coast to Ny Ålesund is not possible.

To make sure that our emergency calls are not misunderstood again we put a large SOS sign out of large pebbles in the snow and keep our emergency signals ready. Otherwise we can't do much. At a fire out of drive wood we try to dry the sleeping bags out of downy feathers which got wet by the rain, but the radiation heat of the fire is not able to do any good at the low air temperature. The wet downs of the sleeping bag have turned my feet into ice bones up to the thigh. The following night is thus even more comfortless, although it does not rain anymore.

The next day we see far away at the outlet of the Engelsbukta a ship of the Hurtigruten passing by direction Ny Ålesund. We use this situation and fire our emergency signals, maroons, from the pistol and a rocket, which shoots a long burning light signal at a parachute in the air. Our hope, that the crew of the ship passes information to the station in Ny Ålesund, is in vain, as we get to know later. Thus we have to stay overnight a third time under the scanty conditions.

Early in the morning I am woken up by Wolfgang. During the night the wind had turned and driven the ice barriers at the beach into the open sea. The sea is free and smooth and we are now able to escape from our bad situation. Hectically we push the boat in the water. Together with Burkhard and the Rudolph's I start direction Ny Ålesund with the promise, to pick up Wolfgang later.

After a few hundred meters, however, we enter a dense foggy wall with a sight of not more than 10 to 20 m. A problem is the bypass of Kvadehuken. The Norwegians at the station had urged us, to keep enough distance to the coast because of the sharp rocks reaching the water surface. Thus we had to steer a short while on an imaginary bow around Kvadehuken in the fog, turn after some time right angled towards the completely invisible coast and, if Bernd-Ulrich Rudolph, seated at the bow, reported to see a rock in the water, to turn away again towards the open water. In this way we fumbled successfully and in segments around the coast which was so dangerous for rubber boats. We reached finally the fog-free Kongsfjord, but are not able to continue to Ny Ålesund because of the still prevailing ice cover. Therefore we pull the boat at the boarder of the ice sheet to the land and walk the rest of the way through the melting water of the rivers and through snow fields.

Due to the unforeseen snow depth at Spitsbergen, the unusually long frozen fjords and not least due to our camp in the Engelsbukta the time schedule of our experiment was afflicted. The participants had to be taken blood samples for checking the Li^+ level, the food boxes still waiting on the gang way in Ny Ålesund had to be delivered and to make things worse the Norwegian participants of the expedition had announced, they would terminate the experiment, if they would not receive the missing food until a certain dead line.

Therefore Burkhard decided after arriving in Ny Ålesund, to order the helicopter stationed in Longyearbyen and to solve all problems in the shortest time possible. In this way we were able to fly in not even an hour to both huts, to deliver the food, to collect blood samples and to bring Wolfgang back to Ny Ålesund. The costs of this helicopter use amounted to 1200 DM and were for a long time a hot potato...

As an addendum to the report of Waldemar on our Survival Camp: During the last of our four over'nights' (it was, mind you, light all the day) outdoors I experienced for the first time of my life coldness shivering. Thereby the body uses automatically muscle work for the production of heat. Since, however, the muscles have to be supported in a higher degree with blood, much heat is also lost. In men the yield amounts to about 11 %. A special experience, which I do not wish anybody, however.

After Waldemar had transported the Rudolph's and Burkhard to Ny Ålesund, I had walked to Geopol (the rivers were passable again) and visited the slightly annoyed Aud and Olav. They had not found the boxes, the location of which we had noted on a piece of paper at their door. So we walked together to the place and got them. I furthermore told them about our mischiefs and that Burkhard will send a helicopter with the remaining food boxes (and to take blood samples).

From Geopol I walked to Stenehytta, to tell them about the helicopter use for discharging the food boxes. There I was picked up by the helicopter, after Burkhard had taken blood samples from the Norwegians.

7 Life under Spitsbergen's continuous light

Figure 7.1: *The staff was housed in a wooden building of the research station in Ny Ålesund. Here a view out of one of the windows*

Figure 7.3: *Package of Li^+ tablets. Eye inspection could not detect differences between these tablets and the placebo tablets*

About living in continuous light according to the internal clock, about the huts, the landscape, and the plants and animals of the environment, visiting the participants and unforeseen disturbances, which resulted in changes of the huts in two of the groups.

The staff (Anders, Waldemar, Burkhard and I) stayed during the experiment in a wooden house of the Research station in Ny Ålesund (view out of the window see figure 7.1). We got meals in the canteen of the station.

After the groups and the food boxes were distributed to the various huts (first the two Norwegian groups, then the three German groups, see figure 4.3), the recordings of the body temperature, activity and the sleep-wake rhythm began. Depending on the group, Li^+ was either given in the first or in the second half of the experiment as tablets (figure 7.2). In the other half the participants obtained placebo tablets which looked identical and were packed in the same way (figure 7.3). The number of tablets was determined in the pre-experiments in Tübingen and Trondheim for each of the participants individually. During the experimental time blood was drawn from all participants weekly (figure 7.4), which were later used in Tübingen to determine the Li^+ concentration in the serum. During the visits the printouts of the recorders were collected. Since the times of going to bed and rising and the times of meals were noted on the print roles, we were able to plot during the experiments the data on millimeter paper as diagrams and to recognize in this way the course of the body temperature, the arm movement and the sleep-wake-rhythm for the various groups. That helped us to visit the participants in the huts at times when

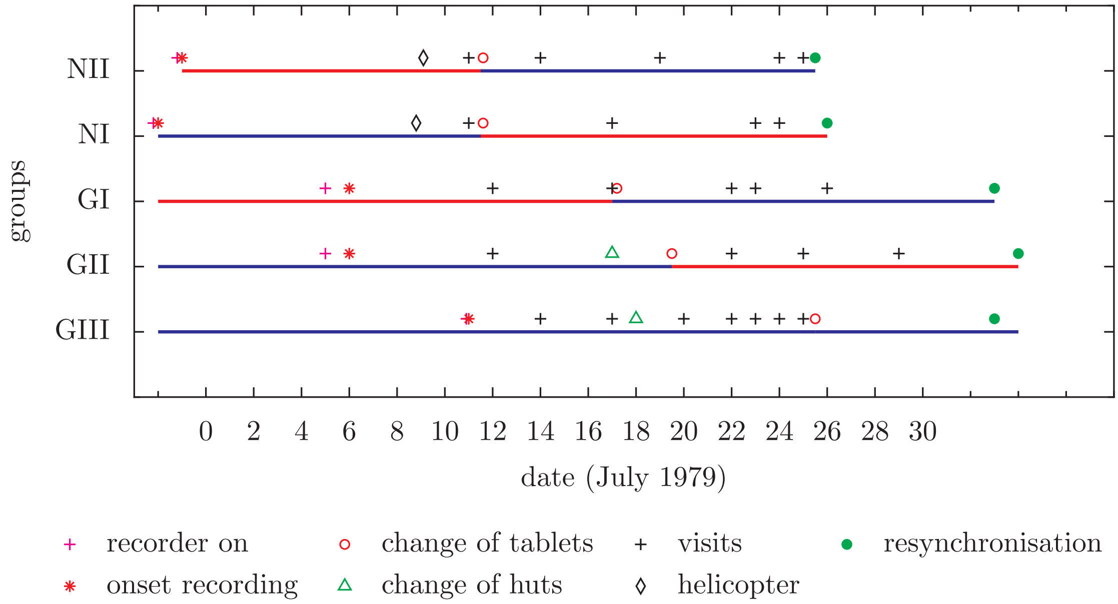


Figure 7.2: *The two Norwegian groups NI and NII and the three German groups began recording of the body temperature and arm activity (recorder on+, begin of recording*) shifted by an interval of a week. GI and NII got first* Li^{+} *tablets (GI from 25th of June until 17th of July two and a half tablets per day, placebo until 2nd of August; Inga of NII from 17th of June until 20th of June half a tablet per day, at the 21th of June one and from the 22nd of June one and a half tablet per day, Lars-Erik at the 17th and 18th of June half a tablet, on the 18th and 19th one, on the 20th and 21st one and a half and from the 22nd of June until the 11th of July two tablets per day) and afterward placebo, GII and NI first placebo and then* Li^{+} *tablets (NII two and a half tablets per day from the 11th of July onward; GII two and a half tablets from the 20th of July to the 6th of august). The group GIII took only placebo tablets, since they showed internal de-synchronization with long sleep and wake phases. Change of tablets marked by o, visits by + respectively by rhombus at visits by a helicopter. Re-synchronization began at the green dots (NI on July 25, NII on July 26, GI on August 3 and GII on August 2). The groups GII and GIII had to change huts (green triangles)*

Figure 7.4: *Taking blood sample at one of the participants by our medical doctor, Burkhard. The content of Li^+ was later determined in Tübingen.*

they were according to our data already awake.

7.1 Visiting the huts

For collecting the data stripes and notes we visited the participants in their huts. This was -due to the unusually long ice on the fjords- connected with long hikes. Otherwise we could have made the journeys with the rubber boat. Once the ice in the Kongsfjord was gone, we had it much easier. The Norwegians had to be visited once with a helicopter, in order to distribute the food boxes and to take blood samples for the Li^+ determination. For an overview see figure 7.2

7.1.1 Albrecht Gorthner and Ulrich Schäfer in Gorillaheimen

Albrecht Gorthner and Ulrich Schäfer had surely the most beautifully located hut. It was at the northeastern part of the Blomstrand peninsula at the Irgensfjäll. From there one had a wonderful panorama at the posterior part of the Kongsfjord and the Kongsbreen (Kings glacier, see figure 7.5).

The two had taken a lot of equipment along, as shown by figure 7.6. Included was also a telescope. They had even chemicals and a box for developing pictures and could thus run the most northern film laboratory (see figure 7.7).

In a letter to his parents Ulrich describes the hut and the surrounding:

Just now Albrecht has seen with his telescope, that the triumvirate is marching towards our hut, which means, that mail is taken along. There is some time left, until they will arrive here... The weather has been so far excellent, we had already more sunny days as compared to the two from last year during all their stay. The day before yesterday I took even a shower in front of the hut in the sun with our foldable canister; that was superb, the sun very intensive, and if there is no wind, one could stand it for hours without clothes in the sun, in spite of 6° air temperature in the shadow. Yesterday we have developed here a film (see figure 7.7) *and made first test enlargements, if we have more, I will send you one too...*

The fjord is now under this weather thawing fast and we will surely be reachable soon by boat...

Our hut is (especially now, after having cleaned everything, remodeling and tidying up, repairing, sorting and stowing) pretty neat, an about 20 m^2 sized sleeping room with two double-deck beds, four chairs, two small tables, as well as a kitchen with coal fireside, table with chairs, storage- and small cupboards. Behind the house is the toilet, primitive, but better than the creek, which the other group here has to use. The creeks have namely temperatures of 1 to 3° C. That is even for washing quite cold,

Figure 7.5: *Albrecht Gorthner and Ulrich Schäfer stayed in Gorillaheimen on the Blomstrand peninsula with view at the posterior part of the Kongsfjord and the Kongsbreen. Left: Visit of Burkhard Pflug and Wolfgang Engelmann. Right: The Kongsbreen at the posterior part of the Kongsfjord, hut in foreground*

Figure 7.6: *Left: Albrecht Gorthner next to all his equipment. Right: Telescope in front of the hut*

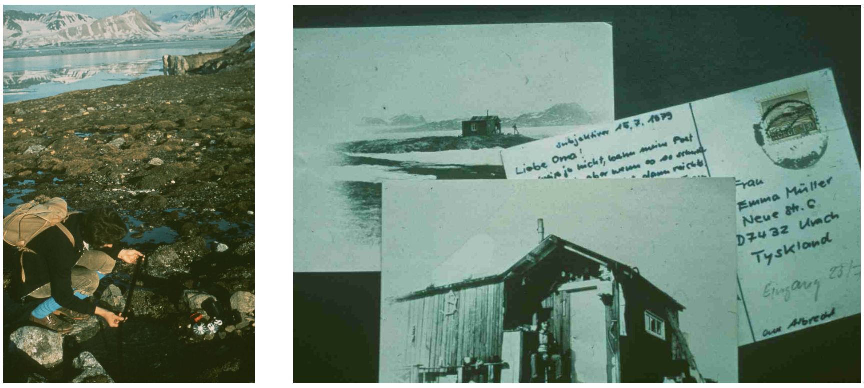


Figure 7.7: *Albrecht Gorthner was even able to develop pictures (left) and to send post cards of them away (right)*

because we usually use pre-warmed water out of the canister.

So much for today, soon the three will arrive, unless Albrecht has been mistaken…

Here a further letter of Ulrich to his parents:

Perhaps one develops transcendental skills in the isolation. My last letter I had written in a hurry, since Albrecht believed to have seen the three in the telescope to come. He has indeed been mistaken, but some time later they did really arrive. Judged by the time, your mail takes to arrive here, you might have the letter already. We expect here a visit again, therefore I want to start writing early enough. It might be, of course, that they are not able to cross the fjord by boat.

The sea water ice, which had covered the fjord until now in a thickness of 50 to 100 cm, has been driven out, but now arrive from the glaciers a chaotic mix-up of icebergs and -hanks, so that the whole gets quite muddled. It is probably the impounded ice of the last winter from the glaciers, which could not calve as long as the sea was frozen. It is unbelievable how fast the fjord got rid of the winter ice. The two others living on our peninsula reported, the largest part of the ice broke off in one piece of several square kilometer size and was driven in a fast pedestrians speed towards the open sea.

Today I would like to tell you a bit about the Blomstrandhalvøya (halvøya=peninsula), in first approximation round, about 5 km in diameter, mountainous up to 400 m. Although it is a peninsula, the way to the main land is blocked by a glacier, which, coming from the main land, flows directly to the (half-)island, bumping so to speak onto it, and breaking off into the sea at the left and right of it. Without vegetation the soil consists of rocks or boulders. Because of the strong frost and probably also because of the permafrost (burying waste we hit rock-hard frozen soil already at a depth of 40 cm) everything which is not frozen or rocky does flow here. So one can see here "rivers" of pebbles, which -of course unnoticeable slow, slide down the mountains glacier like, form tongues, flow around barriers, or just shatter stones on their way, which the frost has worn down, and pushes them along. Probably because of the different speed of flowing it often comes to a sorting between larger and smaller stones, and as a result parallel stripes run down the hills. Clay and soil are likewise flowing, and water apparently amplifies this process, under-washes and softens, and the edge of the snow fields, where the snow is crusted or frozen, is often the only place which offers some protection against ankle-deep sinking in. Since our arrival the situation has improved a lot, and one knows much better now, where one can step on and where it is not recommendable.

From the mountains one has a beautiful panorama over the entire fjord, the glaciers entering it and the surrounding mountains. The most characteristic are the "three crowns", block like uniform rock massifs on top of steep boulder fields. These boulder fields are here apparently much steeper as they are in the Alps, probably because of the edges of the boulders broken pointed and knife-sharp by the frost, which is otherwise not exposed to any rounding effect. Where the island is flat or protected, the vegetation is spreading, in the first days of our stay here besides many mosses more or less only two flowering plants and the centimeter high polar willow, the only tree. That was the early spring, now, during the spring, some more flowering plants show up.

The fauna is represented first of all and above all by numerous birds, Great Skua, Herring gull, Kittiwakes and other gulls, Arctic tern, Eider, Ptarmigans, Polar geese and others. Mammals are the polar fox, which we have not seen yet, but which has rummaged our garbage, messed it up, and emptied the nest of an Eider breeding close by, furthermore very shy, only in a long distance observable seals on the ice; furthermore we were able to see for some time in a few kilometer distance two polar bears on the ice, while the fjord was still frozen (with the telescope). Insects are scarce.

On the picture our hut (see figure 7.7)*. The right, slanted roof covers the kitchen, left the living and sleeping tract. I am leaning at the shower (the canister). At the left, where the pots are staying, we use to wash the dishes. The mountain at the right does not belong to the peninsula...*

P.S. Mother, You did ask me, why I need a Norwegian dictionary in this solitude: For instance to read the cooking instructions on the food packages!

And a further letter:

At the bright illumination of the midnight sun and brilliant blue sky I want to write you now, so that the letter is ready, if we get a visit next time... If we get a visit here, the mail is the most important aspect, and, if they bring some along, it is each time cause of joy.

Today I want to tell you in a loose way -loose insofar as I will write for simplicity unsystematically and unchronologically, just what strikes me -what we are doing here.

Once we climbed one of the mountains of our peninsula during very nice weather (we had so far, as compared to the normal conditions here, extremely often good weather). From there one has a glorious panorama over the whole fjord, sees also very nicely the glacier, which connects us - or divides us, as you like, with the main land. We have walked already to this glacier. From the distance it looks gorgeous, but close to it, especially there, where the ice can not break off and is thus quite old, it is very dirty. When we were there, the sea was still frozen, so that it could not calf, but at its front side one could hear a continuous, jingling noise, caused by always falling, uncountable, small ice pieces.

At both sides of our hut, in about 50 and 100 m distance, are creeks; the closer and smaller one depends apparently on the season, since it has now, where the snow fields are almost melted, less and less water. Until now, however, we can supply the needs out of it. We looked at the begin for a favorable place, where a large stone allowed to step on it, enlarged the basin in front of it, deposited some stone plates to reach it without sinking in the mud, and got thus a proper wash or bail basin. The water had admittedly only 2°, which is quite cold. In addition to the step plates we excavated a small drainage, which dried off slowly the mud (which might have happened anyway). Yesterday I have dug out a several meters long channel -one has to say first, that the creek, being dependent on the season, has no proper bed, but flows broadly down the hillside. In this way I concentrated the creek towards our bail basin, since it is slowly fading.

Apropos digging - it reminds me of the removal of the garbage. Combustible one is burned, the rest is mainly glass and cans, which we as well as possible reduce in size and bury. This is not optimal, since the frost brings everything up to the surface again in the process of time (also in the case of graves), but is here the cleanest method. One can not dig deep, already from

40 cm depth onward one hits the stone hard frozen permafrost soil.

Again in the bright light of the (almost) midnight sun after a wonderful day with a seven hour lasting round walk covering the whole peninsula (paradox) the continuation of my letter.

Today i washed the second time. In this way I need only two shirts and three pieces of underwear including socks. The blue shirt I could wash only today, after having stitched yesterday in a three and a half hour work a 10-12 cm long tear in the sleeve. The material is there already quite thin. With my woolen cardigan... the last piece of cloth was today in the washing, which was still soot blackened due to our enlarging campaign (picture enlargements).

That happen as follows: Albrecht had brought along all chemicals and necessary utensils for developing and enlarging. We produced a black and white film, darkened our hut (by the way 11 m^2 living/sleeping and 7 m^2 kitchen, in contrast to an earlier estimate) hermetically and artistically, developed the film - which worked superb- and began with the enlarging, which made all kinds of conceivable problems.

As a kind of watch to measure the duration for illumination and developing in the copying process I constructed a swinging pendulum that has a to-and-fro movement which was one second long. I had to juggle for a while (since I was without reference book) with differential equations, in order to deduce the oscillation time - pendulum length - formula; that worked right away with high precision.

Among the utensils, which Albrecht had brought along, were also two flash lights, one for illuminating, and a railway lamp for lighting the room (red). Though he had replacement batteries, he had unfortunately no spare bulbs. First the red bulb of the safe light blew, and so we had to use the other bulb covered with a red plastic foil for illumination, which was quite cumbersome; then the bulb of this lamp burned out, which meant that the whole action seemed to have fallen through.

Fortunately I had an idea, which Albrecht thought first impossible, but then forced himself to try it out; we took his photo-flash as an illumination device, and belief it or not, it worked, as you -hopefully!- can see in the attachment of the last letter. The problem was, however, the room illumination with red light. We took for this purpose the petrol lamp, which was already in the hut, and put it in a chest, which had a hole for the ascending hot air and a red screen in front (my plastic plate -which I otherwise did not need at all, since there were plenty of dishes in the hut). The only problem was, that we did not notice in the darkness, that the lantern got not enough oxygen, became darker and darker, produced more and more soot, and when we switched on the light, we noticed that the whole room -beds, luggage, clothes, writing table with everything on it, walls, floor, ceiling and last not least we our self were covered with a uniform soot layer. It took some time, until everything was bearable tidied up!!!

Occasionally I am also finding time for reading... As a good-night reading I have Sabina's "Polar bears" by M. L. Kaschnitz on my night stand (besides a photo of hers, my diary, a ballpoint, the revolver, the lightning pistol, munition, the signal rocket and a pile of porno books, which we found here)...

Report of Albrecht Gorthner

This report was handed out to us by Albrecht Gorthner at our visit on July 22, 1979.

13. day, 17. 7. This morning I thought, if I have written my postcards, everything is done and I have now finally time. The island has for us only one undiscovered side. That will be a day trip. I know all the birds. I get to know the flowers, as they come to flower. We know, that we will stay in our hut. Our food has been delivered. We won't get a visit for some time. The course of the day becomes a routine.
I was writing my postcards. Ulrich was busy the whole morning to reveal new water channels. I washed dishes and cooked our lunch meal. At 2133 Klemke (that was their expression for the time coding on the printer paper) *we took a seat at the table. As dessert we had fruit soup. I was just beginning to eat it, when I heard at the wall to my right in the direction of the fjord two rumbles. I lifted myself a bit from the stool, to be able to look out of the small horizontal window -and looked directly in the eyes of a polar bear. I could not even see the whole head in the small window, because he was so close. He had straightened up his body slightly and could thus easily look into the 1.5 m high window.*
I said: "Uli, a polar bear". Uli was seated with his back to the wall and could not have seen anything. He turned around and raced immediately, after a brief glance, in the direction of our living room. He forgot his recorder, got caught with the cable, pushed the table away, emptied his hot fruit soup over my hand and wanted to run right through myself. I called "Uli, calm down". He was aiming for the revolver. After he had it in his hand, he said "we must load the revolver, you take the signal pistol". The bear had disappeared already from the window after Uli's storm. That was at 2137Klemke.
We distributed our self at the windows. We could overlook almost the whole visual field. However at the food boxes to the right of the door and at the whole back side there was a dead angle. Since we did not see the bear, we had to assume that he was there. We wanted to calm down after the first panic, to cause no sensation and to wait. We did not hear anything. And if, it was a squeaky board, a twittering snow bunting (how grotesque) or our own pulse. If he would have been at the boxes, one should have heard him.
Now I was also for Ulis proposal, to fire a warning shot. He shot with the revolver through the ventilation strainer. Nothing moved. Before I had secured the door with the broom.
We thought of the next steps. We had to find out, whether he was at a hidden place. Uli as the weapon carrier overtook this nerve wracking task. Nothing around the corner. We discussed in the hut the next step. We had to check behind the house. With the door open for retrieval we sneaked around the edge -nothing. In the immediate surrounding it seemed to be alright. I took down the signal pistol.
We climbed the roof, to search for the bear. I took the telescope and a stool up and checked first the beach at the left. There was nothing. Then I looked towards Ny Ålesund. There everything was as usual. The landing gang, which was clearly visible, was empty. In front of the canteen somebody walked. That meant, it was day time. Our fireworks was of no use. Now I turned the telescope to the ice field and saw the bear at once. He walked in about 400 m distance to the right and lied down. Judging the situation to be safe for a moment, I took my sweater and anorak and the photo equipment. My camera I had laid ready already while we were listening for the bear.
Uli fetched as a further emergency signal the red flag. We pondered, what we wanted

to achieve with it. We wanted help in case of later dangerous situations and needed also a second revolver to be better armed. The signal shells were worth nothing.
After having taken two pictures, the film was finished, as is usual in those situations. We fired a few more shots, as the bear got up and went away. Since I could not sit all the time at the telescope, he got finally out of sight. He must have crept behind an ice-berg.
Now I also took pictures of our "defense tower". That looked quite impressive with stool and red flag on the roof (see figure 7.9). *At 2147 Klemke the action was over. I tidied up the mess in the kitchen and continued to eat my fruit soup.*
This situation, as the bear looked into the window (see drawing of Albrecht 7.8), has since been the subject of our jokes and fantasy stories again and again. For instance, that the bear sits on the WC, was one of the ideas. As I went just now to the WC, I took the revolver along. It is an uneasy feeling to be there without overview and protecting walls.
We will from now on use other precaution measures. What would have happened, if the bear would not have come at lunch time, but at a time, when I was washing dishes in front of the hut and Uli 100 m further away digging? Now we will construct an alarm system. We have already mounted a mirror to cover the previous 'dead' observation angle where we could not see anything.

7.1.2 Anna Schneider and Peter Klein in the Londonhytta and later in the Tyskerhytta

Anna Schneider and Peter Klein stayed first in the Londonhytta on the Blomstrand peninsula and later in the Tyskerhytta about 5 km east of Ny Ålesund.

Anna wrote beside the official diary also a more detailed private one with copies of letters. I am citing parts of two letters of Anna to a friend covering the journey to Ny Ålesund and the time in the two huts[1].

Gosh, it is now about one o'clock in the night (CET = 529 local time measured with the recorder) and I am sitting outside the door in the sun...

The journey to this place was already an adventure - until we, with all our belongings ... had changed trains; the compartment was always stuffed up to the ceiling. And than the crossing on the first ferry boat -we including the psychiatrist ran around like children- and rendered the ship uncertain...

Well, the last phase in Tübingen was hectic. On Monday we got a telephone call, we should take snow glasses and ski bindings along and it will be damn cold...

Now I continue on the ship.... We drank our last beer, enjoyed the last night and so on, until we finally landed in our sleeper cabin. Before, our psychiatrist gave us a newspaper report about a polar bear attack to read, during which a person was killed - and two of the group we met later in the airplane.

...In Spitsbergen Anders, the Norwegian physicist, welcomed us and explained, that we could not continue the journey with the scheduled ship, because the whole fjord was still frozen. Three of us (the psychiatrist, Peter and me) *had to take now an ice-breaker and four of us a motor plane... We reached the ice not before the next morning - at the first crash I fell almost out of the bed. Only half of the fjord was still covered with ice, but it took us for five hundred meters almost three hours.*

[1] my changes/notes in normal fonts, Anna's in italic, omissions marked with ...

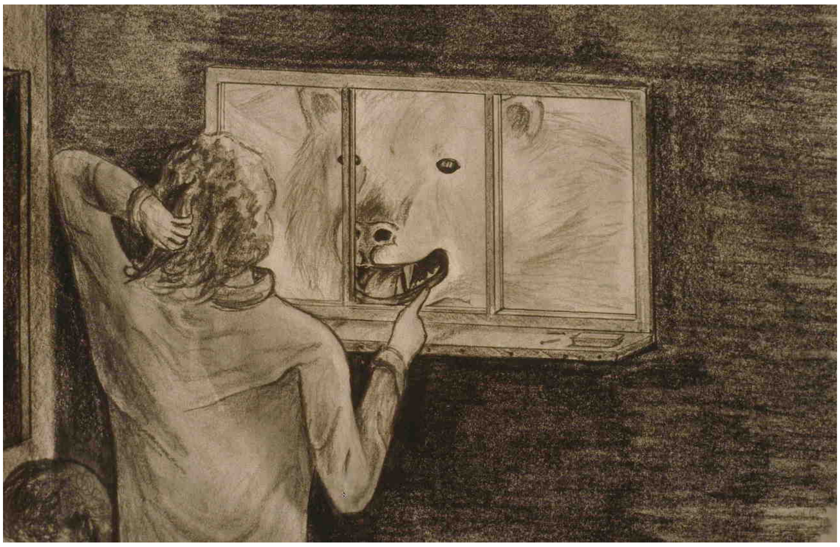


Figure 7.8: *Drawing of Albrecht after a visit of a polar bear at Gorillaheimen*

Figure 7.9: *Red flag as an emergency signal on the roof of Gorillaheimen; the sign in the foreground is a warning for the tumble wire. This wire activated an alarm as a protection of polar bears*

And than it got really hectic - loading boxes, unloading boxes, again loading -death and devil- because we had to leave the ice again with the ship, since one can't use the rubber boat otherwise.

We had finally more time and walked on the ice, visited the seals which were sun bathing and listened to drastic stories of polar bears. They walked on the frozen fjord two days before our arrival.

Back to the ship we got our medications and first help boxes, the revolvers, signal ammunition and all those things. Then the ship left again.

Once out of the ice, we were shipped out with food, luggage and rubber boat in the midst of the sea. The crew laughed at the crazy Germans. We found a landing (see figure 6.1)*: Two meters of stones, and a snow wall behind. Until all the luggage was brought, the boys had to drive three times. The others build a way to the top and below the high tide was rising. The stony strand became smaller and smaller, we hurled the bread- and apple boxes (Mauzanas de Argentina) up. We just made it.*

And than we four were shipped to the other side of the Kongsfjord *- in three goes, since the huts for the three groups were there. 15 km with the rubber boat. We went with our luggage to the closest one, were we will live, than back again to fetch the food. But the type did not come. We ate the leftovers from the pack sacks left there (three cameras, passports and god knows what else was laying there all alone).*

Finally we saw the boat from the distance, and our fingers were itching -one should after all also try it out- and we fired the first signal rocket. Carrying the food stuff almost killed us.

