



Erwin Bünnings hundredth anniversary

January 23, 2006 at the Department of Botany in Tübingen

by Wolfgang Engelmann, 2018 translated from the German edition

23. Januar 2006

This Book is translated (and shortened) from a German version, which was delivered to the participants of the hundreds anniversary of Bünnings birthday. Since there was interest in an English version, I have translated and shortened it with the help of several persons (see chapter 11 and various footnotes for details). The title page image was drawn by Ulf Hauri.

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¹final secondary-school examination

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1 Introduction

This is a collection of informations, events, figures in connection with the celebration of the hundreds birthday of Erwin Bünning on January 23, 2006 by the faculty of Biology at the University of Tübingen, Germany¹.

In the following you will find:

- A few short notes to the Studium generale lectures of the Faculty of Biology at the occasion of the hundreds anniversary of the birthday of Professor Erwin Bünning during the winter term 2005/2006 (chapter 2)
- The birthday celebration (see chapter 3); the address of welcome; the lecture of Charlotte Helfrich-Förster, Regensburg and of Anand D. Karve; Poona (India); a summary of both lectures; a speech of Ilse Franklin: *For my Father, Erwin Bünning at his 100s birthday*; an exhibition with informations on Bünning
- Bünning-data (see chapter 4): curriculum vitae, Bünning's areas of interest and fields of work, examples of the organisms used by him
- Lectures, articles of Bünning and about him (see chapter 5):
Bünning's inaugural address for his rector-ship 1952 (see section 5.1).
Bünning's rector talk 1953 (see section 5.2).
Bünning on Pfeffer (see section 5.3 and Bünning (1975)).
Inaugural address at the Heidelberg Academia (see section 5.4).
Talk of Schwemmler at the 70th birthday of Bünning (see section 5.5).
Talk of Haupt 1990: *The Tübingen school*; excerpts in respect to Bünning and Tübingen (see section 5.6).
From a talk of Mohr 1987: *E. Bünning - not only the physiological clock has stirred him* (see section 5.8).
A poem for the 80th birthday of Bünning (see section 5.7).
Chandrashekar 1985: *Erwin Bünning - an appreciation* (see section 5.9).
Tazawa 2006: *What I learned in Tübingen* (see section 5.10).
Baillaud 2006: *A Frenchman at the Botany Institute in Tübingen* (see section 5.10).
Chandrashekar 2006: *A Centennial homage* (see section 5.12).
- Bünning's thoughts for education (see chapter 6):
School leaving examination and general qualification for university entrance

¹Wolfgang Engelmann, EMail: engelmann@uni-tuebingen.de, Tel: 07071-68324. See also the German version *Fest zum hundertsten Geburtstag von Erwin Bünning am 23.1.2006 im Botanischen Institut Tübingen* at TOBIAS-lib - publications and dissertations of the Tübingen University Library.

1 Introduction

(see section 6.1).

The problem of general education (see section 6.3).

Looking back: why it was easier in earlier decades to do autonomous scientific research (see section 6.4).

Biology in our our times (see section 6.5).

- Bünning's traveling (see chapter 7):
 - Short report on a journey through Northern Sumatra (see section 7.1).
 - Botanical observations in Sumatra (see section 7.2).
 - In the woods of Northern Sumatra (see section 7.3).
 - Reunion with Indonesia (see section 7.4).
 - The salt mountains in Pakistan (see section 7.5).
 - Step-, sand- and salt deserts in the river basin of the Indus (see section 7.6).
 - In the Chittagong-Hill-Tracts (see section 7.7).
 - Plant life during the seasons in the arctics (see section 7.8).
- Obituary (see chapter 8):
 - Haupt: *Erwin Bünning 1906-1990* (see section 8.1).
 - Schwemmler: *Obituary for the passing of Professor Erwin Bünning* (see section 8.2).
 - Chandrasekaran: *Erwin Bünning (1906-1990): A Colossus of Chronobiology* (see section 8.3).
 - Masuda: *Remembering Professor Bünning* (see section 8.4).
 - Masuda: *Visiting the grave of Professor Bünning* (see section 8.5).
 - Tazawa: *Commemoration of Professor Bünning* (see section 8.6).
 - Engelmann: *Address to the Marburg Meeting of the International Society of Chronobiology 1991* (see section 8.7).
- Bünning-stories (see chapter 9):
 - Bettina Brommer (see section 9.1).
 - Vera Hemleben (see section 9.2).
 - Dietrich Gradmann (see section 9.3).
 - Claus Schilde (see section 9.4)
 - Marianne Hetzer (see section 9.5).
 - Wolfgang Engelmann (see section 9.7).
 - Gottfried Wiedenmann (see section 9.6).
 - Ilse Franklin (see section 9.8).
- Literature (see chapter 10).
- Acknowledgements (at the end of the book, chapter 11).

2 Studium generale lecture series of the Biology faculty at the occasion of the hundreds birthday of Professor Erwin Bünning

Before the actual centennial Birthday celebration a Studium generale¹ lecture series “*Biology in Tübingen: For the hundreds birthday of Erwin Bünning*” was offered by the faculty of Biology:

Professor Erwin Bünning was from 1946 to 1971 chair of the botany and plant physiology department at the University of Tübingen. On January 23, 2006 would have been his 100st birthday. The faculty of biology dedicated this great biologist a Studium generale lecture series, in which the 14 representatives of the various biology institutes talk about their work. Additionally two external biologists will speak about biological clocks, a central topic of Bünning. A summary of the lectures and the curriculum vitae of the lecturers is available on request: engelmann@uni-tuebingen.de

¹The Studium Generale is a service of the university where during the semester scientists of Tübingen and other universities offer evening lectures for students of all faculties and the public on topical and interdisciplinary themes. It covers basic questions of humanity and tries to stimulate discussions between the various disciplines.

3 Birthday celebration

3.1 Address of welcome

Engelmann 16:45: Welcome to our guests:

Dear birthday guests,

in this year the Biology at the University of Tübingen celebrates twice the 100 year anniversaries of great biologists of our University: The one of Georg Melchers and the one of Erwin Bünning. Melchers was two weeks older, as he always stressed (whereby he usually did not mention the two weeks), and his birthday was therefore celebrated already two weeks ago at the MPI¹ guest house.

We are pleased, that two of Bünning's children, Frau Ilse Franklin from Basel and Ingrid Hancke from Pfrondorf are with us.

I am especially happy, that a PhD student of Bünning, Dr. *Anand D. Karve* from Poona in the state of Maharashtra in India will tell us today about his work, and I thank the *Alexander von Humboldt-Stiftung* for allowing Karve a detour to Tübingen on his flight to Canada. Nandu Karve is an example of one of the many scholars of Bünning, who put their knowledge not only in the service of science, but also in the service of their fellow men.

I am also obliged to Frau Professor *Helfrich-Förster* of the University of Regensburg for addressing one of the lectures today. I realize, how short in time she is and appreciate her spontaneous acceptance, when I asked her to give this lecture.

Many students and scientific grandchildren of Bünning are also musically talented, perhaps a byproduct of rhythmicity, Bünning's main field of interest. I am glad, that Dr. *Jürgen Mack* from Kusterdingen will play with his acoustic guitar blues in New-Orleans-Style.

I am thankful to Ilse Franklin for informations, help, and the translation of the French article of Professor Baillaud. Thanks to Baillaud for his kindness, to

¹abbreviations used in this book: *BBSRC* Biotechnology and Biological Sciences Research Council (UK); *BMBF* Federal Ministry of Education and Research (Germany); *Caltech* California Institute of Technology; *CERN* European Organization for Nuclear Research; CD compact disk; *DFG* German research association (Deutsche Forschungsgemeinschaft); *EMBO* European Molecular Biology Organization; *ETH* Eidgenössische Technische Hochschule; *ESA* European Space Agency; *ESRS* European Sleep Research Society; *EU* European Union; *FU* Free University (Berlin); *IPK* Institute for Plant genetics and cultivated Plant Research; *JSPP* Japanese Society for Plant physiology; *JSPS* Japan Society for the Promotion of Science; *MPI* Max Planck Institut; *NATO* North Atlantic Treaty Organization; *NSF* National Science Foundation; *NPK*: nitrogen, phosphate, potassium; *O.M.S* Office Militaire de Securite; *PhD* Doctor of Philosophy; *SFB* Sonderforschungsbereich (Special Research Field); *SNF* Swiss National Science Foundation; *USDA* United States Department of Agriculture; *ZMBP* Center for molecular Biology of Plants

3 Birthday celebration

tell us about his time in Tübingen. Likewise I thank Professor Masashi Tazawa from Japan for his report on Bünning. Thanks also to the botany institute for the rooms which we can use today, and help of Professor Harter, Herr Steinmetz, and the workshop of the institute.

We arranged a small exhibition on Bünning in the big lecture hall of the botany institute with books of and about Bünning, interesting articles, pictures, special events, three reports of excursions to Lapland, which were kindly made available by Inge and Ulf Haury in Lauffen. A movie on a Lapland excursion will be shown. Herr Plesse, author of the book *Erwin Bünning* (Plesse, 1996), has send me a poster show on Bünning, which is also displayed. He could unfortunately not come to the anniversary.

There will probably be a number of inputs and add ons during the evening. At least from Ilse Franklin I know, that she will tell us at first hand something about her father, from Rudolf Gunst, who will recite a poem, and of a choral group. In any case I believe, that this kind of celebration Bünning would have enjoyed more than a formal laudatory which I or somebody else would have held, and I think, that you would agree.

We had planned that we would present a short overview of Bünning's travels to Indonesia, in the salt deserts of Pakistan and India, and in the Chittagong Hill Tracts, and Ulrich Seitz offered to do that. Many thanks, Ulli. However, he was realistic enough to see, that the time for it would be too short besides the two ceremonial lectures. You will find Bünning's reports and some extracts in the exhibition and in chapter 7.

After the lectures around 19:00 o'clock there will be a light meal and drinks available. Food is free, for the drinks you should pay.

3.2 Speech of Charlotte Helfrich-Förster, Regensburg

And now I would like to introduce Frau **Helfrich-Förster**, who will give the first talk. Charlotte Helfrich-Förster comes from Swabia and attended the secondary school from 1967 until 1976 in Stuttgart-Feuerbach and in Leonberg. She studied from 1976 until 1982 Biology at the University of Stuttgart and Tübingen. Her diploma and doctoral work about *the circadian system of flies* was done in my team. From 1981-1986 she designed at the institute for Chemical plant physiology educational books on *"Biological principals of Ecology"*. 1984 she worked for two month in the institute of zoophysiology at the University of Warsaw with Cymborowski, 1986-1987 in Tübingen as a postdoctoral in a DFG-project on *rhythmic form changes of a marine unicellular*.

In 1985 and 1987 her children were born, so that she had to interrupt her research from 1988-1991. With a grant *for re-entry of the Hochschulsonderprogramm II des Landes Baden-Württemberg* she continued her studies with a project for the localization of the locomotor activity oscillator in *Drosophila melanogaster* from 1992-1993.

At the zoology institute of the University of Konstanz she learned 1992 immunohistochemical methods and at the pharmacology institute of the University of Barcelona she became acquainted with simulation models.

3.2 Speech of Charlotte Helfrich-Förster, Regensburg

From 1994-1995 she worked at the MPI for biological Cybernetics in Tübingen with Professor Kirschfeld on *The effect of anesthetics on the spontaneous activity of pyramid cells in the neocortex of the rat* and with Professor Götz on *The role of mushroom bodies in the circadian system of Drosophila*.

1996-1997 she obtained a Research grant of the DFG for *characterizing circadian pacemaker neurones in the brain of Drosophila melanogaster*.

1998-2000 Frau Förster held a habitation position in the frame of the Margarete von Wrangell program of Baden-Württemberg at the institute for zoophysiology in Tübingen. 1999 she obtained the *Venia legendi* in Zoology.

Since 2001 Charlotte Förster holds a *C3-Professur for zoology* at the University of Regensburg and is since 2003 the acting director of the zoology institute.

Charlotte Förster was and is intensively engaged in the training of students. She was involved from 1986 until 2000 in the graduate student college “*Neurobiology*” by the DFG, 1996 until 2002 in the focal program “*Functional and adaptive mechanisms of circadian systems*” by the DFG and participates since 2002 in the graduate college of the DFG “*Sensory Photoreceptors in Natural and Artificial Systems*” at the University Regensburg. Since 2006 she is involved in the *Euclock* program of the EU.



Figure 3.1. Charlotte Helfrich-Förster receives in 2005 the Aschoff-Honma-Price

Charlotte Förster obtained a number of awards, such as in 1986 the *Attempto-Price* of the University Tübingen for her *neurobiological research*. 2003 the *Price Aschoffs Rule* was given to her. In November of the last year she got in Japan the *Aschoff-Honma Price for chronobiological research* (see figure 3.1).

Bünning himself was engaged with daily rhythms in animals. Already in 1936 he published a paper on rhythmic eclosion of *Drosophila* flies out of the pupal case. Charlotte Förster will speak today on the topic

The physiological clock - Bünning's theses and chronobiology today.
A short summary of her talk follows.

3.2.1 Summary of the talk of Charlotte Helfrich-Förster

The physiological clock -Bünning's theses and chronobiology today-

Here is a short summary of the lecture with some references. The slides shown are compiled in chapter 3.2.2. In the following

(●) means: Bünning's theses

(-): what he and others found

- All organisms possess an internal clock (page 20, figure 10).

3 Birthday celebration

- “On the basis of the known facts it is likely, that all animals and all green plants including the unicellulars among them possess a circadian rhythm.” (Bünning, 1977), (page 20, figure 11)

Examples for internal clocks in plants (page 20, figure 2 and 3), fungi (page 20, figure 4 and 5), mammals (figure 6) and insects (figure 7-9) are shown.

- “It might be questionable, whether this is true for all fungi.” (Bünning, 1977)

- “Circadian rhythms have often been searched in prokaryotes (bacteria and blue-green algae). Most of these efforts have been unsuccessful.” (Bünning, 1977)

In the meantime circadian Rhythms have been found also in blue-green algae due to seminal work of Takao Kondo (Kondo and Ishiura, 2000), page 20, figure 12-15. Most of their genes are here under their control.

- To inherit an internal clock has a selective advantage (page 20, figure 16).

- “Cyclic timing of organisms has such a high selective value, that they are found from primitive unicellulars up to the most developed vertebrates” (Bünning, 1977).

- “Errors concerning morning- or evening phases, the approaching spring or fall, the coming ebb or flood are deadly. Wearer of internal clocks, which are not synchronizable with the external world and are thus going wrong, have a reduced survival- and propagation probability” (Bünning, 1943)

The selective advantage of the diurnal rhythm was first verified in bluegreen algae (Johnson et al, 1998; Ouyang et al, 1998) (page 20, figure 17-18). Later it was shown, that *Drosophila* flies lacking an internal clock have significantly less progeny (Beaver et al, 2002) and ground squirrels without the circadian pacemaker center have a reduced chance of survival in the free nature as compared to “normal” animals (DeCoursey and Krulas, 1998). Last year the team of A. Millar showed, that even the daily clock of higher plants has a selective advantage. “clock mutants” of *Arabidopsis* have a reduced rate of photosynthesis, growth, and reproduction compared with wild-typical plants (Dodd et al, 2005).

- The endogenous daily rhythm has a genetic basis and is thus heritable (page 20, figure 20).

- “In the F_2 -generation the intermediary character stayed. There was no clearcut split up recognizable. These results suppose, that many genes are involved in the determination of the period length.” (page 20, figure 21)

In addition to these results of Bünning in bean varieties more recent results using *Drosophila* mutants are shown and the molecular mechanism of the circadian clock explained (Konopka and Benzer, 1971;

3.2 Speech of Charlotte Helfrich-Förster, Regensburg

Sehgal et al, 1994; Allada et al, 1998; Rutila et al, 1998; Price et al, 1998), (page 21, figure 23-25).

- The internal clock is temperature compensated (page 21, figure 26 and example figure 27).
 - “*The oscillator itself is a physical and not a temperature dependent chemical system*” (Bünning, 1959) (page 21, figure 28)
The oscillator of the blue-green algae consists of a system of the protein molecules KaiA, KaiB and KaiC forming complexes and using phosphorylations and functions even in a test tube. It oscillates at different temperatures at the same speed (Nakajama et al, 2005) (page 21, figure 29-30).
- Circadian oscillations are cell autonomous (page 21, figure 31).
 - “*It is known for long, that in plants even isolated leaves, parts of leaves, halved pulvini, isolated parts of petals and so on are able to display circadian turgor- or growth variations. Even in tissue cultures of plants the rhythm continues to run in a light-dark alternation, in continuous darkness or constant light*” (Bünning, 1977), there on page 35
 - Isolated and cultivated protoplasts of the bean pulvini show circadian oscillations in their volume (Mayer and Fischer, 1994) (page 21, there figure 32)
- Multicellulars possess a multi-oscillator system.
 - “*The higher organism has not just one or two clocks: It is a multi-oscillator system*” (Bünning, 1978), (Bünning, 1935) (page 21, figure 33, 34)
 - “*Multicellular plants do not own a control center, which is responsible for synchronous oscillations in the various organs. This is mainly the task of the light-dark change*”. page 35 in Bünning (1977) (page 21, figure 35, 36)
This has been shown in the meantime *in Arabidopsis* using a luciferase as a reporter gene (page 21, figure 37). Likewise different leaves of a plant (page 21, figure 38) or parts of a leaf, which are treated with a differing light-dark change and kept afterward under constant conditions, oscillate independently from the other leaf or the other leaf parts (page 21, figure 39).
 - “*Animals possess a control center in the brain, but this takes essentially only care for the manifestation of the Rhythm or for the synchronization between the individual autonomous clocks of the multicellular*” (Bünning, 1977), there on page 36 (page 21, figure 40).
The autonomy of the various circadian clocks has been demonstrated in the meantime in cultures of *Drosophila* tissue or organs (Plautz et al, 1997) (page 21, figure 41) and in fibroblasts of mice (page 21, figure 42).

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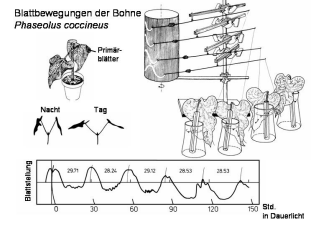



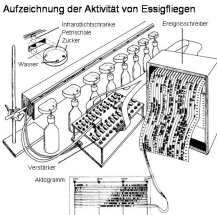
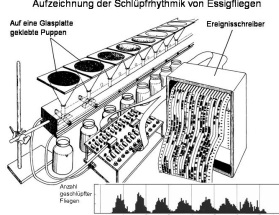
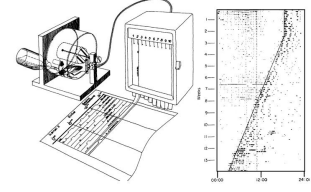
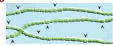

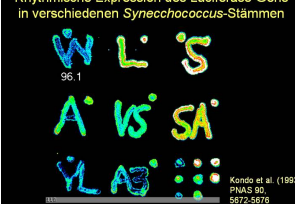
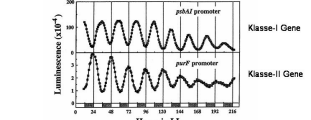
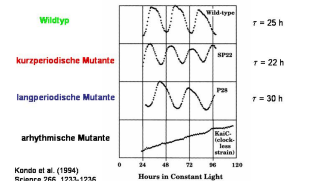
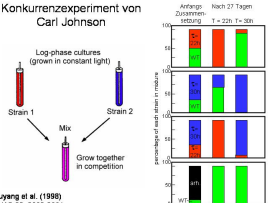
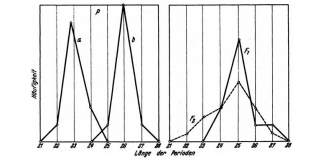
- Differences between plants and animals: In animals a control center in the brain steers the rhythmic behavior; the peripheral oscillators are not as important (page 22, figure 43). In the behavior (e.g. in the locomotor activity) internal desynchronization might occur (Wiedenmann, 1984) (page 22, figure 44). *Drosophila* as an example shows the same (page 22, figure 45-46). Localization of the controlling pacemaker cells see page 22, figure 47-50.
- The internal clock uses multiple photoreceptors (this was not included in my lecture for lack of time) (page 22, figure 51).
 - * There must exist a cellular photoreceptor:
 - “cryptic” blue light receptors (already postulated by Bünning, Zimmermann, Truman and Pittendrigh in the 1950ties);
 - 1993 discovered by Ahmad and Cashmore (1993) in plants and called cryptochrome;
 - 1998 identified by Stanewsky in *Drosophila* (Stanewsky et al, 1998);
 - 1999 found by Todo in mammals.
 - The various photoreceptors and their localization are demonstrated in *Drosophila* (page 22, figure 52-55).
- “*The circadian clock is not constructed for constant conditions. Instead, the clock was developed in such a way, that the synchronization with the rhythms in the environment can occur as easily as possible and that a physiologically optimal time relation is established between the different phases of the external rhythms*” (Bünning, 1986) (page 22, figure 56)

In the following the slides are arranged; the references listed in slide 24 are given here: Konopka and Benzer (1971); Bruce (1970); Feldman and Hoyle (1973); Ralph and Menaker (1988); Sehgal et al (1994); Vitaterna et al (1994); Kondo et al (1994); Millar et al (1992); Hicks et al (1996); Schaffer et al (1998); Allada et al (1998); Rutila et al (1998); Price et al (1998); Somers et al (2000); Toh et al (2001)