In the hut we noticed, that the boxes did not contain the same and that we had the boxes containing the trimmings. Now we have to eat only ketchup-bred and spaghetti with rice sauce or potato mash in the evening as long as the ice has been gone here, allowing them to come over. But this happens unbelievable fast -during the two days we are here, the surrounding has changed completely by the melting, you could flip out. During the time I am writing this, a lake of at least 100 m width has formed between the ice. The ice flows drift away extremely fast - it is quite funky (see figure 7.10)*.*

Actually one experiences here bizarre situations. The birds are quite aggressive, if one happens to come close to their nests; I once stepped almost in one, the eggs are well camouflaged -NATO-olive green, difficult to see, although they lie in front of your nose. I will from now on more frequently go and see, what will come out of it.

And otherwise -my time sense is almost gone and the time is much shifted, I would not have expected it. Well, we are after all free running.

2nd letter: *On the next day the boys arrived for the first time here. They were pouring of ice- and mortal life situations, helicopters-... I was quite annoyed that they could experience those hot adventures while we have to live in the land of milk and honey.*

But I was reimbursed directly. While we were lying on a rock in the sun waiting for the next food transport, we saw our first polar bears. They were strolling around on the ice and took bathes. The boys (Waldemar and Burkhard) *threw the food boxes on land and went immediately with the rubber boat to them and looked at them from close by.*

... Our larder is completely filled up, we are apparently supposed to hibernate here.

... We have afterward made some hikes and have now been at almost all places of

Figure 7.10: *Ice flows on the Kongsfjord*

the peninsula. … The landscape is changing constantly depending on the illumination. The snow is melting and each day beaks occur on other places. Behind the hut we have in the meantime a delta. The ducks mate and we have seen also a fox which is steeling the eggs, and the ducks probably too.

… two subjective days later, the boys (Waldemar, Burkhard) *were here again. They wanted to tell the other two* (siblings Rudolph)*, who live further away from our fjord, that they are soon relocated. The reason is, that in the meantime the ice on the fjord is driven away and the polar bears might settle down there. And since without ice flows they can't catch seals anymore, they become dangerous.*

Just now the bears are asleep. They lie in the next bay … and we went to them with one of the researchers (Waldemar) *for taking a movie. If they can't get seals anymore, they might beleaguer our hut. It seems to be certain, that they will stay here this summer. This will be no laughing matter. I'm curious about it. Perhaps we have to be evacuated too.*

As far as the time calculation is concerned, it is not as bad. The weather is unusually good for the usual conditions here and I don't even need to look at the sky to know where the sun stays. Furthermore, we know, how long the time intervals are between the printouts. First of all the boys, and especially the recorder-specialist, can not lie well enough, furthermore they let something slip, and finally the two gorillas (the two back in the fjord, the hut of whom is called Gorilla Heimen) have constructed a pendulum with a 2 second rhythm *and measured it. The recorders run with the same speed as in Tübingen, namely 8.32 minutes. This time interval is called in the meantime Klemke and we do now everything in Klemke. Rice takes about two Klemke. We can also calculate, how late it is in CET and things like this. At present we rise probably around 18:00 o'clock and go to bed around 10:00 and what is weird, we have the most beautiful weather...*

Now it's just getting somewhat unpleasant here. A giant ice floe is passing our window, which means, the bears are already on land or have to leave soon for the land. And the bad side is, that we do not know where they are. Peter is with the fully loaded revolver on the look-out. I am curious, whether he finds them. We don't have binoculars any more...

I woke up, because some people were talking in front of the hut. ... They are planning to repair their hut next week. ...

Anna likes it here. She and Peter explore the peninsula, climb the house mountain, enjoy the view of the glacier, which confines the island, and have settled in.

Otherwise I have found out now for sure, that our subjective days are different. Peter has a long morning and I have a short one (if it is three o'clock for him, it is only one for me). On the other hand my evenings are longer. I eat between five and seven, and Peter at eight. Peter is in the bed, *whereas I am not tired at all.*

..And now came the red dwarfs[2] *out of the sea and relocate us from the morning to the evening of the same day, only, because our neighbors of the hut plan to repair their hut and this could of course disturb our holy free run. ... I feel thrown out of my path. Wrench. It was nice in the London hut and I am now eager to see what is coming for us.*

Well, the only pleasing thing on the day of relocation was the boats trip and the discovery of the new hut (see figure 7.11)*. Otherwise I am annoyed, that my subjective time feeling has gone during packing; it is crazy, if you can't tell anymore whether a space of time is short or long - quite confusing also, if something is gone which is normally self-evident.*

.. our new hut is called German hut (Tyskerhytta) and so it is (figure 7.11)*. A strictly planned bunk - there is actually no superfluous space in it. The hut is from the DDR, as inscribed thick and fat on the wall, and it consists of boards screwed together like a chest. Could easily be unscrewed and put up again in the garden. That it is much more cramped here as compared to the London hut is bearable, but I don't get along with the beds.*

The first night I slept on it it started already with several adversities. First of all, the bed is quite small, secondly the bed, which is at the time being the backrest, hinders my turnings, thirdly the bed covers are like those in a train made of some plastic, and with the synthetic material of the sleeping bag there is no support and one is sliding around quite annoyingly while turning around, fourthly I had added another blanket on top of myself, because I am mostly cold, and I had to fight constantly with it, because it was slipping around, and fifthly I had my recorder for the first time on my right side and that did not suit me at all. In the morning I was of course completely tangled, my thermometer was pulled out of the ass and lied somewhere under my head. I cursed quite a lot.

During the day I explored the closer surrounding; only water, boulders (the mountains are here like the mining waste heaps

[2] Waldemar and Burkhard with their overalls

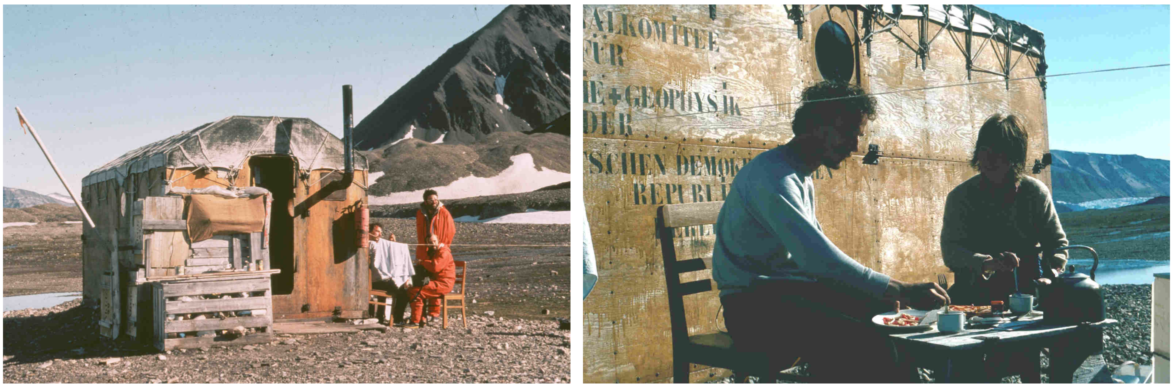


Figure 7.11: *Anna Schneider and Peter Klein together with the little red Männlein (Burkhard and Waldemar) in the Tyskerhytta* (left). *It was constructed in 1965 by the German Akademie of Sciences in East Berlin and served as a basis camp for a geological expedition (right). It was very compactly build and resembled in occurrence and smell a railway wagon of the DDR*

in the Ruhr district) and ice. During my walk I got partly bleak - the surrounding of the London hut was much nicer...

The second night wasn't better either. Although I took the upper bed on the other side, in order to have more space and have my apparatus on the "correct" side, it did not help much. I was freezing like a lap dog - ... I forbeared from doing the battle with the blanket - but I was at war with the cable in spite of it. In the morning I was very cross - my outer thick sleeping bag was twisted, my inner youth hostel sleeping bag too, but in an other way, my thermometer was pulled out and the cable turned around my neck; ...

I have the impression, because I am cross with our relocation, I am pulling out the cable again and again, and Wolfgang is punished with zeroes; I suspect, my subconsciousness or something else is playing tricks with me and I want it, because it is fascinating and because I have time for it, and at the same time I do not want it, because I like our scientists and do not want to fuck it up.

.. I was quite sad this morning about it and I am curious, whether this break can be puttied. At the moment I tend more backward - I want to be back in my lost home -back to the steam engine and the meadows and the droppings-deltas and my bears- here everything is so bleak, I don't like the surrounding it does not appeal to me. I hope this will change with time. After having brought all this to paper I am feeling a bit better. I calm down.... Tidying up the hut. Hike to the glacier. Here one can march for hours on debris slides, scree material and ice, and a giant delta is behind the house and I am completely wet, because my jumps over the creaks are not wide enough.

..Today is the second subjective day in the new hut and I just can't get familiar with it.

.. and otherwise nothing happens here except that our scientists mess up things and did it again. Our tablets have been exchanged - since yesterday we get the other half (placebo or Li^+) - being blind we don't of course know which one. But since Li^+ is normally not given this way, but in slowly

increasing doses - as was done in my case in June already - and this slow increase is now not debated at all, it is quite certain, that we eat placebo. I am curious whether it is correct.

.. I do not know yet, whether our expedition blood sucker, who leaves a week earlier, should take the letter along. If I calculate -which is strictly forbidden-, he leaves in three days...

In the meantime we have since three days storm with fog, icebergs and rain, the kind I imagine the typical Spitsbergen weather.

We seem to lie here at the mountaineer race course... In the midst of the night I woke up: Somebody read aloud the instructions for dealing with us, than a face looked through the bull's-eye; than they continued after backbiting in a faked Saxon dialect about our exclusive railway wagon (seeing the in-script DDR and talking Saxon is what every German does passing here)... The first time since our stay here we did not have a tourist for breakfast.

Anna's report of a glacier tour and a dream about it:

From 1063 to 1104 (almost 5 h) we made a great hike, a glacier tour (see figure 7.12)*: The Lovenbreen up, between Grönliet and Nobilefjället crossing a grate and the debris slide down and than over the Pedersenbreen (one side of which we termed Instaut glacier, because we always broke in melted lakes, where real glaciers have ice) back.*

It is mind-blowing, at the begin not ten horses would have brought me on a glacier, but in the meantime it is the safest to walk around. Although Peter broke twice in a crack, but always with just one leg, and afterward we payed more attention. I slipped twice on the ice, and if Peter would not have caught me at the coattail, I would have landed in the crack or I would have managed to cross it. On that day I was anyway especially brave. We climbed down a rock wall, I hang with all fours around, I never knew whether a loose stone would hold me or not if I would fall, and than we had to climb up all the way, because we could not pass further down the icing.

My relationship to dangerous situations has changed here - they are not as frightful anymore as they were at the begin, you see, what is coming up to you, and than you can do it or not. We have talked about it and the outcome was, that we civilization twerps are too much and unnecessarily afraid of natural things (firstly - because they might be dangerous - but more so, because we don't know them). We should be more afraid of the civilization.

My glacier day-dream: I hike with Peter up the glacier - next to torrential melting water rivers in routed and deepened bobsled runs, three-storied below- and above each other. Shortly we reach the grate, I fall into a crack - for no reason. I am only thinking, nothing has happened - and I have to behave now just like a bob sled and take care not to run out of the run. The only danger is to freeze in the ice water - but the thought does not save me. Feet in front, slightly lifted, the arms close to the body - occasionally I dare to lift the head a bit - I rush down the glacier mostly on its surface, but also below the surface. Nothing will happen if I keep my body tension and let the water drive me. I can't think of the coldness - everything happens so fast - until I lie down in the boulders. I am cold - I think, that this accident is bad enough not to adhere to the interdiction and walk to Ny Ålesund. I need some more time to get rid of my bad consciousness and to get rid of my pack sack and the recorder, in order to be able to walk faster.

At four I arrive in the canteen - the scientists are all drinking coffee. They are

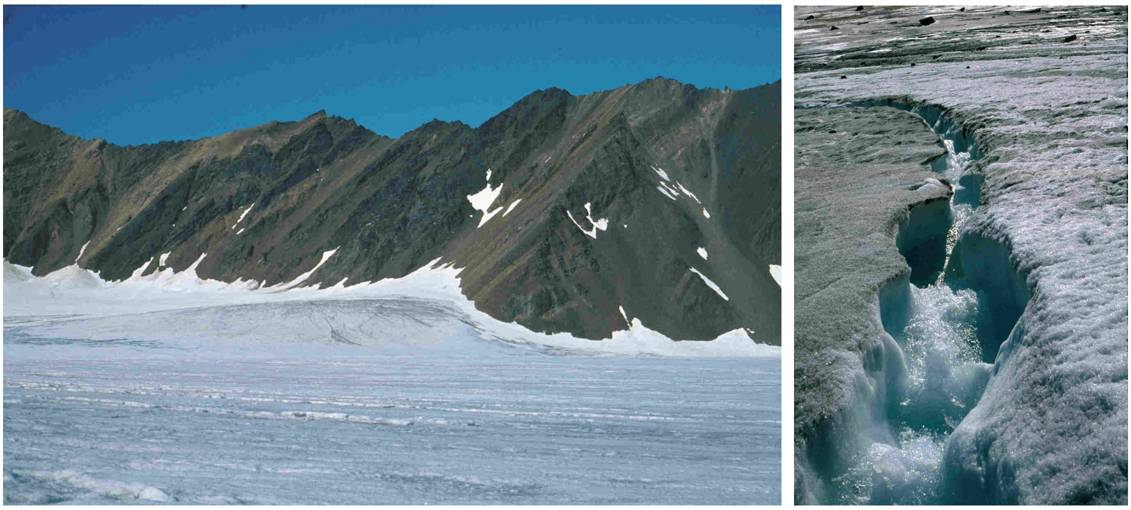


Figure 7.12: *Glacier tour of Anna and Peter over the Lovenbreen; a crack at the right*

surprised and annoyed, firstly, that I come, and secondly without recorder. They do not believe a word of my story, which I tell them confused and unconnected - but they see that I am wet and cold, red and trembling, and they offer me tea. I am drinking it. While I come around slowly, Peter busts in the door. He wanted to get a helicopter and help for me. He had searched for me in the crack, didn't find me and since he could not do anything by him self - he had started running - however, I was of course faster in the ice channel. He too does not understand, how I can be here, but he trusts in me. The others walk finally up the glacier - through paint in the hole, in which I was fallen, and the colored water came fortunately out below - and they finally believed me.

Peter and Anna hiked at the end of the experiment to Ny Ålesund. They ate at the Hurtigruten. After the meal the German groups met and we told them about the results as far as we had analyzed the data. Afterward we sailed with the ship to Longyearbyen.

7.1.3 Siblings Rudolph in Ragna and Nilseby Hytta

Since the originally planned Kjärsvik hut for Angelika and Bernd-Ulrich Rudolph could not be reached by boat because of the ice floes, we changed the arrangement. Anders was in the meantime back from Tromsø and selected after talking to the people in the station the Ragna hut on the northern part of the Kongsfjord east of the Krossfjord. Both of them were transported together with their luggage by Waldemar Himer with his rubber boat from Ny Ålesund to this place (figure 7.13). The surrounding was very impressive and for Bernd-Ulrich as an ornithologist interesting (figure 7.14).

Soon after their arrival a Swiss group camped directly at the hut. Angelika and Bernd-Ulrich were strongly disturbed by them in their experiment, to live without

Figure 7.13: *The Rudolph's (left with pack sacks) are transported by Waldemar (in the boat) with the rubber boat to the Ragna hut (right figure). There arrived, unfortunately, after some days a Swiss group, which camped close to the hut*

Figure 7.14: *Not far from the Ragna hut the brake off edge of the Blomstrand peninsula glacier could be seen (left picture). For Bernd-Ulrich the bird rocks were interesting (right figure)*

Figure 7.15: *Polar bear in the neighborhood of the Ragna hut (left). Stove and kitchenette in the Ragna hut (right)*

Figure 7.16: *Nilsebu hut in the neighborhood of Ny Ålesund, view to the mountains (left) and the river Byelva with Kongsfjorden in the background and the mountains on the other side (right)*

time cues. There was furthermore a polar bear close to the hut, which one day visited the tent with the food supply of the Swiss people and had to be chased away by loud screaming (figure 7.15). The Rudolph's had therefore to change huts and were brought to a hut (Nilsebu) on the Brögger peninsula west of and close to Ny Ålesund. The hut was reachable from Ny Ålesund in about 30 min walk (see figure 7.16).

Bernd-Ulrich Rudolph was quite interested in the birds of Svalbard, was familiar with observing and determining the species and kept a report. Out of it stem some of his notes, which can be read in the appendix (section 11.5.12). The Rudolph's spent their days with work in and around the hut (for instance making fire wood), with walks and hiking.

At the later analysis of their data it turned out, that the Rudolph's had an extremely long physiological day, much longer than 24 h. If one checks their diary from this point of view it is evident that during the very long nights wake phases occurred and likewise during the long days tiredness and sleeping phases were noted. Examples are notes of the 3rd day (slept extremely long), 5th day (slept a bit too long), 9th day (woke up three times, stood awake, very abnormal, that I had to go to the toilet immediately after falling asleep), 12th day (it is a problem to decide, whether I am well rested or not, 13th day (strange night, was for 34 units awake, woke up additionally later several times, slept too much, long hike, time to go to bed overdrawn). At the end of the free run on the 3rd of August (after 25 d) both of them had gone through 15 subjective days only.

Afterward they measured another 6 days body temperature and arm movement during the re-synchronization to the 24 h day.

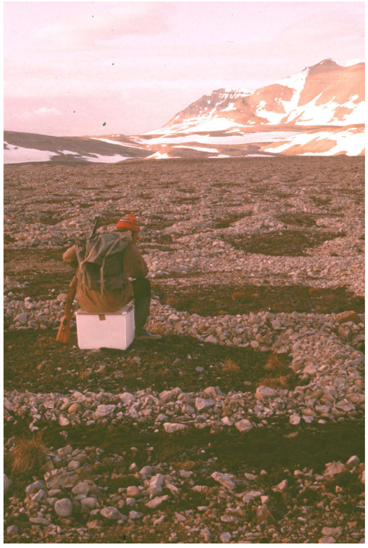


Figure 7.20: *Polygonal patterns are formed by frost and water on the soils of Kvadehuk. For comparing sizes Anders on a food box*

7.1.4 Aud and Olav in Geopol at Kvadehuk

An oil company had looked for oil on the Kvadehuk planes (figure 7.17) and set up a hut. This "Geopol" was inhabited by Aud and Olav (see figure 7.18 and 7.19). Kvadehuksletta was a flat nose west of the Brögger peninsula. During the melting of the snow the small creeks turned into broad water streams. Interesting pattern formations of the sand and stones, often hexagonal ones, were observable. They arise by the combined effect of frost and water (see figure 7.20 and appendix subsection 11.5.13).

7.1.5 Lars-Erik and Inga in Stenehytta

Lars-Erik and Inga walked after the landing from the Polarstar at the coast of Kvadehuk together with Olav and Aud to the Geopol hut, stayed there over night and hiked on

Figure 7.17: *Planes of Kvadehuk after melting of the snow. Geopol hut in the background*

Figure 7.18: *Aud and Olav stayed in the Geopol hut. At the arrival the landscape of Kvadehuk was completely covered with snow. A few days later all the snow had melted (see figure right, with Aud, and 7.17)*

Figure 7.19: *Anders with Aud and Olav outside their hut (note the instrument cases they are wearing). Right part Aud inside the hut*

Figure 7.21: *Lars-Erik and Inga in front of* Stenehytta *(left) at the Leinstrand with view towards Prins Karls Forland (right)*

Figure 7.22: *Inga at a bone fire (left) and (with gun) in front of a wall of ice floes, driven by the wind from the sea and piled up at the beach (right)*

the next day to Stenehytta at Leinstrand on the Engelsbay south of Ny Ålesund. There they stayed during the experimental time. Their hut and surrounding was almost as nice as Gorillaheimen (see figure 7.21). At the beach there was plenty of wood and whole logs, which the sea had driven to the place. They were without rind and bark and bleached white. During the period of ice floes at the beach they were used for long bone fires (see figure 7.22).

In the northeast were the mountains and glaciers, behind them Ny Ålesund. Anders and I should get to know them later, as we stayed overnight after a long hike to Geopol and Stenehytta. The next day we did not want to take the same long way back, but crossed the mountains to Ny Ålesund. More about this adventurous hike later.

Figure 7.26: *Fossil leaf from pit head stock*

7.2 Some impressions from fauna and flora

An island which is situated so much up in the north, owes its relatively rich fauna and flora to the Golf stream. It carries warm water to this region. Additionally the sun is shining the whole day during the summer. As soon as the snow has melted and the ice has disappeared, the first plants appear and many of them start to flower in a short time (see figure 7.23, 7.24, 7.25, for literature see http://svalbardflora.net/index.php?id=188). 173 vascular plants[3], 373 mosses (example 7.27 right), 597 lichens (example figure 7.28 right and figure 7.29) and 705 fungi (example 7.28 left) are described so far. Additionally 1122 Cyanobacteria and algae in the fresh- and saltwater. During the short vegetation period the seeds and fruits of the flowering plants are rapidly formed. They offer food to numerous birds.

In earlier eras of the earth Svalbard was located much further south and possessed a rich vegetation. This is testified by the coal stocks, which exist in Spitsbergen and which are mined even today. Fossils are also found (see figure 7.26).

There are some larger land mammals in Svalbard: Svalbard reindeer (about 10 000 animals, figure 7.30) at and mainly in the sea polar bears (figure 7.8), as well as seals and sea lions (figure 7.31). Finally, whales belong to the sea mammals around Svalbard.

Birds migrate in large numbers during the summer to Svalbard. They breed in the tundra vegetation (figure 7.32 left and center), where they might also become victims of the polar fox (figure 7.32 right).

[3] guide book: Rønning 1979, Svalbards Flora, Norsk Polarinstitutt Oslo

Figure 7.23: *Cushion plants (left* Dryas octopetala*, right Moss Campion (Silene acaulis)*

Figure 7.24: *Flowering Cotton grass (*Eriophorum scheuchzeri*) grows on wet areas. Right a closeup, at the right corner fruit stand of the Alpine Bistort* Polygonum viviparum

Figure 7.25: *Dwarf willow (*Salix myrsinites*): Nobody would assume in this tiny little thing a willow. Right figure: Plants of dry habitats (*Arabis petraea *left).*

Figure 7.27: *Club moss (left) and moss cushion (right)*

Figure 7.29: *Lichens and mosses on rock (left), black lichens growing on a rock in a circular pattern (right)*

Figure 7.30: *A Spitsbergen reindeer (*Rangifer tarandus platyrhynchus*)*

Some birds breed at steep rocks, where they are relatively protected against enemies (figure 7.33). These bird rocks are recognizable by the abundant vegetation at their foots, the result of the rich bird manure.

7.3 Crossing the mountains

On the next day we study the map for our mountain tour (figure 7.34). Lars-Erik and Inga join us for a while. At the begin it was a very nice mountain trip back to Ny Ålesund with glorious views back to the Forlandsund and the Prins Karls Forland and up to the snow covered mountains and the glaciers. In spite of the intensive study of the map we noticed too late that it was not exact since the glaciers were changing, and we made a mistake.

It was, however, too late for turning back. The higher we came, the more inhospitable it became. Finally we reached the ridge. Behind it was a steep cleft down to an extended glacier. Without Anders my courage would have left me and I would have turned back. He started, however, to climb down, and there was nothing I could do but just follow him. It went better then I had expected. However, the most dangerous part began, while we walked down the glacier. It contained clefts, which were hidden by the snow on top of it. Anders suddenly broke with his right leg into one of these clefts. Fortunately he could control himself and we continued our way with even more care. Then we noticed, that we came down the mountains too far east of Ny Ålesund. But we were too exhausted to continue. Fortunately there was Franskeleiren, a French Camp (figure 7.35). We slept in one of the three barracks in our sleeping bags and hiked back to Ny Ålesund the next day. We arrived with a big hunger.

Figure 7.31: *Swimming harbor seal (*Phoca vitulina*, top) and bearded seal (*Erignathus barbatus*, bottom)*

Figure 7.32: *In spite of the excellent camouflage, birds become often victims of the polar fox (right)*

Figure 7.34: *Anders and I study carefully the map before we cross the mountains (left). Start (right)*

Figure 7.35: *After having crossed the mountains north of Stenehytta (see figure 7.12), we slept in Franskeleiren (bottom), before we walked back to Ny Ålesund. Kungs glacier in the background, left mountain block Collethøgda. Painted after a postcard by the author*

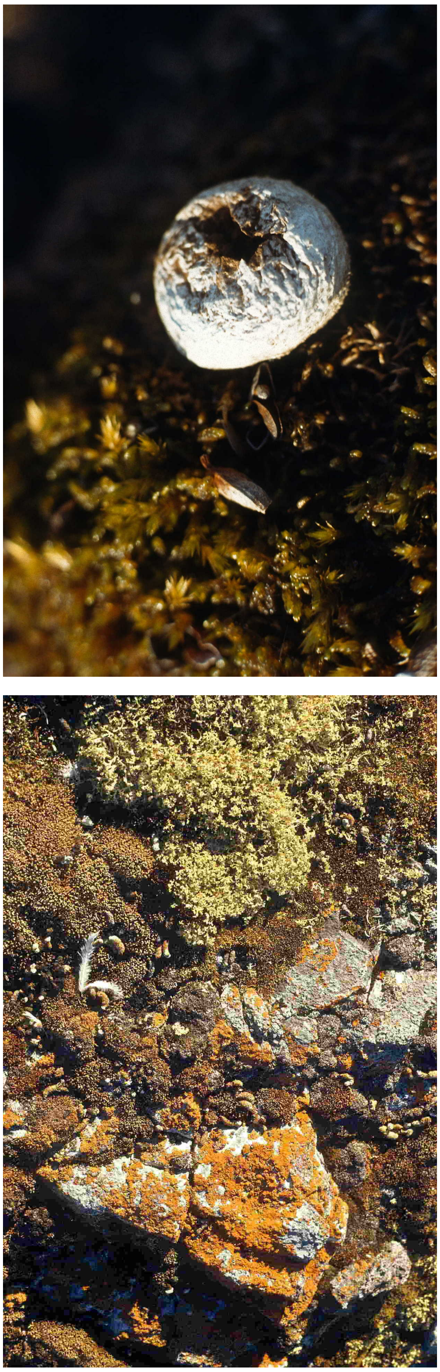


Figure 7.28: *Puffball top, various lichens bottom (reindeer lichen on top of lower image)*

Figure 7.33: *Protection against enemies provide the steep rocks, at which quite a number of various bird species breed. They are recognizable by the luxurious vegetation at their feet (top). Bottom: A group of breeding kittiwakes*

8 Back to the 24 hour day: Re-synchronization

After the experimental period in free run, the participants measured their temperature and activity for a few more days when adapting to the normal 24 h day.

The experiments under free run conditions ended for the Norwegian group I on Wednesday, June 26, and for the group II on Thursday, June 27. They were advised too leave all medications in the huts. Aud and Olav walked from Geopol to Brandalpynten, where they arrived in the afternoon and raised the red flag, in order to be picked up by the rubber boat.

The participants had agreed to continue recording during the re-synchronization to the normal day. In the evening of the 26th of June we had a "seminar" with the Norwegian students, at which we presented our aims and the preliminary results of the experiments in Spitsbergen.

As the time to go to bed during the re-synchronization we agreed to 22:00 o'clock.

With Anders I talked about possible future plans in the bunker in Germany and an experiment in Ny Ålesund with a medical doctor and a depressed patient, who was treated with Li^+. The presence of the doctor would be necessary from an ethical point of view, so that no problems with medication etc would arise, and for performing and analyzing the experiment. The patient would live in one of the two London huts and the accompanying doctor in the hut next to it. The experiment would then clarify if a depressed patient had a period which was characteristic for the depressed state under Li^+ treatment and without Li^+. Any period changes should thus be detectable.

For a week the patient would record his body temperature and activity in free run conditions. Afterward the Li^+ would be abounded (for instance in a patient, for whom it was indicated in any case) and he would continue to record for another week under free run. Afterward the re-synchronization would be measured in 24 h days.

Since the German students had started recording a week later, their free run continued one week longer. The analysis of newer data (judged by the body temperature minima during the sleep time) of the German group II in the Tyskerhytta did not show any difference between the period length under Li^+ and the placebo time. On the other hand the reactions of the Li^+ treatment were now clearly visible in the German group I from Gorillaheimen.

Lars-Erik was asked by the chief of the station, whether he could overtake the work of the Norwegian who was responsible for the meteorological station, until he would be back from vacation. Inga stayed during this time in the Nilsebu hut close by. Food for a week was available in the Tysker hut.

On Monday, the 30th of June the German group I in Gorillaheimen was visited and "new" tablets brought (they were the same placebo tablets as before, since they received already earlier in the experiment

Li^{+}. We wanted to confuse them. On the same day day the GI in the Tyskerhytta was visited. We had left Ny Ålesund at 13:00 o'clock and arrived at 14:45 there. Both of them had made a mountain tour at this day for about four (subjective) hours and had just returned. We took pictures of the hut and its surrounding, the artful water wheel made by Peter in a water run-let, of bird rocks close by, and had to fend off the attacks of the Skua birds.

On Wednesday, the first of August, Waldemar visited the Rudolph's and repaired one of the actographs. They had a long hike around the Brygger peninsula. In the morning a boat ("Aurora") took two of us to the Blomstrand peninsula. From there we walked to Gorillaheimen. Since Albrecht and Ulrich were asleep, we left a message, that they should pack their luggage and walk to the London hut. In the evening (20-22:00 o'clock) the luggage of Peter and Anna was picked up by boat from the Tysker hytta. In the night Norwegians of the station brought most of the luggage of Albrecht and Ulrich from Gorillaheimen to Ny Ålesund.

On Thursday, August 2, Waldemar picked up Albrecht and Ulrich from Gorillaheimen. They had not walked to the London hut. Afterward he fetched the heavy luggage from the Tysker hytta. With light luggage Anna and Peter walked on the next day to Ny Ålesund. In the evening we all sat together and talked.

On Friday August 3 Anna and Peter arrived in Ny Ålesund at 13:30. They from now on started to re-synchronize to the 24 h day.

In the canteen Bjarne Nordnes, a Norwegian Fangman and writer, told stories about polar bears and seals, which he experienced during his over-wintering in Svalbard (see Nordnes (1982)). I gave him my electronic calculator with a timer and asked him, to note his daily sleep times during the over-wintering of the current year in Grøhuken in the North of Svalbard. The diagram is shown in figure 8.1.

At 14:00 we gave a lecture on our experiment. At 14:30 we had lunch on the Hurtigruten ship. The music-band of Ny Ålesund played farewell and we said good bye to Lars-Erik and Inga, who will stay here longer. The route from Ny Ålesund to Longyearbyen offered wonderful panoramas. No wonder, that Peter and Anne went asleep at 24:30 and Waldemar and the Rudolph's at 3:00.

On Saturday, the 4th of August we entered the Ice fjord, passed Tempel and Pyramiden and reached Longyearbyen around 11:00 o'clock. Brattlien drove us to the boats house in Coalharbour, where we slept for the next three days. We left him and thanked him for all his efforts. The house is situated about 45 min walk from Longyearbyen. We had our evening meal there.

On Sunday, the 5th of August we hiked to Björndalen in the afternoon. We passed the ventilation duct of a former coal mine, followed a river, crossed a plane and walked back at the fjord. Some dead terns and gulls were evidence of the hard struggle of life in these northern regions.

After breakfast on Monday, the 6th of August, we assisted in insulating parts of the Vetenskapens hus. In the evening I was collecting algae at the pier for a colleague in the Botany department in Tübingen.

On Tuesday, the 7th of August we flew with SAS at 3:50 from Longyearbyen via Tromsø to Oslo. With a taxi we got from the airport to the East station, were we deposited our luggage.

Since we had plenty of time until the train left for Germany, we strolled through

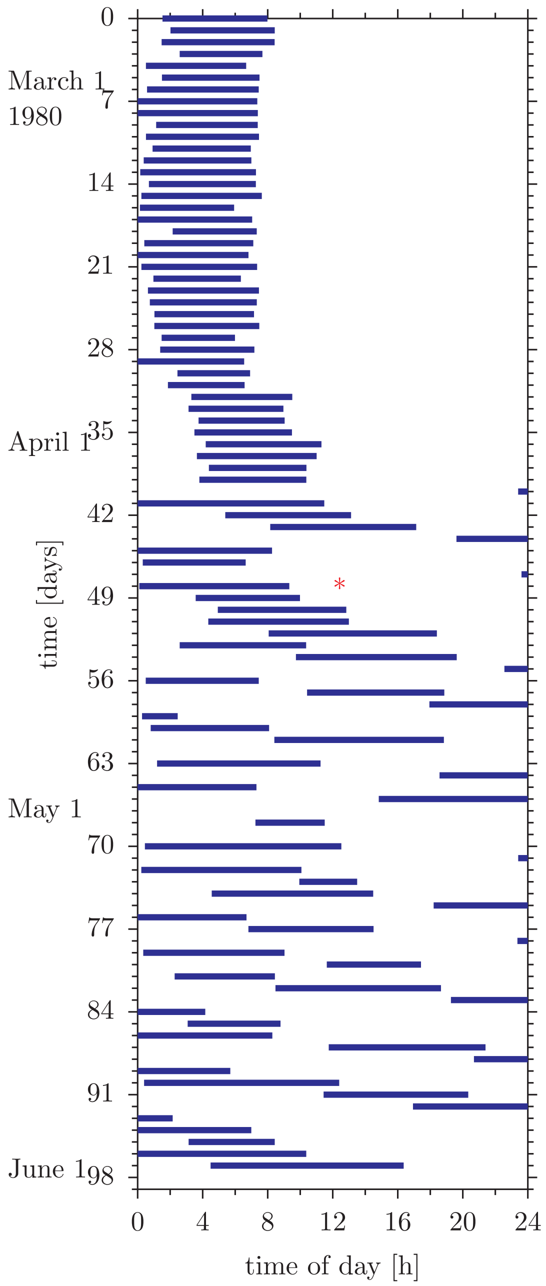


Figure 8.1: *Sleep times of Bjarne Nordnes, a Norwegian writer and hunter during the arctic winter in the north of Svalbard. Midnight sun seen for the first time marked with a red **

the city and took a ferry boat from the Rådhuskai to Bygdøy, where we visited the Fram- and Kon-Tiki-museum. The Fram museum is dedicated to the three famous Norwegian polar explorers Fridtjof Nansen, Otto Sverdrup and Roald Amundsen. It contains the Fram, with which Nansen sailed over the Northern Ice sea and tried, to reach the north pole by ski. One can enter the ship. Sverdrup led an expedition to Greenland, where he discovered more than 200 000 km^2 square kilometers new land and mapped it. Amundsens expedition to the South pole as well as his discovery of the Northwest passage in the Northern polar sea and his trial, to reach the North pole, are here also documented. Animals from the polar areas such as polar bear, penguins and musk oxes are exhibited.

Thor Heyerdahl (1914-2002) performed in 1937/38 the Fatu-Hiva expedition, 1952-53 the Galapagos expedition, 1947 the Kon-Tiki expedition, 1955-56 and 1986-88 expeditions to the Easter islands, 1969 and 1970 the Ra expeditions, 1977-78 the Tigris expedition and conducted in 1988-93 archaeological excavations in Túcume (Peru). In the Kon-Tiki museum (see `http://en.wikipedia.org/wiki/Kon-Tiki` and the book Heyerdahl (1950)) the original boats of Heyerdahl are exhibited. The ship was named Kon-Tiki after the sun god of the Inka culture. Heyerdahl believed, that people from South America were able to reach the Polynesian islands with primitive boats in the time before Columbus. He wanted to prove by the Kon-Tiki expedition, that this was possible with ships made of material and constructed with technologies available at that time. Heyerdahl sailed together with five companions almost seven thousand kilometers over the Pacific and landed after 101 days on an island of the Tuamotu group.

The journey with the train from Oslo to Stuttgart and Tübingen went smoothly. For the students an interesting time in a fascinating country had come to an end.

Albrecht Gorthner gave with his slides for several years lectures in adult education centers and found apparently so much joy in traveling, that he is nowadays offering Safari tours in Africa (mainly seldom visited regions which are difficult to reach in Southeast Africa such as Malawi, Zambia, Tanzania, Mozambique, see http://www.livingstone-tours.de/impressum.php).

For us the analysis of the data began and the preparation of the publications.

9 Analyzing the data in Tübingen and Trondheim

First the chronobiological phase type of the participants is shown before and during the Spitsbergen experiment. Then, by using various methods of time series analysis, the data of the Li^+ *experiment were evaluated. Those methods include periodogram analysis, Fourier analysis, complex demodulation. It turned out, that in two of the four groups, which obtained* Li^+ *and placebo,* Li^+ *carbonate lengthened the period of the circadian rhythm of body temperature, sleep-wake rhythm and activity (arm movement), as predicted by our original hypothesis. One group showed the phenomenon of internal de-synchronization with an about twice as long sleep-wake- and activity rhythm compared to the rhythm of the body temperature. It is discussed, how* Li^+ *affects the circadian system by comparing the phase relationships between the recorded rhythms of body temperature and the sleep-wake cycle.*

9.1 Chronobiological phase type

Already at the medical examinations in Tübingen and in Trondheim before the actual experiment in Spitsbergen the participants filled out a questionnaire concerning the chronobiological phase type. It shows, whether one belongs more to the morning- or to the evening type or to the indifference type. The same questionnaire was filled out by the participants also at the begin and at the end of the recording in the continuous light experiment[1]. The results are compiled in table 9.1 and do not show much difference (the morning types -lower scores- tend to increase their score, that is, their morning type is less pronounced). You can perform this test yourself and determine your own chronobiological phase type (see subsection 11.5.8 in the appendix).

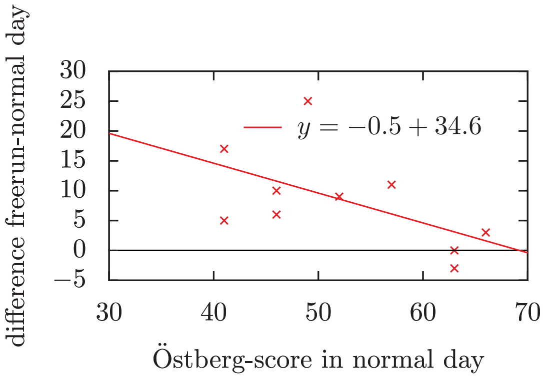


Figure 9.1: *Alterations of the results of the chronobiological phase type during free run in Spitsbergen compared with the values in normal days*

In most cases the values under free run conditions are higher, the persons thus shift their type more towards morning type. This tendency is more pronounced in the evening types (low values) (see figure 9.1).

[1]For this purpose we have changed the text of some of the questions slightly, in order to adapt it to the free run conditions in Spitsbergen; see appendix page 150

Table 9.1: *Participants, their age (years), results of the Östberg tests (Ö-test) in 24-hour day and (behind /) under free run in Spitsbergen (difference in parenthesis), sleep duration in hours and time of body temperature minimum (BT↓). Highest possible score of Östberg-test is 86 (extreme morning type), lowest 16 (extreme evening type)*

Name	Age	Ö-test	sleep duration	BT ↓
Gorthner, Albrecht	22	50/74(+24)	7.05 (7.16)	4:40
Schäfer, Ulrich	24	41/46(+5)	6.93 (7.03)	5:35
Klein, Peter	30	63/63(±0)	7.50 (7.63)	4:40
Schneider, Anna-Maria	26	46/56(+10)	8.40 (8.47)	1:05
Rudolph, Angelika	22	46/52(+6)	8.58 (8.65)	5:20
Rudolph, Bernd-Ulrich	19	66/69(+3)	8.02 (8.18)	2:50
Tveito-Ekse, Aud	26	41/58(+17)	7.68 (7.78)	
Ytre-Arne, Olav	24	52/61(+9)	7.73 (7.93)	
Strömme, Inga	23	63/60(-3)	7.32 (7.49)	
Berg, Lars Erik	23	57/68(+11)	7.22 (7.51)	

The results of the questionnaires during the Li^+- and placebo periods of the individual participants did not differ.

9.2 Analysis of circadian rhythms

The data were analyzed in Tübingen after the return from Spitsbergen, whereby I got help by my technical assistant, Frau Caspers, and by Aud Tveito-Ekse from Trondheim. For evaluation the program "Timesdia" of Wolfgang Martin at the Botany Institute in Bonn was used (Martin et al. (1977)). The biggest task was the transfer of the data from the printer paper to a machine readable format.

First the body temperature-, activity- and sleep-wake data were plotted as a function of time in diagrams. Then the period lengths were determined by periodogram analysis (example: Figure 9.2).

The results of the periodogram analysis of the temperature data for the various groups are presented in figure 9.3 and table 9.2. Out of the four placebo and Li^+ treated groups two (NI and GII) reacted with period lengthening to the Li^+ treatment, two (NII, GI) did not react. The groups, which changed from Li^+ to placebo, reacted directly with period shortening; the groups, which changed from placebo to Li^+, reacted after seven days of Li^+ intake with a lengthened period of the temperature rhythm.

Similar results were obtained by analyzing the sleep-wake pattern in the various groups. Here again two groups reacted to the Li^+ uptake by lengthening the period (NI, GII, see figure 9.4 from Johnsson et al. (1980)).

We have also averaged the course of the sleep-wake rhythm and of the body temperature (so called average days, method explained in figure 11.6 in the appendix) during the time with (10 to 14 d) and without Li^+ application (12 to 16 d), see figure 9.5. Fourier analysis was used for determining the amplitude and phase of the harmonics[2] of the basic circadian frequency. In

[2] A harmonic is a whole-number multiple of the basic frequency. Using Fourier analysis, periodic

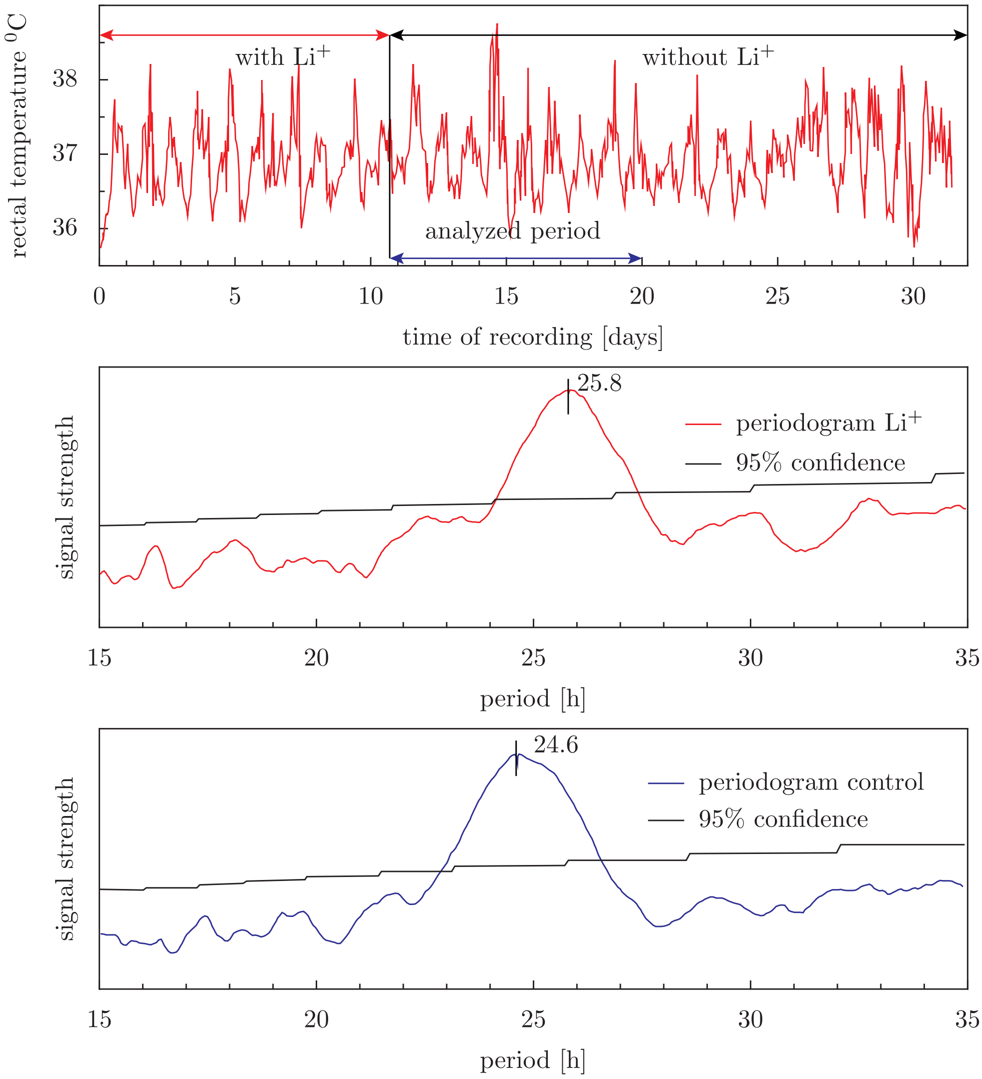


Figure 9.2: *Course of body temperature* of A.G *of group GII under Li$^+$ (tablets were taken daily already 14 days before recording started; then 10 days during recording, red double arrow). Afterward no Li$^+$ until the end of recording. Periodogram analysis for the Li$^+$ period: Red curve, with 95 % confidence steps shown. The periodogram analysis for the analyzed period (blue arrow) in the upper curve is shown in the bottom curve, likewise with 95 % confidence limit of the signal strength. Maxima above the staircase line are significant. From Johnsson et al. (1979)*

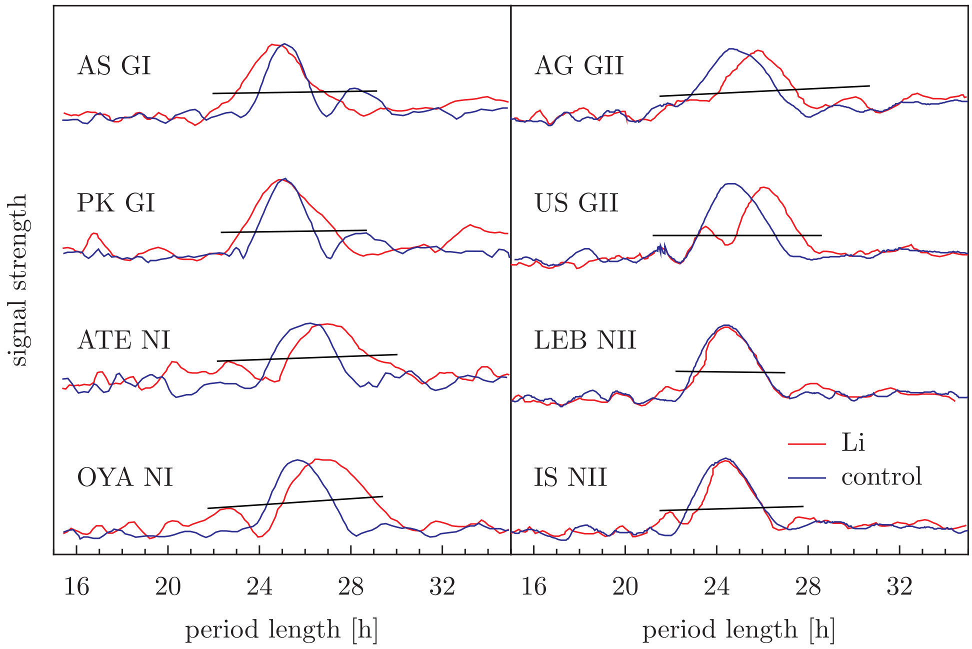


Figure 9.3: *Periodogram analysis of body temperature rhythms of the German group GI (A.S., P.K.) and GII (A.G, U.S) and the Norwegian group NI (A.T.E, O.Y.A) and NII (L.E.B, I.S). The blue curves are for the placebo period, the red one for the Li^+ period. The slanted lines show the 95 % confidence limit of the signal strength. The maxima beyond this line are thus significant. The resulting free run periods are compiled in table 9.2*

Table 9.2: *Period lengths of the participants in the various groups NI, NII (Norwegians) and GI, GII (Germans). They were calculated by periodogram analysis according to Wittacker/Enright (Martin et al. (1977)). Group NI and GII obtained first placebo and then Li^+, group NII and GI first Li^+ and then placebo. After* Johnsson et al. (1979)

Group		1st part of experiment		2nd part of experiment		
		treatment	τ [h]	treatment	τ [h]	$\Delta\tau$ [h]
NI	A.T.E	placebo	26.4	Li^+	27.0	+0.6
	O.Y.A		25.7		27.0	+1.3
NII	L.E.B.	Li^+	24.35	placebo	24.3	+0.05
	I.S.		24.3		24.2	+0.1
GII	A.G.	Li^+	25.8	placebo	24.6	+1.2
	U.S.		25.9		24.6	+1.3
GI	A.S.	placebo	25.2	Li^+	24.8	-0.4
	P.K.		25.1		25.0	-0.1

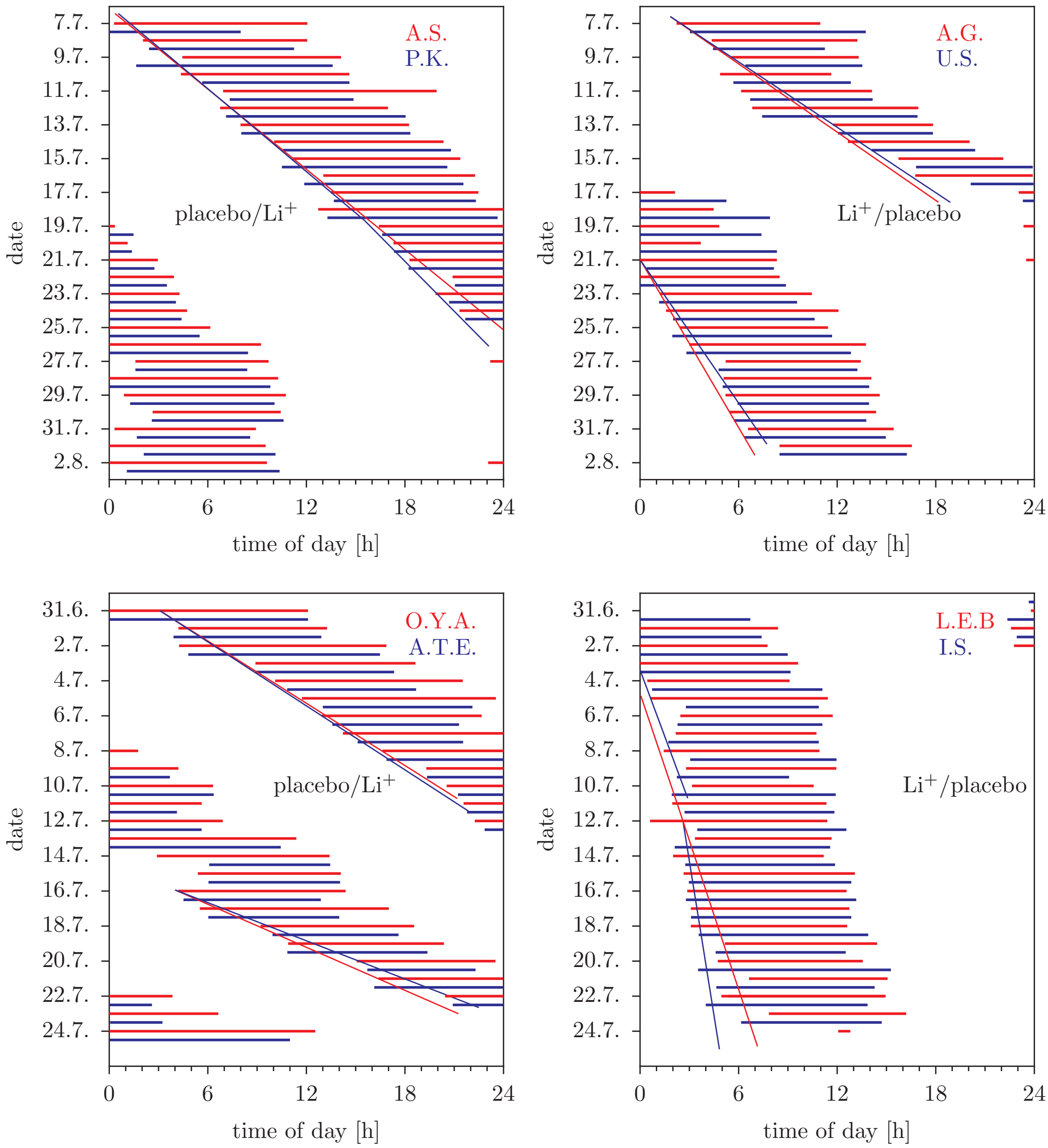


Figure 9.4: *Periodogram analysis of sleep-wake rhythm of the German group GI (A.S., P.K.) and GII (A.G, U.S) and the Norwegian group NI (A.T.E, O.Y.A) and NII (L.E.B, I.S). The change from placebo to Li^{+} respectively from Li^{+} to placebo is marked. The blue and red vertical lines represent the sleep times of the corresponding group members. The inclined lines are fitted to the onsets of sleep during the Li^{+}- and Placebo periods and the* slopes reflect the period lengths (the flatter, the longer, the steeper, the shorter). After Johnsson et al. (1980)

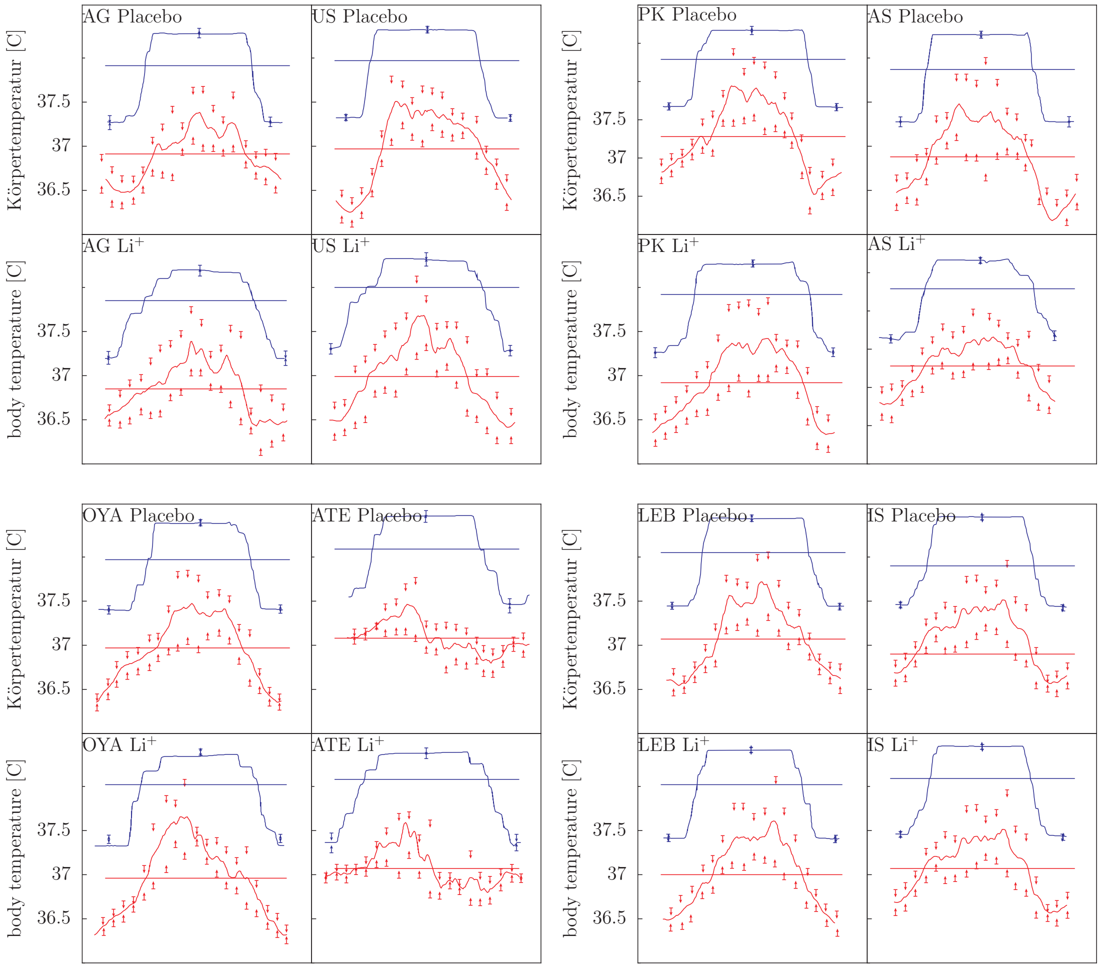


Figure 9.5: *Average days of the sleep-wake pattern (blue curves) and the body temperature (red curves) in the groups GII (AG and US upper left), GI (PK and AS, upper right), NI (OYA and ATE, bottom left) and NII (LEB and IS, bottom right). Placebo parts in the upper, Li^+ in the lower part. Standard error of values shown. After Engelmann et al. (1983)*

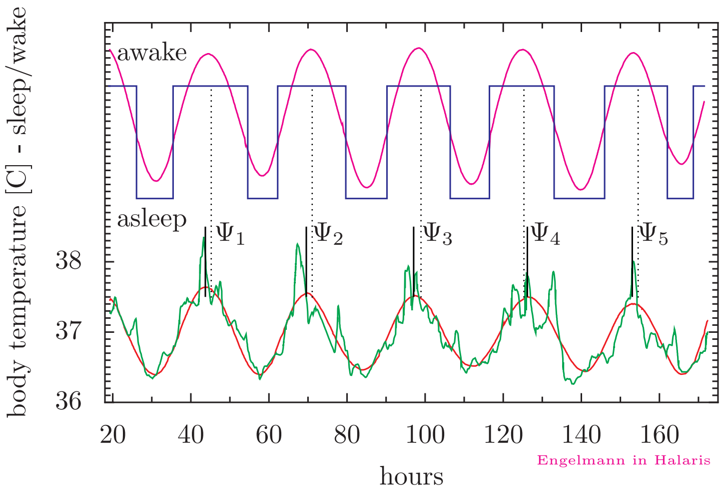


Figure 9.7: *Phase relation between sleep-wake rhythm (blue, first harmonic magenta) and body temperature rhythm (green, first harmonic red) in the example of the data of Olav (group NI). The phase relation between both is Ψ_n. After* Engelmann et al. (*1983*)

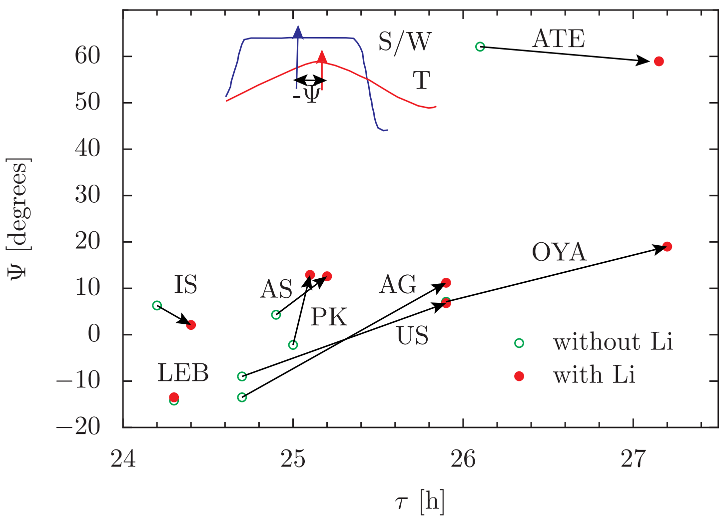


Figure 9.8: *Phase relation Ψ (y-axis) between sleep-wake rhythm and body temperature rhythm (see the explaining upper inset with sleep-wake rhythm, blue and body temperature rhythm, red) without (green dots) and with Li^+ (red dots). The arrows indicate the changes under Li^+. Period length plotted on the x-axis. In the groups non-responding to Li^+* (NII:IS and LEB, GI:AS and PK) the periods stay the same. *After* Engelmann et al. (*1983*)

this way and with the method of complex demodulation[3] (see figure 9.6) alterations in the phase relationship of the various rhythms measured (body temperature, activity and sleep-wake cycle) could be determined (figure 9.7). The alterations of these phase relations under the influence of Li^+ is shown in figure 9.8. In those participants, which lengthened the period under the influence of Li^+, the phase relation between the sleep-wake rhythm and the body temperature rhythm did also change. The maximum of the body temperature occurs later under Li^+ treatment as compared to the placebo period. Interestingly this is also true for the groups GI (AS and PK), the rhythm of which was not lengthened by Li^+.