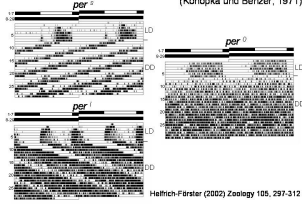
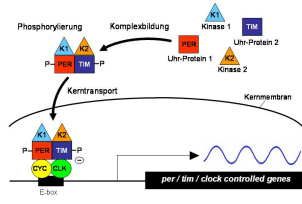
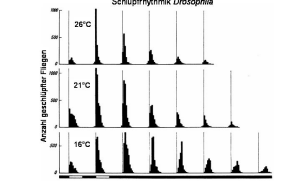
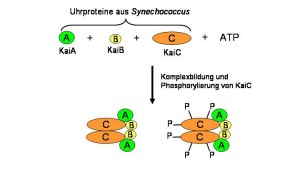
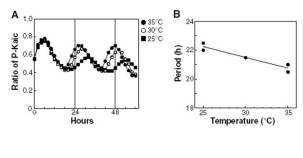
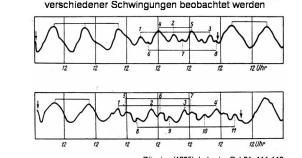
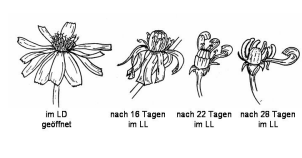
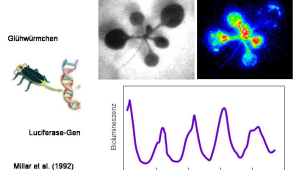
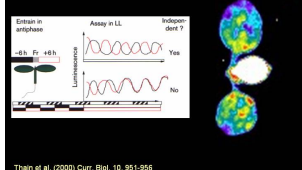
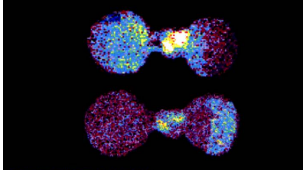
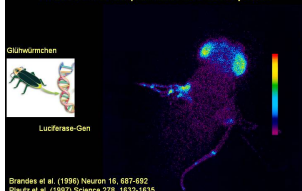
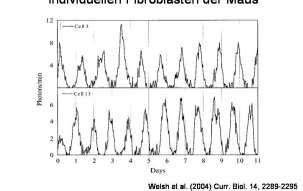
3.2 *Speech of Charlotte Helfrich-Förster, Regensburg*

3 Birthday celebration

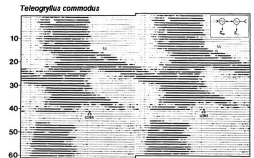
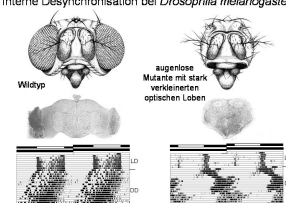
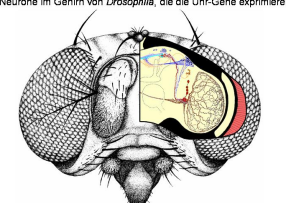
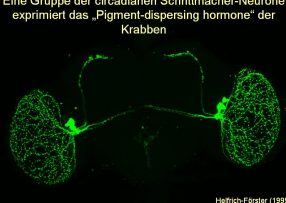
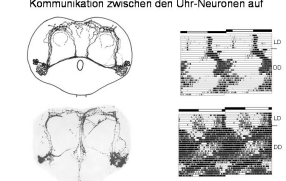
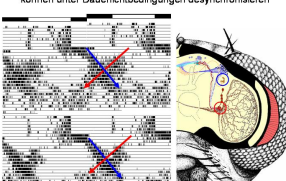
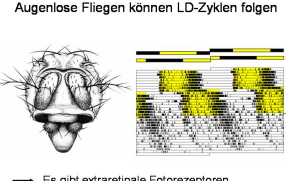
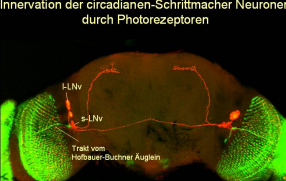
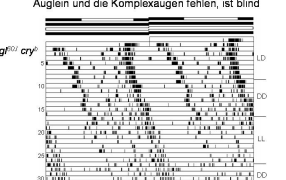
3.2.2 The slides of the lecture of Charlotte Helfrich-Förster

<p>Die physiologische Uhr</p>  <p>Bünning's Thesen und Chronobiologie heute</p>	<p>Entdeckung von circadianen Blattbewegungsrhythmen bei der Mimose durch Jean Jacques de Mairan (1729)</p> 	<p>Blattbewegungen der Bohne <i>Phaseolus coccineus</i></p> 	<p>1-3</p>
<p>Rhythmen in der Konidienbildung bei Pilzen</p> 	<p>Rhythmus in der Konidienbildung beim Brotschimmel <i>Neurospora crassa</i></p> 	<p>Aktivitätsrhythmen von Säugern</p> 	<p>4-6</p>
<p>Aufzeichnung der Aktivität von Essigfliegen</p> 	<p>Aufzeichnung der Schüpfrythmik von Essigfliegen</p> 	<p>Der Aktivitätsrhythmus einer Schabe (<i>Periplaneta americana</i>)</p> 	<p>7-9</p>
<p>Bünning's Thesen</p> <ul style="list-style-type: none"> Alle Organismen haben eine innere Uhr 	<p>„Aufgrund der jetzt bekannten Tatsachen muß es als wahrscheinlich gelten, daß alle Tiere und alle grünen Pflanzen einschließlich der Einzeller unter ihnen eine circadiane Rhythmik haben.“ „Zweifelhaft mag es sein, ob das auch für alle Pilze zutrifft.“ „Oft ist nach circadianen Rhythmen bei Prokaryoten (Bakterien und blaue Algen) gesucht worden. Die meisten dieser Bemühungen blieben erfolglos.“</p> <p>Bünning (1977) Die physiologische Uhr, S. 20</p>	<p>Viele Blaue Algen können molekulare Stickstoff fixieren</p> $N_2 \xrightarrow[\text{(Fe-Mo-Protein)}]{\text{Nitrogenase}} 2 NH_4^+$ <p>Nitrogenase ist empfindlich gegen Sauerstoff Photosynthese und N₂-Fixierung können nicht nebeneinander stattfinden</p> <ul style="list-style-type: none"> räumliche Kompartimentierung (N₂-Fixierung in Heterozysten) zeitliche Separierung (Photosynthese am Tag, N₂-Fixierung in der Nacht) 	<p>10-12</p>
<p>Sichtbarmachen der Transkription des Photosynthese-Gens <i>psbA I</i> durch Luciferase</p>  <p>Ein Reporter-Stamm von <i>Synechococcus</i> (PCC 7942) wurde generiert, der das Luciferase-Operon <i>luxAB</i> des Bakteriums <i>Vibrio harvey</i> unter der Kontrolle des Promotors des Photosystem II Gens <i>psbA I</i> exprimiert</p>	<p>Rhythmische Expression des Luciferase-Gens in verschiedenen <i>Synechococcus</i>-Stämmen</p> 	<p>Zufällige Insertion des <i>luxAB</i> Operons ins Genom von <i>Synechococcus</i></p> <p>800 Klone mit deutlicher circadianer Rhythmik wurden gefunden Jedes Gen von <i>Synechococcus</i> scheint unter circadianer Kontrolle</p> <p>Die Rhythmen hatten ähnliche Perioden, aber unterschiedliche Phasen</p> 	<p>13-15</p>
<p>Bünning's Thesen</p> <ul style="list-style-type: none"> Alle Organismen haben eine innere Uhr Der Besitz einer inneren Uhr hat einen Selektionsvorteil 	<p>„Zyklische Zeitmeßvorgänge der Organismen haben einen so hohen Selektionswert, daß sie von primitiven Einzellern bis zu den höchstentwickelten Wirbeltieren weit verbreitet sind.“</p> <p>„Irrtümer über Morgen- oder Abendphase, über herannahenden Frühling oder Herbst, über kommende Ebbe oder Flut sind tödlich. Träger nicht mit der Außenwelt synchronisierbarer, also ihr gegenüber falsch gehender innerer Uhren haben ein geringere Überlebens- und Fortpflanzungswahrscheinlichkeit.“</p> <p>Bünning (1943) Naturwiss 31, 493-499</p>	<p>Stämme mit stark abweichender Periodenlänge bei <i>Synechococcus</i></p> 	<p>15-18</p>
<p>Konkurrenzexperiment von Carl Johnson</p> 	<p>Bünning's Thesen</p> <ul style="list-style-type: none"> Alle Organismen haben eine innere Uhr Der Besitz einer inneren Uhr hat einen Selektionsvorteil Die endogene Tagesrhythmik hat eine genetische Basis und ist damit erblich 	<p>Kreuzung von Bohnen mit unterschiedlicher Periodenlänge</p> 	<p>19-21</p>

3.2 Speech of Charlotte Helfrich-Förster, Regensburg

<p>„In der F₂-Generation blieb der intermediäre Charakter erhalten. Es war keine klare Aufspaltung erkennbar. Nach solchen Ergebnissen kann vermutet werden, daß viele Gene an der Determination der Periodenlänge beteiligt sein können.“</p> <p>Bünning (1935) Jahrb wiss Bot 81, 411-418</p>	<p>Die <i>period</i> Mutanten von <i>Drosophila melanogaster</i> (Konopka und Benzer, 1971)</p>  <p>Helfrich-Förster (2002) Zoology 105, 297-312</p>	<p>Rhythmusmutanten</p> <ul style="list-style-type: none"> • 1971 <i>period</i> Mutanten von <i>Drosophila</i> (Konopka and Benzer, PNAS 68) • 1972 <i>w</i> und <i>Lo</i> Mutanten von <i>Chlamydomonas</i> (Bruce, Genetics 70) • 1973 <i>Reaper</i> Mutanten von <i>Neurospora</i> (Feldman and Hoyle, Genetics 75) • 1982 <i>tau</i> Mutanten von <i>Mesorhynchalis</i> (Ralph and Menaker, Science 241) • 1984 <i>timeless</i> Mutanten von <i>Drosophila</i> (Gehrig et al., Science 263) • 1984 <i>clock</i> Mutanten von <i>Mus</i> (Matsuda et al., Science 284) • 1984 <i>Kai</i> Mutanten von <i>Synechococcus</i> (Kondo et al., Science 286) • 1985 <i>Evening</i> of <i>rab</i> expression Mutanten von <i>Arabidopsis</i> (Miller et al., Science 267) • 1988 <i>early-flowering 2</i> Mutanten von <i>Arabidopsis</i> (Picks et al., Science 274) • 1988 <i>later elongated hypocotyl</i> Mutanten von <i>Arabidopsis</i> (Schaffner et al., Cell 93) • 1988 <i>clock</i> Mutanten von <i>Drosophila</i> (Alada et al., Cell 93) • 1988 <i>cycle</i> Mutanten von <i>Drosophila</i> (Rüla et al., Cell 93) • 1988 <i>double time</i> (<i>dbl</i>) Mutanten von <i>Drosophila</i> (Price et al., Cell 94) • 2000 <i>zeitlupe</i> Mutanten von <i>Arabidopsis</i> (Somers et al., Cell 101) • 2001 <i>period</i> (<i>familial advanced sleep syndrome</i>) Mutanten von <i>homo</i> (Yoshida et al., Science 291) 	<p>22-24</p>
<p>Die Basis circadianer Oszillationen</p>  <p><i>per / tim / clock</i> controlled genes</p>	<p>Bünning's Thesen</p> <ul style="list-style-type: none"> • Alle Organismen haben eine innere Uhr • Der Besitz einer inneren Uhr hat einen Selektionsvorteil • Die endogene Tagesrhythmik hat eine genetische Basis und ist damit erblich • Die innere Uhr ist temperaturkompensiert 	<p>Bei Temperaturen zwischen +10°C und +30°C sind die Oszillationen in ihrer Periodenlänge temperaturunabhängig</p> <p>Schlüpfrythmik <i>Drosophila</i></p> 	<p>25-27</p>
<p>„Der Oszillator selbst ist ein physikalisches und kein temperaturabhängiges chemisches System“</p> <p>Bünning (1959) Nova Acta Leop N. F. 143, 179-194</p>	<p>In vitro Ansatz</p>  <p>Nakajima et al., Science 2005</p>	<p>Die Phosphorylierung von KaiC erfolgt circadian rhythmisch und ist temperaturkompensiert</p>  <p>Nakajima et al., Science 2005</p>	<p>28-30</p>
<p>Bünning's Thesen</p> <ul style="list-style-type: none"> • Alle Organismen haben eine innere Uhr • Der Besitz einer inneren Uhr hat einen Selektionsvorteil • Die endogene Tagesrhythmik hat eine genetische Basis und ist damit erblich • Die innere Uhr ist temperaturkompensiert • Circadiane Oszillationen sind zellautonom • Vielzeller besitzen ein Multiozillatorsystem 	<p>„Es ist lang bekannt, daß bei Pflanzen auch isolierte Blätter, Blattteile, halbierte Blattgelenke, isolierte Bruchteile von Blütenblättern usw. noch circadiane Turgor- oder Wachstumsschwankungen zeigen können. Sogar in pflanzlichen Gewebekulturen läuft die Rhythmik im LD, DD, oder LL weiter“</p> <p>Bünning (1977) Die physiologische Uhr, S. 35</p> <p>Isolierte und kultivierte Protoplasten aus dem Bohnengelenk zeigen circadiane Oszillationen im Volumen</p> <p>Mayer und Fischer (1994) Chronobiol. Internat. 11, 156-164</p>	<p>„Der höhere Organismus hat nicht ein oder zwei Uhren: Er ist ein Multiozillatorsystem.“</p> <p>Bünning (1978) In: Arzneimittelforschung 28(II), 1811-1813</p>	<p>31-33</p>
<p>„Der höhere Organismus hat nicht ein oder zwei Uhren: Er ist ein Multiozillatorsystem.“</p> <p>Bem Studium von Blattbewegungen können Überlagerungen verschiedener Schwingungen beobachtet werden</p>  <p>Bünning (1935) Jahrb wiss Bot 81, 411-418</p>	<p>Interne Desynchronisation der Blütenblätter innerhalb eines Blütenkorbens von <i>Cichorium intybus</i></p>  <p>Todd (1982) Z. Bot. 56, 1-21</p>	<p>„Vielzellige Pflanzen verfügen nicht über ein Steuerungs-zentrum, das für synchrone Oszillationen in den einzelnen Organen sorgt. Hierfür dient vielmehr in erster Linie der LD.“</p> <p>Bünning (1977) Die physiologische Uhr, S. 35</p>	<p>34-36</p>
<p>Arabidopsis: Die Luciferase als Reporter der rhythmischen Transkription des Photosynthese-Gens <i>Cab2</i></p>  <p>Miller et al. (1992) Plant Cell 4, 1078-1087</p>	<p>Experimentelles Design von Andrew Millar.</p>  <p>Thain et al. (2000) Curr. Biol. 10, 951-956</p>	<p>Auch innerhalb eines Blattes synchronisierten sich die Oszillationen nicht</p>  <p>Thain et al. (2000) Curr. Biol. 10, 951-956</p>	<p>37-39</p>
<p>„Tiere verfügen über ein Steuerungs-zentrum im Gehirn, aber dieses sorgt im Wesentlichen nur für die Manifestierung der Rhythmik oder für die Synchronisierung zwischen den einzelnen autonomen Uhren des Vielzellers.“</p> <p>Bünning (1977) Die physiologische Uhr, S. 36</p>	<p>Drosophila: Die Luciferase als Reporter der rhythmischen Transkription des Uhr-Gens <i>period</i></p>  <p>Brandes et al. (1996) Neuron 16, 687-692 Pfeutzi et al. (1997) Science 276, 1632-1635</p>	<p><i>period</i>-Biolumineszenzrhythmen in individuellen Fibroblasten der Maus</p>  <p>Weish et al. (2004) Curr. Biol. 14, 2289-2295</p>	<p>41-42</p>

3 Birthday celebration

<p>Unterschied zwischen Pflanzen und Tieren:</p> <p>Bei Tieren kontrolliert ein Steuerungszentrum im Gehirn das rhythmische Verhalten; die peripheren Oszillatoren sind hierbei nicht wichtig.</p>	<p>Auch im Verhalten (z.B. in der Aktivitätsrhythmik) kann es zur internen Desynchronisation kommen</p>	<p>Die circadianen Schrittmacher beider Gehirnhemisphären können durch unterschiedliche Beleuchtung intern desynchronisiert werden</p>  <p>Wiedemann (1983) J. comp. Physiol. 150, 51-60</p>	<p>43-45</p>
<p>Interne Desynchronisation bei <i>Drosophila melanogaster</i></p>  <p>Wildtyp augenlose Mutante mit stark verkleinerten optischen Loben</p>	<p>Neurone im Gehirn von <i>Drosophila</i>, die die Uhr-Gene exprimieren</p>  <p>Heiflich-Förster (2005) Neuron 48, 161-163</p>	<p>Eine Gruppe der circadianen Schrittmacher-Neurone exprimiert das „Pigment-dispersing hormone“ der Krabben</p>  <p>Heiflich-Förster (1999) PNAS 96, 612-616</p>	<p>46-48</p>
<p>Die augenlosen Mutanten weisen eine gestörte Kommunikation zwischen den Uhr-Neuronen auf</p>  <p>Heiflich-Förster und Homborg (1993) J. Comp. Neurol. 337, 177-190</p>	<p>Die dorsalen Lateralen und ventralen Lateralen Neuronen können unter Dauerlichtbedingungen desynchronisieren</p>  <p>Rieger et al., J. Neurosci. in press</p>	<p>Bünning's Thesen</p> <ul style="list-style-type: none"> • Alle Organismen haben eine innere Uhr • Der Besitz einer inneren Uhr hat einen Selektionsvorteil • Die endogene Tagesrhythmik hat eine genetische Basis und ist damit erblich • Die innere Uhr ist Temperaturkompensiert • Circadiane Oszillationen sind zellautonom • Vielzeller besitzen ein Multioszillatorsystem • Die innere Uhr verwendet multiple Fotorezeptoren 	<p>49-51</p>
<p>Augenlose Fliegen können LD-Zyklen folgen</p>  <p>— Es gibt extraretinale Fotorezeptoren</p> <p>Heiflich and Engelmann (1983) Physiol. Entomol. 8, 257-272</p>	<p>Innervation der circadianen-Schrittmacher Neuronen durch Photorezeptoren</p>  <p>Travis vom Hofbauer-Buchner: Auglein</p> <p>Heiflich-Förster et al. (2002) J. Neurosci. 22, 9256-9266</p>	<p>Es muss einen zellulären Fotorezeptor geben</p> <ul style="list-style-type: none"> • „kryptischer“ Blaulichtrezeptor (von Bünning, Zimmermann, Truman und Pittendrigh bereits in den 50-iger Jahren gefordert) • 1993 von Ahmad und Cashmore bei Pflanzen entdeckt und als Cryptochrom bezeichnet • 1998 von Stanewsky bei <i>Drosophila</i> identifiziert • 1999 von Todo bei Säugern entdeckt 	<p>52-54</p>
<p>Die innere Uhr von Mutanten, denen Cryptochrom, die H-B Auglein und die Komplexaugen fehlen, ist blind</p>  <p><i>g¹¹⁴ cry⁰</i></p> <p>Heiflich-Förster et al. (2001) Neuron 30, 249-261</p>	<p>„Die circadiane Uhr ist nicht für konstante Bedingungen konstruiert worden. Die Uhr wurde so entwickelt, daß die Synchronisation mit der Umweltrhythmik möglichst leicht erfolgen kann und daß auch die physiologisch optimale Zeit-Relation zwischen den einzelnen Phasen der Umweltrhythmik erreicht wird.“</p> <p>Bünning (1995) Naturwiss 73, 70-77</p>		<p>55-56</p>

3.3 Lecture of Anand D. Karve, Poona, India

For the second lecture I would like to introduce **Dr. Anand D. Karve** of the Appropriate Rural Technology Institute in Poona, India (figure 3.2²).

After getting his Bachelor of Science at the Poona University in the state Maharashtra he made his doctoral thesis as a stipendiary of the Alexander von Humboldt-Stiftung from 1956 until 1960 with Professor Bünning in Tübingen and returned 1961 to India. After several years as postdoc and lecturer at various universities in India he was from 1964 until 1966 head of the botany institute of the Shivaji University in Kolhapur, Maharashtra.

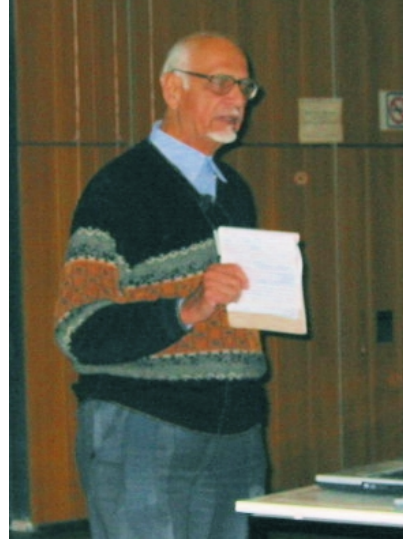


Figure 3.2: Anand D. Karve

Afterward Nandu Karve decided to use his knowledge in natural sciences and technology for the battle against poverty in the third world. He was from 1966 until 1984 director at the Nimbkar Agricultural Research Institute in Phaltan, founded afterward the *Appropriate Rural Technology Institute* in Poona, which works for the improvement of the standard of living and quality of life of the rural population in India, and whose president he is. There technologies are developed for agriculture and forestry and for the rural craftsmen, which together with the available raw materials, water and energy can be applied. In this way villager might gain the same income as “white collar worker”.

He is director of various institutions and has more than 50 research- and development projects successfully conducted. He obtained numerous prizes and tributes, among them from the *United States Department of Agriculture*, the *Indian Science National Academy*, the *Ashden Award for Renewable Energy* 2002.

He was frequently in foreign countries, thus from 1980 until 1983 as a peanut expert in Burma, 1983 with support of the Alexander von Humboldt-Stiftung for 6 months at the Institute for Biology II of the Freiburg University, he gave lectures in 1999 at various German universities.

Dr. Karve has published more than 200 research papers and reports, over 250 popular articles, four books in Marathi, and 15 Video CDs, in which agricultural technologies are described, which he and his coworkers have developed.

His lecture is:

Burning dung with no reservations: Energy problems and solutions in India

²Pardon for the “Red Indian”. The original was too dark and in lighten it the red became dominant.

3 Birthday celebration

(see section 3.3.1)

After the lecture:

Thanks to Nandu, afterward discussion.

Cordial thanks to all, who contribute for the rest of the evening, especially the helpers for getting and preparing food.

3.3.1 Summary of the lecture of Karve, Poona

Burning dung with no reservations: Energy problems and solutions in India

A.D.Karve

Appropriate Rural Technology Institute, Poona, India

EMail: adkarve@vsnl.com

Overview:

Dung as fuel or fertilizer?

Dung serves in Africa, Asia and Latin America as fuel in household (caloric value 2600 kcal per kg). The textbooks say, Dung should not be burned, but used to fertilize the fields. To obtain energy as well as fertilizer, the biogas technology was introduced in India and China.

Disadvantages of this practice

Disadvantages for the user

- 40 kg dung per day are needed for a standard site. It produces only 250 g methane with a caloric value of 2750 kcal.
- 6 to 8 animals are necessary for it.
- The dung has to be mixed with 40 liter water
- In villages are no water pipes; the water has to be carried by woman from partly far away wells. During times of drought this is even more difficult.
- The site produces daily 80 liter sludge as waste, which has to be removed.
- The whole process takes 40 days.
- The site is therefore quite large with 3200 liter space for the digestible and 1000 liter gas. Very few households possess so much space.
- Because of the size the price is high (about 250 €), which is more expensive than a microwave oven.
- Methane from dung is too expensive: If the farmer sells 40 kg Dung as Dung cake, he earns 40 Cent. He uses in fact fuel, which costs more than the food.