Looking at the curves in figure 9.5, a few particularities show up. In ATE and to a smaller degree in AG the amplitudes during the placebo- and the Li^+ periods are relatively small. In the case of ATE the temperature rhythm precedes the sleep-wake rhythm under placebo as well as under Li^+ application, whereas in the case of OYA this is found only during the Li^+ period. In all the other cases the maxima of the temperature rhythms occur in the middle of the wake time.

The average temperatures are in almost all experimental subjects very similar during the placebo- and the Li^+periods.

A detailed analysis of the results is, however, difficult without mathematical

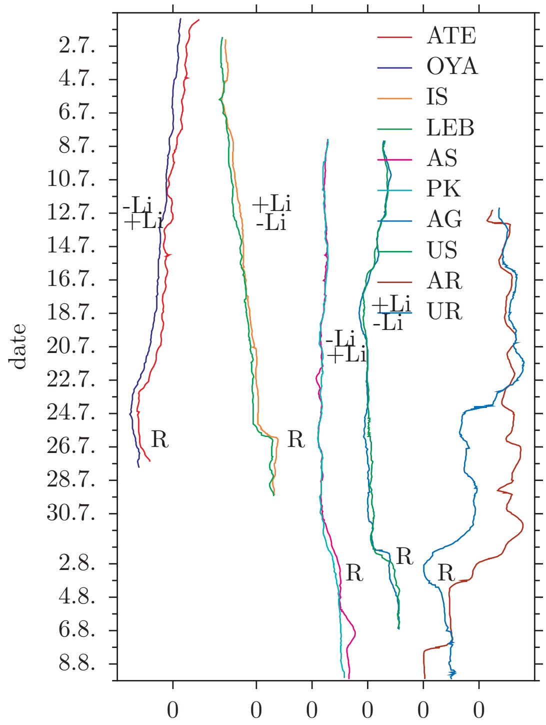


Figure 9.6: *Complex demodulation of body temperature data of the four groups NI (OYA and ATE, left), NII (LEB and IS, second pair of curves), GI (PK and AS, third pair of curves), GII (AG and US fourth curve pair) treated with placebo and Li^+ carbonate, and the group GIII (AR and UR, at the very right) treated with placebo only. Date at y-axis, the zeros at the x-axis correspond to the corresponding demodulated of the five groups consisting of two persons each. Colors shown before the abbreviated names. R indicates the time of onset of resynchronization to the 24 hour day. After Engelmann et al. (1983)*

signals can be broken down in their frequency spectrum. These signals are usually -besides the sinusoidal signal with the basic frequency f- composed of further sinusoidal signals with frequencies 2 f, 3 f, 4 f etc. These harmonic frequencies are related to each other and to the basic frequency in a whole-numbered relation

[3]The method of complex demodulation is used for analyzing a time serie with changing period lengths. Thereby low pass filters are used

methods, especially in the case of the temperature rhythms, since the basic circadian rhythm is overlaid by higher frequencies and noise. Therefore all data were subjected to a Fourier analysis. There is no significant difference in the amplitudes of the four harmonics of the temperature rhythms, and this is true also for the four participants, which reacted to Li^+ with period lengthening (OYA, ATE, AG and US). The amplitudes of the basic oscillation and the fourth harmonic of the sleep-wake pattern are, however, reduced during the Li^+ period, and this is even more so for the participants reacting to Li^+ .

These and further analyses pointed to the following effects of Li^+:

- In the responders (those which reacted to Li^+) the period was lengthened by 5.5 % (7.5 % in the Norwegian, 3.5 % in the German participants).
- Non-responders might have a too low Li^+ concentration (this seems to be true for at least LEB in the NII group). Another of the nonresponders, AS of the GI group, was later tested in an isolation unit and showed there a lengthening of the measured circadian rhythms (see figure 11.2).
- In all participants sleep was shortened by 4.9 % as an average (6.7 % in the case of the Norwegian[4], 3 % in the case of the German participants). The amplitudes of the first[5], fourth and sixth harmonic were reduced.
- Mean body temperature was not significantly changed when comparing the Li^+- and placebo times (differences $+0.07\pm0.05$; responders -0.03 ± 0.27). Neither was mean activity time changed (differences $+0.07\pm0.17$; $+0.34\pm0.12$ in responders), even if the sleep duration shortened under Li^+ (differences -3.06 ± 1.27; -2.68 ± 0.26 in responders).
- The phase relation Ψ between the activity rhythm and the temperature rhythm of the first harmonic was under Li^+ more negative, the temperature maximum was delayed by an hour in respect to the maximum of the activity rhythm. This was expected, if the period is lengthened by Li^+. Thus, Li^+ affects generally the activity rhythm by shortening the sleep[6] and the amplitude was reduced (which might be due to an increase in the variability of the time point of sleep onset). Only in responders the period is also increased.

[4] this is not caused by the longer periods of the Norwegians!

[5] except Lars-Erik; he by the way had the lowest Li^+concentration in the blood plasma

[6] exception Lars-Erik and Anna

10 Depression and circadian rhythms

What are endogenous depression and which kinds of this disease are known? What are endogenous depression in the context of affective diseases? Which kind of therapies are used and what are the causes of endogenous depression? Are there connections with disturbances of the circadian system?

In table 10.1 the various types of depression are compiled. According to the severeness of the disease one differentiates between light, average and severe once. Endogenous depression occur without external reasons and can be unipolar (depressive phase) or bipolar (depressive phase alternating with manic phase). Types of endogenous depression are also winter depression or very seldom summer depression (Seasonal Affective Disorders SAD).

Depression can be caused genetically, have neurobiological reasons (for instance an imbalance of neurotransmitters) or further factors (for instance thyroid disease).

In the Internet a self test is available (http://www.depressionen-wiki.de/d,selbsttest,43.html).

10.1 Seasonal Affective Disorders (SAD) and therapies of this disease

Seasonally caused affective diseases (SAD) and their therapies, especially the light therapy, are presented in more detail.

Seasonal Affective Disorders (SAD) were described for the first time in 1984 by Rosenthal et al. (1984). This disease is characterized by annually recurring depressive conditions, tiredness, hypersomnia, hyperphagia, hunger for carbohydrate containing food, weight gain and loss of libido. SAD occurs in the fall and winter (”winter depression”) and disappears in the summer (there is, however, also a form of SAD, which occurs during the summer). SAD is differentiated from the classic manic-depressive diseases (major depressive disorders) by its lower frequency (1-3 % of all adults in the temperate latitudes), is less severe, shows other symptoms, and typical seasonal fluctuations occur (Magnusson and Boivin (2003)). In the higher latitudes with their more pronounced seasonal day length differences SAD was said to be found more frequently, but this is a matter of discussion (pro: Kegel et al. (2009), Rosen et al. (1990), against: Levitt and Boyle (2002), Brancaleoni et al. (2009), Mersch et al. (1999)).

The circadian system plays a role in SAD: The phase position of the circadian oscillator is delayed in respect to the sleep-wake cycle. According to the phase delay-hypothesis the symptoms can weaken or disappear, if the circadian system (or a part of it) is advanced. This can be done for instance by light (see Terman (2007)). The biochemical mechanisms, which underlie SAD, are not yet known. It is known, however, that the melatonin secretion of the pineal organ and the serotonin synthesis are abnormal.

Table 10.1: *Various forms of depression (D=depression)*

depression		
endogenous	somatogenous	psychogenic
bipolar unipolar	symptomatic pharmacogenous organic	neurotic reactive exhaustion-D

The characteristic symptoms including hypersomnia and weight gain reflect a genetic program, in which at times of food shortage energy expenditure is reduced (evolutionary model of SAD, Davis and Levitan (2005)). Among the largest energy costs are those of reproduction. Studies concerning the birth rates at the various seasons show, that in the temperate latitudes the symptoms of SAD reflect a predisposition to conception in the late spring and early summer. Birth would in this case occur in late winter and early spring. Davis and Levitan (2005) discuss the adaptive value and role for the natural selection in humans.

Lam and Levitan (2000) present an overview of the pathophysiology of SAD and the circadian, neurotransmitter- and genetical hypotheses. The various hypotheses are partly contradictory. For the ethiology and pathophysiology of SAD, studies of the molecular mechanism of the circadian clock and the light transmission via the retina might be helpful in the future. For the connections between neurobiology and chronobiology see Levitan (2007).

In the diagnosis of SAD one has to take care, to differentiate it from other similar diseases such as subsyndromal SAD and atypic depression. Seasonal fluctuations of the symptoms with worsening during the winter are namely found also in "non-seasonal" depression and in other psychiatric diseases. SAD is probably a heterogeneous form of disease, as shown by different results of studies of the circadian conditions, the neurotransmitter functions and the genetic conditions. A dual vulnerability model was proposed, to explain the results (Westrin and Lam (2007a), Sohn and Lam (2005)).

Light was used for the therapy (Gross and Gysin (1996), Wirz-Justice and Graw (2000)), but also antidepressants (Westrin and Lam (2007b), Winkler et al. (2006), Magnusson and Boivin (2003)).

10.2 Circadian system - hands, Zeitgeber and mechanism

What have endogenous depression to do with the circadian system of man? We have first of all to deal with more recent results, which were obtained by studying circadian rhythms. Results of molecular biological and genetical studies are also important

The organisms on earth have adapted to the 24 h rotation of the planet around its own axis. For this purpose circadian clocks are used, which are synchronized by Zeitgeber, especially the day-night cycle and temperature differences. In this way regular changes in the environment can be foreseen, activities and metabolic events set to times biologically advantageous to the organisms, and seasonal reactions such as hibermation can occur. These clocks are located in the suprachiasmatic nucleus (SCN) in the hypothalamus. The molecular mechanisms of these daily clocks have been studied. They rely on self sustained transcription/translation feedback systems with a circa 24 h period length. One or several clock components are directly sensitive to light, and in this way they are synchronized to the local time (Edery (2000), figure 10.1).

There are, however, also circadian clocks in numerous organs and tissues. They can be controlled by the central clock in the SCN. On the other hand external Zeitgeber can directly control these peripheral clocks.

A very reliable hand of the clock in the SCN is melatonin in the sputum or in the blood plasma, or degradation products in the urine. As a rhythmic indicator the begin of the melatonin secretion during weak continuous light is often used. Melatonin measurements allow also to find out, whether the circadian rhythm is synchronized to the light-dark cycle and whether it is normal, advanced or delayed. Therefore, in patients with sleep- and mood disorders such as SAD melatonin measurements are conducted. They serve also to indicate an optimal timing of therapies and medication (Pandi-Perumal et al. (2007)).

To decode the mechanism of the daily clocks, mutants of animals were studied, the clock of which differs from the one of the wild types by running faster, more slowly or not at all. By using molecular biological studies the involved genes and their interactions can be clarified.

A (simplified) molecular model of the circadian clock of mammals is shown in figure 10.1. It consists of several clock genes, which inhibit their own expression by feedback, time delay and interaction with transcription factors and thereby producing a circa 24 h rhythm -even without Zeitgeber of the environment (Reppert and Weaver (2001), Ko and Takahashi (2006)). Light synchronizes the oscillator by being absorbed by photo-receptors and by sending a signal to the clock genes.

According to more recent studies the model is more complicated. First of all, there are more clock genes (cg's). Furthermore, an additional feedback loop is involved (see the legend in figure 10.1 and Ripperger and Brown (2010)).

How are endogenous depression and the circadian system related with each other? Figure 10.2 tries to illustrate various possibilities. According to the first one the endogenous depression results from a disturbed circadian system. According to the second it is vice verse: The disturbed circadian system is the result of the depressed state. A further situation would be, that the depressive disease as well as the disturbed circadian system can be attributed to a common (so far unknown) factor. Finally one has also to reckon with the possibility, that there are various kinds of endogenous depression, out of which only one is responsible for the altered daily rhythm (Engelmann (1987)).

10.3 Li^+ influences the circadian system

The period lengthening effect of Li^+ on the daily rhythm of a number of organisms was already mentioned on page 25. Period of the circadian rhythm has been shown to be influenced furthermore in

- unicellulars (*Skeletonema*, Östgaard et al. (1982) and figure 10.3, *Euglena*, Kreuels, personal information), fungi (*Neurospora crassa*, unpublished observations of Engelmann, Jolma et al. (2006)), plants
- animals
  - mollusks
  - insects

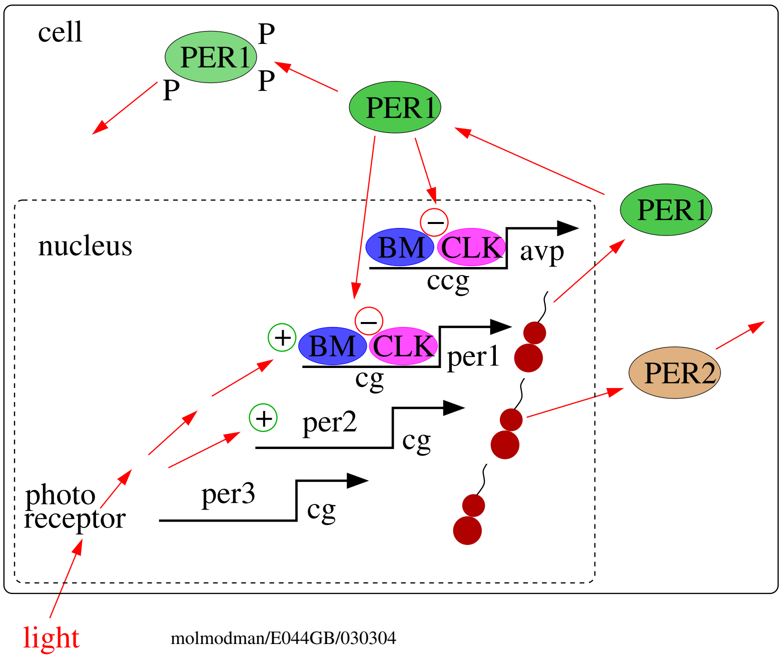


Figure 10.1: *Molecular model of the circadian clock of mammals: Clock gene per1, per2 and further ones (not shown) inhibit their own expression with time delay the transcription activators BMAL (BM) and CLOCK (CLK) (heterodimere) (per1, per2 and per3 are clock genes cg, brown: mRNA).*
In detail this feedback circle works like this: PER reaches, like CRY (cryptochrome), after being translated in the nucleus, the cytoplasm, is there phosphorylated by CK1ε and δ and by GSK3β (P, lighter green color), whereby the dimer becomes destabilized and dissociates. The parts enter the nucleus and bind there to the E-box sequence in promoters of many genes, influencing their transcription positively or negatively. In the same way Per and Cry are inhibited by CLK/BMAL1.
There is additionally a second feedback loop, in which CLK/BMAL1 activates the transcription of Rev-erbα and Rorα (not shown).
Light synchronizes the oscillator by being absorbed by photo-receptors and by sensing a signal to the clock genes. In the same way clock controlled genes (ccg = clock controlled genes) such as the avp gene, which expresses AVP, are inhibited by PER1. Nucleus dashed, cell continuous box. After McClung (2007), there further literature

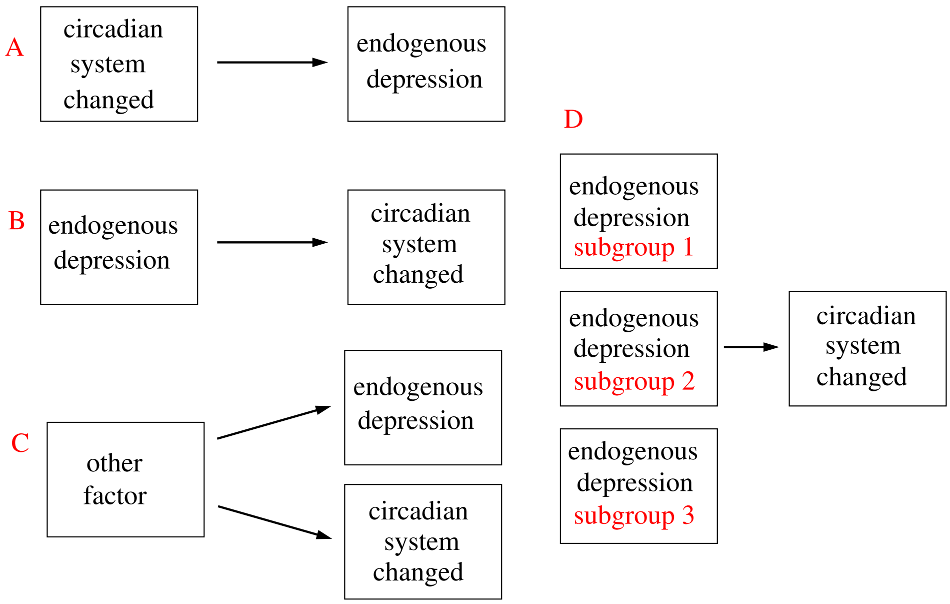


Figure 10.2: *Possible relations between endogenous depression and disturbances of the circadian system. A: An abnormal circadian system causes the depression. B: The depression is causing the altered circadian system. C: One or more other factors are responsible for the endogenous depression and the altered circadian system. D: Only a subgroup of endogenous depression is responsible for the altered circadian system*

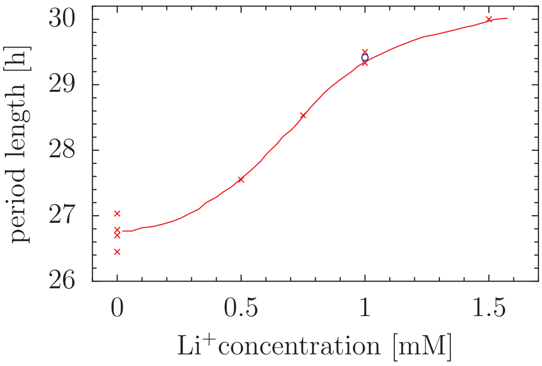


Figure 10.3: *Li salts (LiCl x and LiNO$_3$ o) slow the clock of* Skeletonema costatum *(belongs to the diatoms (Bacillariophyta)). After* Östgaard et al. (1982)

- fish
- birds
- rodents
- monkeys

In higher plants (besides the one mentioned already on page 25) for instance the daily periodic potassium uptake of the duck weed *Lemna* (Kondo (1984)) is slowed by Li^+. Photoperiodic reactions of flower formation are also influenced by Li^+ (long day plant *Lemna gibba* and short day plant *Lemna perpusilla*, Kandeler (1970), the short day plant *Pharbitis nil* and *Chenopodium rubrum*, Engelmann et al. (1976)). This is interesting, since the day length measurement in these reactions are based on the circadian clock (Bünning (1936)).

In lower animals the circadian firing of the eye nerves of the marine snail *Aplysia* is slowed by Li^+ (Jacklet (1981), Woolum and Strumwasser (1983)). The circadian locomotor activity of *Drosophila* is lengthened by 0.4 h, if 1mM Li^+ are added to the drinking water (Mack (1980)).

The period lengthening effect of Li^+ on the running wheel activity of Syrian hamsters was mentioned already (page 25). However, this effect can not only be due to a lengthening of the period by Li^+, since the range of entrainment is increased by Li^+ in light-dark cycles larger or smaller than 24 h (for instance 11:11 or 13:13 h L:D, Reinhard (1983), Reinhard (1985)). In the case of a simple period lengthening one would expect, that the range of entrainment is shifted to longer periods. The extension of this range by Li^+ might be caused by a higher sensitivity of the photoreceptors or the oscillator to the LD Zeitgeber by the ion (which has, however, been excluded experimentally, see Rauch et al. (1986)), that the strength of the oscillator has been reduced, or that the coupling of oscillators has been altered by Li^+ (Engelmann (1987)).

Among other vertebrates it was shown in Goldfish, that the period length of the circadian swimming activity increases (Kavaliers (1981)). It is possible, that the importance of environmental stimuli is reduced, resulting in a reduced effect of the Zeitgeber (Johnson (1979)). A singular application of Li^+ shortens the activity-rest cycle of Canaries, if applied in the morning, but is without effect, if given in the evening (Wahlström (1968)).

The feeding rhythm of rats is slowed by Li^+ (Wirz-Justice (1982)), and also the running wheel-rhythm (Kripke et al. (1979)).

Li^+ does not only lengthen the circadian rhythm, but can also shorten it. This was shown for the locomotor activity rhythm of the bat *Taphozous melanopogon* under weak continuous light of 5 lux. The longer the period was *before* the treatment with Li^+, the more the period was shortened (Subbaraj (1981)). The shortening of the period showed up also in further studies in Golden hamsters using a higher number of experimental animals. Li^+ increased in 50 % of the cases, shortened in 25 % and had no effect in the remaining 25 % on the running wheel rhythm (Delius et al. (1984)). Later experiments in the same laboratory resulted in period lengthening only (Han (1984)). Taking all the results together, the results show, that *animals with a long period before the Li^+ treatment speed up their rhythm under Li^+, whereas animals with shorter periods lengthen their rhythm*.

These results can be explained with a system of coupled circadian oscillator. In favor of coupled oscillators is also the finding, that in rats as well as in Syrian hamsters the running wheel-rhythm can split in weak continuous light in two components.

Other antidepressants that can also slow the running wheel-rhythm of Syrian hamsters or split it in a morning- and evening component with different periods ("splitting") are chlorgyline and imipramine Wirz-Justice and Campbell (1982)). In 24 h LD cycles Li they and other antidepressants delay the running wheel rhythm (Wirz-Justice (1982)), the rhythm of prolactin in the plasma, corticosterol, parathyroid hormone, Ca^{++} and Mg^{++} (McEachron et al. (1980)), whereas the rhythm of 5-hydroxytryptamin and melatonin is not influenced. That might mean, that Li^+ affects only one of the oscillators, whereas the other is not influenced (McEachron et al. (1983)). On this observation the phase advance hypothesis and therapies for endogenous depression are based (see page 132). The results could be explained by a lengthening of the period of both oscillators, by a changed sensitivity towards the synchronizing LD cycle, or by an alteration of the coupling strength of the oscillators. The sensitivity towards the LD cycle is indeed influenced by Li^+: To shift the phase of Li^+ treated animals by using one hour of light to the same amount, an intensity of 75 lux is needed instead of 7.5 lux in the untreated controls (unpublished results of Han 1984). This is, however, only true for the range, in which light advances the rhythm: Han (1984) compared phase response curves towards light pulses of control animals with those of animals under chronical Li^+ treatment (figure 10.4). The phase shifts by light pulses under Li^+ are smaller during the advancing part of the phase response curves, whereas they are larger during the delaying part. Thus, the animals do not react during the whole circadian cycle with a reduced shift of the rhythm to light pulses under Li^+, but only during the subjective night.

Welsh and Moore-Ede (1990) found a period lengthening of the circadian rhythm of the locomotor activity (perch hopping) by Li^+ carbonate in the squirrel monkeys *(Saimiri sciureus)*. The carbonate was offered eight males in the food pellets during at least 27 sequential days. The serum concentration was between $0.76\frac{mE}{l}$ and $2.02\frac{mE}{l}$ and corresponds thus to the therapeutic dose during the treatment of bipolar depressed patients (0.6-$1.2\frac{mE}{l}$). The circadian periods were in 7 of the 8 monkeys lengthened by 0.55 h as compared to the control time. After stopping the Li^+ application the value reached the control values again. In most cases the period lengthening is visible a few days after the begin of the Li^+ treatment. Intensity and pattern of the locomotor activity and the amplitude of the rhythm were not altered. Food uptake and body weight were reduced during the Li^+ treatment. Both normalized again after the treatment. The period changes correlated with the Li^+ dose (p below 0.05), but not

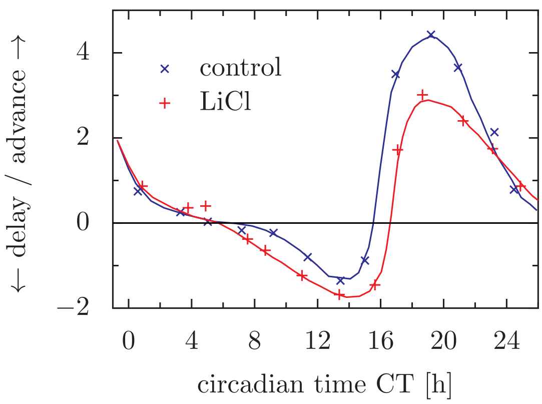


Figure 10.4: *Phase response curve in Syrian hamsters without (blue) and with Li$^+$ (red) in the drinking water (47 mM). Light pulses were administered at various times of the circadian cycle (x-axis). Circadian time CT 12 is the onset of activity (hamsters are night active!). Period length normalized to 24 h. Advances (above the zero line) and delays (below the zero line) are plotted on the y-axis (in h). After Han (1984)*

with the amount of food, the body weight and the control period. Thus Li$^+$ increases the circadian period in primates.

Behavior and mental state of healthy experimental subjects under Li$^+$ were studied among others by Pflug and Engelmann (1987) and Pflug et al. (1980) in long-term studies. During the Li treatment shorter and longer periods of the body temperature rhythm were found in addition to the 24 h period.

10.4 Endogenous depression - Facts, hypotheses and therapies

Here we concentrate on endogenous depression, since they stood in the focus of our Spitsbergen studies and since the Li$^+$ therapy is and was used in this disease. Other therapies and their successes/failures are mentioned such as the use of antidepressants or sleep deprivation.

We got to know already in the preceding chapter seasonally occurring depression (SAD). Now we turn towards the non-seasonal depression. In comparison to SAD the endogenous depression are much more severe. The patients feel sad, without hope, are pessimistic, feel guilty, are often self-centered and avoid social contact. Energy, activity and libido are often reduced, the ability to concentrate and to memorize are afflicted, the sleep disturbed.

Here too connections with circadian rhythms (Germain and Kupfer (2008), McClung (2007)), and the cyclic course, diurnal variations of the symptoms and a disturbed sleep-wake- and body temperature rhythm indicates, that the circadian system might be disturbed and might underlie the depression (Srinivasan et al. (2006)).

Sleep disturbances are frequently observable in endogenous depression: 90 % of the depressives have difficulties to fall asleep, to sleep through or they wake up too early (Germain and Kupfer (2008)).

It was furthermore observed, that in evening types depression occur more frequently and are more severe (Gaspar-Barba et al. (2009)), whereas morning types are more stable (DeYoung et al. (2007)).

There are a number of findings, which point to an altered circadian system in endogenous depression (Germain and Kupfer (2008), Engelmann (1987)). The following hypotheses were put forward:

1. Phase shifting: The daily rhythm is in respect to healthy people advanced or delayed, which shows up also in the SCN. For therapy strong light pulses can be administered, which normalize the rhythm again (Lam et al. (1999), Rosenthal et al. (1990)). Morning- and evening light improves the state (Eastman et al. (1998), whereby morning light seems to be more effective (Lewy et al. (1998), Terman and Terman (2005)). An advanced melatonin rhythm does also reduce the depression (Terman and Terman (2005)).

2. Internal phase coincidence: There is a sensitive phase of the circadian rhythm (Borbély (1982)). If the rhythm is shifted, the dissonance between circadian phase and sleep phase is reduced (Wehr and Goodwin (1975)).

3. Antidepressant such as MAO inhibitors (MAOI) are also able to shift the rhythm and act therapeutically (Kripke et al. (1983)). Rolipram, a new antidepressant, slows the free run rhythm of the locomotor activity of chipmunk in continuous light (Eckhardt et al. (1983)).

4. Depression are characterized by short REM latencies. If the REM sleep is suppressed by pharmaceutics or by the behavior, the mood improves (see however Argyropoulos and Wilson (2005), Grözinger et al. (2002))

5. Increased REM at the expense of the *Slow Wave Sleep* (SWS): According to Borbély (1982) the S process is thus disturbed (see however Sharpley (1995))

6. Social and therewith connected physiological rhythms are disturbed (Ehlers et al. (1988), Frank et al. (1997), Grandin et al. (2006))

7. Clock gene polymorphism leads to depression according to more recent studies (Bunney and Bunney (2000), Benedetti et al. (2003), Serretti et al. (2003), Serretti et al. (2005), Joyce et al. (2005))

The hypotheses assume, that a single oscillator controls the circadian system. There are, however, a number of more recent findings, according to which the circadian system consists of (at least) two different oscillators. Their period lengths might differ. One of the oscillators could, for instance, be faster as the other. If now their coupling is too weak, both oscillators could oscillate in their own measure. Under normal conditions with 24 h Zeitgeber of the environment (for instance the light-dark cycle) it might happen, that one of the two oscillators is synchronized by the 24 h day, but the other one is too fast (for example with a period length of 21.8 h only). It can therefore not be synchronized to the 24 h day. As a result there are at least at certain times disturbed phase relations, which could be the cause of the depression (Kripke (1984)). Consequently the sleep pattern is disturbed, the body temperature maximum is too early. Depression occurs, if the maximum of the body temperature lies after midnight. Mania occur, if the maximum lies in the afternoon or evening. The sleep duration depends on the phase, in which the sleep begins. It is short, if the sleep begins in the minimum of the body temperature. It is long, if it begins in the maximum. In normal people depression and sleep pattern anomalies are inducible, if they have to sleep from 10 o'clock onward.

Endogenous depression can be treated, if the sleep is advanced by several hours. Body temperature rhythm and sleep-wake rhythm are then synchronized again with each other. Reports of patients from the airport Heathrow speak also in favor of this idea (Jauhar and Weller (1982)).[1]

10.5 Therapy of endogenous depression with Li^+

Endogenous depression are treated successfully with Li^+. They slow in various organisms the circadian clock. Later it was also shown in monkeys, that Li^+ decelerate circadian rhythms (Welsh and Moore-Ede (1990) and page 121).

With Li^+ manic episodes are successfully treated in bipolar depression. Many studies have also demonstrated an antidepressant effect in clinical cases. According to Bauer et al. (2003) about 45 % of the patients reacted to Li^+ as an additional medication in depression. None of the other treatments has a comparable success. Sole Li^+ therapy is prophylactic in unipolar depression (Souza and Goodwin (1991)). Because of these promising clinical data one would like to understand the action of Li^+ and has therefore used a rodent model of depression (O'Donnell and Gould (2007), figure 10.5).

10.6 Newer results regarding the effect of Li^+

Two effects of Li^+ are discussed in the context of therapies of endogenous depression (Gould and Manji (2005)):

1. Li^+ inhibits the inositolmonophosphatase and similar enzymes, leading to a reduced inositol concentration in the brain. Inositol is important for signal cascades.

2. Li^+ inhibits glycogen synthase kinase (GSK-3), a pluripotent serin/threonin kinase, which phosphorylates glycogen synthase and thereby deactivating it. This occurs in in neurons and in glia cells of the brain, and in fact in the cytoplasm, nucleus and mitochondria. Furthermore the "nuclear factor activating T-cells" (NFAT) is phosphorylated by GSK-3 and thereby inhibited.

Many signal paths converge in GSK-3 and furthermore in the biological events depending on it. Some of these signal paths are the insulin/insulin-like growth factor IGF-1, the neurotrophic factor-signal, the Wnt-signal path and others. Which of these paths are affected by the inhibition through Li^+ is unknown.

[1] In patients admitted from Heathrow Airport to the nearest psychiatric hospital depression was diagnosed significantly more often on flights from east to west (which delays the circadian rhythm) versus west to east (which advances the circadian rhythm). No other associations with direction of travel were seen in other diagnoses such as schizophrenia

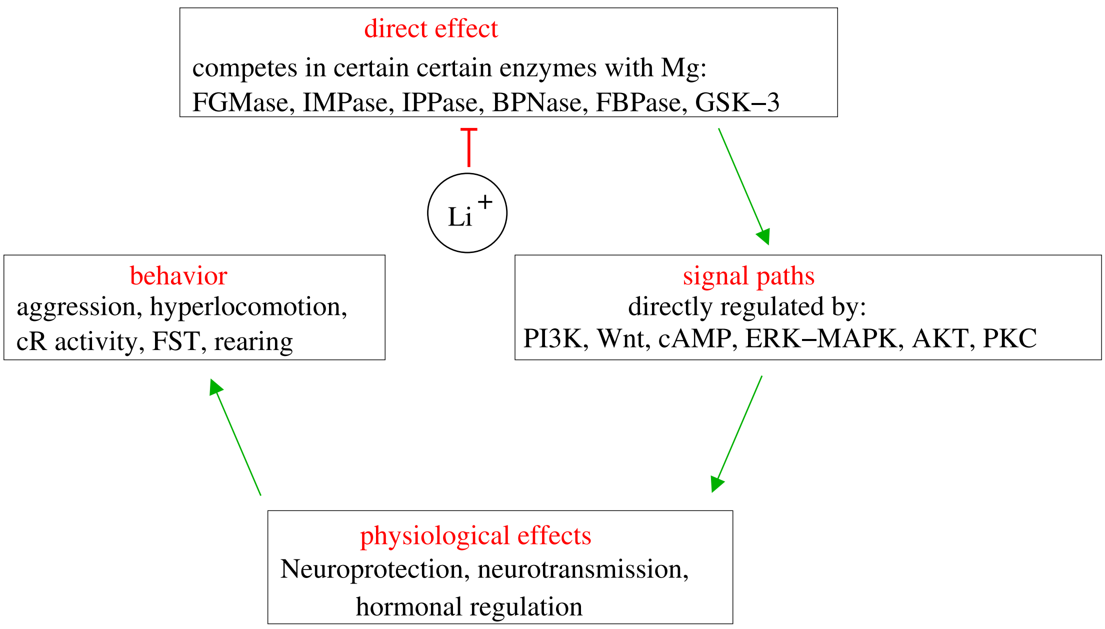


Figure 10.5: *Effect of Li^+ on metabolism, signal paths, physiology and behavior of rodents. After O'Donnell and Gould (2007)*
Abbreviations: FGM formononetine-7-O-glucosyl-6"-malonate; IMP inositolmonophosphate; IPP inositol polyphosphate 1-phosphate; BPN bisphosphate nucleotide; FBP fructose 1,6-bisphosphate; GSK-3 glycogen synthase kinase-3; cyclic AMP; ERK extracellular signal-regulating kinase; mitogen-activating protein kinase (MAPK); AKT active human protein kinase; PKC protein kinase C; FST forced swim test

The inhibiting effect of GSK-3 was described by Klein and Melton (1996) and Stambolic et al. (1996). Li^+ competes with Mg^{++} (Gurvich and Klein (2002), Ryves and Harwood (2001)) and Zn^+. Interestingly thymoleptika such as valproate, MAO's and electro shock affect GSK-3.

1. GSK-3 regulates monoaminergic signals, which play a role in affective disorders (Rajkowska (2002))
2. protects neurons
3. regulates the brain metabolism
4. influences circadian rhythms.

From circadian rhythms it is known, that they are disturbed in bipolar disorders (Bunney and Bunney (2000), Healy and Waterhouse (1995), Klemfuss (1992), Wehr and Wirz-Justice (1982)). Thus, the free run period is shorter as compared to the one in healthy people. Sleep deprivation and Li^+ aid in bipolar depression (Klemfuss and Kripke (1995)), whereby Li^+ lengthens the period. It thus affects GSK-3 (inhibiting) as well as the circadian rhythms (Martinek et al. (2001). In bipolar patients a single nucleotide polymorphism in the GSK-3b promoter region correlates with the onset of the disease (Benedetti et al. (2004)). Besides Li^+, which inhibits the GSK-3b activity in vitro (Ryves and Harwood (2001)) and in cell cultures (Stambolic et al. (1996)), valproate is also inhibiting this kinase (see figure 10.7). Both substances are used to treat bipolar depression. How this affects the circadian behavior is unknown. The therapeutic effect of Li^+ could be connected with its effect on the circadian system (Ikonomov and Manji (1999), Manji and Lenox (2000) and figure 10.6).

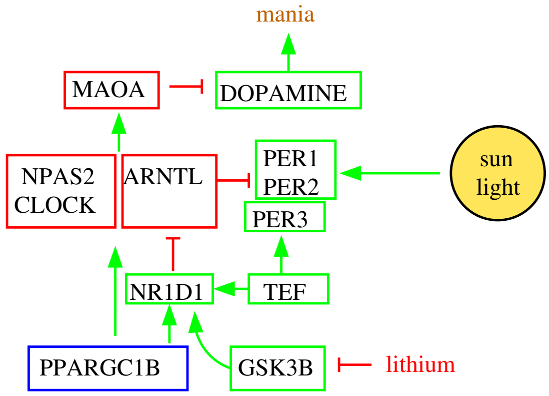


Figure 10.6: *Model of the connection between sun light, Li^+, circadian genes, MAOA (monoaminoxidase A) and mania. Green arrows: Assist function of the affected components. Red paths: Inhibit function of the affected components. Components in the green boxes: Lead to mania. Components in the red boxes: Prevent mania. Blue box: PPARGC1B (peroxisome proliferator-activated receptor gamma, co-activator 1 beta) stimulates ARNTL (aryl hydrocarbon receptor nuclear translocator-like, or Bmal1 or Mop3) as well as NR1D1 (nuclear receptor subfamily 1, group D, member 1, or Rev-erbα), whereby NR1D1 inhibits ARNTL. Positive feedback of ARNTL-CLOCK and ARNTL-NPAS2 (NPAS2 is an analogue of CLOCK) heterodimeres on NR1D1, TEF (a transcription factor), PER1, PER2, and PER3 as well as other components and interactions in the circadian system are not shown. After Kripke et al. (2009)*

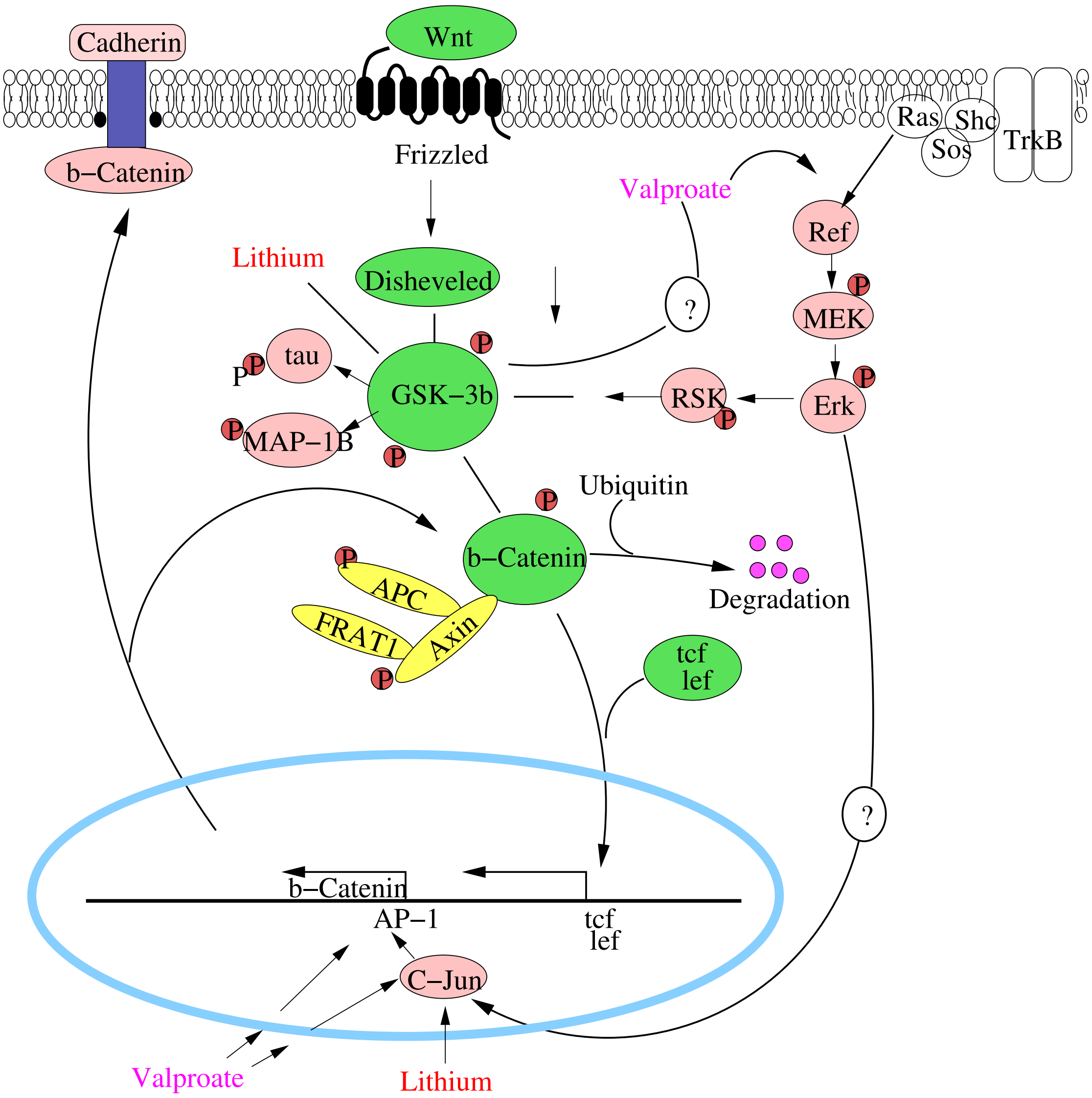


Figure 10.7: *Possible effects of Li^+ and valproate on glycogen synthase-kinase-3β (GSK-3) or C-Jun. Signals activate via Wnt glycoproteine and "frizzled" receptors "disheveled", which inhibits GSK-3β. Phosphorylation of β-Catenin by GSK-3β leads to degradation by ubiquitin. Intact (non-phosphorylated) β-catenin binds to lef/tcf transcription factors, allowing the transcription of specific genes. Li^+ competes with Mg^{++} in inhibiting GSK-3β. Valproate might also be an inhibitor of GSK-3β. Alternatively it could act via the Wnt-signal path by inhibiting the histone deacetylase, or via its known effect on c-Jun by up-regulating β-Catenin-mRNA, or via the Ras/RSK path (Yuan et al. (2001), Phiel and Klein (2001))*

To test this, Dokucu et al. (2005) used the mutant shaggy of *Drosophila melanogaster*, which does not have any GSK-3 activity and possesses a long period, as a model for mammals. *Drosophila* is genetically well studied and its circadian behavior well known (Wang and Sehgal (2002)). In other affective disorders the circadian behavior is also changed (Klemfuss (1992), Bunney and Bunney (2000), Leibenluft and Frank (2001)). Since the circadian behavior has been highly conserved during the phylogeny between insects and vertebrates, the signal paths of mood-stabilizing substances might be alike or identical. Indeed, Dokucu et al. (2005) could show, that Li^+ lengthen the period of the locomotor activity also in *Drosophila*. Valproate shows also this effect (see figure 10.8).

How Li^+ and valproate might act is shown in figure 10.9.

Hirota et al. (2008) studied 1280 pharmacologically effective compounds with quite diverse structures (from the LOPAC Chemical Library, which contains many of the substances being on the marked at present and under clinical test) in respect to a period lengthening action of the circadian clock in luminescent reporter cells (reporter: Bmal1-dluc) of humans (U2OS-cells). The newly developed system for screening identifies many of the already known substances, which change period or phase. In addition low molecular inhibitors of glycogen synthase-kinase 3 (GSK-3) were found, which in contrast to Li^+ do not lengthen, but shorten period. Knockdown of GSK-3 by siRNA shortens also the period, which testifies, that GSK-3 is involved in the circadian clockwork of mammals. Many of the compounds thus identified are connected with the already known paths of circadian

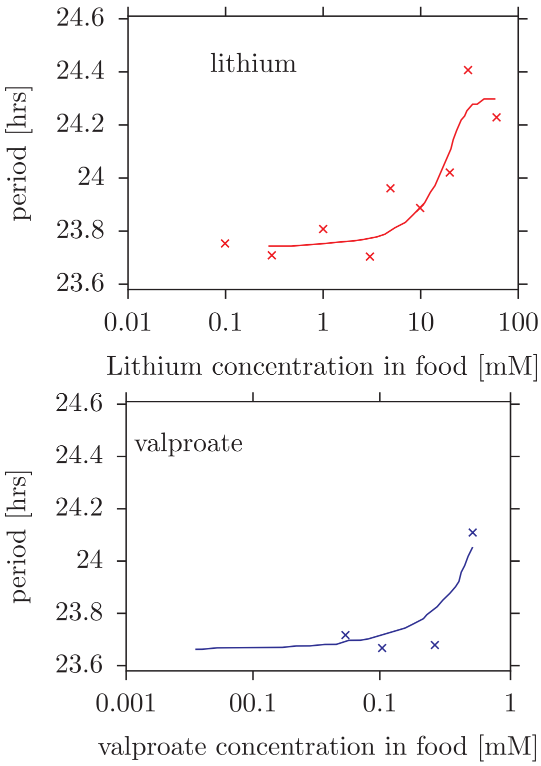


Figure 10.8: *Lengthening of period of the locomotor activity rhythm* of Drosophila melanogaster *by adding LiCl to the food (top) or potassium valproate (bottom)*

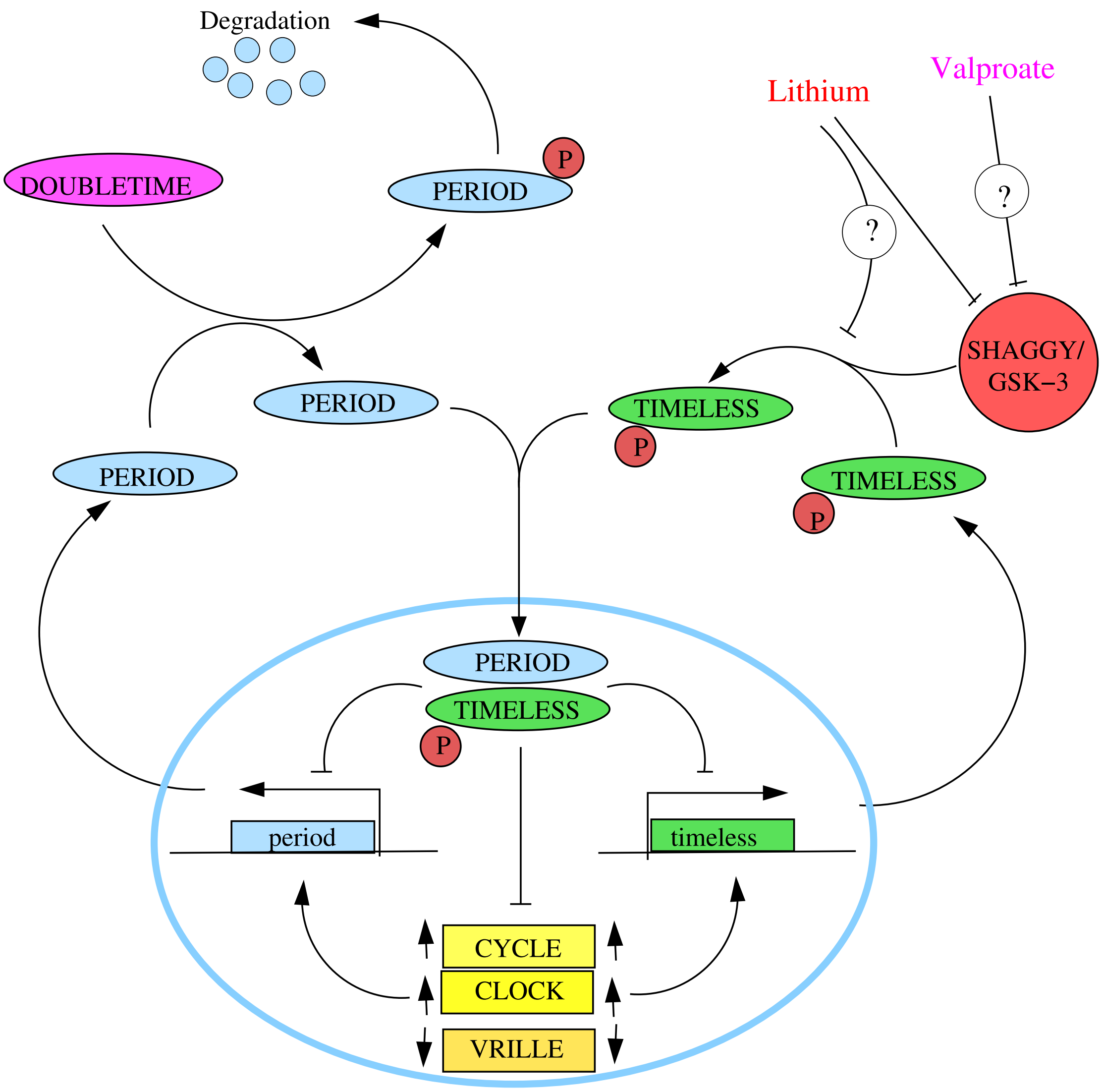


Figure 10.9: *The period lengthening effect of Li^+ and valproate in* Drosophila melanogaster *(studies of Gould and Manji (2002))*

functions, such as roscovitin, a CDK inhibitor, SP600125, a JNK inhibitor and SB 203580, an analog of the p38 MAPK-inhibitor SB 202190, which lengthens the period in cultured *Aplysia* eyes, mouse tissue and pineal glands of chicken. Period shortening substances such as indirubin-3-oxim and azakenpaullon inhibit CDK and GSK-3. Roscovitin, which inhibits CDK - but not GSK-3-, lengthens the period. It turns out, that GSK-3 inhibitors like Chir 99021 and 1-azakenpaullon shorten the period, whereas CDK-inhibitors did not. Interestingly the period shortening effect of the GSK-3-inhibitor contrasts with the period lengthening effect of Li^+, which according to Quiroz et al. (2004) is supposed to work via GSK-3 inhibition. Knockdown experiments by transfection with GSK-3 siRNA reduces the endogenous GSK-3 mRNA level and *shortens* the circadian period. The same was found in primary fibroblasts of mice.

In contrast to these findings in mammals the circadian period in *Drosophila* is lengthened, as reported before, if the GSK-3 activity is reduced by genetic manipulation. In this case GSK-3 phosphorylates the TIM protein (Martinek et al. (2001)), but there is no tim-ortholog in mammals. In mammals GSK-3 phosphorylates PER2 (Yin et al. (2006)), whereby CRY2 is decomposed (Harada et al. (2005)) and Rev-erb stabilized. Cry2 knockout mice show a long, Rev-erb mice a short phenotype (Thresher et al. (1998), van der Horst et al. (1999), Preitner et al. (2002)), which might indicate, that the shortening of the period due to GSK-3 inhibition is brought about by the regulation of CRY2 and Rev-erb protein concentrations (stabilizing of CRY2 and degradation of Rev-erb). Although Li^+ lengthens the period in quite a number of organisms, its effect is thus not yet known. Since it -besides GSK-3- inhibits also inositolmonophosphatase and other phosphomonoesterases (Quiroz et al. (2004)), the period-lengthening effect might be caused by this.

In favor of it speak the following results of Williams et al. (2004). They studied the effect of Li^+ (and two other psychotropic medications, valproate and carbamazepin) on growing neurons in cultures. They offer arguments *against* GSK-3 as the common target molecule of mood-brightener. Instead they seem to inhibit the inositol-monophosphatase, resulting in a depletion of inositol (the enzyme is responsible for the re-use and new syntheses of inositol; figure 10.10).

10.7 Peculiarities of depressives

Manic-depressive patients, especially women, are hypersensitive towards light. Depression are also more frequent among women. Perhaps women need more light for synchronizing the rhythm (Kessler (2003)).

Besides these peculiarities there are also a number of biochemical and physiological distinctions. Thus, endogenous depressives[2] contain in respect to healthy people lower concentrations of the monoamines serotonin and noradrenalin in the brain. The density of the noradrenalin receptors in the cortex is compensatorily increased. The hypothalamus-hypophysis-adrenal gland axis is deregulated, because

[2] 5-12 % of males and 10-20 % of females in the USA underwent at least once in their life a severe depressive episode, half of them more than once. Each year 30 800 persons in the USA commit suicide. The costs amounted in 1992 to 43 billion dollars.

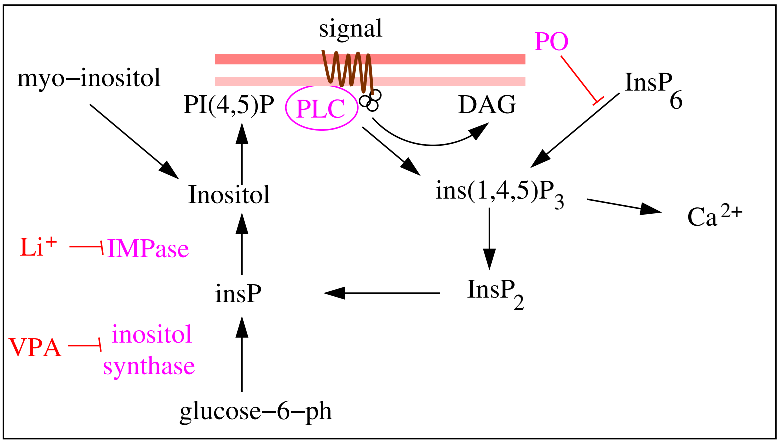


Figure 10.10: *According to Williams et al. (2004) Li^+ and valproate influence the inositol phosphate signal transduction. Myo-inositol is the limiting enzyme of the phosphatidylinositol-bisphosphate, PIP2 (here shown as $PI(4,5)P_2$). If the cell is stimulated by a signal, this membrane lipid is hydrolyzed by phospholipase C (PLC) and soluble $Ins(1,4,5)P_3$ is formed. It discharges Ca^{2+} from intra-cellular storages. It is subsequently de-phosphorylated. Inositol monophosphatase (IMPase), which catalyzes the last de-phosphorylation step, is sensitive to Li^+. Inositol is isomerized by inositol synthase from glucose 6-phosphate. The activity of this enzyme is inhibited by valproate (VPA). Since both substances, Li^+ and VPA, reduce the amount of myoinositol, their effect can be canceled by adding myoinositol. Myoinositol can be generated also by de-phosphorylation of higher inositol phosphate ($InsP_6$). This step is negatively regulated by PO (prolyl-oligopeptidase), which prevents the inositol depletion by inhibitors of this enzyme*

due to an increased stress (genetically predisposed, problems in the childhood) more CRF is secreted. As a result more cortisol ("Fight or flight hormone") is produced (Nemeroff (1998)).

The suicide rate of persons with bipolar and "major depressive disorders" is higher as it is in the normal population. It is, however, difficult to find the specific factors which lead to the the higher suicide risk, since drug- and alcohol misuse, suicide in the family, differences in the distribution of alleles, comorbide anxiety, frequency of depression, seasonal effects, hospitalization history and other factors contribute. According to the known studies Li^+ seems to suppress the suicide behavior of patients with affective deceases (Dunner (2004)).

Further literature:Downes and Liddle (2008), Fieve (1999).

10.8 Non-invasive therapies such as sleep deprivation

A number of non-invasive therapies were proposed and used against endogenous depression. Among them are sleep deprivation, strong light exposure and advanced sleep time. A combination of these methods acts in 40 to 60 % of the patients faster (within one or two days) and more sustaining as compared to medication only (two to eight weeks, Wu et al. (2009), figure 10.11). Sleep deprivation is the best documented chronotherapeutic method (documented in more than 1700 patients in more than 60 studies (Wu and Bunney (1990), Benedetti et al. (2007)). The advantages of this method is described in overviews (Machado-Vieira et al. (2008), Wirz-Justice et al. (2005), Riemann et al. (2002)). Total as well as partial sleep deprivation have a lasting and immediate effect in 60 % of all diagnosed subgroups of affective diseases. The effects can be amplified by additionally offering Li^+, pindolol, serotonergic antidepressant, strong light or subsequent treatment with phase advance (see next section and Wirz-Justice and den Hoofdakker (1999)). The immediate and sustained effect can be described with a "Two process model of mood regulation", which is based on a model of sleep regulation, namely the interaction of a circadian and a homeostatic process (Borbély and Achermann (1999)). The therapeutic efficiency of sleep deprivation can be explained in this way. The model is also in accordance with the serotonergic receptor hypothesis of sleep deprivation.

More recent studies in Europe suggest, that phase advance of sleep has the same effect as total sleep deprivation with and without simultaneous treatment with antidepressant. Li^+ treatment enforces the effect of sleep deprivations (Benedetti et al. (2001)). According to the internal coincidence model this might be due to the period lengthening effect of Li^+, whereby the biological rhythms are better synchronized with the sleep-wake cycle.