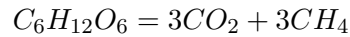
Fermentation technology

Methane and fermentation technologies

In the fermentation Technology normally molasses (i.e. sugar) is used as nutrient for the microorganisms. Methanogenic bacteria are not able to fermentize the dung directly. They need help of other bacteria, which produce acetic acid

from dung. Not till then the methane bacteria are able to produce methane, which takes about 40 days.

Methane production from sugar occurs in the following way:



and the reaction takes just one day instead of 40. 1 kg sugar produces 250 g methane. Would one use 1 kg dung (dry weight), one would obtain only 25 g methane (=440 kcal).

If sugar would be used as substrate, the efficacy would increase by 400.

The compact biogas system

The new biogas system is smaller (1000 liter) and cheaper (125 €). About 500 of these facilities are already in use. Each month 100 new ones are produced.

Sugar is, however, expensive. One can use additionally starch or cellulose (polysaccharides), e.g. spoiled food, overripe fruit, seeds of all plants, peels of banana, mango or papaya, non-eatable fruit, rhizomes, onions and so on.

India is the largest producer of non-eatable vegetable oils. The oil cake is toxic and used only as dung. It could be used also as a methane producer.

Green leaves of all plants, including those, which can not be eaten by livestock, can be used.

Dung in agriculture

Symbiosis

Since the conquest of the land by green plants 500 million years ago exists a symbiosis between the soil microorganisms and the plants.

Minerals

The carbon demand of soil microorganisms is covered by fallen foliages, flowers and organic compounds solved in the guttation water. The mineral elements are retrieved by the soil microorganisms from the soil by solving them; this is an extracellular event. A part of these ions is taken up also by the roots of the green plants. Does the soil become impoverished by it? (Liebig's hypothesis of the chemical fertilization).

So called recommendations

For fertilizing with organic waste the farmers are recommended to use compost.

However:

Its nutritional value for the microorganisms is very low. The recommended amount of compost lies between 20 and 50 tons per hectare (shown by NPK analyses).

The reality

This portion costs more as chemical dung. Therefore the Indian farmer use hardly ever inorganic fertilizer.

The danger:

By the chemical fertilizer the natural symbiosis is disturbed. The soil loses its fertility.

Fertilizing with non-compostible waste

Experiments showed, that 25 kg per hectare of non-compostible organic material with high nutritional value are sufficient to lead to the same high crop as with the recommended amount of organic or chemical fertilizer. Thousands of

3 Birthday celebration

farmer use nowadays this method successfully. Most of them use sugar. But oil cake or green leaves can be used as well.

Usage of waste

saves oil!

India produces annually 600 million tons of agricultural waste and 200 million tons of dung. This biomass can supply gaseous, fluid and solid fuel, which together contain the same amount of energy as 700 million tons of coal.

India imports 70 % mineral oil. A large part of it can be replaced by agricultural waste.

Conclusion

Thus: Burn dung without hesitation!

3.4 Ilse Franklin-Bünning's contribution to her father's centenary celebration, 2006

It is now more than 50 years since we arrived in Tübingen. Up until then we had not had much contact with father³. And now we were all there in the large empty official residence reserved for the Director of the Botanical Institute of the University of Tübingen, actually a barely heatable apartment. We all slept in the ballroom, a magnificent hall boasting a high ceiling decorated with lovely stucco. Oma (our maternal grandmother) sent us practically all her furniture. Our parents slept in an old-fashioned matrimonial bed featuring a massive wooden frame. Us four children shared two beds. Our beds were far removed from our parent's bed and the room was divided by a huge curtain which father had put up.

In those times father could be very tired after his long working days and therefore actually slept very well. One night I woke up because I heard someone coming into the room. With "*Father, there is someone in the room*", I woke him. And, in the semi-darkness, he realized that someone was bending over him. Father leapt out of bed, grabbed his neck-tie, which he put on, and then, with his own father's walking cane, dressed in neck-tie and long dressing gown, raced after the intruder. He chased that fellow the entire length of the long corridor, through the Botanical Institute, down the stairs to the unlocked back entrance leading to the Botanical Gardens. He never did catch that intruder. Who could it have been?

As winter approached rats moved into our cellar. Father ignored those guests. But with Christmas on the way father was suddenly very busy. It was our first Christmas with father. He was so fond of Christmas trees that he exchanged some valuables for one. And in the large kitchen he was busy pulling candles. He also extracted syrup from turnips and even fermented this syrup to vinegar. The boiled turnips were cut into small pieces for salad – a change from our usual diet. Many of his travel souvenirs were transformed into bacon and eggs.

Oma had given us practically all of her remaining belongings, things such as cutlery and linens. She sewed a dress for me from her own house coat. In order

³because he was in the war

3.4 Ilse Franklin on her father Erwin Bünning

to knit woolens for my older brother and for her dear son-in-law (father), she unraveled her own woolens.

Father made soap, something which our rodent guests nibbled. In the new year father planted potatoes. My job was to eliminate the potato bugs.

Once father collapsed during a lecture; he hadn't eaten anything that day. Then, one day, the first package arrived, from Switzerland. These packages, full of chocolate, condensed milk, and real coffee, then arrived regularly. Leo Braun (he was assistant professor in Jena when our father was assistant there; when Braun was expelled by the Nazis (1933) our father helped him and his wife to escape from Germany and finally to a position as professor in Istanbul where he remained until well after the war) had arranged this. He had written to Jewish philanthropists in New York. They in turn sent money to a Swiss organization which then sent these packages to father. We were not supposed to eat all of the chocolates since they could be exchanged for eggs and butter. Sometimes father would give a chocolate bar to children we had brought home with us.

The garden behind the Botanical Institute ran as far as the Ammer⁴. This garden belonged to our official living quarters. Father pulled out all of those flowers which had grown so high, including those lovely red ones which had blossomed so magnificently in a large flower bed. The flowers were replaced with soy beans, something we could not stand. But neither could the night-time thieves who had no idea of their value and therefore left them alone. On the other hand, the hens which father kept in a stall were a prey for these " "friends" of ours.

Early in the morning we often watched father feed his chickens. Once my older brother woke me very early with "*You should see this.*" Father stood at a tree stump with a struggling chicken in his left hand. Horror-stricken and trembling, he was attempting to whack the bird's neck with a hatchet. I then traveled with that chicken to Cologne, accompanied by Herta Sagromsky⁵, and then on to Velbert and grandmother. This adventure was in a train compartment full of thread-bare people. "*Don't let that basket out of your sight*" said father at the Tübingen station. Herta never closed her eyes, even when sleep overwhelmed me. That trip was indeed very long.

Then father was suddenly off, accepting a lecture invitation from Sweden (Schweden). "*Well what is that?*" I asked. "*We are already here in Swabia (Schwaben)!*" Father returned from Sweden with presents for all and a hat on his head. Mother received fine stockings and a blouse; for me there was a sky blue dress. Actually I did not like that dress but I did not say so. Mother, on the other hand, found it just fine. With a much older father we did once talk about colors. Of the two plush pullovers I had sent him from Switzerland he preferred the dark red one over the light blue one. But mother found the light blue pullover better suited to him. In a careful, gentle manner he confessed to me "*Actually I also am not so fond of blue; you must have inherited this dislike from me since you almost never wear blue. Mother, on the other hand,*

⁴a tributary of the Neckar river

⁵a research associate of Prof. Bünning, later, 1961-1968, Professor at the Gatersleben Institute in the German Democratic Republic

3 Birthday celebration

wears blue well. So be it if mother likes it.” Indeed, he admitted that he liked subdued shades of orange best, those tending to rust brown, a range of colors he discovered on Sumatra in his younger days.

After the death of our elder brother in the Dolomites, father no longer talked about his first son. Perhaps it was meant for us not to feel less important. Often he silently stole away to the graveyard with mother. Evenings he often spoke of Otto, his second son. Otto was a young man who father always tried to help in a most generous fashion. He admired that boy’s call to the sea. “Yes”, he thought aloud, “if it had not been biology I would also have liked a profession at sea.” He certainly had no desire to be a businessman like his uncle nor a schoolteacher like his father. He had observed how exhausting a profession this had been for his dear father, so much effort with so little to show for it and so little comfort for his family. His father only bought books from time to time and little silver tokens for his wife, my father’s mother; that was his simple life. Until the end of his life our father talked about his good hearted father and his diligent mother, a woman who never complained, a fulfilled woman.

Thank you for your attention.

Ilse Franklin-Bünning⁶

3.5 Exhibition in the big lecture hall

On the desks in the big lecture hall are the following informations displayed:

3.5.1 Informations about Bünning

1. Curriculum vitae in form of a table (see section 4)
2. Bünning’s article from the Annual Reviews of Plant Physiology ([Bünning, 1977a](#))
3. Bünning’s address on the occasion of the honorable handover of the rectorship at the begin of the summer term on the 8th of May 1953 (see section [5.2](#))
4. Bünning’s traveling (see section 7)
5. Speeches at round birthdays of Bünning (see section 5)
6. Bünning’s contributions to education (see section 6)
7. Obituaries (see section 8)

⁶Translated by Richard Franklin-Bünning, Basel 2018; alternative title: To my dear father Erwin Bünning at his centenary celebration - vignettes from the earliest days in Tübingen to his days there

3.5.2 **Presentation boards by Plesse**

Erwin Bünning 23.1.1906 - 4.10.1990:

Facets of his personality and his actions

... Not only the physiological clock has stirred him ...

Plesse⁷ has illustrated the following stations of Bünning's life with photographs and text:

1. Studies in Berlin and Göttingen
2. Assistant time in Jena
3. Königsberg
4. Strasbourg
5. Köln
6. Tübingen
7. Excursions and Traveling of Bünning to Indonesia
8. to Pakistan
9. to India
10. to Lapland (photographies by Haury and Hetzer)

⁷he is the author of the Bünning monograph [Plesse \(1996\)](#)

4 Bünning-data

4.1 Curriculum vitae

- 23.1.1906 born in Hamburg
- 1925 school in Hamburg, Albrecht-Thaer Oberealschule, Holstentor
- fall 1925 school leaving examination
- 1925-1928 studies at the University in Berlin and Göttingen
- 1928 graduation, afterward state examination in Berlin
- 1928-1929 scholarship of the “Notgemeinschaft der Deutschen Wissenschaft”,
Institute for physical foundation of Medicine (Dessauer), Frankfurt (Main)
- 3 Mo 1930 scholarship Botany Laboratory at the University of Utrecht, Netherlands (Went)
- 1930-1931 assistant of Renner, Botany Institute Jena
- 1931 habilitation (qualifies for professor)
- 1931-1935 assistant professor Botany Institute Jena
- 1935-1938 *Diätendozent* University of Königsberg
- 1938-1941 applied professor University of Königsberg
- 1938-1939 research journey to Java, Sumatra
- 1939-1945 military service
- 1941-1945 associate professor University of Strassburg
- 1945-1946 full professor University of Köln
- 1946-1971 full Professor, Botany Institute of Tübingen
- 1947 dean of the Natural Sciences Faculty
- 1948 guest lectures in Sweden
- 1949 guest lectures in Great Britain
- 1949-1950 guest lectures in Pakistan
- 1951 first Lappland excursion from Tübingen
- 1951,1953 journeys to Indonesia and Ceylon
- 1952-1953 vice chancellor of the University of Tübingen
- 1953 declines call for Munich
- 1953 corresponding member of the Academy of Sciences in Göttingen
- 1953-1959 member of the Senat of the DFG
- 1954 member of the Leopoldina, Halle
- 1956 Editor of “*Planta*”, later in the editorial board, honorary editor
- 1957 Call to Göttingen declined
- 1957 honorary member of the Japanese botanical society
- 1958-1963 member of the science council, involved in reform proposals (1960)
- 1958 member of the Heidelberg Academy
- 1960 Chairmans address Cold Spring Harbor Symposiums on biological clocks
- 1961-1967 member of the founding commission of the University of Bremen
- 1964 member of the Bavarian Academy
- 1964 member of the New York Academy of Sciences
- 1964 corresponding member of the Botanical Society of America

4.2 Areas of interest and fields of work of Bünning and his students

- 1968 member of the National Academy of Science, USA
- 1971 Emeritus
- 1973 honorary member of the American Society of Plant Physiologists
- 1973 honorary doctor of the Juristic Faculty, University Glasgow
- 1975 guest professor in Canada
- 1975 honorary member of the Swiss botanical Society
- 1976 honorary member of the University of Erlangen
- 1976 honorary doctor of the University of Göttingen
- 1978-1979 guest lectures in Madras, India
- 1986 member of the Indian Academy of Sciences
- 4.10.1990 died aged 84 in Tübingen

4.2 Areas of interest and fields of work of Bünning and his students

Bünning's interest in biology was quite broad: physiology of stimulation, electrophysiology and membranes, plasma streaming, tissue cultures, plant hormones, chemotropism, phototaxis, phototropism, light perception, phytochrome, photomorphogenesis, furthermore photoperiodism, annual rhythms, circadian rhythms (cells, tissues, sleep movements, activity rhythms, chemical influences, inhibitors) and development, differentiation, pattern formation, regeneration, polarity.

He and his students used all forms of the living world such as prokaryotes (bacteria, cyanobacteria), algae (*Euglena*, *Chlamydomonas*, *Porphyra*, *Oedogonium*, *Acetabularia*, *Chladophora*, *Dictyota*, and others), fungi (*Aspergillus*, *Saccharomyces*, *Coprinus*, *Omphalia*, *Saprolegnia*, *Phycomyces*), mosses (Sphagnaceen) and ferns, higher plants (*Sparmannia*, *Tradescantia*, *Utricularia*, *Iris*, *Allium*, *Sinapis*, *Phaseolus*, *Mimosa*, *Glycine*, *Pisum*, *Xanthium*, *Chenopodium*, *Bryophyllum*, *Kalanchoe*, *Avena*, *Cuscuta*, *Cichorium*, *Populus*), insects (*Periplaneta*, *Pieris*, *Drosophila*) and higher animals (Hamster, Guinea pigs). See also the topics of the PhD theses published under the guidance of Bünning (see section 10.1).

5 Talks, articles of and about Bünning

5.1 Designation address at the occasion of the election of Professor Bünning as rector on the occasion of a torchlight procession on February 18, 1952

Highly respected Herr Professor!

The biologists and some of their annex did spare no effort and ways to congratulate you with our torchlight-like procession for your election as rector of our university. We beg you to apply *the* “*Ut desint vires, tamen est laudanda voluntas*” for our efforts.

Although you mentioned today in your lecture, when we plaudited you by especially intensive and long lasting knocking, almost reigniting: The laugh is always on the loser. We respect your opinion - at least at the moment. We would, however, stress, that the mental cause of our presence is by no means the carnival time, but for us biologists it is really a great and honest delight, to hear by the broadcast and by man to man talk, that a biologist will take the fate of our dear Tübingen *alma mater* in his hands in the next terms. On the one side we are proud to have you as our Magnificence, on the other side we are afraid - probably not without good reasons,

that your surely not too easy position will detach you from your work in our botany institute, but we will try to take comfort in the hope, that this distance is not an Indian distance, with other words: We hope confidently, that your high position will keep you at least for a year in our Tübingen. We biologists have never been such narrow-minded party followers, that we would not grant our university and with it our fellow students of other faculties some of it, what we ourselves estimate. We know you, honored Herr Professor, from the institute and predict with certainty from these our experiences, that under your rectorship the matters of our *civitas academica* will be steered in a solid and good route. Nobody will blame us, when we biologists hope a little bit, that your special affection applies to us.



Figure 5.1. Bünning as rector of the university of Tübingen

We wish you for your future work full success with a minimum of anger and believe, that you will gladly remember after your rector-ship this time full of beneficial work for our *alma mater Tuebingensis* and thus also for yourself.¹

5.2 Bünning's addressing talk during the ceremonial handing over of the rectorship at the begin of the summer term on the 8th of May, 1953

An academic year involves such an amount of questions, changes and duties, that it is difficult to select from it those, which give a certain impression of the diversity. Who, like me, had the opportunity, to gain some more insight in this diversity during a whole year, must be even more then the outsider impressed or almost astonished, that such an institution as the Tübingen University could survive successfully 475 years and thereby, as we believe, did not grow older. Of course, even an University does not stay unaltered. Even the image of the studentship is rapidly changing. The number of war participants, the older students, has declined rapidly. Whereas the average age of a student was 26 years in the first years after the war, it is now rapidly approaching 22 years, which will soon be reached. We see in the lecture halls nowadays again many young high-school graduates. We are glad about this development, although we clearly experienced, that the greater life experience was impermissible to overcome the after war problems.

Likewise the teaching staff underwent a continuous change. Several chairs had to be restocked ...

It is impossible, to give an impression of the scientific work done in the various faculties, the hospitals, institutes and seminars. It is in fact these works, which demand our accounts. That the University of Tübingen has continued to have strengthened its reputation, should be sufficient as proof ...

... demands of the universities ... Fulfillment of urgent building wishes and increase of the number of assistant positions ... The universities hospitals are partly very antiquated, and new buildings can not longer be delayed. The medical hospital will be newly build on the Schnarrenberg ... 17 million ... Later the university gynecological hospital and the neurology will be moved to the Schnarrenberg.

In the budget for 1952 the last rate for building the new institute of pharmacy and chemistry has been allowed for 1460000 DM. The institute can probably be used for the winter term 1953/54 ... a second rate for building the student house ... construction of the observatory of the astronomy institute ... new building of the institute ... expansion of the zoology institute ... new building of the seminar of the philosophy faculty ... expansion of the university library ... private allowances ... society of the friends of the University of Tübingen ...

Financial problems turned always up, if financial suffering students had to be helped. Of the about 4000 students of our university the fees of about 1000

¹Author unknown

5.2 Handing over of the rectorship

could be dispensed or reduced. We know, that this help was not sufficient. ... About 70 students were found to suffer under lung diseases, and many other diseases were diagnosed.

... the Mensa "*Prinz Karl*" could finally reopen again ...

The run to our university is still strong. However, a substantial change has occurred in comparison with the years after the war. Whereas we could account for not much more than 10% of the applications, we need to refuse now only about 15% of the candidates. For several academics restrictions are not necessary any more. Difficulties do still exist only in the mathematic-natural science and in the medical faculty ... We do hope strongly, that in 1 to 2 years the restrictions in applications can be dropped completely. We must try until then, to modernize our facilities to such an extend, that Tübingen will further be a center of attraction for the academic youth. ... We should thereby not forget, that -although most of our students come from Württemberg, more than 1/3 are from other parts of Germany. At least this proportion, and additionally the foreign country students can only be retained, if we give our best. Presently about 90 foreigners study at our university ... I believe, that the University of Tübingen can cope with its duties, if the number of foreigners is much larger ... We do by far not use the excellent chance, which we as a nation without colonies have. In the same way as our harbors are again the doors, through which the products of our technique are shipped to the whole world, the universities should become doors, through which the exchange of thoughts proceeds ...

Another problem of our university is, that the number of professors -as in all other German universities- does by far not correspond anymore the increased number of students. ... If we want to sustain our position in the future, we need a larger number of people with an academic training as we need in earlier centuries, in the same way as we need a larger number of technicians and skilled workers.

The discrepancy between the number of students on the one side and of professors and lecturers on the other side led to the situation, that we can't care enough for the scientific education. ... I want to point out the successful, but not sufficiently accredited work of the AStA² ... and its efforts in the frame of the academic self administration. The cooperation with the AStA will always be a nice memory ...

I hope, that my successor will find time and strength, to compensate for several of my neglects. A part of these neglects I beg to excuse, because I had my commitments for the institute and teaching obligations; both of it I could not dismiss completely. The Great Senate knows these concerns of a natural scientist well enough, since according to the statistic during the last 55 years only twice in half a century a member of the mathematic-natural science faculty was elected as a rector; and according to this statistic we have to expect again a rector from this faculty for the 500s anniversary of the university of Tübingen in 1977 ...

I ask you, honored Herr Kollege Wenke, to come to the catheter and take over

²Academic student association

the troublesome function ...³

5.2.1 Address to the outgoing rector Professor Bünning

Since I have received the Insignia of the rector dignity out of your hand, my first words shall be a thank you in the name of all my colleagues ... I personally have a special reason for this, since, what you have done for us, makes it much easier for me to meet the tasks, which I have to tackle. You acted with unostentatious objectivity and placed back all personal points even in those cases, where only your most personal decision turned the balance. ... You mentioned, that colleagues turned down calls from abroad. But you did not mention the names only, because you did not want to be forced to speak of yourself. In honoring your modesty, I might be allowed to complete this: Honorable calls received ... and the ordinary of botany Erwin Bünning by the University of Munich. For declining this call we are indebted our colleagues very much. Name and importance of a university do not only rely on the appointments of famous academics, but also by remaining approved masters for research and teaching ...

5.3 Bünning about Wilhelm Pfeffer

This introduction to a symposium in memory of Wilhelm Pfeffer held from June 3 and 5, 1987 in Blaubeuren, Germany is published in [Bünning \(1988\)](#).

It begins with: *We still appreciate the many great scientific achievements of Wilhelm Pfeffer (see figure 5.2) such as his researches on osmosis, chemotaxis of bacteria and lower plants, and on movements of higher and lower plants.*

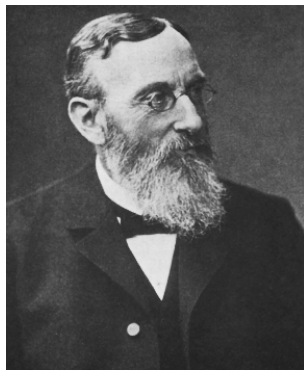


Figure 5.2: Wilhelm Pfeffer

Pfeffer was particularly fortunate to have been born at an opportune time. Had he been born earlier, he would have been considered by philosophers such as Friedrich Wilhelm Schelling (who was so appreciated in Tübingen) as “destroyers of natural sciences” along with Bacon, Newton and other founders of the modern natural sciences. According to Schelling, for example, it was an irrefutable fact that the gender would be the root of animals, the flower the brain of plants.