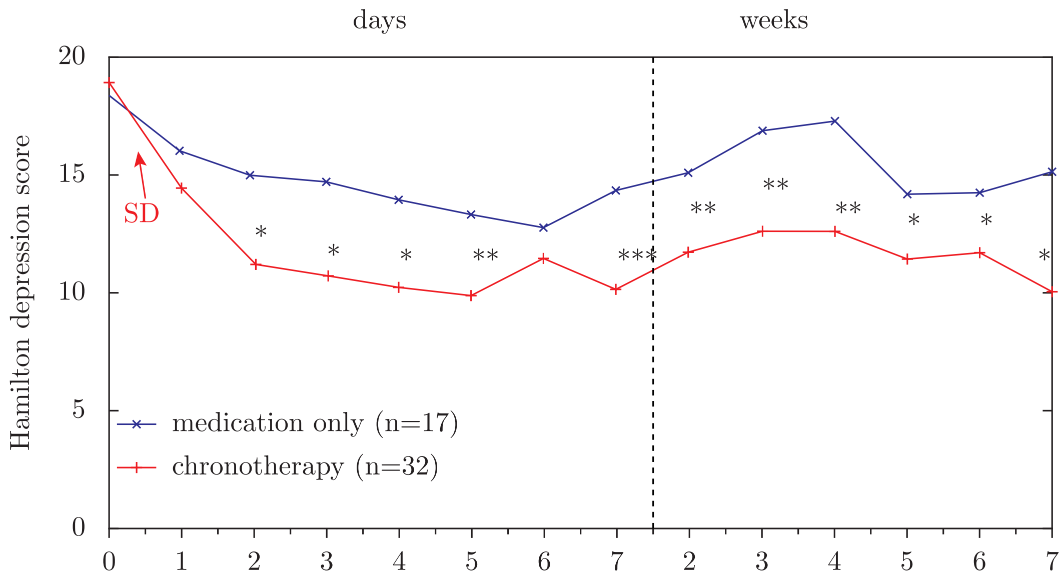


Figure 10.11: *Chronotherapeutic treatment (red curve, sleep deprivation SD, strong light exposure and advancing the sleep time) reduces depression significantly (*p=0.05; **p=0.01; ***p=0.001), fast (in one to two days) and sustainable, whereas treatment with medication only (blue curve) is less effective. Before the vertical dotted line days, afterward weeks. y-axis is a 19-scaled Hamilton rating of the degree of depression. After Wu et al. (2009)*

11 Appendix

11.1 Acknowledgments

This book is dedicated to Anders Johnsson, who proposed to test the effect of Li^+ on the daily clock of humans in Spitsbergen. Without him this project would never have been realized. He had contact to the important persons and places, raised money and arranged the travels. He furthermore indicated errors and proposed improvements to this book. Waldemar Himer, diploma biologist from Tübingen, took care for the technical part of the project, from the planning and construction of the recorders to the actual recording, and he managed the transport of the participants to the huts and the provision with food. Burkhard Pflug was the attending doctor for the medical care of the participants and conducted also the medical checkups in Tübingen[1].

For an undertaking such as our Spitsbergen project much help was needed. For financial help we have to thank the German Research Association and the Norwegian Polarinstitutt[2].

Special thanks are due to the Norwegian and the German participants of the project, Helmut Ellinger and Fritz Mörgenthaler (for the pre-experiment), Aud-Tveito Ekse, Olav Ytre-Arne, Inga Strömme, Lars Erik Berg, Albrecht Gorthner, Ulrich Schäfer, Peter Klein, Anna Schneider, Angelika and Bernd-Ulrich Rudolph. I am thankful to them also for allowing me to use some of their photographs in this book.

Anders Johnsson's wife, Dr. Margareta Johnsson of the St. Olav University hospital Trondheim and doctors of the Psychiatry at the University of Tübingen took care of the pre-examinations of the participants, the adjustment of the Li^+ values and the analysis of the blood samples from Spitsbergen. The Smith Kline Dauelsberg company in Göttingen provided without charge the Li^+ tablets and placebo packages.

The following persons of the University of Trondheim gave information on Svalbard and helped in Longyearbyen and Ny Ålesund: Professor O. Rønning, Department of Botany, furthermore members of the UNESCO-project "Man and Biosphere"[3] from Trondheim. Harald Celius welcomed us at our arrival in Longyearbyen, escorted us during our adventurous skiing tour to the Geopol hut, instructed us in shooting, and was more than once a salvaging angel in difficult situations.

We have to thank the Sysselman of Svalbard in Longyearbyen, Jan S. Grøndahl for

[1] see chapter 11.2

[2] Norway's main institution for the exploration, observation and mapping of the polar regions with about 110 employed people in institutions in Tromsø, Svalbard and the Dronning Maud Land. It goes back until 1906, when the first scientific expeditions to Svalbard took place. Since 1979 belonging to the environment-ministry. Publishes also public reports, among which the "Polar Handbooks" are especially widespread. Keeps a library with a large collection of scientific and historical literature back to the 16th century

[3] The "Man and the Biosphere program" (MAB) was established in 1970 after an UNESCO Biosphere conference in 1968.

his sympathetic support of our experiment in Ny Ålesund. The captain and the crew of the Polarstar helped in adverse circumstances to ship our food and equipment to Ny Ålesund and to bring us to the Kvadehuk coast, from where we could deliver the participants to their huts. The pilot of the Cessna flew us safely from Longyearbyen to Ny Ålesund and we could take interesting pictures of the landscape during the flight.

We owe the head of the research station in Ny Ålesund, Kristian Sneltvedt, valuable pre-information, support and help during the unexpected difficulties by providing us with emergency food, skies and guns, and by offering us board and lodging at the research station. Ingvar Brattbakk, Botany Department, Trondheim, supported us extensively.

Bjarne Nordnes offered me kindly his notes of the sleeping times during his overwintering in the north of Svalbard.

The forestry office in Bebenhausen near Tübingen lend us two guns for the two participants of the pre-experiment in 1978.

For analyzing the data we used the time series analysis program ”Timesdia”, which was written by Wolfgang Martin, Botany department, University of Bonn. He helped also if we had questions and problems. The computing center of the University of Tübingen supported us in the practical procedure of the data analysis. The transfer of the data from the printout of the recorders in a machine readable form and the various analyses and graphical display was done by my technical assistant, Frau Caspers, and by Aud-Tveito Ekse, Trondheim.

11.2 Curriculum vitae of Burkhard Pflug

Burkhard Pflug was born on February 10, 1939 in Frankenstein. His father was pastor. The family had to escape from Silesia to Bleicherode in the Southern Harz. There he attended the school, learned to play piano, organ, horn, cello, cembalo and trumpet, sang in the church choir and would have loved to study music. After his school leaving examination in 1957 he went to Berlin, where his father has taken over a directorate.

He studied medicine at the Free University in West Berlin. He earned his livings by playing the organ in churches. After the Physikum he went to Göttingen and was Famulus in Bad Harzburg. There he married Susanne nee Fendesack. They got five children. He was internist and went in 1968 as a psychiatrist to the Psychiatry hospital at the University of Tübingen. During this time he studied intensively endogenous depression. In 1982 he got a call as a chairman of the Psychiatry Hospital II at the University of Frankfurt. He retired there in March 2004, but continued to work privately as a psychiatrist.

On March 4, 2009 his lifetime expired (see figure 11.1). For me he stays alive.

Figure 11.1: *Burkhard Pflug drops symbolically his wrist watch into the sea, when we were transported with the Polarstar to the beach of Kvadehuk, from where the groups of the German students had to be delivered to their huts: From now on the internal clock is the timer*

11.3 Anna's Li^+-experiment

Anna and Peter were offered, after the Spitsbergen experiment, by the Max Planck Institut für Verhaltensphysiologie in Erling-Andechs, to have their daily rhythms recorded with and without Li^+. Anna let me read her diary and some of her notes, which are relevant for her sense of time and her mental state in the bunker, can be found in a more detailed book which can be asked for by Engelmann. Figure 11.2 shows her sleep-wake pattern and the maxima and minima of her body temperature rhythm during her 'underground' time. The data were taken from a sketch from Anna, which she had obtained from Dr. Wever of the Max Planck-Institut für Verhaltensphysiologie (experimental person No. 242). I have replotted these data in a 24 h pattern. If the body temperature minima are fitted to straight lines, period lengths of 25.18 h and 24.11 h are found for the Li^+- respectively placebo intervals. It can be seen, that the sleep times are especially during the Li^+ application short and that during most of the subjective days two sleep intervals are present. The same is true for the first part of the placebo application (I should mention, that it takes some time, until all the Li^+ has been eliminated from the body).

In this connection is is interesting, to compare the notes in the diary of Anna with the data. For Anna the time in the bunker passed faster, since she experienced the short sleeping time as belonging to a distinct day. She was therefore quite astonished, when she noticed, that her time in the bunker had not yet come to an end. Possibly some of her complains are caused by these short nights and subjective days.

It is furthermore also interesting, that her data from Spitsbergen (and the one of Peter) showed no period lengthening, whereas she had in the bunker under Li^+ a longer rhythm. Her Spitsbergen notes indicate, that she and Peter were able to estimate the time of day in the Tyskerhytta due to the unusually sunny weather by the sun direction. This might have played also a role in the case of Inga and Lars-Erik, since the only window in their hut looked south.

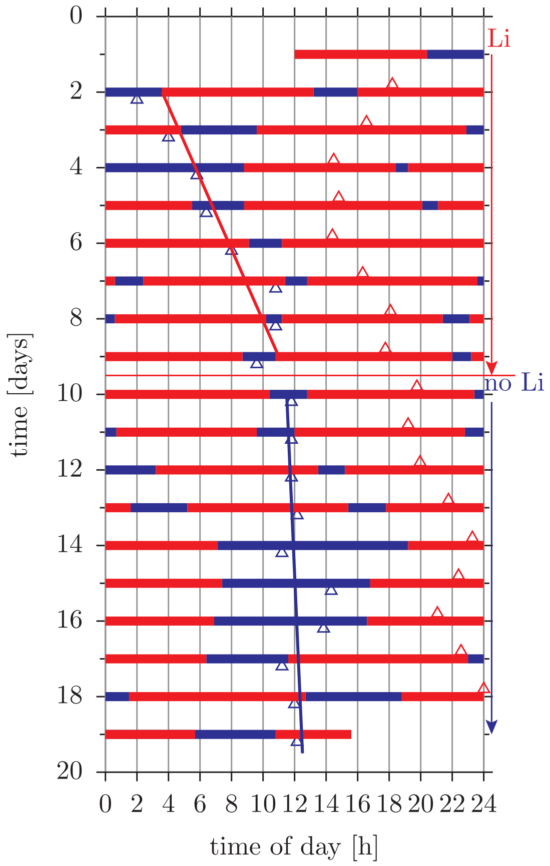


Figure 11.2: *Anna Schneider's sleep-wake- (blue respectively red bars) and temperature minimum/maximum data (blue respectively red triangles) during the experiment with (red arrow right) and without Li$^+$-tablets (blue arrow right) in the bunker in Erling-Andechs from January 5 to 25, 1980. The red line during the Li$^+$ application has been fitted to the minima and corresponds to a period length of 25.18 h, the blue line during the placebo application, likewise fitted to the minima, results in a period of 24.11 h. Data from a sketch of Anna, which she received from Wever (experimental person No. 242).*

11.4 Literature on Svalbard, biological clocks, depression

The following books, articles and maps give more information of the country, its nature, fauna, flora, geology and geography and human activities: Hisdal (1976), Løvenskiold (1964), Rønning (1964), Østreng (1975), Kartaschew (1960).

As literature concerning biological clocks in humans I recommend Wever (1979) and Moore-Ede et al. (1982). Further literature in Engelmann (2009).

On depression, also in connection with daily rhythms, the following books give information: Kripke et al. (2009), Germain and Kupfer (2008), Nemeroff (1998), Healy and Waterhouse (1995), Lenox and Watson (1994), Wehr and Wirz-Justice (1982).

11.5 Further information

The following specifications shall deepen certain things or illustrate additional points. They would hamper the easy reading in the main text.

11.5.1 Placard of the MPI for behavior physiology in Erling-Andechs

Max Planck Institut für
Verhaltensphysiologie
Abteilung Aschoff

We are looking for test persons of any age and both sexes, who would like to live alone or with partner for about 4 weeks in a soundproof room with kitchen and bath. The rooms are subterranean. Each contact with the outer world takes place by letter via a lock, which is used also for food

and other wanted items of the daily needs. In the rooms prevails continuous light respectively an artificial light-dark-cycle. During the wake period additional light sources can be switched on, if wanted. An air conditioner takes care of fresh air and a comfortable temperature. You prepare your own meals for yourself on an electric stove; The food is delivered free and according to your wishes ("home-style cooking").
The test person has the task, to collect urine samples in portions and to deposit it in a refrigerator in the lock. Several times per day time estimations, self assessments and, depending on the experimental conditions, other small tests are conducted. During the whole experimental period a rectal thermo probe is carried, that is an instrument, which records continuously the gut temperature. Experience tells, that one is used to it in about two days in such a way, that it is not noted any more. Removal for a short time does not run counter to the experimental conditions.

These are principally already all items, which we wanted you to do. You need for performing the tests and so on one hour per day. In the remaining time you can do what you please. A record player with classic or light music, tape recorder, sunlamp, expander, games and so on are to your disposal. You are allowed to bring along all kinds of music instrument, books and working material, as many as you want. As has been proved the experimental time is excellently suited for concentrated work (for instance preparation for an examination).

The purpose of our experiments is the study of the so called "internal clock" of humans. For this purpose all indications of of objective time have to be eliminated: Clocks, day- and night cycles, current newspapers, dated letters, radio, television and direct contact to persons outside the subterranean rooms, all this one has to abstain from during the course of the experiment; you are allowed to receive undated mail and older journals.

An interest in the somewhat unusual situation, in which you will be during about a month, should determine your decision, to go into "isolation". The pocket money of DM 10.- per day (under certain conditions even more), which we can offer you besides the travel costs, does perhaps ease your decision.

Concerns regarding the isolation or in respect to the aloneness have always occurred, but have never substantiated: Everybody liked it and many test persons have participated already several times in these experiments.

(End of the placard)

11.5.2 Instructions for the DE101

Temperature probe and actograph are connected to the recorder (secured with knurled screw). Recorder on: Rocker switch inward. Numerator begins with 0000 (for a temporary printout press knob, until printout is done; this does not influence the normal printout and numerator). Important: Note down at the first print out time and date. Instrument should always run (exception: Battery- and paper change after 14 days). By switching off the recorder the numerator is reset to 0000!

Compare once in a while your recorder with that of your partner. Since both have been started at the same time, the numerator should coincide. If not, write down the numerator of your partner (for instance H 530 = F 533). What is the cause of the difference? Change of 9 V battery? If the temperature values (the last three digits) are too low (normally between 300 and 700), the 6 V battery set has to be ex-

changed. Exchange paper role, if the red stripe turns up, otherwise after 14 d. Note down the exchange of the battery and of the paper on the instrument.

11.5.3 Objections of the referees

1. Although our studies on the effect of Li^+ on circadian rhythms in plants and animals are appreciated, the jump from a plant model and from *Drosophila* to humans seems to be a bit to over-hasty. Whether free running rhythms in mammals are also slowed by Li^+ is easy to find out in experiments with animals. Afterward the studies on humans could be performed on the basis of information by animal experiments with more tightly focused hypotheses. Furthermore the studies could be better done in Zeitgeber free rooms such as in Erling-Andechs, because here standardized conditions are given, under which already a large number of test persons have been studied. In Spitsbergen, however, the experimental conditions are unclear. We our self had changed already in our addendum of June 12, 1977 the concept by housing the participants now in huts instead of tends. Reliable statements could be possible in the experiments in Spitsbergen, but by no means certain. In studies in isolated rooms a scientifically sound result could be expected.

2. In isolated rooms a large number of variables could be studied, not only the rhythms of body temperature and urine. In order to judge the effect of lithium on patients with endogenous depression, this would be decisive. After all we would assume, that various circadian rhythms are shifted against each other. Therefore one has to measure these various rhythms.

3. It would suggest it self, to study a patient suffering of an endogenous depression during a period of depression and during the interval in an isolated room in Erling-Andechs. In Spitsbergen such a study would be without any chance.

4. In this way a lot of money would be saved, the more so as the planned project, if indeed performed, would be considerably more expensive as the calculated 56 200 DM.

5. A scientific conclusion regarding the effect of lithium is only possible, if the lithium level is known. In Spitsbergen it should be difficult, to determine in the test persons regularly the lithium values and to administer accordingly the correct amount of lithium tablets. It would mean, that a physician has to visit the persons, take blood and have the lithium values analyzed. If these determinations are not done, the lithium adjustment is not completely risk free, since the values could reach the toxic range. Since it is planned, that Dr. Pflug from the University Psychiatry takes over the medical care in Spitsbergen, he could probably do this also in studies done in an isolated room in Erling-Andechs.

6. Recorders for continuous recording of the body temperature are already available for the clinical sector. The planned new development is therefore not needed.

11.5.4 Answer to the objections of the referees

I answered this letter on November 11, 1977:

Dear Dr. XX

I would like to thank you for your letter of November 24, 1977. I am glad that the experts report underlines the principal importance of the study. In respect to the objections I would like to comment the following:

1. objection: Before studying humans one should test the lithium effect on daily rhythms in animals.
   Four years ago I published a paper with reliable data on a period lengthening affect of lithium chloride in *Kalanchoe* flowers and a vague indication of a period lengthening effect on the activity rhythms in small mammals. At that time I had only four running wheels at my disposal and I had hoped, that these studies would be verified in better equipped laboratories in a larger number of animals. Since this was apparently not the case, we have in the meantime continued the experiments with Syrian hamsters and got the same results (see appendix). The period is lengthened by Li^+ also in cockroaches and *Drosophila* flies. We are now repeating the experiments with more hamsters.

2. objection: The experiments should better be performed in an isolated room in Erling-Andechs.
   The plans for our studies have been discussed with scientists from the MPI in Erling-Andechs, as suggested by the DFG. They have approved the Spitsbergen plans. One experiment on the effect of lithium on the daily rhythm of humans had there been conducted already in an isolation room. However, a series of experiments there is out of question, since "we are booked out for years with experiments' (citation Wever). This vitiates also point 2 (a larger number of variables can be studied in the bunker) and point 3 (experiments with patients in the bunker) in the letter. By the way, there are principally no experiments done in Erling-Andechs with patients. We did also not plan to study later in Spitsbergen patients suffering under endogenous depression.

3. objection: The experimental conditions in Spitsbergen are largely unknown.
   Dr. Lobban has studied already in Spitsbergen daily rhythms of humans (references in our application), and Dr. Simpson has tested in Greenland the chronobiotic function of a substance in humans (reference in our application). Such experiments are thus indeed possible. We would regard the stay in tents or huts as an unimportant experimental condition. Huts are just more comfortable and offer protection against the weather. At the time of our application in June we did not yet have any information concerning the locations and numbers of huts. The concept is thus by no means changed.

4. objection: The lithium level has to be known and therefore blood has to be drawn by a physician; medical care has to be warranted.
   From the very begin medical care during the Spitsbergen stay was of course planned (application page 6 below). The adjustment of the lithium level for

the individual participants is done before the begin of the studies in Spitsbergen. This allows to recognize possible side effects early enough and to determine the individual dose, by which the needed blood level is reached. Intoxication by too high doses in Spitsbergen can be excluded, since the free run periods of humans are usually longer as 24 hours. Since the adaptation is done in a 24 hour day, the values in Spitsbergen should rather be somewhat lower, if the same dose is taken up. Since according to Wever the group member with the longest period determines the period length of the group, there would be no danger, even if a group member would have a shorter period. After all, all members are informed of signs of a Li^+ overdose. The physician would furthermore once in a week visit the various groups and take blood samples, which are used to determine the lithium level.

5. objection: The planned technical development of temperature recorders are not needed in the hospital.
   This objection is disproved by the high request for these recorders (Psychiatry Tübingen, Psychiatry München, Institute for occupational Physiology in Dortmund, Swedish Society for Heart Sciences). Furthermore, for Spitsbergen the recorders used so far in hospitals are not usable, since they draw much more current.

6. objection: The project is too expensive.
   We consider the costs of this project to be relatively low, since the construction of an adequate isolated room or the extension of caves would certainly be more expensive. The costs of the recorders of 20 000 DM carry no weight, since they are used later in the psychiatry. We are sure, that the DFG supports numerous projects with a similar starting position. The known high incidence of suicide rate in endogenous depression -which, by the way, has also financial consequences borne by the public- should justify in our opinion the costs of the application.

We are thankful for the critical objections and hope to have invalidated them.

11.5.5 Report to the DFG about a pre-experiment in Spitsbergen

Report to the DFG about a pre-experiment in Spitsbergen to the grant application at the DFG "*Studies of the effect of Li^+ on the daily rhythm of humans under arctic continuous light conditions in Svalbard (Spitsbergen)*".

Professor, Johnsson, Dr. Pflug and I had applied on the 30th of November, 1976 and on the 19th of June 1977 for a grant at the DFG, to test the effect of Li^+ on the daily rhythm of humans. Since at the planned period the application was not yet decided, we conducted a pre-experiment with two students, which should consider the main objections of the referees

- that under the conditions in Spitsbergen a free run of the daily rhythm is not possible
- that psychological difficulties might occur.

The experiment took place in July 1978. Helmut Ellinger and Fritz Mörgenthaler flew on the 4th of July from Oslo via Tromsø to Longyearbyen and took a ship

to Ny Ålesund. By mediation of Prof. Johnsson members of the UNESCO project ”Man and Biosphere” from Trondheim, who stayed at that time in Ny Ålesund, took care of the two, transported them with a boat to the London hut on the Blomstrand peninsula and visited them there occasionally. Food was supplied by Prof. Johnsson. On the 9th of July began the experiments and recordings. The temperature recorders were started on the 9th of July at 13:15 (quartz watch, which was left in Ny Ålesund and served to keep track of the numerator of the instrument during the visits). They printed every 512 sec data (see the description of the instrument on page 162), which are shown in figure 4.7 and 4.8. Furthermore urine samples were collected, volume and pH measured and the mood tested. The analysis of the concentration of the electrolytes is not yet finished (K^+, Na^+, Ca^{++}, Mg^+, Cl^-).
The sleep-wake times show in both participants a clear free run. Fritz Mörgenthaler undertook some longer hikes, which lead to a shift of the activity pattern on the 14th /15th and on the 19th /20th of July. The analysis of the temperature data during July 12 and 26 resulted in the data listed in table 1. On July 27 the participants were brought to Ny Ålesund again, took the ship to Longyearbyen and the airplane via Tromsø, Trondheim back to Oslo. The analysis of the data is not yet completed. The following results were obtained:

1. Under the conditions of the London hut free run was shown. Possible 24 h Zeitgeber such as noise during work in the harbor of Ny Ålesund (about 5 km away), numerators of the recorder and sun direction did not synchronize (even at sunny weather).

2. According to the list of the mental state of the participants and their report the conditions were very pleasing. Difficulties of psychological nature did not occur, the test persons were healthy and well throughout the time.

3. The recording method stood the test. The temperature recorder should, however, better be carried in a small pack sack. A mechanical device for the paper role is needed to prevent the printer paper from getting jammed (occurred three times in both recorders) and to avoid seeing the numerator. Towards the end of the experiment the rectal probe slipped easily out of the gut. Skin compatible adhesive tapes would help. The pH determination with a pH electrode and a newly developed lightweight pH meter is too laborious and could perhaps be replaced by using pH paper.

4. The test persons should not undertake longer and strenuous excursions and bigger individual undertakings, to avoid mutual de-synchronization. A flag at the hut should inform visitors, whether the inhabitants are asleep.

We believe, that the hitherto results are sufficient, to undertake the planned experiment in 1979. The objections regarding the checking of the Li^+ level and possible side effects are discussed in our application and in our letter of December 26, 1977. Furthermore, in the course of this year studies of Dr. Pflug will take place on the participants for the studies in 1979, which will test among others the Li^+ compatibility and dosage.

11.5.6 Letter to the Norwegian embassy and their answer

Dr. W Engelmann
Tübingen, 8th of June 1978
To the Norwegian Embassy
Post office box
5300 Bonn

In collaboration with Prof. A. Johnsson, University of Trondheim (Department of Physics, Section Biophysics) scientific studies concerning the daily rhythm of humans shall be conducted from the begin of July to the begin of August of this year in Svalbard. Two students of the University of Tübingen, Mr. Ellinger and Mr. Mörgenthaler, will stay in a hut close to Ny Ålesund.
*The Norwegian authorities insists, that the group carries a gun for safety reasons (polar bears). For obtaining a license the proper German authority demands a written permission, that the Norwegian side has no objections for importing the rifle (Krieghoff-rifle caliber 8*57 IRS Nr. 55045, owner forestry office Bebenhausen). The Sysselman of Svalbard has been informed by Prof. Johnsson.*
I would appreciate a proper certificate.
I remain respectfully
Yours
Dr. W. Engelmann, lecturer

And the affirmation asked for from the Norwegian Embassy in Bonn:

*We confirm, that Mr. Helmut Ellinger, biology student in Tübingen / BRD will participate in a German-Norwegian study program in Ny Ålesund, Svalbard. The participants will stay in an isolated hut, and the Norwegian Polar institute, Tromsø, recommends, that Mr. Ellinger brings along for safety reasons a rifle. It concerns the gun Krieghoff, caliber 8*57 IRS Nr. 55045, owner forestry office Bebenhausen. Mr. Helmut Ellinger will bring along the rifle from the Federal Republic to Svalbard by flight SK 364 on the 5th of July 1978 10:40 Oslo, SK 382 19:35 Longyearbyen.*

Royal Norwegian Embassy, Bonn, 20th of June 1978
Randi Emaus, Vice consul

11.5.7 Letter of Anders to Helmut Ellinger and Fritz Mörgenthaler

5th of July: Arrival in Longyearbyen. Spend the time until the departure of the Hurtigruten from Longyearbyen with normal activities and normal recordings. Meals and lodging are available at the location. Use your sleeping bags.

6th of July: Departure of the Hurtigruten to Ny Ålesund. Most people prefer to stay up all night - it is a wonderful voyage. In this way you can also avoid, to stick to the normal activity pattern. This diminishes synchronization.
Arrival in Ny Ålesund. Contact the leader of the Research Station, Einar Ellingsen. He is of course informed about this Norwegian-German project and about your arrival. Contact also the participants of the MAB-project (Man and Biosphere), which uses Ny Ålesund as a base. Olaf Rønning and Ingvar Brattbak (both from the University of Trondheim) know the plans of the experiment and especially Brattbak is well acquainted with the details of all practical things.

Ny Ålesund:

Your food should have arrived under the name Johnsson (sent and packed by Carl

Evensen eftr. Oslo) and have to be brought to the London hut.

Wood and coal have to be collected for the stay in the London hut. Ask for it!

Tell the post office at the place, that you arrived and inform them, that people will visit you at irregular times in the hut and that they are allowed to bring you your mail. If you buy things needed for the experiment, ask, whether you can pay by billing A. Johnsson, Fysisk Institutt, NLHT, Universitet i Trondheim, N7000 Trondheim. Until your departure to the London hut you will get housing and food at the cost of the project. The bills are payed by Johnsson (the best is again via the above address).

Ask Ellingsen, what you should do if a polar bear turns up in the surrounding of the hut. Ask him also for his opinion regarding your stay in the London hut before leaving Ny Ålesund.

Do not ask people for the times, at which ships, boats and air planes pass Ny Ålesund. Avoid, that people inform you incidentally about things, from which you might later be able to infer the time of day.

Discuss and arrange with the people in Ny Ålesund a practical way, how to install a letter box at the London hut: A place, where people can drop letters or messages, if you are asleep or away.

You will be brought to the London hut as soon as possible. But remember, that the people, who help us, have their own projects and their own work. Do not disturb them and do not ask for unnecessary help.

London hut:

Brattbak and his colleagues have kindly promised us, to help us in controlling your stay at irregular times of the day and in varying periods. If you are not asleep or away (in this case you should leave a message), pay attention, not to ask for the time of day, how many days are left for the return and so on.

If you have arrived at the hut, check the important things: Stove, food, maps, water, rifle, munition, instruments, urine bottles, books and so on. Make sure, that everybody knows, where the letter box is. Where is the best place for attaching a sticker, which informs others about your stay in the hut. Attach it as soon as possible.

You have to do also practical work by helping the Ny Ålesund Station, to clean up around the London hut. Ask for details.

But now: Relax, try to desynchronize from the people around you. Do not try to use the sun for orientation, to pay attention to ships passing by and so on. Follow your internal clock!!

Leaving the London hut: You have the return ticket for the Hurtigruten on the 28th of July. To reach the ship, the MAB people in Ny Ålesund will tell you, when you have to leave.

Depending on the possibilities it might be decided, that you will be brought by plane to Longyearbyen. In this case you would stay a few days longer in the London hut and take your recordings somewhat longer. In this case you will be informed and the air tickets payed by Johnsson (procedure as mentioned already).

Do not forget to clean up the hut at your departure. Continue to measure.

Ny Ålesund and Longyearbyen: A detailed time schedule can not yet be supplied. Depending on the kind of transportation your stay in Longyearbyen will be short or quite long (if you take the Hurtigruten). Be prepared for it and plan your activities in Longyearbyen. Continue recording during this time.

Do not forget any scientific or personal things in Ny Ålesund and Longyearbyen.

Good luck

Anders Johnsson.

11.5.8 Chronobiological phase type: Lark or owl?

The following Östberg test (Östberg (1975)) shows, to which chronobiological phase type you belong[4]. A changed version was used for tests in Spitsbergen and is shown in subsection 11.5.9.