And it ends with:

Nowadays a lot of young people only help to enlarge a mediocre student body at our crowded universities. A few entered university with the help of a lawyer payed by a father with means. Given our present legislation, a gifted young man

³composed by Engelmann from: Annual report of the rector of the University for the rectorship year 1952/53, [Bünning \(1953b\)](#)

5.4 Addressing talk of Bünning at the Heidelberg Academy

like Pfeffer may just have ended up as an assistant in his fathers pharmacy once he had left school early, and he may not have become a professor of Botany in Bonn, Basel, Tübingen and Leipzig. A number of important scientists before the turn of the century would not have succeeded at our present universities where so much energy is wasted on petty lawsuits of no academic value.

5.4 Addressing talk of Bünning at the acceptance in the Heidelberg Academy of sciences 1957

According to the classification of biology, which is still valid at our universities, I am classified as a botanist (*Bünning as a lecturer see figure 5.3*).

I am not too happy about this denomination, because most of those, who are not familiar with the natural sciences, think of a plant lover, at best of a representative of systematics and floristic. With this statement I do not intend to denote this kind of botany as less valuable, and I can't even deny, to do more in lectures and at excursions, then to remind me, that just the occupation with the manifold of forms of the living nature, which is characteristic for systematics and floristic, led me already as a pupil to the biology. My actual work, however, developed from a combination of this enthusiastic interest in the multifaceted appearance of life together with the disposition towards abstract theorizing and causal analyzing. Philosophy, theoretical physics and mathematical logic did tie me at the begin of my studies for periods more than botany and zoology.

But coincidences parted me more and more from these interests, which my highest respect and adoration count for and in some respect still do. One of these coincidences was, that I was handed over in the botany course of the university an object with seismonastic movements. Stimulated by Kniep and Metzner this led to my doctoral thesis about such movements induced by agitation, and I started to become interested also in other movements of plants. Later it was mainly light induced movements.

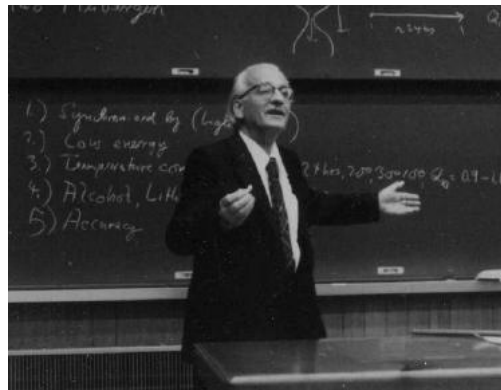


Figure 5.3: Bünning as a lecturer

As a lucky coincidence in the hapless getting stuck with biology I would regard the fortunate possibility soon after my promotion, to study at the institute for the physical basis of medicine in Frankfurt among others the diurnal leaf movement. The endogenous, that is physiologically self regulated daily rhythm of these movements seemed to me something, which is of a general interest in biology.

I looked for events, in which the diurnal cycles -running in analogy to a clock work- could be more important as those leaf movements. Thus I began to put my interest on photoperiodic reactions, the astonishing ability of plants and animals, to inform them self about the course of the seasons reliably by measuring the

length of the day exactly. To this area of my special scientific interest, i.e. the studies of the physiological mechanisms and the biological significance of “cellular clocks”, I may say, that just in recent times the importance of endodiurnal physiological oscillation has become visible for very different processes in plants and animals, especially for the behavior of animals, from simple developmental events up to the complicated phenomenon of sun navigation. I found also interest in physiological problems of development, especially the differentiation, and for the analysis of the order in time and space during development. Finally I had on several of my travels again and again the chance, to spend time on my youthful hobby of the non-laboratory botany. Two years stay in the tropics and subtropics of Asia, distributed in four journeys during the pre- and postwar years, offered the opportunities for it in the same way as excursions with students, which often brought me to Lapland.

Thus my doings have been -dictated by chance- a compromise between observing the manifold of nature phenomena in the organic world and the interest in the exact-theoretical. I am not unhappy about these chances, which gave my own life something of the variety of the biological objects, which confronted me with many problems of science and allowed me to get in contact with many of the researchers all over the world.

I should not forget to mention the external stations, which were for the course of my work in the same way decisive as my scientific interests. After my school time in Hamburg, the studies in Berlin and Göttingen, a temporary research period in Frankfurt and Utrecht I came in 1930 to Jena, where I habilitated in 1931 under Renner. From 1935 until the begin of the war I was lecturer in Königsberg. There I was drafted at the begin of the war and had to stay in military service until the end of the war, with a short interruption in connection with a call for an extra ordinariness in Strasbourg. After the war I was for a short time ordinary at the University of Köln and stayed from 1946 onward in Tübingen.⁴

5.5 Berthold Schwemmler: A Henlein of the “physiological clock”

Honored by a colloquium of the faculty of biology, Professor Erwin Bünning, director of the Botany Institute of the University of Tübingen, was yesterday 70 years old. Only this number forces us to believe it! Because - although emeritus since five years - we see him each day in the institute as an attentive observer of the university scene, as a critical listener in colloquia, and especially as an active editor of journals. On his 65th birthday the members of the faculty biology and his friends gave him a torch light procession and thanked him in this way for his work in and outside of the university. He published not only several original papers and reports, but also and especially a book in the series “Great Natural Scientists” a book on Wilhelm Pfeffer, one of the fathers of plant physiology, the ideas of whom he developed further and decisively, and who was one of

⁴Reprint of the Jahresheft 1957/58 der Heidelberger Akademie der Wissenschaften (Bünning, 1957a). Identical with the text, which was reprinted in Bünning (1966)

5.5 Berthold Schwemmler: A Henlein of the “physiological clock”

his predecessor on the Botany chair in Tübingen. In addition, he was a guest professor in Canada, thus a true “active retirement”.

During the celebration of the 70th birthday the various sections of life might lose their importance, they were also at earlier occasions appreciated in this newspaper. Therefore I remind briefly, that Erwin Bünning was promoted in 1928 after only 7 terms in Berlin, that he was habilitated already three years later in Jena, and that his way led him via an extraordinary in Königsberg and Strasbourg as an ordinary in Köln. Already one year later he was called to the chair in Tübingen which is rich in tradition by predecessors like Hofmeister, Pfeffer and Vöchting. Under him the first new natural science building on the “Wanne” was planned and constructed, the Institute for Biology I, in which the Botany moved at the end of 1967; The old institute on the Wilhelmstraße next to the Neuen Aula was much too small for quite some time. He belonged for several years to the Science Council and was leading in the reform proposals of this committee. He initiated the installation of separate chairs for genetics and microbiology besides the classical chairs in the biological fields.

After the last war, which interrupted all connections, and which Bünning had to pay toll as an airplane observer, he was among the first, who reanimated the relations to foreign countries with all consequences of mutual informations. Already in 1948 he gave lectures in Stockholm, 1949 in England, in Switzerland and in Pakistan. His colleagues and the generation of his students, some of whom obtained chairs, witnessed this and did not forget it!

His drive in distant countries belongs to the characteristics of Bünning, perhaps the consequence of his origin from Hamburg? His excursions to Lapland are even today still a solid “institute inventory”, he traveled several times to Indonesia, India, Ceylon and Pakistan; he was in Australia and North America. As the result of his travels in the tropics arose a small book of him with exciting reports and many ecological considerations. He brought back from these journeys also a large herbarium and a rich stock of pictures, which he used to illustrate his lectures enormously.

To describe Bünning's scientific work on polarity and determination, of movements in plants and its control up to the “*physiological clock*”, this basic phenomenon of the living protoplasm in short is sheer impossible. His importance for the development of botany and its stand today is proofed clearly by the numerous inland and foreign academies and scientific societies, which elected Erwin Bünning as a member or honorary member. Although being ill-disposed towards such appraisals, he has to put up with the remark, that he has prompted almost hundred PhD thesis which were done in Tübingen, and his own publications with up to 250 titles. The papers which were motivated by his work and ideas in his students who continued to work in science and those of their coworkers, and furthermore in researchers all over the world who cite Bünning's papers goes into the thousands.

In a week the biology faculty of the University of Freiburg will add another scientific tribute by awarding him the honorary doctor of natural sciences. This complements the Honorary Degree of Doctor of Laws (!) he received in 1973 from the University of Glasgow in Scotland and above all the Dr. phil., which Erwin Bünning earned in Berlin. At that time there did not yet exist mathematic-

natural science faculties allover, compared to Tübingen, where already for more than hundred years (1863) such a faculty was founded; the botanist Hugo von Mohl was its first dean. In this way Bünning will finally get a natural science doctor degree!⁵ ⁶

5.6 Wolfgang Haupt: The Tübingen school

Lecture of Prof. Wolfgang Haupt 1990 in Freiburg at the occasion of the 60th birthday of Hans Mohr. Extracts concerning Bünning and Tübingen.

... This similarity was not confined to place and time, but meant mainly, what could be termed "*Tübinger Atmosphäre*" or expressed more factually: as the "*Tübinger Schule*" ...

Humans are especially during the youth coined by contacts with outstanding personalities. ... I was lucky enough, to get to know and estimate all these personalities, most intensively of course our common doctor father Erwin Bünning, honorary doctor of the universities of Freiburg and Erlangen. I was coined by him in the same way as Hans Mohr. He was for us, what I call the "*Tübinger Schule*".

I would like to bring closer to you the teacher-student relation, which we both had by telling you a few of my own experiences. ...

We learned autonomous scientific work ... from Bünning, when we made our qualification at the end of our studies. The guidance was directed not so much towards scientific working, but more autonomy, which we should learn; exactly this was the distinguished character of Bünning as an academic teacher, to give his candidates complete autonomy. But this was also obligatory; the given freedom had to be used as well as possible and had to be realized - this is what he just expected from us. He came very seldom in our laboratory, but was always available for us, if we needed it. I said "*always*", because Bünning did not have consultation hours, which we had to follow or for which we had perhaps even to apply for before. That was in other institute completely different and can nowadays hardly be realized again.

How did one obtain from Bünning a theme for a state examen- or PhD thesis? ... In 1950 was the time, in which photoperiodism and thermoperiodism in seed germination should be placed on a broader basis. Thus Bünning told one of my fellow students: "*why don't you heat up seeds in the hot-air cabinet to 110°C and let them germinate; perhaps something interesting happens*". Not more. It resulted in a nice doctoral thesis, and you all know probably the successful PhD candidate from the radio or TV: Ernst Waldemar Bauer. He is at the same time an example, that a specialization under Bünning did by no means determine the future road of life.

How was it in my case? I expressed my interest in photoperiodism and/or endogenous rhythm, as the physiological clock was called at that time. Bünning

⁵Erwin Bünning at the occasion of his 70th birthday, Schwäbisches Tagblatt January 24th, 1976 by Berthold Schwemmler; he got his PhD under Bünning in 1953 and was Professor at the Botany Institute in Tübingen

⁶Peter Henlein, 1480-1542, was the first to produce pocket watches in Nuremberg around 1510

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allowed for it: based on a state examination thesis which had just been finished I was supposed to find out, whether the outflow of auxin from the leaves is controlled by the physiological clock. No hint for methods, extremely short mentioning of literature. I would certainly have gotten rich informations, if I would have asked - but one just did not ask, and least of all “*how do I do it*”; since it was supposed to be an *independent* work. . . .

After half a year I was threatened to fail . . . not before this crisis I asked Bünning for an advice, got it and could finish the state examen thesis. But I failed with the extension of this work for a PhD thesis, and I had to start with a new theme. Again the short way of Bünning: He handed me over a short note from the Swedish “*Botaniska Notiser*”, 2 pages with a table, according to which etiolated peas are able to form flower buds in complete darkness. “*Why don’t you look at this, you could perhaps cut off the cotyledon*”. Again I could develop my own ideas, whereby photoperiodism played a role, and again I had rather swallow my tongue than to ask Bünning for appropriate methods. After almost a year I was almost at the brink of loosing, the experiments did not seem to give enough hard data . . . In 2 or 3 talks Bünning guided me with a gentle hand, hardly noticeable for me, towards the path of success, and a quarter of a year later the work was finished. . . .

Then the assistant time followed. Here too I was completely free and independent. . . . twice in the term Bünning appeared for 10 minutes, and not for controlling me, but to turn up for the students, and at the end of the term all drawings had to be handed over to him. Bünning trusted his assistants almost completely, even the youngest, and I had to meet the challenge. I think, I could in this way fulfill my task with more responsibility, as if I would have been controlled daily, and if I could have given all discomfoting question th the Professor. But I learned also from Bünning, that it is not a shame, if one could not answer the question of a student, and that this is quite the contrary a very important part of the academic education. . . .

Thus my first term as an assistant for courses was extremely hard; in preparing the content I was just a few weeks ahead of the students, and this diminished to zero until the Christmas vacation. After the second course in the third term I was hoping to draw now on unlimited resources. Error; I had to change now to the Großpraktikum I (anatomy of higher plants), with the same problems as one year before, but with a bit more routine to cheat, if it was unavoidable. This was a hard education, but I do not want to miss it; and Bünning was probably not aware, that he has fulfilled such an important educational task. For him it was just self evident, that each assistant had to give his best for the community.

But the education for more independence continued. I could become familiar during two terms with this course, and I had just reached the begin of routine. But then the delegated teacher for microbiology fall out from one day to the next - at that time there was no chair. What had to be done? “*Herr Haupt, could you overtake the lecture and course in microbiology in the next winter term*”. For the first time I dared to object, that I have no hunch of microbiology. “*Then you could go for a few month somewhere else, perhaps in a foreign country; the DFG pays for it. Your colleague X. in the MPI was, for instance, at the Carlsberg Laboratory*”. I heard from this colleague, that Carlsberg is in Copenhagen, but

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had still not any idea, what was done there. I could finally apply for a training grant, from which I profited a lot. But still: The teaching of microbiology afterward was again a big challenge. . . .

The plant physiologist Bünning offered occasionally excursions for advanced students. That meant, that each of the participants had to prepare a special part, such as nature of the country, cultivation, vegetation, characteristic taxonomic groups; They were then on location experts and contact person for the co-students. The participants did in this way for sure profit more - or in other ways - as compared to conventional excursions. And the following was also passed to us by Bünning. "*Herr Haupt, I found in the Southern alps a valley, which you should visit with your trainees*". It was the start of a series of eventful and unforgotten Pentecost excursions . . .

A new step of education turned up, when at our time the *Handbook of Plant Physiology* by Ruhland occurred. Whereas most editors of volumes looked for the most prominent and most experienced representative of the specialist area as an author, Bünning entrusted his young assistances or lecturers important chapters or conveyed them to other editors of volumes. . . .

Bünning had always an open ear for constructive criticism, he even asked for it. That was at that time by all means not self-evident. . . . we proposed a physiological Großpraktikum, and Bünning gave the green light for it. As a first step a not too small part of physiology should be integrated into the anatomy course. Bünning took up these thoughts, and we could with him or for him and for us develop a concept and try it out. . . .

From Bünning we learned not only, that without ideas, precision in our work, diligence and perseverance one does not progress, but we learned also to see the essential. Examples for it have almost an anecdotal character: With somnambulistic certainty Bünning found the weak points of a student. I mean the "*somnambulistic*" literal; Bünning used to sleep during the seminar, if the student lectured too boring. But as soon as the presentation came to an end, he asked the decisive question, which hit exactly the weakest part of the talk. For example, a nowadays very prominent colleague was asked as a student, what Arachis oil is, out of which auxin is extracted. The student, instead of pointing to the peanut *Arachis hypogaea*, he answered quite naively: "*Well, it is a kind of salad oil*".

With the strong sense of the essentials was connected Bünning's demand for a short and concise way of expression in wording and writing, in which he agreed, by the way, with our distinguished zoologist Kühn. It happened, that he got 30 minutes for a congress talk, but that he declined and asked for 20 minutes only, to which he of course stuck to. Thus the common expression *short and sweet* (in German "*kurz und bündig*") was used by us as "*short and Bünning*". . . .

Although autonomy and the view for the essential was decisive for us - we learned something else from Bünning: Cooperation and coexistence. In the rather small institute in the Wilhelmstraße was besides Bünning also the extraordinary for special botany, Walter Zimmermann. . . . at the occasion of Zimmermann's 70th birthday Bünning would say "*Herr Zimmermann, we both have a sound desire to expand; in spite of it we went along with each other quite well*".

Scientific cooperation was at that time among us an almost unknown word.

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But in the botany institute in Tübingen it was already practiced. . . .

Bünning exemplified a keen sense of justice, unselfishness, and a personal modesty through his own life. What is nowadays self-evident for us, was at that time not always the case: The contribution of a coworker in a scientific work found always an adequate expression as a coauthor; and if the boss had the impression, to have contributed nothing essential, he abstained from having his name as a coauthor. . . . His sense of justice had also a material side: At that time the tuition fee was brought to account and the prominent university teacher possessed a guarantee for it. For Bünning it was as a matter of course, that each assistant, even the youngest, was participating in the tuition fee, if he had given a course on his own responsibility. And thus he transferred at the end of each term the corresponding share from his own tuition fee receipts.

We grew up quite liberal, and . . . tried to influence our students in the sense of our teacher, i.e. to pass on the spirit of Tübingen to the next generation. However, the liberty of a chief can also be miss-used or wasted in disqualified, and this could lead to quite annoying situations. Bünning too was not spared from it. . . .

Another important aspect of the education of a scientists is the responsibility towards the society. Bünning was at our time the most prominent and internationally esteemed plant physiologist in the German speaking part. He was actually too good to do administrative work and science policy. In spite of it he did not shut himself off the many honorary posts, which he was offered - I just mention the rector-ship and the work for many years in the science council. For him it was an obligation for a scientist, to act for and into the public, wherever he was asked for it; that he had to offer his specific competences and experience there, where it is of use for the common good of the society; that he pays an adequate tribute for the gift of the large academic freedom, which is afforded to the university teacher. He has, as far as I know, never lost any word about it, for him it was just a matter of course. . . .

You might in the meantime wonder, why I am not talking of the “*Bünning-school*”, but in general of the “*Tübingen Schule*”. Tübingen was at that time a center of natural sciences, in which much prominence had gathered. Outside of the botany institute were important for me mainly the zoologists Kühn and Weber, the biochemists Butenandt and Karlson, the physicist Kossel, and of course in the MPI Max Hartmann and Georg Melchers. . . . But there is another important aspect: The relation between the fellow students and later assistant colleagues; because this too is decisive for the atmosphere of a Schule. . . . I can't remember, that there was ever any jealousy or resentment, of somebody advanced faster than the other. There was thus no competition, and mutual help - especially before the examination, was a point of honor. This allowed the fruitful discussions, at which one could be unabashed “*stupid*”.⁷

⁷Wolfgang Haupt studied at the university of Erlangen and Tübingen, where he got his PhD under Bünning in botany. Since 1962 ordinary at the university of Erlangen

5.7 Poem for Erwin Bünning for his 80th birthday

According to the melody: Die Mary Ann, die ließ ihn nicht los⁸

Sie hieß Naturwissenschaft und war sein Schiff,
er hielt ihr die Treue, was niemand begriff,
über 60 Jahre aktiv und groß:
Die Naturwissenschaft, die ließ ihn nicht los ...

In Hamburg gebor´n, dem Tor zur Welt,
da hat er sich in ihre Dienste gestellt,
ist gewandert mit ihr von dort nach hier,
seit langem ist er Tübingens Zier.

Er führte Kommando als Rektor und so ...
Die Botany - ja - die war manchmal ein Zoo.
Vielfältigkeit, so hieß das Programm:
Und der Käpt´n der hielt das Ganze zusamm´.

Im Jahr 1936, da hat er´s formuliert:
und viele, die es hörten, die haben resigniert.
Von Mystik sprachen sie und Spinnerei,
Glasperlenspiel war auch dabei.

Die Jahre gingen hin, doch er blieb dabei.
Inzwischen ist die Rhythmik von Mystik frei.
Die Physiologische Uhr, ein Wertebegriff ...
Sie hieß Naturwissenschaft und war sein Schiff.

Er zog sich zurück, doch blieb immer am Ball:
Die Naturwissenschaft, die ist sein Fall.
Er schreibt und liest, reist inkognito ...
Schön, schön, sagen wir, und mach weiter so.

5.8 Hans Mohr: E. Bünning - not only the physiological clock has steered him

A few remarks and excerpts, which deal with Bünning and Tübingen from the talk of Prof. Hans Mohr, Freiburg, at the celebration of the 80th birthdays of Erwin Bünning (Mohr, 1987)⁹.

It starts with "To write down the appraisal of a prominent contemporary, is already quite difficult, particularly, if respect and reference does not allow a cool distanced attitude. To speak about the man, as he is sitting vitally and skeptically in front of one, is an adventure. I can only engage in it, because I

⁸Presented on January 23, 1986 in Tübingen-Hohenentrigen; author at present not known. Placed for disposal by Vera Hemleben. Not translated.

⁹Hans Mohr studied biology, physics and philosophy at the university of Tübingen. PhD in 1956 under Bünning, Postdoc in Beltsville at the Research Station of the U.S. Department of Agriculture under Hendricks. 1959 habilitation at the university of Tübingen, 1960 ordinary for botany at the university of Freiburg

know from experience, that Bünning respected a striving effort even then, if the result did not quite convince him". To praise Erwin Bünning is of course easy and nowadays without a risk. He is - for good reasons - a worldwide well known and respected person. His achievements as researcher and thinker earned him a high international reputation.

After mentioning Bünning's "Physiological clock", Mohr refers to other activities of him which founded his personal reputation: His engagement for the university and policy of science, his teaching, his editorial work, his reform proposals in the science council, his function in the senate of the DFG.

Mohr reminds us of Bünning being "an exceptional and prudent Doktorvater". He also points out, that his interest was not restricted to physiology, but that "His thinking roamed all the time in the boarder zone between science and philosophy". He cites a chapter of Bünning's famous book *Theoretische Grundlagen der Physiologie* (Bünning, 1945), where he elaborates on the topic of freedom: "The experience of freedom is for us ... connected to the same extent with the conviction of being true as is the recognition of the causal order. Each attempt to reconcile the experienced freedom with the causal order of nature is in vain. Such an attempt occurs if one seeks gaps in causality for the sake of saving the freedom, as well as if one rejects freedom by pointing out the airtight truth of causality ... The attempt to combine freedom and causal necessity to one concept of nature is in vain. We have to drop this attempt if we don't want to regard freedom as a misconception ... As rational beings we cannot abandon the idea of moral freedom because of ethical reasons, nor can we abandon the causal necessity if we pursue science."

From Bünning's textbook "Physiology of development and movements in plants" Mohr mentions, that he cites in the introduction a sentence of Schleiden from the "Grundzüge der wissenschaftlichen Botanik" of 1849, which describes Bünning's own conviction accurately:

"The noblest mission of Botany is, to sketch out for the general physiologies of organisms the simplest and most reliable fundamentals and thus to offer an essential contribution for expanding the fundamentals of this interesting and perhaps also most important discipline of science."

Mohr mentions three examples, which characterize Bünning's approach to scientific inquiry: simple, basically important, and (in principle) analyzable:

1. The pattern formation of multicellulars, for instance the trichoblast of many dicots, was explained by Bünning by a barrier effect, the incompatibility of embryonic loci.
2. The formation of primordia in the shoot meristem, decisive for the morphogenesis of plants, was explained by Bünning by inhibitory areas ("Nest of increased division rates"). This explanation is the only one which has prevailed.
3. Polarity: Bünning recognized the importance of the unequal cell division for the development of plants. He says, that "the polarity of the mother cell establishes the gradient, which is necessary for the inequality of the

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daughter cells, in which plasma and nucleus (in spite of the same gene outfit) behave differently.”

Mohr cites from a lecture note he has taken: *“Those, who are interested in developmental processes, have to take into account not only the physiology of gene transfer, gene nascence and gene alterations, but also the physiology of gene effects in the ontogenesis. Developmental physiology is mainly developmental genetics, and the genetics of the future will mainly be developmental genetics.”* and says: *“This is exactly what happened”.*

“What shall I say at the end - how shall I summarize the Laudatory?”

Bünning was stirred by a lot in his rich life. And he has stirred a lot; he left a broad trail in science; a trail, which will not vanish.”

5.9 Maroli K. Chandrashekar: Erwin Bünning – An appreciation

I am citing the start and a few more remarks of Chandrashekarans article ([Chandrashekar, 1985](#))¹⁰:

Professor Erwin Bünning will be eighty years old on January 23, 1986. For over fifty years now he has dominated the scene of biological rhythm research like a colossus. It is a singular tribute to the qualities of Bünning as a scientist and as a person that there will be no two opinions about the fact that he is *the* pioneer and doyen of the field that is today called chronobiology. Characteristically Erwin Bünning will be the first to disclaim this distinction. His favorite quotes as remembered by his students and colleagues are *“Pfeffer has done similar things nearly hundred years ago”* and *“most discoveries in science are only rediscoveries”*. I successfully goaded Professor Bünning to have at least the key findings and seminal passages of *“Wilhelm Pfeffer (1845-1920)”* (see [Bünning \(1988\)](#)) translated into English (*Pfeffers views on Rhythms, Bünning and Chandrashekar (1975)*). He was won over by my argument that no one today would have the patience to learn German and to rediscover Pfeffers discoveries and findings. Bünning incidentally held the Pfeffer chair in Plant Physiology in Tübingen 1946–1971 and has written a delightful biography of his favorite biologist Pfeffer – alas in German.

Here Shekar reports on Bünning's life and his scientific interests and achievements. Towards the end of the article he continues:

In 1981 he was asked by the National Academy of Sciences, USA, *about “discoveries you consider most important”*. His answer was Bünning all over: *“Experiments from 1928-1935 proving that certain biological 24-hr rhythms in plants and animals are endogenous and inherited. Also proving that, under constant conditions, the periods of these rhythms are not exactly, but only approximately 24 hr (therefore now called circadian rhythms) . . .*

¹⁰Maroli K. Chandrashekar got his PhD in zoology at the University of Madras. Did his postdoc work under Bünning in Tübingen, founded Indian Chronobiology at the University of Madurai, and later after several stays in Germany and the US he became Professor at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) in Bangalore

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During those years, and later on, I demonstrated that those rhythms have adaptive values, for example for measuring the length of days (photoperiodism)". This summary conforms very well with one of Bünning's own statements "what is worth stating can also be stated briefly". . . .

Bünning's entirely original idea that *circadian rhythms act as yardsticks* in measuring seasons was first set out in a paper he published in 1936. This paper (Bünning, 1936b) became a "Citation Classic" of *Current Contents* and the idea conveyed in it is today known as Bünning's hypothesis. . . .

5.10 Masashi Tazawa 2006: What I learned in Tübingen

Manuscript of Masashi Tazawa¹¹

Dear colleagues!

I am glad to be able to tell you about my memories of my esteemed Professor Bünning and my early studies in Tübingen.

It was the early morning of November 10th, 1955, when I arrived at the main station in Tübingen. Nobody was there, because I had taken an earlier train from Stuttgart, and not the one which I had sent Bünning by telegram from Genoa. There I left the ship on the evening of November 8 after 43 days of seafaring from Kobe to Genoa. At the station I took a cab to the Waldhäuserstraße 20. Passing the Neckar bridge I saw the Neckar front and was fascinated by the old fashioned buildings and the warm brown colors of their roofs. Tübingen was the first city, which I saw in Germany, since my trains to Stuttgart were running during the night. For a Japanese it was a surprise, to see the city without any signs of bombing.

When I rang the bell, Frau Bünning opened the door and was surprised, to see a Japanese. She had expected me to arrive with the car of her husband. She called him up in the institute. Bünning arrived soon. He appeared to me as a professor with a majestic composure, but shook my hand very friendly. He brought me to my accommodation in the Waldhäuserstraße 27 and introduced me to my landlady, Frau Horning. I was invited to lunch at Bünning's house. After the meal Bünning took me to the institute. I was introduced to Chechen Rummer. He was a PhD student and at the same time responsible for the plant morphology course. He guided me through the institute and afterward through the city. Since then we are good friends, and our friendship continued after he left Germany in 1958 for Santiago de Chile. He went afterward to San Diego in the USA and finally after his retirement to Corvallis in Oregon, where he died in 2004. Bünning offered me three topics; the first one was the effect of light quality on the growth of carrot tissue cultures, the second was the analysis of the negative phototactic behavior of *Euglena* and the third the effect of temperature on the endogenous diurnal rhythm of *Phaseolus*. All topics were new for me, and I experimented with much enthusiasm. When I came to Bünning, to show him about the results of my experiments, he said *schön! schön!* (nice! nice!)

¹¹Assistant and Associate Professor at the Osaka University (1977-1990), Professor at the University of Tokyo (1977-90), and at the Fukui University for Technology (1990-2002); since 1990 emeritus; I had asked him to send me his memories of his time in Tübingen

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and I was very proud, to hear this *schön!*, since I thought in my bad German, that he was complimenting my work with his *schön!*. One day I told Jochen about it. His reaction was very disappointing for me. He told me, that Bünning would tell everybody in the institute '*schön*'. But today I believe, that his *schön* at that time was a true *schön*.

One evening I came home to my housing quite drunk. A flower pot with a green plant stayed close to the entrance to my room. I staggered and the pot and its stand fell over. The pot was broken. At the next morning Frau Hornung told me: "*Herr Prof. Bünning has promised me, that the Japanese, whom I take, is very polite*". Before coming to Tübingen, I had written several times letters to Bünning. These letters were corrected by my German teacher, a woman from Berlin. She married a Japanese, Mister Ochiai, and came long before the outbreak of the second world war to Japan. She was kind enough, to correct my letters to the great Professor and used extremely polite expressions. Frau Hornung was a very religious old lady. Once I gave her a booklet "*Klein-Erna*". I had bought it, because Bünning had recommended it. The booklet contained many interesting stories about a little girl Erna in Hamburg. Next morning Frau Hornung returned the booklet with a gloomy face and said: "*The level of the book is too low*". I told my Professor about it. He simply laughed and said "*nicht schön*".

One day foreign students were invited by the university for a small banquet. My host Bünning was also there. The planned time had already passed. We became impatient. Bünning, who was sitting at the other side of the table, took suddenly a spoon and knocked at his cup. It was a surprise for me, to see a professor doing this and not a student, who did this, in order to make progress with the party. It worked immediately. The delayed process began, and we could soon get a drink.

After leaving Tübingen in December 1957, I re-visited the city often. Bünning asked me at this occasion always, whether I could give a lecture. He gave me the advice: "*Herr Tazawa, the shorter, the better*". After his retirement he did not confine me anymore. Instead he stood up after my talk and remarked: "*Herr Tazawa says always, that the experiment can be done quite easily, but in reality it is quite difficult. Only a Japanese with his great skill is able to do it*". I was very thankful to him, that he complimented me by stressing, how difficult my experiments were.

During his and his wife's visit in 1978 in Japan as a guest professor of the Japanese Society for the Advancement of Science he traveled full of energy through Japan, gave lectures at various universities and liked to discuss problems of the biological clock with Japanese scientists. Bünning and his wife visited us also in my house. In a relaxed situation he told me: "*I can tell you a story, which characterizes the nature of a Hamburger citizen. Hamburg is a city with many channels. Two friends meet each morning on the bridge over one of these channels, but they just look all day on the surface of the water, leaned with their elbow on the bridge railing. The conversation between them consists only of "good morning" and "good bye". One day one of the two brings his nephew along and introduces him to his friend. All three look at the water, as the two have done it before. Suddenly the silence is interrupted by the young man: "Look,*

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there floats a corpse!”. *In the evening by saying good bye the other one says: “Your young man speaks too much. Don’t bring him along again tomorrow.”*

At the begin of my stay in Tübingen Bünning asked me for the exchange of scientists between Japan and foreign countries after the war. “*Very sparse*” I answered. In 1950, when I was in my first term at the Osaka university, Professor Kamiya was invited to the USA. It was a big news and was published in a leading newspaper, the Asahi. Bünning told me, that the exchange in Germany began quite early, almost immediately after the end of the war. I realized the difference in the re-establishment of scientific activities of the two countries. More alarming was Bünning’s remark: “*Herr Tazawa, the good times in Germany are already gone*”. What he meant, was, that many excellent scientists had left Germany and emigrated to the USA and other countries. He was very sorry about this.

I arrived as an exchange student of the German Academic Exchange Service (DAD) in Germany. My grant covered the expenses of my stay for a year. Since I wanted to study for another year in Tübingen, I asked for a prolongation of the grant. It was declined. At this time my work on the temperature effect on the endogenous rhythm of *Phaseolus* had ended with results, which were not quite clear. I asked Bünning, whether I could learn something about tissue culture at Jacob Reinert, because I thought, tissue culturing would be useful for my future plant cell biology. Bünning agreed. When my application was refused, Bünning told me, he would find another way. He gave me a scientific assistant position. The payment was much better than the DAAD grant. I was very much impressed by his generosity towards me, since I actually did not work with him, but with Jacob Reinert, who had just come back from White’s laboratory in the USA.

Bünning’s way of helping his students was not obtrusive, but just quite natural. My friend Jochen Kummerow has send me in 2003, one year before his death, his recollection of Bünning. I would like to pass it on.

“During the summer of 1965 I had finished my diploma thesis at the botany institute in Mainz. I decided, that I should finish my studies with a PhD work. The botany institute of the University of Tübingen was quite attractive for me. The director Prof. Bünning had a good reputation, and I decided, to visit the botany institute and to try, whether I could perhaps begin with a PhD work under the guidance of Prof. Bünning. After a short talk Prof. Bünning asked me, to come back on the following Monday. I was not too optimistic in respect to the PhD work, but went to the institute at the arranged time. How big was my surprise, when he told me, that I could begin my work. The secretary managed all the formalities and Prof. Bünning asked me additionally, whether I am willing to take over smaller tasks in the institute. I liked this proposal and answered without digression, that it would be alright with me. Then he asked furthermore for details of my preparatory training. The course, which he offered at that time, was very much in line with physiology, and with the help of an assistant, who was morphologically interested, he planned to balance it somewhat. In this way I had immediately a task. I had the best impression of the liberal and unorthodox way, how he performed his work. One rule in his institute was, that students and PhD candidates and all other coworkers did not need to wait in his anteroom,

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until he had time; on the other hand, administration official were received often after having to wait for some time.

Bünning's open way towards students, which impressed Kummerow so much, was also stressed by Wolfgang Haupt in his talk in 1990 during a special colloquium at the occasion of the 60th birthday of Hans Mohr. The title of the lecture was "The Tübingen school" (see section 5.6).

I would like to tell you another story, which illustrates the humble character of Bünning. When he finished his function as rector of the university in May 1953, his successor said: *"You acted with unostentatious objectivity and placed back all personal points even in those cases, where only your most personal decision turned the balance"* (see subsection 5.2.1).

In 1999 I sent a letter to Haupt, asking him for his reminders of Bünning. He recommended his *"obituary"* in the *Botanica Acta* 1991 (see section 8.1 and Haupt (1992)) and the lecture referred to in section 5.6). In addition he sent me his personal recollections of Bünning. If he would have been here, he could have told these stories himself, namely the following:

1. If I wanted to meet Bünning - which was rare -, and he did not have time at the moment, I could be assured, that he would do it as soon as possible - not that I was called to him, but he came up the stairs to the room under the roof, where I had my room at that time.
2. Bünning possessed a humor, which did not show up often. Per Halldal from Norway was with us and gave a lecture. At that time English lectures were still rare, and one apologized for talking in English. Thus Bünning introduced him with the words: I am thankful to mister Halldal, that he will talk to us; I thank him, that he will not use Norwegian, but has chosen a congress language; But I am especially grateful to him, that he has chosen as the congress language English, and not Chinese.
3. In his lecture *"developmental physiology"* pattern formation was a topic, which Bünning covered quite thoroughly. There was a pattern based on cell division (e.g. in *Chara*), patterns due to areas of inhibition (many patterns of stomata, leaf primordia), but also patterns caused by chance. The latter he illustrated by saying: *"It is the same as here in the lecture hall; here somebody is sleeping, another one just next to him, the next one at the rear end to the left, and another one here at the front, completely randomly distributed"*, and he pointed in different directions in the auditory. It was amusing, to see, how many students startled thereby, because they thought, they were meant.
4. As I got my habilitation and still not have a call for a professorship, Bünning once told my wife, that unfortunately there are at the moment no positions available, but *"we can't just kill one, so that your husband gets a call"*.

Another part from the letter of Jochen Kummerow: *"Especially popular were his Lapland excursions. Towards the end of the summer term each year a group of about 10 students were selected, who took part in a 10 to 12 day hike there under*

5.10 Masashi Tazawa 2006: What I learned in Tübingen

his guidance. The costs had to be covered by the students. Professor Bünning had, however a money source, which he had used to get tents, cookware and other useful things, to have the best possible equipment for the excursion. - The railway ride from Stockholm to Kiruna was usually brightened by a card game. We played for money and Professor Bünning was often the loser. During these games he fought for each penny."

I am writing now a book in Japanese with the title "*Biological clock - the story of Erwin Bünning*". I plan to revive and stress the contributions of Bünning for the biological science as the discoverer of the biological clock. I have the impression, that many chronobiologists in Japan do not read the monumental and basic work of Bünning from 1936 (Bünning, 1936b), although they cite it in their publications. In one of the chapters on the birth of the idea of the biological clock I offer the complete content of the paper in the hope, that the reader will understand the kind of thinking and the experiments of Bünning. In the foreword I cite the paper of Colin Pittendrigh, which he dedicated Bünning to his 60th birthday. He said: "*There is hardly any doubt, that his most important contribution, provided already 30 years ago, was the complete novel proposal, that -what we call nowadays circadian oscillation- serves somehow as a clock and allows the organism to react to the seasonal changes in the daily duration of light or darkness.*" In another paper, which appeared in 1993 in the *Annual Review of Physiology*, he writes: "*Bünning divided the (nowadays so called) circadian cycle in a photophilic and a scotophilic half, which corresponds to what we now call subjective day and subjective night. . . . At the begin this idea got some reception in Europe, but almost none in the United States. That was especially true for the 1950s after the brilliant work of Hendricks and his coworkers in Beltsville, where the pigment phytochrome was identified, which effects the photoperiodic reactions of the green plants.*" In the same paper Pittendrigh writes: "*The position of the American researchers towards Bünning occurred in 1959, when Nanda and Hamner reported about their new and now classical experiments with soybeans.*" In the laboratory of Hamner the Japanese plant physiologist Atsushi Takimoto obtained results by using a variety of the morning glory, which supported Bünning's view strongly, that the circadian clock underlies the photoperiodic control of flowering. In the following chapter I try, to summarize more recent results of studies of the biological clock and of the photoperiodic flower formation. Since the 1970s the biological clock got its molecular basis by the discovery of clock genes. In this respect I admire Bünning's foresight. In an article for the commemoration of the recently deceased Bünning (ASPP Newsletter 1991) Anton Lang says: "*1953, when the molecular genetic was still in its infancy, Bünning wrote: Those, who are interested in developmental processes . . . have to deal with the physiology of gene activities during the ontogenesis . . . the genetic of the future will mainly be developmental genetics.*" Since the 1990s studies on the molecular genetics of the biological clock flourish in respect to photoperiodic regulation of flowering. The main problem is, how plants recognize the change in the length of the day during the course of the year. Nowadays we know, that the *external coincidence model*, which was first proposed by Bünning, has been accepted by representative researchers. In 2003 Steve Kay, a leading scientist in the USA, wrote in a review article: "*What Bünning says specifically,*

is, that a circadian clock controls a rhythm in a light sensitive process, and that photoperiodic reactions support (in longday plants), or inhibit (in shortday plants), if the light period of a day overlaps with the most sensitive phase of this endogenous rhythm." The model was experimentally confirmed at the molecular level. According to Kay in the longday plant *Arabidopsis thaliana* CONSTANS, one of the genes, which regulate the flowering time, is controlled in its expression by the circadian clock. Flower formation is only induced, if a high amount of CONSTANS protein and Light fall together. This coincidence occurs only under longday conditions. My book contains a chapter, which describes the life of Bünning as a child, as a student and as an academic teacher. The chapter contains many episodes, which have been kindly provided by his students and acquaintances Haupt, Drumm, Mohr, Kummerow, Krause, Schilde, Baillaud, Plesse and further persons. Finally I am presenting the reader the present state of chronobiology in Japan. In 1993 the Japanese Society for Chronobiology (JSC) was founded. The number of members has now reached 600. Our society arranges annual meetings and organized in 1993 the first world congress of chronobiology in Sapporo. In 2002 I gave a special lecture with the title "*The father of the biological clock: Erwin Bünning (1906-1990)*". Its content was published in 2003 in the Journal of JSC. There are many active group, which work on biological clocks in *cyanobacteria*, *Neurospora*, *Arabidopsis*, morning glory, rice and photoperiodism. The chronobiology in Japan is now exactly, what Bünning had hoped for the relation between Japan and Germany. In his letter send to me on January 30, 1989 he writes: "*Japan and Germany have always been closely connected in science. This should remain so*".

Thank you!

5.11 Lucien Baillaud 2006: A Frenchman in the Botany Institute in Tübingen (1952-1953)

After the war Tübingen belonged to the French occupation zone. At the begin the French army supervised, what was going on in the industry, the universities and so on. This was done by the military security office. The supervision was, however, gradually reduced. This office "Office Militaire de Securite", or O.M.S. set in young Frenchman in the German universities.

During my military service I was lucky, to be in a situation which was more like a "teamwork". My head at the University of Besancon studied the circumnutation and excitability of tendrils. He knew the grandeur of Bünning and the esteem of Tübingen. He wrote Bünning and he agreed to receive me at his institute.

I was in Tübingen from August 1, 1952 until March 31, 1953, afterward July 15 until October 15, 1953. I lived and ate in the French Military hospital "Amile Roux", (the name of a coworker of Louis Pasteurs). I had the military rank of a hospital nurse second class, in other words no rank at all, and later of first class. This was a somewhat better rank, but still below that of a lance corporal. Since 7 years, after the end of the German occupation, I had hardly seen any German. On August 1, 1952 I arrived at the Botany institute at the corner

5.11 Lucien Baillaud: A Frenchman in the Botany Institute in Tübingen

of Wilhelmstrasse and Silcherstrasse. I was in military uniform. I was told to meet Professor Karl Paech. After knocking at his door I heard a “Herein”. Herr Paech greeted me cordially. I was surprised to hear, that Professor Bünning was in Lapland; he botanized with students; he loved the quietness of the Northern region. Shortly afterward I was told by the O.M.S., to go to the Botany institute in civil and not in military uniform. During the next weeks I made observations on circumnutations of winding plants.

When Bünning returned, I explained him my situation; I told him, that I had to send a report of my work at the end of my stay to the O.M.S.. I found it funny, to tell him, that I formally would be a spy; he laughed, but I think it was not a good joke. He proposed a research project: The influence of light on the speed of growth of mays or bean plants. I measured the roots by eye and marked it with ink. They grew in glass containers, in which light, temperature and humidity interacted. I did not know, that Bünning sometimes proposed projects which left the researcher complete freedom for his studies. I thought I would waste my time with worthless measurements. But I understood, how important it is, to do experiments under different conditions.

Then he asked me to take up again the topic of circumnutations. I worked in the basement at almost constant temperatures. I used water bathes, a refrigerator, and I got a clinostat, surely the one of Pfeffer. I obtained results, which appeared to reasonable. Thereupon Bünning proposed to measure the osmotic pressure in the vacuoles of the cells of various sides of the winding shoot; that had been done by other researchers in Besancon.

He offered me to participate in the Handbook of Plant physiology, which was a big honor for me. Afterward he came twice to France to take part in congresses on biological rhythms held by the French plant physiology society.

However I belonged to an occupation army; no doubt I felt a kind of grandeur towards the Germans, not the grandness of a winner nation, but that of a nation, that - as I believed - could never have done the atrocities, which France felt victim. I would have found it perhaps normal, that the Germans felt a grudge against the intruders. I was also surprised by the sympathy of all Germans which I met. Only once in a bus, I was in uniform, I had the impression as one talked about me. I did not understand a bit, but heard the word “Siegerle” (little victor), perhaps because of my small stature! Often I had the impression, the Germans preferred the French occupation instead of the Hitler dictatorship. Almost as they were pleased having lost the war. One Sunday, at the begin of the university year, I went to my first concert, the Matthaues passion of J. S. Bach in the Stiftskirche¹². It was magnificent. At the exit I met Dr. Haupt¹³. We talked about the music, we had just heard. That has perhaps helped me to regard the Germans as a civilized folk — and vice versa.

Some words about the daily life. I was amazed by the working atmosphere in the botany institute. Even among students the word *studious* was a compliment. To regard himself in France as studious would have been perhaps a badinage. At 8 o'clock in the morning everybody was at his work. At noon many stayed, for

¹²collegiate church

¹³Haupt was also in the botany institute

5 Talks, articles of and about Bünning

instance with a bottle of milk. Many worked in the afternoon until 18 o'clock and from Monday to Saturday. And not much time was lost with unnecessary talks. Back in France I told this my senior associate scientist, who answered "do not tell this our chief!".