Questionnaire for the chronobiological phase type
This list consists of questions, which are related to your activity and your feeling awake in the morning and in the evening. In answering the questions 1 to 4 you should assume, that you have to work during the day for 8 h at a time chosen *by your self*. Answer all questions honestly. Check only one item per question for your answer. Use table 11.1 for your answer

How difficult is it for you if you have to go to bed each day at 1:00 o'clock

- **4** Very difficult. I would be terribly tired for a long time
- **3** Quite difficult. I would be tired for some time
- **2** Not difficult. I would feel slightly tired
- **1** Not difficult, no problem

How difficult is it for you if you have to rise up each day at 6:00 o'clock?

- **1** Very difficult. I would be terribly tired for a long time
- **2** Quite difficult. I would be tired for some time
- **3** Not difficult. I would feel slightly tired
- **4** Not difficult, no problem

You have decided to participate in a fitness-training. Your friend proposes to train twice per week. For him/her the best time would be from 7 to 8 in the morning. How would this be for you?

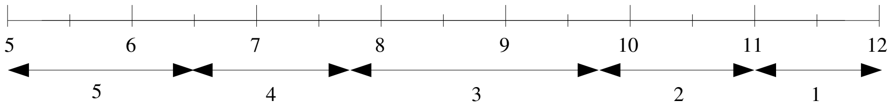
- **4** It would be optimal
- **3** would be all right
- **2** I would have difficulties, I would prefer a later time
- **1** It would be too hard for me

You have decided to participate in a fitness-training. Your friend proposes to train twice per week. For him/her the best time would be from 23 to 24 in the evening. How would this be for you?

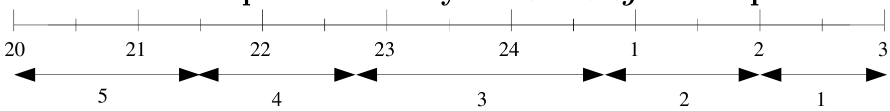
[4] in contrast to the original Östberg-test a shorter one is used for the participants

- **1** It would be optimal
- **2** would be all right
- **3** I would have difficulties, I would prefer a later time
- **4** It would be too hard for me

Mark the time span in which you *normally* go to bed.[5]



Mark the time span in which you *normally* wake up.



Are you a morning- or evening active person?

- **5** extremely morning active
- **4** moderately morning active
- **3** neither
- **2** moderately evening active
- **1** extremely evening active

For the evaluation of the questionnaire see table 11.1[6]

[5] lower numbers are scores

[6] This table should be available only after the question air has been filled out

Table 11.1: *Evaluation of the chronobiological phase type by using the results of the Dutch questionnaire*

Chronobiological phase type	score
extreme evening type	7-10
evening type	11-14
indifference type	15-21
morning type	22-25
extreme morning type	26-31

11.5.9 Altered Östberg test for the chronobiological phase type

For the situation in free run conditions in Spitsbergen the test for the chronobiological phase type of Östberg was varied in some points and some questions asked, which were related to further measurements. They are listed here

- **1- What is your estimated time at waking up?**
- **1a- Would you prefer to wake up at another time and if, which one?**
- **2- What is your estimated time at going to sleep?**
- **2a- Would you prefer to go to sleep at another time and if, which one?**
- **3- Are you woken up by your group member?**
  4 never 3 sometimes 2 usually 1 always
- **8a- Do you go to bed in Spitsbergen later as you do usually at home?**
- **9- The best time for him would be immediately after rising. Would this be a suitable time for you?**
- **9a- Which time would suit you more?**
- **11- 7 o'clock rising (as an example). 23 o'clock going to bed**
  Same for questions 15-, 17-, 18-
- **16- His best time would be immediately before going to bed**
- **20- Would you have answered some of the questions differently, if the test would have been made two weeks ago (that is, during the first half of the Spitsbergen experiments?**
- **21- Would you participate in a bunker experiment?**
  1 yes 0 no
- **22- Would you participate in a re-synchronization experiment?**
  1 yes 0 no
- **23- Did you know the hypothesis of the effect of Li^+?**
  1 yes 0 no
- **24- When did you receive Li^+**
  1 in the first half 2 in the second half 0 don't know

11.5.10 Light measurements

At June 30 and July 4 and 5 Anders measured the light intensities in Ny Ålesund. They are listed in table 11.2 and two days graphically displayed in figure 11.3. It can be seen, that the fluctuations are mainly due to the degree cloudiness.

11.5.11 Weather observations during our experiments

Table 11.3 lists the weather observations by one of the participants during our experiment in Spitsbergen. The weather situation was somewhat unusual, since normally the temperatures are lower and a cloudy sky is dominating. In this year the (short) summer was warmer and more sunny.

11.5.12 Bird watching by Bernd-Ulrich Rudolph in Svalbard

Observations from July 4 until August 3, 1979 on the Brögger peninsula south of the Kongsfjord (the peninsula, on which Ny Ålesund is located, see map in figure 4.3). From August 4 until August 7, 1979 additional observations in the surrounding of Longyearbyen at the time, during which the groups of students from Tübingen were waiting for the flight back to Tromsø.

Red-throated Diver (*Gavia stellata*) were observed frequently on the small lakes in the tundra and on the lagoons at the coast, more seldom on the fjord. There four animals were observed on July 6 between ice floes, three of which were displaying. Two pairs were seen on July 25 on a lake west of Brandalpynten close to Knudsenheia. On August 1 Bernd-Ulrich observed an adult in the rush zone of a lake near Kvadehuken (the outer most western tip of the Brögger peninsula) breeding on two eggs. The flight distance was 200 m. The bird left the nest, swam to the opposite shore and pressed it self between the rush against the waves in the water. Only neck and back were visible. An excellent camouflage in the ups and downs of the waves.

Northern Fulmar (*Fulmar glacialis*) were frequent allover. Both color phases, a darker and a brighter, but also animals of an intermediate appearance were seen. The darker form was somewhat more frequent. It breads not only in the cliffs at the coast, but also allover at rock faces in the mountains, often kilometers away from the sea and some 100 m above the sea (up to 700 m, see figure 7.33).

Long-tailed Ducks (*Clangula hyemalis*) appeared scattered, for instance at the lagoon of Ny Ålesund, and at the Brandal lagoon, at the Tvillinvaten and at the Ragna-Hytta. In front of the Prins Heinrich island east of Ny Ålesund were at least 25♂, 4♀ samples. They were probably molting, since many feathers were washed ashore at Zeppelinhamna.

Common Eider (*Somateria mollissima*) were frequent at the coast (see figure 7.32). There were less in the inland. On July 5 Bernd-Ulrich saw three nests with three eggs each at the beach of Ny Ålesund, partly well hidden between driftwood, three nests on July 10 at Brandalpynten with a breeding ♀, in Ny Ålesund a nest with 4 eggs, between July 11 and 18 at Ragna Hytta up to 20♂, 20♀ samples on the lagoon. On July 14 he finds a fresh kill of a ♀. From July 25 onward assemblies of ♀ with juveniles for instance at Kvadehuken and at Strypbekk about 1 km inland, August 2 at Zeppelinhamna.

Barnacle Geese (*Branta leucopsis*) were not observed, but there were many, partly quite recent molt feathers from the tail at most of the lakes in the tundra.

Table 11.2: *Light intensity at three days in Ny Ålesund measured with a Hagner Universal Photometer Model S1 (Solna, Sweden)*

Data	time of day	lux resp. cd/m^2	remark
30.6.1979	10:00	3200	cloudy
	14:00	4800	cloudy/clear
	18:00	8500	clear
	22:00	5400	clear
4.7.	08:40	10000 cd/m^2, 1°	clear, 3 m distance, sun from back, white paper
	09:40	7000	overcast
	13:28	6000	overcast
	14:41	5900	overcast
	16:00	6500	overcast, rainy
	18:30	4500	overcast
	19:40	3600	overcast
	22:15	2600	overcast
5.7.	05:17	5600	slightly cloudy
	07:13	11000	slightly cloudy, sun on white paper
	09:30	8000	overcast

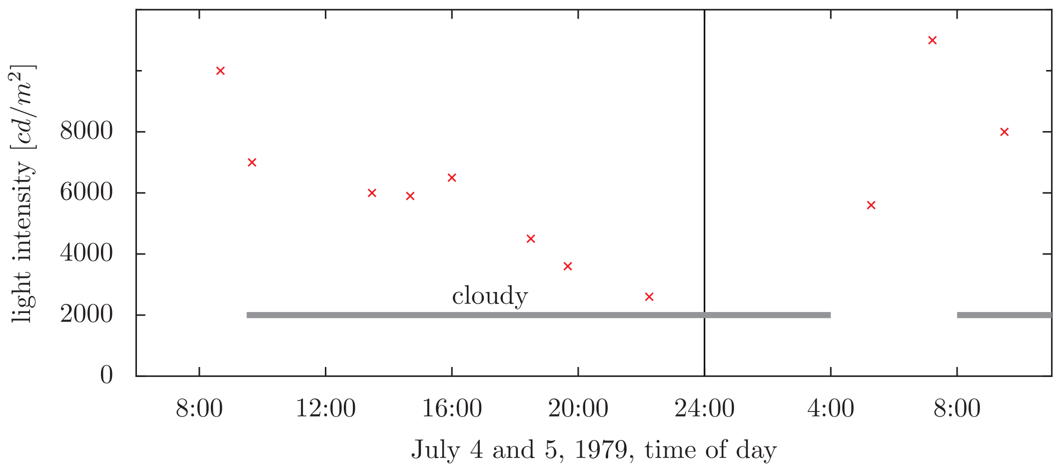


Figure 11.3: *Course of light intensity at two following days in Ny Ålesund, clear resp. slightly covered periods and (gray lines) cloudy periods*

Table 11.3: *Weather observations: Temperature minimum/-maximum, pressure in mm Hg*

Date	temperature	pressure	remark
3.7.1979			journey train to Oslo
4.7.1979	8^0 C		flight to Longyearbyen, Ny Ålesund
5.7.1979	10^0 C		cloudy -> overcast
day 2			rain
day 3		760	cloudy, evening rain, strong wind
day 4	1.5/6.5	768	clearing up, good view
day 5	2.5/7.5	769	getting cloudy
day 6	3/10	769	no clouds
day 7	5/10.5	768	no clouds, clear
day 8	5.5/9	771.5	stark cloudy - overcast
day 9	3/9.5	772.5	getting clear, sunny, fog layer
day 10	3/10.5	770	rain, very cloudy
day 11	3/10	765	overcast, sunny-clear
day 12	5.5/10	764.5	sunny, bright
day 13	4.5/10.5	760.5	bright - cloudy
day 14	4.5/9.5	759.5	overcast
day 15	4.5/10.5	763	very cloudy, very clear
day 16	3.5/8.5	767	sunny, very clear
day 17	3/8.5	768.5	sunny, clear
day 18	3/7.5	767	sunny, clear, wind
day 19	3.5/6.5	766	partly overcast, sunny, bright
day 20	3.5/9	764	cloudy, wind
day 21	3/8	758.5	overcast, rain
day 22	1.5/4.5	760	overcast, rain, stormy
day 23	1/4	760	snow up to 200 m, overcast
day 24	2.5/7.5	760	overcast, cloudy, high fog
day 25	1.5/6.5	758.5	bright, overcast, wind
day 26	1/4	756	overcast, partly overcast,
day 27	2.5/6.5	754	partly overcast - sunny - overcast
day 28, 3.8.			Ny Ålesund, overcast, windy, snow shower
day 29, 4.8.			Longyearbyen, high fog, windy, shower
day 30 5.8.		760	Longyearbyen, high fog
day 31, 6.8.			Longyearbyen, high fog, cloudy
day 32, 7.8.		765	cloudy, sunny in Northern, overcast in Southern Norway
day 33, 8.8.			Germany bright, cloudy

Brent Geese (*Branta bernicla hrota*) were rare. Only once on July 6 six samples were seen at Kvadehuken, which flew direction Engelskbukta.

Pink-footed Geese (*Anser brachyrhynchus*) occurred sparse in the stony tundra and at rocky hills.

A **Ringed Plover** (*Charadrius hiaticula*) performed sing flights in a butterfly-like form similar to the courtship flight of Western Greenfinch with circles and loops of about 50 m diameter, thereby constantly calling. They last up to 3 min.

Ruddy Turnstones (*Arenaria interpres*) are scattered at stony coasts and in the stony tundra at inland lakes.

Dunlins (*Calidris alpina*) are rare and only in Ny Ålesund. Here up to 4 animals displayed simultaneously with sing-flights resembling that of the Eurasian Sky Lark.

Purple Sandpipers (*Calidris maritima*) are frequent at stony coasts and in the tundra. They are hardly shy. At Kvadehuksletta an animal breaded on four eggs on a small ice-free spot tundra. On July 15 Bernd-Ulrich finds a breeding bird on three eggs about 20 m next to the Ragna Hytta, a day later two adults, which are breeding on equal footing and seduce, if disturbed, for a long time. In the Steinflaen about 200 m above the sea at a small piece of tundra below a snow field in the vegetation-free stone dessert seduces a Purple Sandpiper. There are no animals nor animal tracks, except a Northern Fulmar kill.

Grey Phalaropes (*Phalaropus fulicarius*) are found scattered. In Ny Ålesund were at least 3 pairs. They were seen partly on the fjord, partly on the lagoon or on smaller ponds. Some were displaying.

Great Skuas (*Stercocarius skua*) were rare. One sample was at Kongsfjordneset, three flew very high up over Ragna Hytta to the west.

Arctic Skuas (*Stercocarius parasiticus)* were, however, common. They were breeding in the tundra. Most of the birds belonged to the bright phase. Some nests were seen at Kvadehuken, Mörebekk and close to Ragna Hytta. They attack partly man. At Bayelva about 2 km inland a pair of the bright and the dark phase (the ♂ (?) was aggressive) breaded directly at the river. They are, however, very shy. The flight distance is about 150 m. On July 26 was close to the pair at Bayelva another bright bird, which did, however, neither seduced nor attacked, but which did neither fly off.

Glaucous Gulls (*Larus hyperboreus*) are frequent at the sea. The birds vary considerably in size (between Herring Gull and Greater Black-backed Gull size). Two pairs bred at the steep fall of Steinflaen above the large sea bird colony in about 20 m heights. On July 31 troops of up to 30 samples with one juvenile are at the mouth of Byelva. One of the birds was a

Greater Black-backed Gulls (*Larus marinus*). They are very rare, as are the

Ivory Gull (*Pagophila eburnea*). Only one was seen on July 22 high above Bayelva flying westward.

Black-legged Kittiwakes (*Rissa tridactyla*) are, on the other hand, very common allover (see figure 7.33). They don't seem to breed together with other sea birds. A big colony is said to be between the Kongsvegen and the Tyskerhytta (where Anne and Peter were housed).

Arctic Terns (*Sterna paradisea*) are also frequent, colonies exist all along the coast and in the tundra close to the coast. The biggest is at the border of Ny Ålesund in the east, with about 30 pairs.

Brünnich's Guillemots (*Uria lomvia*) are common at the sea.

Black Guillemots (*Cephys grylle mandtii*) are also often found at the sea or close to the coast. One can see them swimming also between ice floes.

Atlantic Puffins (*Fratercula arctica naumanni*) are common,

Little Auks (*Plautus alle*) very common at the sea. The latter breed in almost any of the larger rock faces at the sea or in the mountains (up to 25 km in the inland). Often troops of up to 100 animals fly very high up in the inland (especially from Ragna Hytta eastward). In the tundra and at the coast many kills of these birds are found.

Especially interesting are the **Seabird colonie**s (see figure 7.33). They are recognizable from the distance already by the green vegetation zone below the rocks and on the rock protrusions. In an about 200 m high wall of a 600 m high mountain 4 km northeast of Ragna Hytta about 2.5 km inland existed a colony with Little Auks, Northern Fulmars and some Atlantic Puffin. At the north face of the Zeppelinfjellet close to Ny Ålesund was a Little Auk colony, at the steep face of the Steinfläen thousands of Northern Fulmars and Little Auks, hundreds of Black Guillemots and Atlantic Puffin and at least two pairs of Glaucous Gulls. In the rocks beyond the Hotellneset near Longyearbyen were thousands of Little Auks, individual Northern Fulmars and Brünnich's Guillemot and Black Guillemot. At the rock faces at the entry of Björndalen was also a colony with thousands of Little Auks. At the steep face of the Fuglefjellet, directly at Isfjorden, was a colony with thousands of Little Auks, hundreds of Brünnich's Guillemot and an Atlantic Puffin on a rock band in the middle of the face about 10 m beyond the sea. The Little Auk sit partly in the boulder fields.

A **Fieldfare** (*Turdus pilaris*) was found dead on July 6 at Hukbogen as flotsam.

Snow Buntings (*Plectrophenax nivalis*) are common in the settlements, at the huts and in stony areas. They breed in half-open caves. In Ny Ålesund were at least 12 pairs: Six nests were found on July 5 and on July 6 with 4-7 juveniles respectively eggs. The nests are up to 4 m beyond the ground at buildings, at the floor beneath a wooden staircase and on the ground in a depression filled with debris, about 20 cm deep. The first families with fledged juveniles were seen by Bernd-Ulrich on July 22 in an old mine west of Nilsebu. On August 1 at least three families were observed in Stuphallet at the foot of Steinflaen, further ones between Ny Ålesund and the landing stripe for air planes, at Geopol, at Gooseby, and at Storvaten. A family was also seen in the coal harbor of Longyearbyen. The families consisted of up to five, mostly two to four juveniles.

11.5.13 Pattern on soil of Kvadehuk

According to Kessler and Werner (2003) the polygonal patterns of the soil, which are found on Kvadehuk (see figure 7.20), are the result of frost forming discrete ice lenses in the soil, when it freezes close to the surface. This leads to lateral sorting and squeezing. The soil near the surface expands, because water flows toward the ice lens as it forms, and to a lesser extent, because the water expands as it freezes. The growing ice lens pushes the stones outward, desiccates and compresses the soil below it. If the interface between stones and soil is inclined, stones and soil are laterally displaced. When the ground thaws, the compressed soil reabsorbs water and expands vertically, not laterally. Therefore the lateral displacement of soil by frost heave is not reversed. Since soil-rich areas are more compressible, soil is transported toward those areas.

Other processes are also involved, but cycles of freezing and thawing cause soil-rich areas to attract more soil and stone-rich areas to attract more stones.

In a model, the authors could vary the degree of confinement, the concentration of stones, and the slope of the ground to produce circles, labyrinths, islands, stripes, and polygons of stones.

11.5.14 Further data

Here more detailed data (figures and tables) are given, which are referred to in the book.

Figure 11.4 shows, that Li^+ affects also the periodic effect of light pulses. Details in the legend. This figure is referred to on page 25.

Gerbils lengthen the daily running wheel activity rhythm under Li^+(figure 11.5 and *Engelmann (1973)*).

In Syrian hamsters, some animals increased their rhythm (from 24.01 to 24.1 h; 50, 70 respectively 90 % of the animals in the 3 experiments), shortened it (from 24.18 to 24.04 h; 22, 17 respectively 0 % of the animals in the 3 experiments) or did not react to Li^+ (23.77 h; 28, 13 respectively 10 % of the animals in the 3 experiments, table 11.4, Delius et al. (1984)). All together the control period amounted to 24.03 h in the 110 animals studied and 24.05 h during the Li^+ application.

Figure 11.6 shows how the harmonics defined by period, amplitude and phase were used to simulate the original average curves ("signal average"). The examples represent the temperature rhythm of AG and OYA and show, that four harmonics are sufficient.

11.5.15 Newspaper- and journal articles about the experiment

In the following some newspaper- and journal articles about the preexperiment and our experiment in Svalbard are listed (according to the publication year). See also figure 11.7.

1. Hirth, B.: In der Arktis tickt sie langsamer. In Schwäbisches Tagblatt, 29.9.1978
2. Hirth, B.: Lithium, Biorhythmen und Depressionen. In Deutscher Forschungsdienst 26, 13.11.1979
3. Hirth, B.: Blick auf die Zeiger der inneren Uhr. In Schwäbisches Tagblatt, 1.12.1979
4. Vellykket medisin-fysiologisk undersøkelse på Svalbard. In Svalbard-posten, Nr.7, page 7 to 9 (1978/79).
5. Stuberg, T: Verdens nordligste by våkner hver sommer. In Adresseavisen 4/8 (1979)
6. A. Johnsson und A. Tveito Ekse: Biologiske klokker innenfor psykiatrien. In Sandoz-Informasjon 5, page 7 to 9 (1979).
7. Stuberg, T: Døgnet burde vært på minst 25 timer. In Adresseavisen 13/1 (1979). About Ellinger – Mörgenthaler (with photo of both of them in front of VALHALL).
8. Mennesket: En mengde biologiske "klokker". In Dagbladet 4/6 (1980).

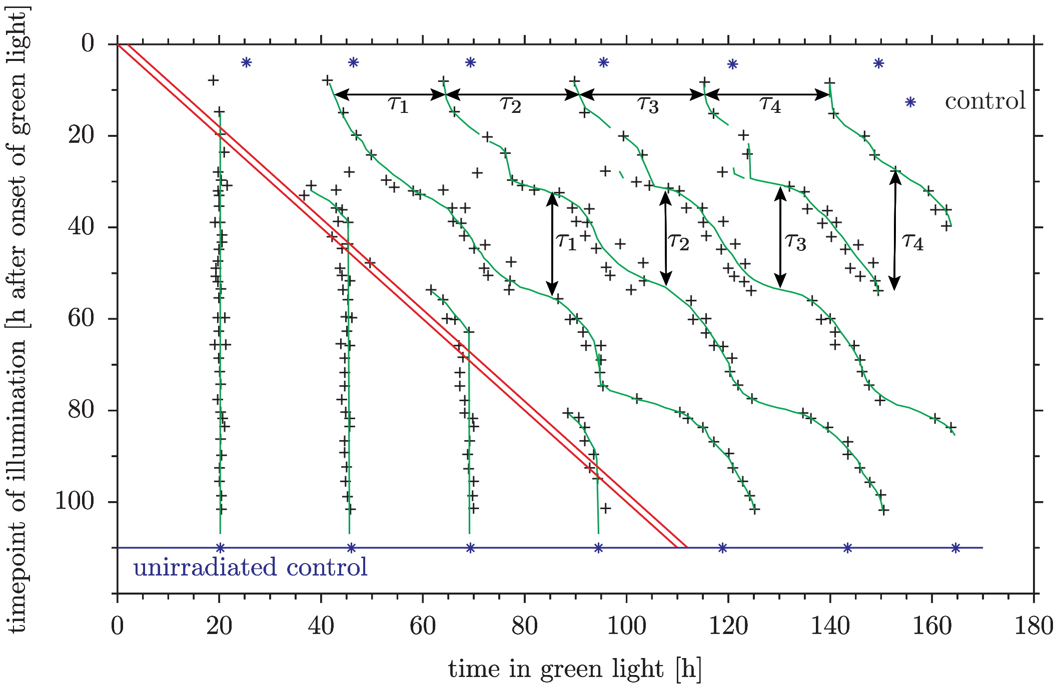


Figure 11.4: *In this (complicated) experiment flowers of* Kalanchoe *plants, which had been grown under a 12:12 h light-dark cycle, were broken off the plant and mounted in a cuvette (see figure 1.6 left) for recording. 3 mM LiCl was added to the water. At time 0 (x-axis) they were transferred into weak green light and a number of groups were exposed for 2 h each at various times (indicated on the y-axis and visualized by the red double line). This light shifts the rhythm of the petal movement. Plotted are only the time points of maximal opening of the flowers (black crosses as mean values of the flowers of a group). Furthermore the corresponding maxima (1st, 2nd, 3rd 4th and 5th) after the light pulse were connected by green curves (eye fitted). These curves reflect the rhythm shifting effect of the light pulses. The period lengths (τ_1, τ_2 and so on) can be deduced by measuring the time distances of corresponding curve points in a horizontal, but also in a vertical direction. The increase in period shows up in both cases! After Engelmann (1973)*

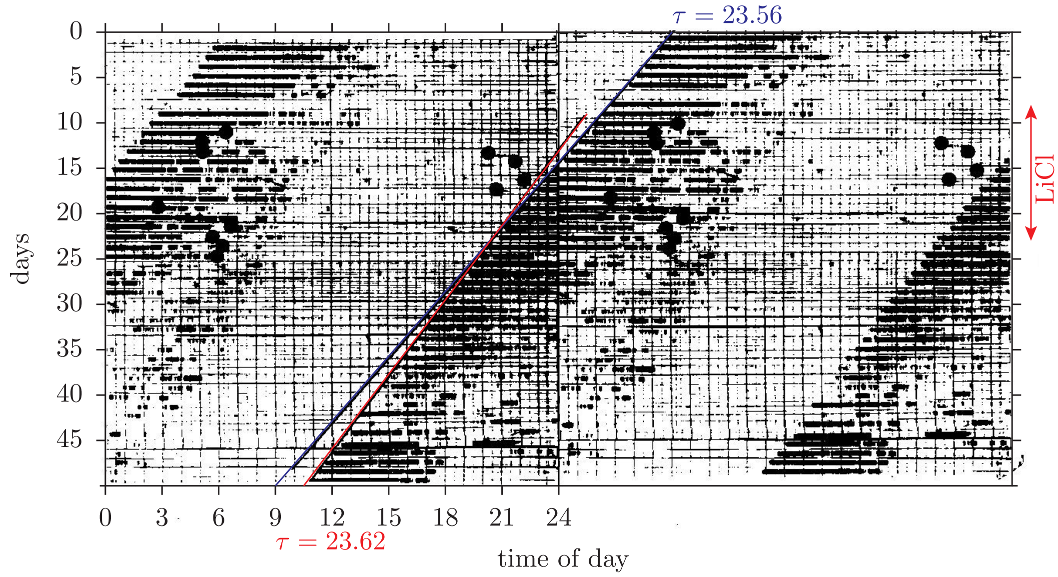


Figure 11.5: *Increase of period length of the locomotor activity rhythm of* Meriones crassus *by LiCl 2mg in 10 ml water offered at times marked by black dots). The blue line connects the onset of activity before and during the* Li^+ *treatment (*τ *is 23.56 h), the red line shows the period afterward (*τ *is 23.62 h). The period is thus increased by 0.06 h. Double plot. After Engelmann (1973)*

Table 11.4: *Effect of* Li^+ *on the period length of Golden hamster activity: 3 experiments. After Delius et al. (1984)*

1st experiment	number of animals	percent	control period	period changes
all	32	100	23.89±0.04	+0.02±0.02
τ increase	16	50	23.91±0.04	+0.10±0.01
τ decrease	7	22	24.18±0.05	-0.14±0.03
τ unchanged	9	28	23.94±0.08	+0.00±0.00
2nd experiment	**number of animals**	**percent**	**control period**	**period changes**
all	30	100	24.08±0.02	+0.04±0.02
τ increase	21	70	24.06±0.02	+0.09±0.01
τ decrease	5	17	24.18±0.09	-0.13±0.03
τ unchanged	4	13	23.10±0.00	0.00±0.00
3rd experiment	**number of animals**	**percent**	**control period**	**period changes**
all	30	100	24.08±0.02	+0.04±0.02
τ increase	21	70	24.06±0.02	+0.09±0.01
τ decrease	5	17	24.18±0.09	-0.13±0.03
τ unchanged	4	13	23.10±0.00	0.00±0.00

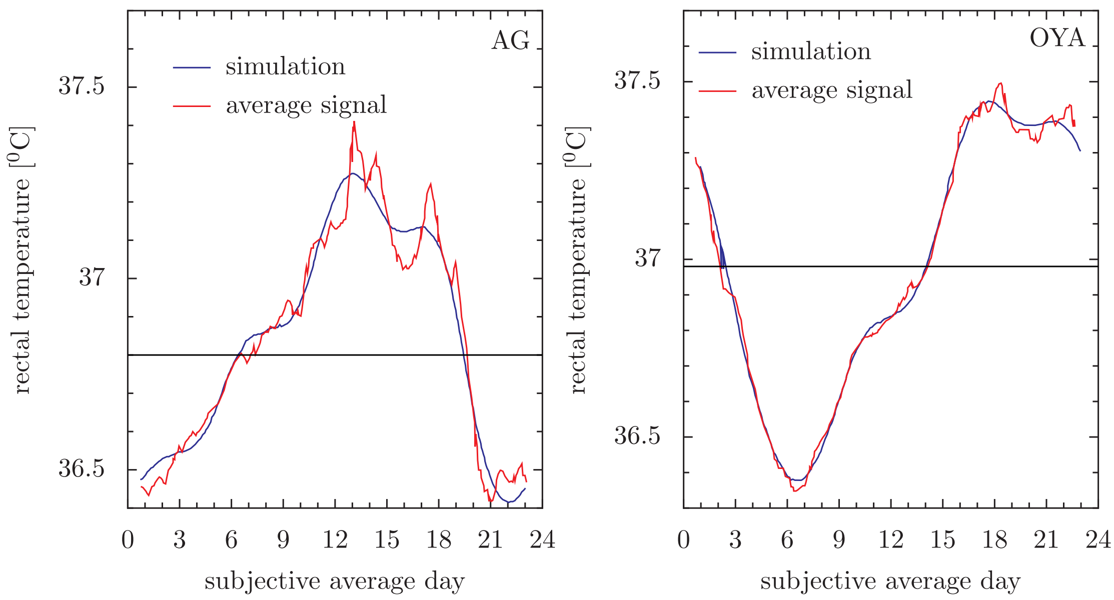


Figure 11.6: *Signal average curve (red curve) of temperature rhythm of participants AG and OYA and its simulation by the first four harmonics (blue curves). The period lengths was first determined by periodogram analysis and afterward subjected to a signal-average procedure and plotted. After Engelmann et al. (1983)*

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Die „innere Uhr" von Tübingern erforscht:

Freitag, 29. September 1978

In der Arktis tickt sie langsamer

Biorhythmiker, Psychiater und Physiker untersuchen die Ursachen von Depressionen

In Ny Alesund auf Spitzbergen, der nördlichsten Siedlung der Welt, wo viele Nordpolexpeditionen ihren Ausgangspunkt hatten, begann vor fast drei Monaten für eine Tübinger Forschungsgruppe ein Experiment, das dazu führen sollte, die Ursachen endogener Depressionen (einer Gemütskrankheit, die von Zeit zu Zeit, ohne äußerlich erkennbare Ursache auftritt) besser zu verstehen. Am Morgen des 9. Juli löste sich dort ein kleines Boot von der Anlegestelle, schob sich, vorbei an treibenden Eisschollen, langsam über den Fjord und steuerte eine kleine Halbinsel an, auf der Helmut Ellinger und Fritz Mörgenthaler vier Wochen in einer abgelegenen Hütte verbringen sollten, ohne Uhr und abgeschirmt von allen äußeren Einflüssen, die ihnen die Tageszeit verraten könnten. Denn hier im arktischen Dauertag sollte erforscht werden, wie sich der Rhythmus verschiedener Körperfunktionen ändert, wenn äußere Zeitgeber wie beispielsweise der gewohnte Tag-Nacht-Wechsel wegfallen. Dieses Experiment war erster Teil eines interdisziplinären Forschungsprojektes, an dem Biologen, Psychiater und Physiker der Universität Tübingen und Trondheim beteiligt sind und das die noch ungelöste Frage klären soll, warum Lithiumpräparate bei der Behandlung von depressiven Gemütskrankheiten helfen. Ausgegangen ist man dabei von der Beobachtung, daß die Tagesrhythmik während depressiver Phasen »durcheinander« geraten ist und von der Vermutung, daß Lithium wieder zu einer normalen 24stündigen Rhythmik führt.