I took all meals in the hospital Amile Roux. Once I ate at noon in the Mensa, the student restaurant. I remember mashed potatoes. Perhaps something else went with it, a sausage, but I can't remember. It was cheap. The students were entitled a daily meal in the Mensa. I asked myself, French students would react to such a menu. But I did not know how the rest of their food was. Certainly the Germans at that time were not fat, not more as the French people during the war.

Bünning invited the researchers of his institute in groups to his house. During these gatherings one never talked about biology. Once in a year he made an excursion for a whole day with the technical personal. I was several times invited to him, be it a meal with the family, or with others. I was also quite touched by the friendship of several people of the institute. For my work I got a place in a room upstairs between two advanced students. Both received me very friendly. One of them invited me to his parents in Pfullingen, and we stayed in mutual consent. These two young persons and several German colleagues have often attested, that the French or Allied were neither better nor worse than the Germans.

Only one person in the building spoke French, namely "Zi-", the well known botanist Walter Zimmermann. Bünning read French quite well and understood a bit if spoken, and this was the case also with Wolfgang Haupt. I could read German, but spoken I did not understand it well. It improved slowly. Helmut Ilg was quite good in Latin and used sometimes German words, which I could fortunately understand. To speak English was never considered. At that time scientists published their work in their own language in journals of their country: The Germans in Germany, the Americans in America, and so on. The library of the botany institute contained the important German English, American journals, but no French one. Due to my advice Bünning could subscribe some.

In 1950 was an international botany congress in Stockholm, at which English was the only official language. The next congress was planned in Paris in 1954. The organizers agreed to accept additionally a Latin language- French. From the begin of our encounter Bünning told me, that he regarded the omission of German as a teasing; under these conditions he wished, that German botanists should not participate in this congress.

I wrote the general secretary of the congress Pierre Chouard. He estimated Bünning highly. Naive as I was, I did not know, that Chouard was much younger as Heim, and that Heim was a member of the *Academie des Sciences*, which Chouard hoped to become some day. Above all, I did not know, that Heim was during the occupation in the resistance and that he was deported in the concentration camp Mauthausen. He had an abhorrent remembrance, which he describes in "La Sombre Route", a horrifying book. I did thus not grasp the whole context of the languages. But around November 1953 Chouard sent me a circular addressed to all German Botanists - each congress participant could talk in his native language and write under the condition, that this is in

5.12 Chandrashekar 2006: Erwin Bünning, a Centennial Homage

Latin letters. That was an acceptable compromise for all. Numerous German botanists came. I was glad to meet Karl Paech again. I was content with me that I played my role as a diplomat well.

Bünning was one of the greatest physiologists of this time; he had a remarkable team around him. For almost a year I was lucky enough to be able to work in Tübingen in a first class scientific institute. This has coined me decisively. I would especially stress the friendly relations with several persons from Tübingen, foremost Herr and Frau Bünning, and with their daughter Ilse and their son in law Richard Franklin.^{14 15}

5.12 Maroli Chandrashekar 2006: Erwin Bünning (1906-1990): A Centennial Homage

In this homage¹⁶ Chandrashekar tells also about his time in Tübingen from November 1964 until 1967 and later. He mentions his first impression in the institute: The Mercedes on the small parking lot at the institute and the seven Volkswagen beetles. The Mercedes did not belong to Bünning, as he thought, but the janitor, Herr Schlauch. He tells about Frau Rätze, Bünning's secretary, Ruth Kautt, the technical assistant, Zimmermann, Mägdefrau, Metzner and Bauer, of the lecturers Richter and Nultsch and of Frau Grahle as a botanist; at that time women were rare in science.

Bünning's "Führerbunker", as the new building was termed, contained air conditioned rooms in the basement. In two of the eight rooms Shekar, as we called him, tried to keep *Carcinus maenas* from the Mediterranean, but had difficulties with it. Therefore Bünning proposed (the meeting took just ten minutes), he should work on the *Drosophila* eclosion rhythm and the coupled oscillator model of Pittendrigh and Bruce on the one side and the more simple oscillator model of Bünning and Zimmer. When the first interesting results popped up, Bünning came each day at 7:30, to hear about the results of Shekar's day- and night experiments¹⁷. Shekar obtained convincing results, which spoke in favor of the coupled oscillator model and Bünning understood immediately its importance.

Shekar writes, that this time from 1964 until 1967 were the best post-doc research years of his life in respect to adventure, creativity, and excitement.

In 1967 Shekar went back to India and worked as CSIR scientist at the National Institute for Oceanography in Goa. From 1968 to 1970 he was Miller

¹⁴Written by Prof. Baillaud after a request of Engelmann and parts of it kindly translated by Ilse Franklin, Basel, into German. She has the original

¹⁵Lucien Baillaud, born in 1926, died in 2018. Studied at the University of Tübingen and Besancon circunutations in plants. 1962 University of Clermont-Ferrand. Cofounder of the *Groupe d'études des rythmes biologiques*. Publication of numerous articles including popular ones. Thanks to his wife and his nephew, Denis Boisdon for informations. The text by Prof. Baillaud was in French, parts of which were kindly translated into German by Ilse Franklin, Basel

¹⁶This article appeared in the Journal of Biosciences in March 2006.

¹⁷at that time we worked still without automatic recordings and had to shake down every third hour the eclosed flies from the bottles and count them

5 Talks, articles of and about Bünning

Invitation Fellow in Berkeley, experienced there the social turbulence and student unrest and yearned for the peace and tranquility of the old town and University of Tübingen.

He returned to Tübingen, but times and the place had changed. The old acquaintances of the student time had left, the botany institute had been replaced by a new building on the hill, called *Institute for Biology I*. Bünning became an emeritus on his 65th birthday and the search for a successor was difficult. Berthold Schwemmler, a former student of Bünning, acted for the chair in the difficult years from 1971 until 1974, until Achim Hager became Bünning follower.

From Shekar's report: "*End of March 1971 I attended an international meeting with Bünning and others from his group in Wageningen (see figure 5.4), The Netherlands, on Circadian Rhythmicity. A. D. Lees of the 'hour-glass' model for circadian rhythms in aphids fame, was there too with D. S. Saunders. Bünning was chairman.*



Figure 5.4. During a meeting in The Netherlands we camped in order to save money. Note the sooted faces: Shekar did not yet know the game! To the left of Shekar is Klaus Brinkmann from Bonn, to the far left Gottfried Wiedenmann, below two students of the Engelmann (with lantern) team

... On 4th October 1990 Bünning passed away. His wife told me in 1991 that the end was peaceful.

Than Shekar tells about his time in Madurai, where he together with S. Krishnaswamy and very good coworkers installed the School of Biological Sciences and a new laboratory. He got through the mediation of Neuweiler in München equipment for his studies, which helped him and his students a lot. In 1978 he and his coworkers organized a Workshop on biological oscillations in Madurai. It was the first of this kind in India and took place from December 16 until 24. E. Bünning, W. Engelmann, David Saunders (Edinburgh) and Klaus Brinkmann (Bonn) were teachers from foreign countries, Vidyanand Nanjundiah from the Center for Theoretical Studies at the Indian Institute of Science, L. R. Ganesan

Shekar continued: *He (Bünning) still came to the laboratory at 8 a.m. and read daily the Frankfurter Allgemeine in the fore-noon. Afternoons he went for long walks with his wife. He continued to go to the University Library Tuesday mornings and worked on the 3rd English edition of The Physiological Clock. I had the privilege of helping him with the English. By then I got to like Bünning's company and spent long hours with him chatting. He really seemed to feel sorry to see me leave Tübingen in 1975 with my wife and daughter, to join the Madurai Kamaraj University.*

I would later return to Germany several times with financial assistance from the U.G.C. and the DAAD for periods of six weeks. During such visits I often stayed with the Bünning's.

5.12 Chandrashekar 2006: Erwin Bünning, a Centennial Homage

from the Madurai College and Shekar were the Indian teachers. Shekar writes: “I was very moved to see Engelmann struggle with heavy baggage on arrival at the airport in Bangalore. In a cardboard box he had a freshly potted *Desmodium* plant, raised for our workshop in the green house of the *Botanisches Institut* at Tübingen. His personal belongings amounted to a tube of toothpaste, tooth brush, and underclothes.”¹⁸

S. Krishnaswamy inaugurated our workshop and Bünning spoke on The History of Chronobiology. We offered ‘hands on’ experiments on sleep movements in Desmodium gyrans the Indian telegraph plant, made famous by J. C. Bose, circadian rhythms in the flight activity of bats, wheel running activity of squirrels, cockroach etc. The workshop was run on the lines of the German university Grosspraktikum. I had gained some skills helping Engelmann conduct his biannual Grosspraktika between 1972 to 1975. Every morning one of the teachers spoke for an hour, mostly about their own work. The rest of the day was devoted to the experiments. Of the participants three turned later to full time circadian rhythm research, in the departments of zoology of the Banaras Hindu University, Meerut University and Raipur University. Looking back that was reward enough for those of us who taught in the workshop. Today chronobiology has struck firm roots in India. The participants vastly enjoyed meeting in person David Saunders already well known for his classic Insect Clocks and Bünning, whose book was the bible of chronobiologists. I got Bünning to inaugurate our first chronocubicles complex of three 8’x8’ rooms with ventilation but without windows. At the close, from Christmas day for a whole week I traveled with the Bünning and Engelmann to Trivandrum, Kovalam and Thekkady. Some time during the week Bünning said “You did the right thing in returning to your country”.

Shekar writes about Bünning’s personality, his scientific achievements, his book publications and his travels. Bünning had spent six months at the Lahore university and six months at the laboratory of P. Maheshwari in Delhi University in the late 1950s. Two Indian students obtained under his guidance their PhD, one being the grandson of Maharishi Karve. Bünning was well read about the real India and was a friend of the famous Indologist Helmut von Glasenap. He used to mention, that the great Glasenap knew everything about religion, philosophy and the cultural inheritance of India, but was at a loss if one asked him what the Indians ate.

Shekar says at the end of his article about Bünning’s character traits: *Like all truly great men he was a humble person. In 1981 The National Academy of Sciences (USA) asked him about discoveries he considered most important.*

His answer is a model of genuine scientific modesty. He wrote: “Experiments from 1929 – 1935 proving that certain biological 24 hr rhythms in plants and animals are endogenous and inherited. Also proving that, under constant conditions, the periods of these rhythms are not exactly, but only about 24 hr (therefore now called circadian rhythms). I made during that time also the first cross breeding experiments with strains of different periods. During these years and

¹⁸Remark: Everything else could be bought cheaply in India. The trials, to rear the Indian telegraph plant in Madurai, resulted in poor examples only. Therefore I took plants with me, although it meant “to carry owls to Athens”.

5 Talks, articles of and about Bünning

later on, I demonstrated that these rhythms have adaptive values, for example for measuring the length of days (photoperiodism)”. Unquote. In an unpublished hand-written piece (in my possession) he had written “I should state that my main basic experimental results and ideas were published between 1929 and 1937. Everything published later on was nothing but going into more details”.

6 Bünning's thoughts about education

Composed by Engelmann using contributions of Bünning in [Bünning \(1967a\)](#) (see section 6.1), in [Bünning \(1967b\)](#) (see section 6.3), [Bünning \(1987\)](#) (see section 6.4) and in [Bünning \(1970\)](#) (see section 6.5).

6.1 Abitur¹ and general qualification for university entrance

From [Bünning \(1967a\)](#):

6.1.1 Questionnaire for students at the start of studying biology, biochemistry, pharmacy, medicine in 1966:

1. Practical exercises in natural science subjects in secondary school (final three years)^{2,3}
 - a) none at all 52 %
 - b) very small amount 33 %
 - c) good 15 %
2. Knowledge of the newest developments in biology:
 - a) non at all 37 %
 - b) quite poor 38 %
 - c) good 25 %
3. Elementary knowledge in chemistry:
 - a) completely inadequate 49 %
 - b) reasonably well 33 %
 - c) well 18 %
4. Conception of light quanta, light- and radio waves
 - a) completely inadequate 80 %
 - b) rather poor 14 %
 - c) well 6 %
5. Overall standings (to be able to follow an introductory biology lecture)

¹final secondary-school examination

²see the displayed publication for the questions

³41 % of the students have never looked through a microscope during school time

6 Bünning's thoughts about education

a) without any special difficulties	20 %
b) not hopeless	30 %
c) certainly not	50 %

This shows, why most students after *13 school years* . . . need at least one year to reach the overall standings as is natural after *12 years* in schools with “*international level*” of the Western and Eastern world.

The reasons for this serious deficit are well known: Under “general education” one understands in the Federal Republic of Germany increasingly the confinement to very special subjects, which were in earlier centuries regarded as important. The engagement with the present world is considered to be unrefined, whether it is contemporary history, or coping with modern languages, technique and natural sciences. In other words: We try, in contrast to all other countries of the world, fiercely to turn back time; this prevents pupils from getting a real view of the presence, and this does not enable them to become humanists in the sense, that they are able to master the problems of the presence and of the future.

6.2 Abitur or secondary school maturity?

From [Bünning \(1967b\)](#):

If a student has never heard of light quanta, who has no idea of the build-up of water, who thinks, air contains 80 % carbon dioxide or 60 % carbon . . . , certainly does not have the right basis for studying natural sciences or medicine.

I don't see how such high-school graduates can prove themselves later as *lawyers, theologians* or *philosophers* in contact with their environment.

We can simply not accept, that in contrast to other countries, we allow pupils to wait for 13 years until graduation, and to leave school in such a way, that the university study is unnecessarily extended by an average of one year.

6.3 The problem of general education

Is graduation sufficient for studies at the university? ([Bünning, 1967c](#))

And where is the root of the malady?

1. The biologists do not want to haul out a maximum of school hours for biology. The basis and framework for the natural science can only be provided by physics. Dropping physics (almost 50 % of the senior class students do that) breaks the neck of the natural science teaching at the senior classes. But here each student should be offered the opportunity, to get to know something about modern questions of *all* sciences. He/she must learn the kind of problems one deals with. Not till then he/she can claim to be well-educated, not till then can the school fulfill its commitments, to show their students where there are subjects which are worth to occupying oneself for a whole life. Only in this way can the chance be increased that graduates choose the profession of a teacher of natural sciences. Those few, which are still trying to reach this goal, come mainly from schools with corresponding motivations in natural science subjects.

6.4 Looking back: Autonomous scientific research

2. A similar evil ... is the restricted number of hours for natural sciences and for ... mathematics. If one has to answer the question, what else could be cut back, one has unfortunately to refer to taboos. Latin and Greek ... ancient history ... religion ...
3. Teaching natural sciences is here often done according to the scheme of education in medieval cloister schools. This is forced by prescribed curricula, juristic considerations ... or the shortage of suitable teachers ...
4. To get good teachers for mathematics and natural sciences, one has to use ... other ways. The doubting of the educational benefit of natural sciences, which are here common ... is certainly not a suitable means to foster natural science academics. One should furthermore not believe, increasing pedagogical instructions during the time of studying and internship could replace scientific training after the examination, which would thus 10 or 20 years later allow teachers to answer questions of interested students, who have read about new discoveries. Mind you, a store manager can not replace missing articles by a more intensive training in selling ... The school system seems apparently to be different, where the theory of teaching becomes more and more important, whereas its praxis and the necessity for continuous learning of, *what* has to be taught, gets less important.
5. At closing it should be emphasized again: There are excellent schools and superior teachers, also distinguished school administrations, which promote all this. To state this is necessary in order to show, that it is possible. That is, we should not believe, it is impossible because German pupils and teachers are less talented, to learn in 13 school years as much in the natural sciences and humanities for the requirements of education for our time as in other countries in 12 years.

6.4 Looking back: Why it was easier in earlier decades to do autonomous scientific research

After a lecture of Bünning hold in Göttingen at the 18th of December, 1986 at the occasion of awarding the honorary doctor by the mathematics-natural science faculty of the University of Göttingen (Bünning, 1987):

Nowadays most pupils are forced to learn many details in a great deal of subjects by heart (instruction of the teacher: For the next lesson read textbook page x to page y). Only in this way a good note for the final can be reached, which has become the prerequisite for the admittance to the studies. ...

Not the teachers have to be blamed for it, but primarily the authorities, which regulate, how the notes in the particular subjects have to be justified, e.g. by notes of written class work, regarding textbook page x to y. The answer of some teachers (students of mine before) towards my objections: We have to do it this way, in order to have documents in case of law disputes. As a consequence

6 Bünning's thoughts about education

many drop e.g. mathematics 1 or 2 years before the final examination, because they have the note “*very good*” and this note will be in the certificate at the end of school. In this way they reach a very good final note, are however lost for the study of mathematics, because they won't find the connection with the mathematic lectures at the university, and because they are with such a good note so to speak obligated to study medicine. This is also the reason, that many students did not learn to handle physical or chemical equipment, and often they did not even learn, that without good English knowledge one can't study natural sciences. . . .

Juristically mandated “*waiting times*” or lottery at the assignment of study places . . . are another reason, to prevent in highly gifted mathematics or natural scientist the start of research early enough. . . . Who of those researchers I have mentioned before, would have been permitted under the conditions, as they are nowadays juristically defined, to be allowed in time to study?

. . . I hope that one day . . . the overreaching bureaucracy and “*jurisdiction*” will be replaced by fairness⁴: In the interest of the next generation and in the interest of all of us.

6.5 Biology in our times

From Bünning (1970):

It is obvious, that biology in the last third of this century has added very exciting and far reaching results in the same way as physics in the first half of our century. . . .

Biological and medical options as mentioned in headlines or best sellers are not revolutionary, but evolutionary at an accelerated tempo.

It was different with really cataclysmic insides in biology. Unfortunately they are not registered by many people, because they are so revolutionizing, that they do not fit in world views taken over, and alone for this reason neglected or deliberately excluded in biological teaching at school. I do not want to speak here in length of the theory of evolution; most of us have learned to live with it in the meantime. In curricula for the secondary schools, e.g. the one for Baden-Württemberg, one finds indeed for the 13th school year at the very end the keyword “*descendant theory*”. It is accepted and not dangerous, since at that time most students do not have biology lectures anyway by dropping it or due to shortage in teachers . . .

Genetics is also in our curricula. But certain elementary findings of classic . . . genetic research do not belong to the general achievements of those who call them self educated. That is shown by daily discussions with pedagogues, sociologists, politicians, lawyers and theologians. Again and again one experiences e.g. with representatives of those professional categories, that their whole construction of hypotheses is based on the assumption of Lamarck, that there exists a heredity of acquired traits.

The statement of biologist is refused, because it does not fit in the ideological concept . . .

⁴*Gerechtigkeit* in German

I plead in view of this switching from one extreme ideology to the contrary one ... for the removal of ideology in questions, which can be answered by natural sciences and which do therefore not belong in any way to the sphere of world view and religion ...

But there are findings in biology, which ... would be able to scatter world views. ... In biology it was reckoned for centuries with mystic factors. For a long time philosophers and also many biologists thought, the processes in organisms are driven by forces, which are comparable with human will and spirit. ...

It is, however, the task of biology, to find for each physiological process the responsible physical and chemical factors. The modern molecular biology has started to tackle this task successfully and has thereby put a final stroke under the Aristotelian, under the mystic biology. ... It was Watson and Crick, who found the famous model of the genetic substance, the DNA. They detected the double helix ...

Of course with this final expulsion of the ghosts from the biological research it is not claimed, there is no psyche, no spirit; but these phenomena are not subject of physiological research ...

The living on in the behalf of Aristotle ... shows up generally in the fact, that the written word is still higher estimated among us as the results of natural sciences ... "*humanities*" means for many people the finer and nobler, although there is more of exact *Geisteswissenschaft*, namely Mathematik, in a Diesel locomotive or in the quantum theory as compared to the trials for centuries of many philosophers, to proof the investigations of life by the exact natural sciences to be impossible ...

I have named a few aspects of biology, which should be known by every body, who claims to understand our present age or who as a politician, sociologist, politician, lawyer, theologians plays an important part in forming our society for the tasks of the next centuries. This should not be a complete catalog of the biology curricula demanded for the schools. The botanists container and butterfly nets typical for the classic education in biology could be reduced for it.

As far as the importance of biology for humans is concerned, many people think first of all of the fight against the hunger in the world. However, this is not mainly a problem of biological research, but a social-political problem of the realization of what can be done already nowadays according to the status of research. What is the sense, to increase with much effort the agricultural crops in the rich countries, if it results in growing butter- and cereal accumulations, if increasing subsidiaries for the agriculture lead to the slow poisoning of birds, fish and humans by pesticides such as DDT? We are dealing with the preconditions for a reasonable living together of humanity. For this end belongs also from the standpoint of a biologist, that we learn, to use biological laws not as guide posts for our human goals, but instead as means for realizing the goals, which we have to set by using our rationality. Our goal has to be "*humanism*" in the broadest sense of this word, our means to reach the goal "*realism*". We do, however, often use biological laws not as such means, but instead as guide posts. For instance, if we conclude from the struggle of life in nature, we have continuously to fight and destroy each other, or if we conclude from the insemination of an egg cell and

6 Binnings thoughts about education

the development of an inseminated egg cell to one or more embryos, as many of the egg cells have to be inseminated and to develop into embryos, as is possible in the frame of the biological possibilities. This biologicistic, anti-humanistic copying from the brutal and wasteful working nature leads, as we know, to war, overpopulation, hunger and misery. . . .

What can we expect from our future biologist and medical people? At most one third of our students have been offered at school subjects, which are in other countries indispensable prerequisite for a 19 year old biology student . . . Of our freshman in biology in the 13rd class 50 % did not have physics, 65 % no chemistry. In the 12th class the situation is similar. And for the other students the teaching was so sparse, that only 6 % of our graduates, which want to study biology, can say more about the man, who is pictured on our 2-Mark coins, as his name Max Planck. But this coin is doomed to be withdrawn from the market, which avoids awkward questions.

. . . Most students need one to two terms, to catch up the most important of what the school has withhold thanks to the decisions made 9 years ago by our ministers of education . . .

Education in one or another world-view, depending on whether one is born East or West of the iron curtain, and in which pryncedom the ancestors of the children lived a few centuries ago, is not the proper preparation for the year 2000. The questions ahead of us are not occidental or European, but world problems. And the majority of the presently living people refuse, to see these problems solved as defined by the occidental culture. The often cited right of education means therefore primarily the right, to get to know the present world, in order to construct the coming one . . .

A word to the excuse for the shortage of teachers. It was inevitably fortified in the Saarbrücken agreement of the ministers of education by the fear of the modern world or by its inability to understand it. No physicist or chemist likes to go as a teacher in the secondary school, if he is told, that he is more or less superfluous in the higher classes, and if one allows students, to make him even more superfluous by dropping voluntarily the topics which seem to be difficult for them . . . Now it would be . . . necessary, that the ministers of education . . . come up with something, which makes the teacher profession more attractive for those, which not only get up the energies, to avoid, that students drop the topics in school which are assumed to be difficult such as mathematic, physics and chemistry, but that they even choose these subjects for an university study.

. . . . Of course, one should thereby also consider the quality. This should include a reform of the curriculum for teacher candidates. This depends on the other side on a reform of the curriculum at the schools. It is not easy: We have tried recently, to achieve in the ministry of Baden-Württemberg, that the classic botany is somewhat reduced in the education of teacher candidates, which want to engage instead of it more intensively with genetics. Answer: *“We regret to tell you, that the proposed change would not fulfill the edict of the ministry of education concerning the scientific examination for the teaching degree for secondary schools”*. The wording be our post guide, from the scripts of Aristotle until the edicts of the presence! And wording stays in our country solid and steadfast like German oaks.

7 Bünning's traveling

Composed by Engelmann from: [Bünning \(1940\)](#) (see section [7.1](#)); [Bünning \(1944\)](#) (see section [7.2](#)); [Bünning \(1947\)](#) (see section [7.3](#)); [Bünning \(1953c\)](#) (see section [7.4](#)); [Bünning and Müsle \(1951\)](#) (see section [7.5](#)); [Bünning \(1951\)](#) (see section [7.7](#)); [Bünning \(1954\)](#) (see section [7.8](#)).

7.1 Short report about my journey through North-Sumatra

During my one year stay in Java and Sumatra I had ... the opportunity, to undertake longer journeys in the areas of North-Sumatra called Atjeh. These regions are, because of the still existing hostile attitude of the natives and because of the difficult accessibility only seldom visited by natural scientists, and if, never without military protection; long ranges are until now completely unknown.

During my travels the forces of nature, hindrances of the jungle and the mountains, torrential flood waters during the rainy season were of greater challenges as the inhabitants, although I abstained from military protection for a better movability ...

My equipment consisted basically only of sleeping bag, tent square, cameras and some scientific instruments. As food i used like my carrier and leader rice as well as fruit and herbs found in the wilderness ... (see figure [7.1](#))

From the Blang-Kedjeren I undertook with a few carriers a trek in the uninhabited area around the Löser mountain. We forced our way by using game trails and rivers with the help of the bush knife. We had to cross several 2000 to 2200 m high mountain chains, to reach our target ...

In the woods and on the tops I had the opportunity to get familiar with the life conditions and the physiological peculiarities of the plants.

Of the more spectacular animals I mention the rhinoceros, the paths of which in the woods are also always welcomed by humans. Furthermore the Oran-Utan ... black Gibbon ...

During my travels in the areas Northwest of Blang-Kedjeren with the Gajo



Figure 7.1. Bünning with his carriers in Sumatra

7 *Binnings traveling*

central mountains I also reached parts with only few and small human settlements. The landscape here offers, however, more diversity. . . .

In the area around the lake Tawar *Pinus merkusii* is so plentiful, that the woods are used to obtain turpentine. . . .

At the North-East coast the Mangrove zone is partly quite extended; it extends 5 to 10 km into the interior land . . .

In Atjeh I had the opportunity, to observe in the woods closer to the mangrove larger elephant herds. Under favorable conditions one can come close to the elephants, who have an astonishingly low sight, by less than 30 steps without being seen. The elephant is nowadays protected in Sumatra, although it can cause considerable damage occasionally, as I have witnessed on plantains in South Sumatra. By the way, the planter can protect himself against those damages quite well, if he takes into account the position of the paths while installing the plantation. According to observation during many years in South Sumatra these paths are namely only rarely replaced by new ones . . .

In the parts of the sea between Nias, the Banjak islands, the island Simalur and the coast of Sumatra I had plenty of opportunities, to get to know the animal- and plant life of the tropical sea.

7.2 Botanical observations in Sumatra

7.2.1 Biology of the Dipterocarpaceae woods

Ecological studies in Sumatra could demonstrate, how premature it is, to generalize our knowledge of the life conditions in the Indomalayen rain forest, which came mainly from the mountain woods of Java. Some of the peculiarities of the woods in Sumatra are caused by the geological structure insofar, as at the surface older, mostly acidic, high-silica rocks predominate, whereas the surface of Java is composed mainly of young volcanic or tertiary nature. Additionally the abundance in rain is in some parts of Sumatra especially high, and the regularity in the occurrence of the amount of rain during the various months can be much more pronounced as compared to the always wet parts of West Java which are rich in rain.

These peculiarities allow for instance the growth of the large Dipterocarpaceae woods in Sumatra, which are bound to high and consistent amounts of rain as well as to acidic soil. Such conditions are in many parts of Sumatra so well realized, that one can find there even at altitudes up to 1000 m woods, which are mainly made up of Dipterocarpaceae . . .

The Dipterocarpaceae woods do not show the non-uniform structure, which have often been regarded as essential for the tropical rain forest; instead the crowns can form a rather uniform closed roof, since all crowns are formed more or less in the same way, and since the differences in the height of the stem are not as large as they are in the mixed rain woods. Therefore the Dipterocarpaceae woods are not only especially dark, but the differences in brightness of neighbored parts is much smaller as it is in the more mixed woods . . . The ground vegetation can be quite sparse or is even completely missing . . .

Most of the Dipterocarpaceae belong thus to the plants, which did not adapt at all to the seasonal change between a favorable and an unfavorable time of the year. This does not mean, that an internal rhythm is here completely absent. But the internally pursuit resting period is much too short for allowing a thriving in periodically dry climate. One does see regularly in the Dipterocarpaceae single branches in rest; but this resting period can be found also in dryer areas, so that in such parts the internal periodicity of whole twigs is synchronized and the whole tree can be almost completely bar, but even then the resting period comes to an end already after a few weeks. . . . One could look at the Dipterocarpaceae . . . as plants, where the internal periodicity . . . has not adapted to the permanently wet areas due to a low mutability.

7.2.2 Flower biology of *Rafflesia*

Since the flower biology of the *Rafflesia* lacks clarity, I have in North-Sumatra build my camp several times in the immediate vicinity of the flowers . . . and the flowers (diameter 50 to 70 cm) observed for several days (see figure 7.2). The life duration of the flowers was longer as usually supposed; from the onset of opening it took 6 to 8 days, until the flower started to die; the opening itself advanced during this time more and more, upper and lower side of the perianth grew during this time by several centimeters. The continuation of the flower opening occurred almost only in the evening and during the night; during the day I did not notice any growth. Parallel to the increase in growth in the evening the smell increased. Likewise the onset of the opening of the buds occurs according to my observations always during the night.

The flowers . . . were visited by insects, mainly flies; together with the increase in smell the number of visits by flies increased in the evening, at times hundreds of flies were on the flower at the same time. That the insects approached directly the white area of the stigmata I have never seen, they stayed, however, almost always for several minutes in the flowers, crept to all parts and touched frequently the stigmata. By marking individual flies I found, that they are able to find in a few minutes a second one, 200 to 300 m away from the first one.

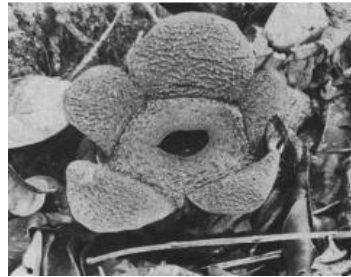


Figure 7.2: *Rafflesia* flower

7.2.3 Root formation in moor trees

At the East coast of Sumatra the conditions for forming moors are not too seldom present (provided limestone is absent and the ground water level is high). Under the trees one finds partly the same genera and species, which live also in the bog forest, which follows the mangrove upcountry. *Eugenia*, *Canarium* and *Myristica* form often the main part. At some places larger trees are missing.

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There Euphorbiaceae and Myrtaceae, *Melastoma*, *Pandanus* and *Gleichenia* form a brushwood. Occasionally one finds even completely free areas with some grasses and mainly Cyperaceae (*Cyperus*, *Fimbristylis*); ferns are also found, whereas one hardly finds mosses.

Allover one can see besides numerous buttress- and prop roots, which exist at almost every tree, many roots such as the one of *Sonneratia* or *Avicennia* growing vertically out of the soil; they reach a height of 20 to 30 cm; knee-like roots are also quite numerous. Very strange is also another root formation, which I have never found in any wood of Sumatra so plentiful and strongly expressed as in this moor wood. These are roots, which were properly described by Koorders as brushlike. In most trees of the genera mentioned above unbranched roots grow out of the stems in clusters; according to Troll they are crests of lateral roots, which emerge from a primary air root that died off early. These “*brushy air roots*” keep the vertical orientation to the stem surface for a long time; not before they reach older stages they grow more irregular. They are often bend downward, but that does not seem to be due to a geotropic retuning, but caused by its own weight. From the orientation of these roots one gets rather the impression, that they grow ageotropic and not diageotropic.

... The significance of the vertical growth direction out of the soil is realized easily, at least one may say so, that these roots fulfill in the moor soil low in oxygen the same function as the air roots of the mangrove plants in the mud low in oxygen. ...

But which function should we contribute to the brush roots growing out of the stems of the moor trees? In mangrove plants such root formations have also been observed repeatedly, though not as regular and plentiful ...

... I could not find another explanation as that the roots serve the uptake of water. The necessity of such a function seems at first unlikely in the moor location, is, however, well compatible with the fact, that our moor plants too suffer for several reasons often under difficulties to get water. ...

In dry air large parts of the brush roots are colored white, that is, filled with air. Under rain the air is completely superseded, and the roots appear dark colored. ... Judged from the ecology of the water balance we could compare the moor trees with epiphytes. This finding might prompt us to ask, whether perhaps the air roots of mangrove trees, which grow out of the soil, might serve also the water uptake besides their further tasks. ... The water uptake must be eased considerably, if the plants are able to uptake water during the flood with the roots growing out of the water.

7.2.4 Zonation in the mangrove area

The informations concerning the more seaward and more landward located zones in the mangrove are contradictory in some points; most notably there is not yet a uniform concept of the causes of these preferences. Mainly ... the differences in the salt concentration are ascribed a special importance. ...

After the observations which I have briefly summarized here I might say, that the zonation in the mangrove belt is not decisively connected with the different salt content of the particular zones. More important are the various requirements

7.3 In the woods of North-Sumatra

of the physical and chemical properties of the soil and of the acidity of the water. These relations might partly be connected with the different oxygen requirements of the roots. . . .

7.2.5 New locations of *Matonia pectinata*

In Sumatra one finds more often as in Java ferns, which need a high light intensity, thus avoiding the shadow of the wood, but need also a high humidity. Such conditions are realized in some parts of Sumatra. To these ferns belong e.g. *Dipteris conjugata*, which stands out immediately by its peculiar form of the frond. I have seen often in Northern Sumatra between altitudes of 1500 to 2000 m very large populations of this peculiar fern. Under similar conditions as in the case of *Dipteris conjugata* there grows another remarkable fern: *Matonia pectinata*. The family of the Matoniaceae is, as is well known, like the Dipteridaceae mostly extinct; we know nowadays only a few representatives in South-Malacca, North-Borneo and Amboina (Moluccas). Up till now no Matoniaceae from Sumatra were known so far, but they are found in the small island groups between Singapore and the Sumatra East coast . . . In the mountains around the Alas (North-Sumatra) I have seen several times *Matonia pectinata*, namely always in altitudes between 1000 and 1800 m. Never were the ferns in completely open and therefore dry locations, but always close to (though out of) the woods. It needs like *Dipteris conjugata* much light as well as a continuously high humidity. During the more dry parts of the day *Matonia* is often seen slightly withered. Apparently the possibilities to reduce the transpiration are imperfect, even more than in other ferns. . . .

I don't think it is correct -or at least not quite correct- if one tries to explain the small extension of the present areas of the Dipteridaceae and particularly the Matoniaceae with the assumption, that these families are used to a warmer climate. In this case the ferns should avoid the altitude. The present distribution is limited not so much by their temperature requirements, but more by the simultaneous demands for light and humidity.

7.3 In the woods of North-Sumatra

Bünning traveled in 1938 to Sumatra. For the purpose of it he writes:

I do not have the intension, to treat in this report any of the questions comprehensive; instead, observations should be dealt with and suggestions communicated. To me it seemed to be necessary to describe the journey in some detail. Each botanist, who has not yet been in the tropics, knows, how difficult it is, to get a truthful picture. The reason for this is, that only a few botanists have indeed been in touch with the tropical nature for a longer time . . .

I traveled on purpose in areas, which are far away from the inhabited locations and in which even natives have never or only seldom penetrated. As the travel time I have not only - as is often done - chosen the months with the lowest rain fall, but stayed even in the seasons with the highest precipitation for weeks in the jungle and the mountains. As travel victuals for this expedition in untouched areas, which will stay in the center of my presentation, I have not carried any

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tinned food and other “European” food along, but lived by the food, which the natives get from their fields or out of the woods; in this way I learned much, what I otherwise would have missed. . . .

The equipment of these expeditions consisted, besides rice and tea, only of a sleeping bag, tent, cooker, camera and several scientific instruments. The scientific instruments were galvanometer, among it a special one of Zeiss, glass color filter of the Schott company, thermoneedles, thermometers, simple equipment for orienting assimilation-, respiration- and transpiration recordings, as well as some chemicals. . . .

If I report in the following pages also travel impressions, which are hardly connected with botany, I believe, that I can increase the interest in such journeys in young botanists, and perhaps such a report might promote the interest in botany in one or the other reader . . .

The journey lasted from June 1938 until July 1939 . . .

The book is displayed.

Especially interesting is for me (Engelmann) *chapter IV. In the Northern Barisan mountains 1. In the Lösers terrain. For instance page 76 below until page 78 top, page 79 middle until page 80 middle, page 81 top until page 81 bottom, page 84 top until page 86 top.*

7.4 To see Indonesia again

If one wants to characterize Indonesia nowadays correctly, one has to speak first of Indonesia during the pre-war time.

(At first Bünning compares the situation in 1938 during his first visit in Indonesia with the situation during his journey at the begin of the 1950s: The bureaucracy and the number of officials has increased a lot (visa, passport, customs, control of foreign currency, money exchange), traveling and cost of living are much more expensive, the country has become more insecure (assaults, looting). He mentions the difficult time during the occupation by the Japanese in the second world war and the inner combats in Indonesia. He tells about the big dominance of Chinese merchants).

. . . Need, riots, robber bands and so on distress the everyday life, but one should not judge the country only by this. One should not forget, that perhaps 1 % of the population cause such trouble, that one might speak of a general demoralization, but that the remaining 99 % present the folk.

The more one departs from the highly populated cities, the more one is reminded of the country, as it used to be before the war. Of course, even far away at lonely villages one might suddenly stay at a remote street in front of a toll gate, which is guarded by 3 to 4 villagers and it is a good idea to pay the charged toll, because the police can't help. And to travel in a bus is sometimes a bit dangerous, but in most cases it works.

But even in Java, the most unsettled among the Sundas islands, are territories, in which one can live as save as in earlier times. I could there, accompanied by a porter, peacefully walk through the fields and villages. Farmers work as before with their primitive plows and hoes on the paddy fields, they set each

plant individually in the sump and still harvest each spike separately. The water buffalo underline and add to this peaceful image, especially if on its back a Javanese boy lies, who sleeps on the grazing animal or smokes his self rolled cigarette. Even more this old nature continuous to live on the volcanoes, without which neither the image of the landscape nor the wealthiness of Java is thinkable. And here dominates still nature, not man. Here are the remnants of the woods, which covered some decades ago, before the population jumped up to the 40 or 45 million people, the island Java in the same way as it is still today in Sumatra or Borneo. And the 30 volcanoes, to which the land owns its fertile soil, and which has to nourish on some places 400 people on one square kilometer, continue to be active.

For a longer time I stayed in the mountain garden Tjibodas, the pretty outstation of the famous garden of Bogor, which survived the war and time after the war without being harmed. However, Tjibodas is not remote enough to be save for assaults. I could not stay there over night, and during the months of my visit the station was repeatedly attacked by gangs, and shortly before a garden master from Switzerland felt victim to one of them. From this station I climbed again the 3000 m tops of the Gedeh and the Pangerango. During the first hours of the ascend it was somewhat eerie in this area which is regularly sought by gangs. The three policemen which protected me, could not have done much with their automatic pistol in case of emergency. The night in the woods, in about 2500 m altitude between the two peaks reminded me of many nights in the wilderness of Sumatra. But the unpredictability was now of another kind. In Sumatra one had to keep the fire going as a protection against tiger and elephants; now it had to be kept small, in order not to attract the more dangerous humans. One could hardly think of sleep, and one looked carefully for the gaps, which could have offered escape into the protective darkness of the wood. But in higher altitudes I could be unconcerned. Here dominated only the solitude of the wood. Many paths through the wood were, by the way, burned after an eruption of the volcano, and it was quite cumbersome to cleave a way through the remnants of trees and ash fields.

One morning, while visiting another part of Java, the whole area was covered with white-gray ash. The Kelut in East Java had erupted, many hundred kilometer away, and so quickly, that the observation post, which had to watch the crater day for day since years, could not bring themselves in safety. The green of the woods, of the patty fields and the tea plantain were covered with a dense gray layer until the next rain. There were no further human victims of this outbreak, because -due to earlier experiences- the crater wall was pierced, to prevent the formation of a large crater lake; the 5500 victims of an eruption in 1919 were not killed by lava flow and ash rain, but by huge amounts of sludge and stones, which were carried along by the 40 000 000 square meter of the crater lake.

In the same way as the nature of the mountains and woods has remained unchanged, the nature of the people stayed unaltered. They are, except those 1 %, peaceful. If their talents are pushed in the right channels, they will make Indonesia to a rich country, perhaps the richest one in the world. Thereby the treasures of nature ... will help them ...

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Those, who have seen and experienced it, love it, and he understands, why even Europeans like so much to live in the surrounding of this nature and those people. It is a country, in which beauty is not only seen on a grand scale, but also in the simple bamboos huts. Every friend of the young Indonesia hopes, that the attending ills of the so suddenly reached freedom will soon be eliminated. This hope is fully justified.

7.5 The salt mountains in Pakistan

Between Lahore, the capital of the Pundjab belonging to Pakistan, and Peschawar, the city at the foot of the famous Kyberpass, is an about 250 km long, still only little explored mountain chain, called salt mountains or salt ranges. These mountains lie away from the main traffic routes. Only the salt- and coal mines at the Southern rim of it can be reached relatively easy. For somebody from middle Europe it is unimaginable, how primitive even today coal mines can be: simple tunnels lead into the mountain, through which one has to feel ones way in a bend down position under scarce illumination. The coal is of bad quality; but Pakistan needs it now much more urgent as before; the reason is the tension with India, which possesses better coal sources.

To reach the more remote parts of the salt chains one has to commit one self to a camel or to one of the small local horses. But such a tour is worth it. During the horse ride under the blazing heat of the sun together with a small group of locals over the white, brown or deep red rocky hills and through the remote settlements with their colorful dressed inhabitants I often asked my self, whether all this is reality or just a fairy tale of "*1001 night*". The camel caravans added to these fabulous pictures as well as the group of woman, who carried clay jugs - often two to three on top of each other - on their head, making their march to the wells many kilometers away from the village. In the villages we had to ride through small, angled alleyways, which are flanked by 2 to 4 m high clay walls. The ways are partly so small, that the oncoming people have to press them self to the clay walls, to give the rider place.

The salt mountain reaches an altitude of only about 1500 m, is thus a dwarf in comparison with the neighboring Himalaya. . . .

Some parts of the mountains are rich in salt. . . . In these areas are also some large lakes, in which the salt is solved up to being saturated, so that not even sea fish could live here. In the dry season a broad edge of several hundred meters of a seam of crystallized salt of the seas surrounds it. The salt deposits are even large enough for a considerable export.

Today only small parts of the salt mountains are covered by a moderate wood. Here and there one finds a few wimpy olive trees and acacia. The olives are damaged by the camels and goats of the mountain dweller to such an extent, that they remind one of the adventures figures, which the gardener occasionally magically performs from a boxwood. There are two further genera which are not familiar to us which contribute to the scrubby woods: *Dodonea* (*D. viscosa*, a representative of the tropical family Sapindaceae) and *Gymnosporia* (*G. Royleana* out of the Celastraceae family, to which our European spindle tree,

7.6 Step-, sand- and salt desserts in the river basin of the Indus

Evonymus europaeus, belongs). Among the bushes, which are mostly spiny and thorny, as well as among the herbs, many of which survive the long dry season only as bulb or tuber, one finds again a number of genera familiar to us. There is for instance the tragacanth *Astragalus psilocentrus* belonging to the legume family and a tulip (*Tulipa stellata*), the leaves and flowers of which protrude from small rock clefts in the same way as an iris (*Iris aitschisonii*). Furthermore a delicate liliaceous plant (*Merendera persica*) enlivens a bit the otherwise naked rock. One has to knock open tediously the rock, if one wants to reach the onions or bulbs of the unpretentious colonizer which sit 10 to 20 cm below the surface. At some places one of the plants related to our snapdragon family (Scrophulariaceae), *Adhatoda vasica*, an Acanthaceae, forms dense populations. Porcupines and jackals belong to the most common animals which live here.

The forestry administration tries to install larger woods again in the salt chains. But for the time being one will not achieve more than merely a containment of the destruction, which goes on since centuries. As allover in Pakistan and India, here too humans destroy the woods. Even worse as compared to the cutting of trees for getting fire wood is the grazing of livestock, which leaves no bush unmolested. Only with much trouble the forestry administration is able to prevent at least in some areas the arrival of cattle and goats. . . .

For agriculture is hardly any space left. . . .

7.6 Step-, sand- and salt desserts in the river basin of the Indus

If one looks at a plant geography map of the earlier British-India, that is the two new dominion Pakistan and India, one would think, the largest part of this subcontinent is covered by woods, by woods greened by rain, and by savanna, at the Malabar coast and in Bengal furthermore of evergreen rain forests. Only in the Northwest of the country exist steppe and desserts, and most of it belongs now to Pakistan.

But this map shows only, how it looked decades and centuries ago or how it would look like, if humans would not use so much of the soil for agriculture and if thereby not so much soil would be spoiled. Even there, where our plant geographic maps show desserts, existed even in historic times forests.