Teilnehmer des Seminars gingen nun daran, zu überlegen, wie diese Behauptung nachgeprüft werden könnte. Um die rhythmikverändernde Wirkung des Präparats testen zu können, brauchte es eine Umgebung, die frei ist von „äußeren Zeitgebern", die den Rhythmus immer wieder auf einen 24-Stunden-Takt zwingen. So kam man auf die Idee, das Experiment im Dauerlicht des arktischen Sommers auf Spitzbergen durchzuführen, um den „Freilauf" der menschlichen Tagesrhythmen zu erlauben. Aus verschiedenen anderen Versuchen weiß man, daß der Mensch dann weiterhin eine Tagesrhythmik zeigt, diese sich aber verlangsamt, wenn keine äußeren Zeitgeber mehr da sind.

Die Uni Trondheim hilft

Ein Vorversuch ohne Einnahme des Präparats sollte zunächst klären, in

Fünf Wochen Dauertag auf Spitzbergen:

Samstag, 1. Dezember 1979

Blick auf die Zeiger der inneren Uhr

Tübinger Forschungsprojekt über die Ursachen von endogenen Depressionen

Fünf Wochen lang lebten sie völlig abgeschieden in kleinen Hütten in Spitzbergen, am Rande des arktischen Eises. Lebten ohne Uhr, Radio oder Fernsehen, ohne Verbindung mit der Zivilisation. Sechs Tübinger Studenten hatten sich als Versuchspersonen zur Verfügung gestellt für ein Experiment, das dazu führen soll, die endogenen Depressionen besser zu verstehen. Nach einem Vorversuch im Juli vergangenen Jahres, der die Lebensbedingungen im arktischen Dauertag testen sollte (wir berichteten darüber) fand in diesem Sommer das eigentliche Experiment des interdisziplinären Forschungsprojektes der Universitäten Tübingen und Trondheim statt. Geklärt werden sollte die Frage, ob Lithiumsalze — als Medikament erfolgreich eingesetzt in depressiven Phasen — den inneren Rhythmus des Menschen verändern.

Hütte gebracht wurden. Dr. Engelmann: „Wir glaubten uns auf eisfreiem Gewässer. Doch innerhalb weniger Minuten waren wir von einem Meer hoher Eis-Blöcke umringt, die uns ans Land drückten. Zum Glück waren wir ganz in der Nähe des Ufers, so daß wir uns mit einem Sprung an Land retten konnten, sonst hätten uns die Eisschollen in dem kleinen Boot zusammengedrückt." Aber am Ufer war man auch eingeschlossen, denn inzwischen hatte das Tauwetter einge-

deutscher forschungsdienst

03262

BERICHTE AUS DER WISSENSCHAFT

13. November 1979 - 26. Jahrgang, Nr.

ithium, Biorhythmen
nd Depressionen

Verstellt ein Medikament die "innere Uhr"? - Erfolgreiches Forschungsprojekt unter der Mitternachtssonne

Med sonde i endetarmen!

— Resultatene fra Svalbard-forsøkene er interessante. Detaljene skal publiseres i forskningsmiljøene i tiden som kommer, sier professor Anders Johnsson og vil oss. Aud Tveito Ekse, som har deltatt i bearbeidelse av data fra forsøket.

Gåten om de biologiske klokker løses:

Depresjonene kommer når kroppsrytmen forstyrres

Tekst og foto: TORE STUBERG

— Vår hypotese er styrket. Vi vet mer om de biologiske klokker, og vi har fått

Verdens nordligste by våkner hver sommer

Kalvede isfjell seiler sakte forbi oss på den speilblanke Kongsfjorden. Den skjærer seg inn på nordvestsiden av Spitsbergen og møter Kongsbreen der tindene reiser seg majestetisk. Vi er i verdens nordligste by, Ny-Ålesund på 79 grader nordlig bredde. Her smalt det i grubene for 17 år siden, over tyve mennesker mistet livet i Kings Bay. Da «døde» også Ny-Ålesund. Et samfunn på 300 mennesker måtte dra vekk, en regjering falt. Men nå puster byen igjen — sommers tid. Under midnattsolen arbeider polarforskernes hjerner. Nå er det akademikerne som rusler rundt ved perlen i polaregnen, grubene er stengt og slusken vil aldri komme hit mer.

4 UKE-ADRESSA

Vår biologiske klokke går galt:

Døgnet burde vært på minst 25 timer

— Døgnet burde ha hatt minst 25 timer! I en hektisk arbeidsperiode vil vel mange av oss nikke samtykkende. Men professor Anders

Professor Anders Johnsson står i spissen for interessante forsøk på Svalbard. Her er han fotografert utenfor polarinstituttets forskningsstasjon i Ny-Ålesund. Han viser noen av instrumentene fra årets forsøk der lithiums innvirkning på menneskets biologiske klokker ble studert.

«Biologiske klokker» kan gi depresjoner

● Føler du deg utilpass om dagen? Ute av humør? Kanskje du plages av depresjoner?

Figure 11.7: *Some newspaper cutouts about our experiments in Spitsbergen*

11.5.16 Technical notes

In the following the technical data of the recorder are described (see page 162): Temperature range 35-40° C, corresponding to 000-999; precision and linearity of the temperature sensor and resolution of the printout better then 0.005° C, reproducibility better then 0.008° C, absolute display can be calibrated, precision of the A/D-converter 0.1 %$\pm$1 digit, clock frequency 4.2 KHz, print cycle 512 sec (or 256, 1024), print time per line about 0.8 sec, voltage supply one 9 V compact battery (Alkali/manganese), 4 1.5 V Mignon-batteries, currency 0.5 mA for 9 V, 250 mA for 1.8 sec per print cycle for the 4 1.5 V batteries. Size of the unit 190*120*110 mm, weight 1.4 kg, dimensions of the probe 25*7 mm (cylindrical). Printer paper available in stationaries.

The temperature sensor produces a voltage, which is proportional to the temperature and amounts to 10 mV/° Kelvin. It contains furthermore temperature stable reference voltage and an operational amplifier. An external circuit allows to set the desired zero position and the scaling factor of the output voltage. The circuit used by us produced at 35° C an output voltage of 0 and at 40° C of 1 V. The display was thus limited to the physiologically relevant range and the readout became very sensitive (see level adaptation in the block diagram). The output voltage is transferred from the rectal probe via a cable to an analogue-digital-converter. It converts the originally analogue temperature information into a three digit BCD-format. The resolution of the temperature is thus 0.005 K.

The actometer for recording the arm movements and the printer function are described in the following:

Moving the arm closed and opened the contact. These on-off signals were transformed into pulses and fed into a binary counter. A priority decoder provided a logarithmic performance curve of this activity counter. The information of the locomotor activity was stored as a one digit BCD character and ranged from 0 to 16 (0 1 2 3 to 9 ? = ; : $<$ $>$).

The time information was not printed as the actual time of day, but as a consecutive four-digit numerator. It was produced by a quartz timer every 512 seconds. Together with the operational control it was responsible for all required control signals.

To trigger the printer the BCD formatted data existing in parallel terms had to be multiplexed. The control signals for the 8 in 1 multiplexer were supported by the printer electronic.

The sequence control took care of the fully automatic recording and printing. During the intervals all functional groups were without current. They were switched on together with the current-sapping printer electronic. Afterward the present records were taken and printed in a line.

Temperature- and activity-sensor, timer, operational control and numerator generation were supplied with current by a 9 V compact battery. Four 1.5 V batteries were used for the multiplexer, the printer electronic and the printer motor. Due to the switching off between the measurements and by using energy saving CMOS-parts the instruments operated for at least four weeks.

There were only a few manipulation elements: The main switch is used at the begin of the experiment and starts recording. There was furthermore a printing knob. It allowed to print out at any time the momentary value of temperature and activity.

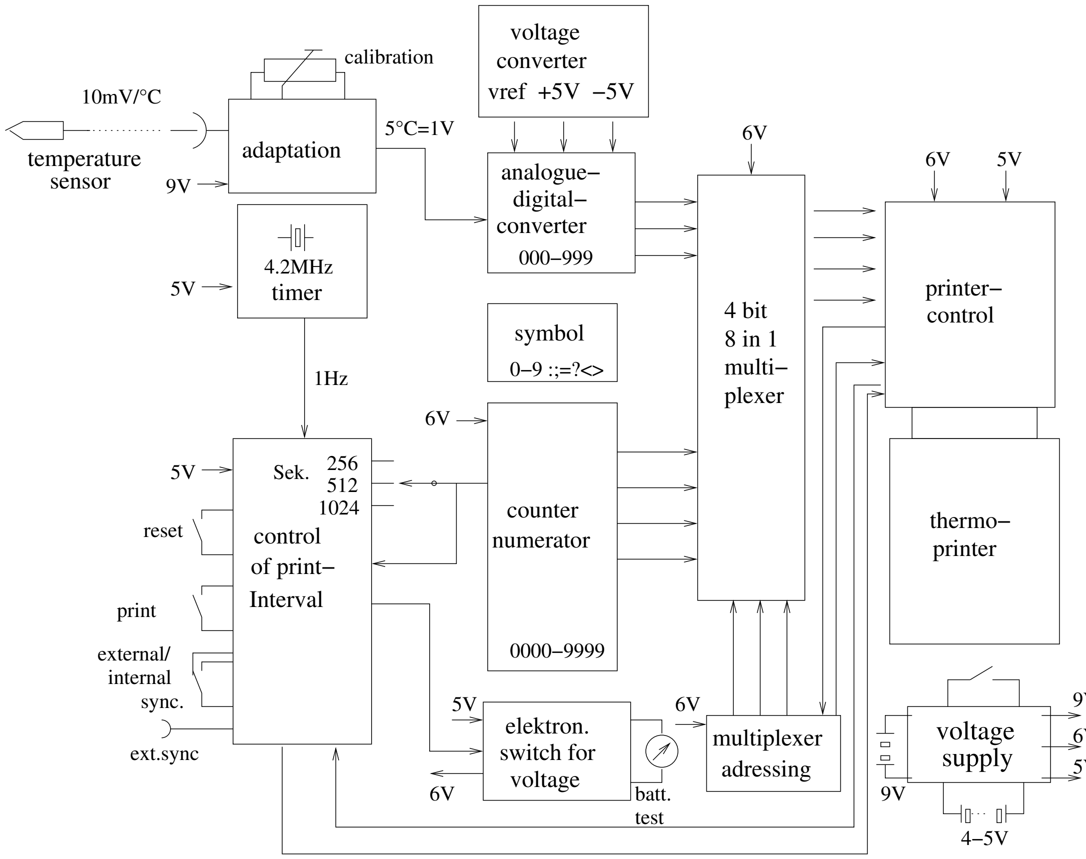

Figure 11.8: *Function diagram of the DE101 recorder constructed by Waldemar Himer. Rectal temperature recording with temperature sensor (monolithic temperature transducer LX 5700 AH of the National Semiconductor company, moulted in small plastic capsules). This integrated circuitry allowed to measure temperature very precisely and in a simple way. More details in the text*

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Index

Nomenclature

allele is the identical or different status of the DNA sequence of a particular gene

antidepressant is a medication used mainly for depression

ARNTL aryl hydrocarbon receptor nuclear translocator-like, called also Bmal1 or Mop3

atypic depression main feature: brightening of mood, increased appetite, weight increase, hypersomnia, lead weight of the body, hypersensitivity against rejections. About 15 to 40 percent of all depressiv disorders

AVP arginin-vasopressin or vasopressin is a peptide hormone of mammals. Controls the reabsorption of substances in the kidney, and the arterial blood pressure

azakenpaullon 1-azakenpaullon inhibits selectively glycogen synthase kinase-3 beta

BCD-format binary-coded decimal, allow fast conversion in decimal numbers for printing and display

bioacustic research field of animal calls (organs of sound production and -function, sound events, organs for hearing and their achievements)

blood plasm blood consists of a cellular and a liquid part, the blood plasm, in which the cells swim. It amounts to about 55 % of the blood volume

CDK cyclin-dependend kinases are involved in the regulation of the cell cycle, transcription and mRNA processing. They phosphorylate proteines at the serine- and threonine-aminoacids, whereby they are activated by cycline

CET Central European Time is the legal time for parts of Europe and Africa. Corresponds to the mean summer time of the 15th longitude east of Greenwich

chronical (greek: time) term for a slowly developing or long-lasting disease (more than four weeks). Some chronic diseases such as epilepsy exhibit acute surges (attacks)

chronobiotic substance influences the daily system. Examples are indoleamines, cholinergic substances, benzodiazepine, melatonin. Used in circadian sleep disturbances such as jet lag, shift work and in blind people

chronotherapy treatment of disturbances of the circadian system such as in certain sleep problems

circadian rhythm (latin circa, about, and dies, day). In chronobiology the endogenous (internal) rhythm with a period length of circa 24 h. 1959 introduced by Halberg

CK1 casein kinase1 are enzymes, which transfer a phosphate moiety from a nucleosid triphosphate. In this way e.g. enzymes can be activated

CLOCK circadian locomotor output cycles kaput, part of the circadian oscillator, which forms together with BMAL a dimer

coincidence model explains photoperiodic reactions by the action of light at certain times of the circadian clock. In the case of internal coincidence light regulates an oscillator in such a way, that it coincides with a further oscillator in a particular way

comorbid simultaneous occurrence of e.g. depression and anxiety or high blood pressure and diabetes

conidia are asexual germ cells of fungi, which are arranged chain-like and delivered for propagation

cortex most external neural brain tissue of mammals. Plays an important role in memory, attention, thinking, speaking and consciousness

corticosterole or corticosteroide: hormones such as cortisol or aldosterone, which are produced by the adrenal cortex

cortisol is a hormone of the adrenal cortex and is released during stress

CRF corticotropin releasing factor, regulates the adrenocorticotropic hormone (ACTH), which stimulates the production of cortisol

cryptochrome (greek hidden colour) blue light absorbing pigment of organisms, which regulates among others germination, elongation, photoperiodism in plants, and the recognition of magnetic fields in animals. Part of the circadian clock

cytoplasm is the part of the eukaryotic cell, which is enclosed by the cell membrane

diagnosis elucidation of the cause of symptoms, e.g. of a sickness

dimer a compound consisting of two structurally similar monomers

E-box DNA-sequence upstream of the promoter region of a gene. Transcription factors with a basic helix-loop-helix protein motive bind typically to E-boxes or similar sequences and increase transcription downstream of the gene

electrolyte (greek amber, electric and solvable) is a liquid, which conducts current in an electric field by directed movement of ions. Examples are Na, K, Ca ions in urine

endogenous internal, out of the organism. Opposite term is exogenous, caused externally

epidermis outermost cell layer of leaves and young plant parts

episode event, attack, surge, interval with symptoms of the disease

ethiology deals with the cause of a disease

expression of a gene is the event, in which the DNA-information is used for the synthesis of a gene product. Often proteins, but in the case of rRNA- or tRNA-genes functional RNA

Famulus (Latin) subassistent

fauna (Latin Faunus, godness of fertility and of earth) animal life of a region or a period fibroblasts are mobile cells in the connective tissue, which play an important role in the synthesis of the intercellular substance. After maturing to fibrocytes they become immobile

fjord a long, small inlet with steep sides, created during the ice ages

flora (Latin, godness of flowers) plant life of a region

geography (greek earth describing) describes the earth, its properties, phenomena and inhabitants

geology (greek: earth and science) is the science of the assembly, composition, structure, physics and development of the earth

gerbils Asiatic gerbil (Meriones crassus), a rodent

glia cell (greek glue) is a collective name for cells in neural tissue which are structurally and functionally distinct from neurons. Smaller as neurons. Support, electric insulation of neurons, involved in metabolism and transport of liquids, information processing and homeostasis in the brain. In the human brain there are about 10 to 50 times more glia cells as there are neurons; they make up for 50% of the mass

glycogene synthase kinase 3 (GSK-3) is a serine/threonine phosphorylating protein kinase with two isoforms, alpha (GSK3A) and beta (GSK3B). The latter one is involved in the energy metabolism, the development of the nerve cells and the form of the body

Hamilton scale for diagnosing the severity of a depressive state. Consists of questions, which the investigator assess on a scale from 0 to 4 or 0 to 2, to find out how pronounced a certain symptom is (e.g. feeling guilty, sleep disturbances, hypochondria or suizide thoughts). One gets a number, which is in the case of a severely depressed patient 25 or higher

heterodimer: dimeres consist of homo- and heterodimeres. In homodimers the two monomeres are identical, in heterodimers they differ, but are often quite similar

histone-deacetylases (HDAC) are enzymes, which remove acetyl groups from the amino acid lysine on histones; they are therefore also called lysine-deacetylases

homeostasis (greek equal-level) self regulation, the ability of a system, to stay stable in certain limits due to negative feedback

hydroxytryptamine (5-HT) or serotonin is a neurotransmitter especially in the gut, the blood platelets and the central nervous system of animals

hypochondria (greek area below the rib) is a mental disorder, in which the affected person is scared to be sick, although this is objectively not the case

hypophysis (greek the from below appending excrescence) is a hormonal gland of the brain, which plays a central role in neuroendocrine regulation

hypothalamus is a section of the interbrain in the area of the crossing of the optical nerve. Medial the hypothalamus is bounded by the third ventricle, and cranial by the thalamus. Produces effector hormons, releasing- and inhibiting-hormons, various neuropeptides and dopamin, with which it controls the vegetative functions of the body

hypothesis (greek hypothesis assumption, postulate, basis) is a proposition which is likely to be true, but not proofed or verified

indirubine-3-oxime inhibits cycline-dependent kinases (CDKs) and glycogen synthase-kinase 3-beta (GSK-3beta) and also Jun NH2-terminal proteine-kinase (JNK)

inositolmonophosphatase or IMPase is an enzyme in cells. Dephosphorylates inositolphosphat to inositol in the phosphatidyl inositol signal pathway. Plays a role in bipolar depression

internist is a consultant for internal medicine

JNK Jun N-terminal kinase, a stress-activated protein kinase

knockdown gene-knockdown means -in contrast to gene knockout- only a partly switching-off of the function of a gene. In this way the new formation of the corresponding gene product is dimished

lagoon (Latin lacuna, pond, puddle). shallow waters, which has been separeted from the sea by sandy sediments (spits) or coral reefs

latency (latin hidden) is the time between an event and the onset of the reaction, that is, the delay time

libido (latin desire, lust, drive, exorbitance) used in psychoanalysis and terms the psychic energy, which is connected with the drives of sexuality

lithium (greek stone) is a chemical element with the symbol Li and the atomic number 3. Alkali metall of the second period of the periodic system. Light metall with the smallest density of all solid elementes. At room temperature stable only at completely dry air. As trace element in form of its salts often in mineral waters. Used in bipolar affectiv disorders, mania, depression and cluster headaches

long day plant is induced by long days to flower

lux unit of the physiological (that is, related to the subjective sensitivity of the human eye) intensity of illumination

mania (greek fury) is an affective disorder and occurs mostly in phases. Drive and mood during the mania much beyond the normal, sleep shortened

MAO-inhibitors or monoaminooxidase-inhibitors inhibit monoamine oxidase (MAO) and in this way the degradation of biogenic amines. Used as antidepressants

MAPK mitogen-activated proteine (MAP) kinase, serine/threonine-specific proteine kinases. React to external stimuli such as mitogen, osmotic stress, heat shock, and regulate diverse cell activities such as gene expression, mitosis, differentiation, division and cell survival/apoptosis

Max-Planck Society for the Advancement of Sciences is an independend nonprofit research organisation. It advances research mainly in own institutions

medication treatment with a medicament

melatonin is a hormon made from serotonin in the pinealocytes of the pineal organ (part of the interbrain). Controls the day-night rhythm of the human body. It is an alkaloide with tryptamine structure

mitochondrium is a cell organelle, in which energy is produced by cell respiration

monoamines are neurotransmitter and neuromodulator, which are made from aromatic amino acids such as phenylalanine, tyrosine, tryptophane and thyroid hormones by decarboxylation

mRNA messenger RNA is the RNA-transcript of a section of DNA of a gene. Is synchronized during transcription by the RNA-polymerase

mutant is an individuum modified by a mutation (qualitative or quantitative modification of the genetic material)

neurotransmitter substances, which transmit information from one nerve cell to another via junctions of neurons (synapses). Examples: Glutamate, gamma-aminobutyric acid (GABA), acetylcholine, dopamine, serotonin

non-invasiv are procedures in medicine, in which devices or catheters do not or only to a small degree (minimal-invasive) intrude the body

noradrenalin or norepinephrine is a neurotransmitter and a hormone. Produced by the body in the adrenal medulla and in the Locus caeruleus of the brain. Stimulates the cardiovascular system

NR1D1 nuclear receptor subfamily 1, group D, member 1, called also Rev-erb alpha. Belongs to the nuclear receptors and is a transcriptional repressor. Involved in the circadian clock mechanism

nuclear factor is a transcription factor, which is involved in immune reactions

ortholog genes of different species are similar, because they are inherited from the same ancestors

parathyroid hormone PTH is a protein product of the parathyroid with various physiological effects

pathophysiology or pathological physiology describes the function of the body (greek physis) under pathological changes and tries to find out which functional mechanisms lead to the morbid changes (pathogenesis)

pea subfamily with many species belonging to the subfamily Faboideae and the family of the Fabaceae

period or more precise period length: duration of a single oscillation pH-electrode is a device for recording the pH value, a measure of the acidity or basicity of a solution

phase coincidence is the coincidence of the phase of an oscillator with that of an external rhythm (external coincidence) or with that of another internal oscillator (internal coincidence)

phase position describes the time relation between one oscillation and another one

phase-response-curve shows the direction and amount of phase shift of a rhythm by a single disturbance (e.g. by a light pulse)

photoelement is an electric semiconductor element, which produces an electric current if illuminated

photoperiodism is the ability of organisms, to determine the daylength and to start -according to the length- various physiological processes. See also shortday and longday plants

photoreceptors are devices of organisms for the perception of light

phylogeny is the evolutionary development and history of a species or higher taxonomic grouping of organisms. Also called phylogenesis

pindolol is a nonselective betablocker

polymorphism (greek): occurrance of one or several gene variations (that is, one or several alleles) in a population. If the gene variation occurs under one percent, it is called mutation

PPARGC1B peroxisome proliferator-activated receptor gamma, coactivator 1 beta, coactivates the nuclear estrogen-related receptor-alpha and -gamma

predisposition inherited anlage or receptiveness for certain diseases or symptoms

prolactin is a hormone, which is produced in mammals in the lactotropic cells in the anterior lobes of the hypophysis. It is reponsible for the growth of the breast gland during pregnancy and for milk secretion during lactation. It has furthermore psychological functions

promoter is in genetics a nucleotide sequence of the DNA, which allows the regulated expression of a gene. This essencial part of a gene interacts with certain DNA-binding proteins, the transcription factors

psychopharmaca (greek soul and medication) are medications, which affect the psyche of patients and are supposed to heal or improof mental disturbances and neurological deseases

psychotropic medication used to treat mental disorders

RAS/RSK pathway or RAS-MAPK pathway for gene activation by RSK2, a growth factor-regulating CREB-kinase (RAS is a mitogene-activating protein kinase (MAPK); RSK2 belongs to the pp90RSK family;
CREB=cyclic adenosine monophosphate response element-binding protein)

reporter cells, luminescent are used for instance to recognize circadian rhythms easily. For this purpose the luciferase-reporter Bmal1-dluc in cultured cells (e.g. the human U2OS-cell line) are taken and the intensity of the luminescence recorded

retina is a light sensitive tissue in the interior of the eye ball. Light sets in motion a cascade of chemical and electrical processes, which finally trigger nerve impulses. They in turn send signals via fibers of the optic nerve to the visual center of the brain

roscovitin inhibits cycline-dependent kinases (CDKs)

running wheel revolvable device for recording the locomotor activity of animals

schizophrenia (greek: separate and soul, diaphragm) is a severe mental disease. Disturbances of thinking, of perception and of affectivity. In the stationary realm of psychiatry one of the most frequent diagnoses

serotonin or hydroxytryptamine is a neurotransmitter mainly produced in the gut, in platelets in the blood and in the central nervous system of animals

short day plant is induced to flower by short days

signal pathway insulin growth factor IGF-1 (insulin-like growth factors, IGF) are polypeptides. They possess a high sequence homology to insulin and affect growth and differentiation of cells. Part of a complex system, with which body cells communicate with their environment

signal pathway of neurotrophic factors consists of extracellular signal molecules, which are important for the development of the nervous system and during the regulation of neuronal survival and death

siRNA small interfering RNA is a class of double stranded RNA of 20-25 nucleotides, which are involved in RNA interference: They interfere with the expression of a specific gene

slow wave sleep (SWS) or deep sleep consists of three stages, which increase in sleep depth from 1 to 3. Alternates with REM-sleep

suprachiasmatic nucleus (SCN) is a central control region of circadian rhythms in the hypothalamus of the brain of vertebrates situated above the optic chiasm and at the lower sides of the third ventricle

Sysselman presides over syssels or districts

therapy (greek therapeia: to serve, to nurse the sick) is a medical term for measures to treat diseases and injuries

TIM proteine is coded by the timeless or tim gene and belongs to the clock genes such as PER, with which it forms a dimer

time series analysis is a statistical analysis of time series to find and characterize for instance rhythms

transcription is the synthesis of RNA on a DNA as a template. Like translation an essential subprocess of gene expression

transcription activators are proteins, which bind to DNA and stimulate the transcription of nearby genes transcription factor is a proteine, which is important for the initiation of the RNA-polymerase during transcription. Transcription factors can bind to DNA (or to other DNA-binding proteins) and activate or reprime promoters. General and tissue- respectively cell-specific transcription factors

transfection inserting foreign DNA in eucaryotic cells

translation is the first stage of the protein biosynthesis during gene expression. The messenger RNA (mRNA), which is made during transcription, is decoded by the ribosome and a specific amino acid chain (polypeptid) formed, which folds late in an active protein

tundra (samic tundar, highlands, treeless mountain areas). Biotop, in which trees can not grow due to low temperatures and short vegetation period

UNESCO United Nations Educational, Scientific and Cultural Organization, an organization for peace and security on earth

vacuole is a cell organelle. Takes in mature plant cells the largest part of the cell. Contains cell sap and is the cause of turgor pressure

valproate (VPA) stabilizes mood in mental disorders such as epilepsy, depression and schizophrenia. It inhibits histon-deacetylase

vulnerability model for the origin of psychosis. According to it people with a (genetically predisposed?) affinity for psychoses are especially susceptible for stress situations. Often in sensitive and creative persons, who are taken ill by a psychosis

wild type phenotype of the typical form of a species in nature

Wnt-signal pathway is one of many signal transduction pathways, by which cells can react to external stimuli. Termed after its ligand Wnt (combination of Wg for wingless, a wingless Drosophila-mutant, and Int-1), a signal proteine with an important function during the development of various animal cells. This signal pathway is essential for the normal embryonic development

Zeitgeber (German time cue) is a factor, which synchronizes an oscillator (e.g. circadian rhythm) such as the day-night cycle, noise, social interactions, physical activity and clocks