I have covered with the air plane 12 000 km over Pakistan and India, additionally some thousand kilometers by the trains or by car, finally also extended rout lengths by foot. One sees during such journeys allover densely populated country, cities and villages, fields, steppe and desserts; in the East, especially in Assam, also forests, otherwise occasionally some small spots of woods. But even in the mountain areas, which are reachable more easily, in the mountain edges of the Himalaya up to an altitude of about 3000 m, in the romantic border mountain between Pakistan and Afghanistan as well as in other mountain chains one finds mainly only bar rocks or a few poor fields. Often one is glad for a relief to come across some brakes or a few tamarinds, Salvador or similar, undemanding, and hardly shadow presenting trees. The forest has been destroyed, wherever man could do it without to much difficulties. Only 3% of the whole surface of West

7 *Binnings traveling*

Pakistan is still covered by forest.

But something else can be seen: obliterated land! Of course, we often hear about soil erosion in America and also in some other parts of the Old World. But this extent is frightening. If we look e.g. at the fertile Punjab (i.e. five river land: Five rivers run through it, which become later the Indus). In Punjab ... are 1/5 to 1/4 of the surface destroyed by erosion to such an extent, that people in this area can hardly do anything else as running brickworks. The same part of the area, which is here occupied by forest, is there taken up by destroyed soil ...

Once ago, but still in historic times, there existed here extended forests. Then the wood was utilized. At least partly fertile fields were generated. As long as artificial irrigation is sufficient, large harvests of wheat, rice, mays, cotton, oranges and many other valuable products are obtained. Some of the devastated areas are utilized again by people in careful maintenance and in further development of the irrigation system. But in other places the erosion spreads further. ... (man) allows cattle, goats, donkeys and camels to destroy the smallest plant growth very rapidly. But the naked soil, which is not hold together by the mesh-work of plant roots, is blown away or washed away by rain. ... Sure, one tries to re-forest it and declares each year a day of planting trees, where everybody should plant a tree in the soil. But what do admonitions help in a nation, which consists of more than 90 % illiterate, which starves and which still uses primitive wooden plows to handle the meager soil? And the population increases continuously and in a frightening speed! Everybody tries to get the ultimate out of the soil for him self and his children. He has to allow goats and cattle to bare-feed everything; otherwise his children would not have the chance, to belong to the third of the Indian mankind, which will reach an age in the thirties. and the next but one generation? Allah is mighty. He will eventually find a way. Inshallah!

In the southwest part of the Indus river area, where the large Indian desserts are, up to the Arabian gulf at Karachi, it rains only 8 to 10 days in a year, and not more than 100 to 200 mm are falling. Here the destruction of the former vegetation had to end up in a sand dessert, in which only a few plants scrape a sparse living. ...

In the upper part of the Indus river area, that is in Punjab, it rains a bit more. Here are at least 20 to 30 days of rain, and on these days it rains so heavily, that it amounts to an annual average of 500 mm. Then the big floods occur, which often cause many death tolls among people and big damages in the domiciles ... The amount of rain falls is, however, sufficient, to wet the rocks internally. Salts are formed, which reach during the seasons with poor rain because of the strong evaporation the surface. Here it crystallizes, and a layer of several millimeter thickness of snow white common salt, soda and sodium sulfate is formed. Only a few specialists among the plants, some grasses and a few species from genera, the representatives of which we know only from the coasts of the sea, find here adequate life conditions.

But even in the salt- and sand desserts one meets almost allover people with their goats, donkeys, and camels. One can walk troublesome for many kilometers in the glowing sun through the loose dessert sand without finding a

7.7 In the Chittagong-Hill-Tracts

single scarce dessert plant, which does not show damage caused by animals. A wimpy existence, not only for the dessert plants, but also for the people and their livestock! Many a beast dies. The fallen animal does not lay long there. The vultures are quickly present. The jackal search during the night for what is left; each night I heard them howl in the vicinity of the tent.

Some soil samples, which I took in the sand dessert, show, that the minerals, which the plants need, are by all means still present. Only water is missing. Artificial irrigation could well allow the existence of fields and even forest. It is, mind you, the territory of the highly developed Indus civilization, the zenith of which was between 2500 and 1500 B.C and which we got to know well only since 1921 due to the findings of Mohenjo-Daro.

Pakistan does realize the problems, which are caused by the destruction of large areas of the country, and it sees the increasing difficulties due to the growing population. Again and again the newspapers point to these imperatives. If at least the further destruction could be stopped, much would be accomplished. Important is also a peaceful relation to the neighbor India, since many of the necessary tasks, especially the further development of the irrigation systems, can only be done together as a fact of nature. . . . The climate of West Pakistan is by all means so excellent, that large areas of the country could become one of the best of the earth, if the cultivation and maintenance of the soil is taken care of.

7.7 In the Chittagong-Hill-Tracts

. . . My destination was the Chittagong-Hill-Tracts East of Chittagong, in the northern parts of farther India. Here I wanted to celebrate the reunion with the tropics and continue my botanical studies, which I had started before the war in Java and Sumatra. There was no disappointment: The war left the tropical nature and the people untouched. It tropic landscape, which I was looking for, appeared at once best. . . .

. . . But virtually the Hill-Tracts . . . can be reached only by the water ways. The main traffic takes place only on the rivers, primarily on the Paraphernalia, which comes from the heart of the Hill-Tracts and flows near Chittagong in the Bengal bay. Through dense woods and grass covered hills the river loops slowly towards the coast. It carries the small boats, in which the people bring jute and cotton, grass for covering roofs and other products of the people in the mountains to the coast in journeys, which take days. The apes are used to this traffic, which exists since centuries and stay quietly at the banks, while the boats pass by; they enjoy a banana, which is thrown toward them. In the night the open fires on the boats add to the magic of the tropic night. The rhythmic creak of the rudder mixes with the animal sounds in the forest. Tree stems, especially the huge stems of the teak wood, and mighty bamboo flows swim down the river. These woods and bamboo are the main wealth of the Hill-Tracts.

The formidable bamboo forests belong to the most impressive of this area; 50 or 100 km, often even further, one can hike on small paths through this area,

7 *Bünnings traveling*

without seeing anything else besides bamboo. It appears like a huge cereal field with 20 to 30 m high halms. They are so dense, that there is no light at the bottom for herbs or bushes. The only change is given by the bamboo collectors, who cut the strongest one and carry them to the rivers, where they are put together to rafts. Seldom, in intervals of about 30 to 35 years, the bamboo is in flower, but then in the whole area. Huge bamboo woods, covering thousands of square kilometers, are simultaneously in bloom. Afterward the root stock is exhausted; the plants die off all over. But of the billions of seeds the birds leave enough, that the bare range is soon covered by seedlings, which grow up as uniformly as the halms of a wheat field, and which get old at the same time in the same way, only much more slowly. Therefore all of them will flower again in the same month about 30 years later. If one takes a piece of its root stock out and cultivates it in an European greenhouse, the plant will flower there in the same year as the sister plants in the jungle, as confirmed repeatedly.

Every time after flowering and seed formation the bamboo can extend its habitat considerably; people help in doing so. . . .

(here the fire clearance of the bamboo is described)

But in spite of this there is still an extended, original tropical deciduous forest present, forest with valuable wood, with the epiphytes, especially orchids, with the underwood of Zingiberaceae, Araceae and palms, with the climbing Rotan palms, Araceae and ferns, which characterize the tropical forest of Asia.

(here the teak wood planting is described)

How happy I and my wife disposed such a solely living Bengali Forrester, while we shared with him for some weeks the bungalow and the struggle with mosquitoes and sand flies. In the evening we sat together on the veranda, while a servant fanned air towards us with a big fan, which was manipulated with a rope, and listened to the voices of the forest. We heard the elephants, braking through the woods on the other side of the river, swimming through the river and passing our bungalow close by. We learned to estimate the daily rice in the same way as the unfiltered, only boiled, turbid water from the Paraphernalia and its small tributary, the Kaptai.

The people . . . their possession is small, but here one does not meet the poverty, which characterizes the cities of India and Pakistan. The forest and the primitive fields offer everything they need: Bamboo for constructing housing and to earn some money, rice and fruit for the daily food, cotton for the yarns, which are spun in each cottage by the woman. What a difference between the diligence, the peace, the tidiness and the beauty here in the remote mountain villages, and the turbulence, the dirt, the noise and the beggars laying in the sludge of the streets in Chittagong! . . .

7.8 Plant life during the seasons in the arctics

One of the factors, which limit the number of vital plant species in the polar regions considerably, is primarily the shortness of the summer. Even in the low land of northern Scandinavia, i.e. in the plains of Lapland, the duration of the vegetation period is restricted to about 3 to 4 months. In the mountain ranges,

7.8 Plant life during the seasons in the arctics

already at altitudes of 500 to 1000 m above sea level, are only 2 to 3 months left for an active plant life, in the rest of the year they stay in winter rest. . . . The shortness of the summer can be deduced quite well from the wood of, e.g. the pines . . . The annual rings are quite small . . . In most cases there is just time for developing the “spring wood” (see figure 7.3). . . . In a similar way . . . most of the other plants . . . are hit by the sudden onset of the cold season and are thus forced to an early winter rest, whereas in our latitudes they can prepare them self very slowly. Therefore there is only occasionally a year, in which in the most northern regions the fruits reach ripeness, for instance the berries of the various low shrubs of the kinship of blueberries . . . The Laplander has to be content with the harvest of the crow berry (*Empetrum nigrum*), the fruit of which are, however, here much more tasty as compared to the one at the few locations in central Europa, for instance in Northern Germany . . . The Lap mixes it with the milk of reindeer and is in this way able to keep it throughout the winter.

. . . The plant species and -varieties of the arctic are characterized . . . by a distinct adaptation to the special conditions of the polar climate, which does not allow them to be vital outside of these regions.

. . . The visitor of Lapland notices immediately the “polar spruce” with its short branches . . . This variety of our common spruce is so much adapted to the special climatic conditions of the arctic, that it develops here better as in the more southern regions. It is not simply the higher temperature, which does not fit it; where it is grown further south, . . . it can be observed clearly, that . . . paradoxically just the coldness harms these trees . . . If one travels in a year, in which relatively late in May frost occurred, one recognizes in . . . the polar spruces displaced to the south often frozen shoots. Further up in the north these frost damages are missing.

This initially baffling behavior can be explained by the different way of the polar spruce to adapt to the transition from winter to summer as compared to the varieties of spruces in the moderate latitudes. In the far north the spring begins late; but if it starts, late frosts as they occur in more souther regions almost regularly, do not show up. That is of course primarily caused by the sun, which does in the arctic during this season not drop below the horizon. The temperature increases rapidly at the begin of the summer. Once the first weeks and days of June with temperatures below 0° are gone, it gets almost every day by about 1° warmer; the summer temperatures are thus reached in not more than two weeks.

. . . the plants of the arctic are extremely fine adapted with this peculiarity in the change of the seasons. . . .

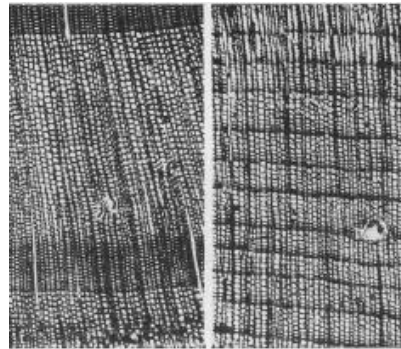


Figure 7.3. Section through pine wood from central Europe (left) and Lapland (right)

8 Obituaries

8.1 Wolfgang Haupt: Erwin Bünning 1906-1990

On October 4, 1990 Erwin Bünning, honorary member of the German Botanical Society, has left us for ever. He was one of the most prominent plant physiologist of our century, not only in the German speaking area.

Bünning was born on January 23, 1906 as a son of a teacher in Hamburg. He was of course a good student - in the subjects, he was interested in. But then he onces bet with his class teacher in the secondary school, that he would improve during one year his modest note in history drastically - since this is only pure study matter and a question of diligence, although the time for it would actually be too valuable. Of course Bünning won the bet!

He did afterward not study in Hamburg, but went abroad - "*according to good Hanseatic tradition*" - as he stressed even at high age. He chose Göttingen and Berlin and was promoted already after 7 terms at an age of 22 years under Hans Kniep.

In the following 3 years we find Bünning as a grant holder in Frankfurt and Utrecht, then as an assistant in Jena, where he obtained his state examination in 1930 and habilitated in 1931 aged 25 - an age, in which only a few students nowadays have started their diploma examination. Only now 4 years of settled time followed in Jena, before he took over an applied professorship in Königsberg. Formally this was for 7 years; but out of it Bünning took one year as a research explorer in Sumatra and from 1939 on he was most of the time in military service. For the same reason during the three years as an extraordinary in Strasbourg (1942 until 1944) there was little time for research and teaching.

The first ordinary took Bünning with 39 years; his activity in Köln was, however, less devoted to science, but more to build up incredible temporary appliances, to "*organize*" the missing, and the "*management of deficiencies*". Bünning had, however, acquired already at that time a considerable reputation by his expert colleagues, so that he in 1946, that is just one year later, got an appointment for an ordinary in Tübingen. Here a small, but undestroyed institute was waiting for him, a chair rich in tradition, if one remembers the names of Hofmeister, v. Mohl, Pfeffer and Vöchting, in the oldest "*natural science faculty*" of Germany. This faculty represented an incomparable "*Biotope*" for a young biologist: The French occupation force had the ambitious effort, to take over the leading role in the cultural reconstruction among the occupation forces. For the French it was therefore quite right, that several of the highly qualified (and politically integer) scientist in another occupation zone could be recruited and was available for Tübingen. The level and the manifold in biology was for the coming decades furthermore decisively shaped by the fact, that several Kaiser-Wilhelm-Institute (today Max-Planck-Institute) found in

8 Obituaries

Tübingen a new home. The section Melchers was until 1950 provisionally housed in the basement of the botany institute. This special Tübingen atmosphere was surely one reason, that Bünning in 1953 and 1957 declined the two honorable calls for München and Göttingen.

In contrast to the relative liberality in the appointment to a chair was the strict control of the slowly developing research by the occupation army: Each year a detailed report about the performed and planned research had to be submitted. And one day came a young French soldier who was stationed in Tübingen to Bünning, introduced himself as a student of biology and asked, whether he could work during his spare time in the institute. He was finally fully integrated in the institute and worked successfully in research. Then he surprised Bünning with the message, that he would from now on be one of the “*spies*”, who had to report yearly to the headquarter about the research activities of German institutes; he would of course talk this report over with Bünning and harmonize it with him. Out of this “*collaboration*” developed a long lasting and friendly connection and scientific cooperation of colleagues in the institute with the well established French colleague.

Bünning was also leading in other connections to foreign countries; he belonged to the first, who were after the war as a German invited to lectures abroad, even in former enemy countries. Therefore we had rather early foreign guests in the institute. For us students or assistants it was a real challenge (today hardly imaginable!), to follow a lecture in English.

The young Tübingen ordinary could look back already upon considerable scientific successes. From the very begin onward his main concern were such biological processes, which could be deduced to physico-chemical principals. His early research was therefore concerned with movements, its mechanics, its control by “*stimuli*” as well as the significance of bioelectric events in the causal chain. This research orientation was extended over time to all kinds of different types of movement and to various signals of the environment (“*stimuli*”). From there further working fields opened up, such as cell differentiation, polarity, pattern formation and regeneration, but also - if one adds the PhD works induced by him - flower formation, regulation of spore- and seed germination, photobiology. In spite of this specialization towards physiology he was always a broadly interested biologist, who had in addition a remarkable knowledge of species; that became apparent especially at the annual Lapland-excursions, which were a lasting benefit for all participants. On the other hand Bünning has treated also boundary issues of the theoretical biology with turns towards philosophy (compare for instance in this connection [Mohr \(1991\)](#)), and he was interested in the history of science.

The preoccupation with “*stimulus*”-movements lead him already rather early to an instance, which could not be reduced, in spite of intensive trials and idea-rich approaches, to regulating external factors, namely the diurnal leaf movement of the bean seedlings. Although Pfeffer had already shown, that these movements can be controlled endogenously, but it was Bünning, who proofed it unanimously. He had thus found his proper research field in biorhythms, which he never left throughout his life and which won him the world wide fame of being one of the most eminent biologists of our time. His permanent achievement lies

8.1 Wolfgang Haupt: Erwin Bünning 1906-1990

beyond the characterization of this single case, which appeared so far to be a play of nature, and the evolution of which was therefore completely non-apprehensible: The diurnal rhythms (*“circadian rhythm”*) was recognized by Bünning as a general biological phenomenon, and it was probably his most ingenious merit, to connect photoperiodism causally with the endogenous diurnal rhythm, for which the leaf movements are only an indicator (a *“hand”* of the *“physiological clock”*). The appreciation by the specialist colleagues was a long time coming; first the function of the diurnal rhythm as the *“clock”* for the photoperiodism was vividly denied (*“it is not true”*), then accepted, but regarded as marginal (*“it may be true, but it is not important”*), and finally nostrified by these colleagues (*“... but I discovered it first”*). By these resistances Bünning was again and again challenged, to work out even better arguments, and then he was for decades a regularly invited lecturer of international chronobiology- or rhythm- congresses (jocular called *“watchmaker congresses”*), as the original initiator of this new research discipline. Finally he tried also, to penetrate into the structural and molecular dimensions of the analysis, and he commiserated the progress of the young generation (including former students) in this field up to his old age.

His book *“The physiological clock”* was translated in many languages and can be regarded as his statement of accounts of this important part of his lifework. Further book editions are compiled at the end. A listing of the about 250 journal articles and the around 100 PhD papers induced by him would go beyond the scope of this obituary.

Large is the number of tributes, which Bünning received from Germany and from foreign countries. An honorary doctorate he obtained from the university of Glasgow (Doctor of law!) as well as from Freiburg, Erlangen-Nürnberg and Göttingen. He was a member of the Leopoldina, of the Heidelberg Academy, the New York Academy of Sciences; corresponding member respectively foreign member of the German Academy of Sciences in Göttingen, of the Bavarian Academy of Sciences, the American Botanical Society and the National Academy of Sciences USA. He was appointed to an honorary member by the Japanese Botany Society (1957), the American Society of Plant Physiologists in New York (1973), the Botany Society in Geneva (1975) and the German Botany Society (1982).

It is not self-evident, that an excellent scientist is also a good academic teacher. But the successful career of an extremely large number of Bünning students in universities, schools and other occupational fields proofs his effective teaching qualities, perhaps even more his function as an educator - although we did at that time not notice, how effective we were educated. Most important of it was the independence in thinking and judging - this was much more important as the mediation of knowledge, for which one should not rely on the professor (*“you don't need to visit my lecture”*). That was reflected in the style of leadership and working in the institute.

The PhD student got maximal independence, but this was also expected. This happened already while asking for a PhD topic: *“Have a look at this paper (4 pages only!) on the flower formation in peas; I am sure there is something to do. One could grow the seedlings or the mother plants under various photoperiods, perhaps also cut off the cotyledons.”* Or: *“You could heat up the dry seeds and*

check the germination". To refer to literature was not common, since there was the library and the comprehensive reprint collection of the boss. Likewise the right methods and the kind of experiment was up to our own initiative. Bünning did not require a regular report and did not trouble us with questions for the newest results. But if we needed his advice, he was always available for us - without a fixed consultation hour and without notice in advance.

For the assistant it was self-evident, that he fulfilled his tasks independent. For these tasks there were no specific instructions, and by no means any "*assistant meetings*", and the assistant was in no way controlled. The assistant for lecture preparations informed himself by asking his predecessor, and Bünning relied on it. The same was true for the assistant for courses, who was neither bossed around with regard to content nor in respect to didactics. Since everybody gave really his best -following the prototype - criticism was normally superfluous; but because this was also self-evident, there was no praise. Here lies probably the deeper reason for Bünning being sparse in praise and criticism, that the young assistant was forced to a critical self-assessment.

But the education reached further and affected the character. Bünning's modesty has been and still is an ideal for us - his students -, and likewise his constant cooperativeness, to take over additional tasks for the commonality (which was never mentioned with any remark). To the task of an university teacher belonged already at that time a good portion of administration, committee activities and science policy. Actually Bünning was "*way to valuable*", to wear his power out in bureaucratic activities. In spite of it he took over for a year the rectorship in Tübingen, as he was called for it, was involved for years decisively in the work of the DFG and the Science board and did not refuse to accept external appointment committees for new university foundations.

This much to short back-sight of a fulfilled life would be incomplete, if the personal contacts would not be mentioned. Bünning's very restrained nature found an ideal antipol in our First Lady, and the many stimulating evenings in the convivial house Bünning - where almost never "*talking shop*" took place - are for all of his coworkers a lasting memory. We can not honor the commemoration of our deceased better, as trying to pass on the spirit of both Bünning's to the next generation.

W. Haupt¹

8.2 Berthold Schwemmler: Obituary for the passing of Professor Erwin Bünning

On October 4, 1990 Professor Dr. phil., Dr. jur. h. c., Dr. rer. nat. h. c. mult. Erwin Bünning died in Tübingen in his 84th year of life. The University and the botany institute honor him on October 12 with an academic commemoration, during which one of his students the botany Professor Hans Mohr from Freiburg, has recognized his personality and his work.

... Bünning's scientific work is based on a rare versatility of interests. It is characterized by the intuitive recognition of open questions and the experimental

¹Haupt (1992)

8.3 Maroli Chandrashekar: Erwin Bünning: A Colossus of Chronobiology

possibilities for its solution. There is hardly any area of the physiology of development and movement of plants, which he or his about 100 PhD students has not enriched by own work. Countless are furthermore the studies which were induced by him directly, or indirectly after scientific discussions of other teams all over the world. The papers dedicated to him at the occasion of his big birthdays bear eloquent testimony of it. His special interest was the internal course of processes in organisms; His book “The physiological clock” was also translated into English, Russian, and Japanese. His textbook “Physiology of Developmental and Movements in plants” is in the mean time a classic. He was again and again also stirred and inspired by the border zones between biology and philosophy. Some of it he has written down in his book “Theoretical fundamental questions of physiology”. As an emeritus he wrote about his great predecessor Wilhelm Pfeffer, the work of whom has again and again stirred him².
...

8.3 Maroli Chandrashekar: Erwin Bünning (1906-1990): A Colossus of Chronobiology

“Bliss it was in that dawn to be alive, but to be young was very heaven”

W. Wordsworth

Colin S. Pittendrigh drew pointed attention in most of his landmark papers of the late 1950s and early 1960s, to what he himself gave the name of the *Bünning hypothesis*. He also recognized, that Bünning's idea was wholly new. This was the paper in which Bünning clearly postulated that circadian rhythms acted much as yard sticks in measuring day length and therefore the season of the year. The paper became a citation classic of the Current Contents in 1982 having been cited in over 135 publications since 1961 and further turned out to be the most cited paper ever published in this journal: [Bünning \(1936b\)](#). Bünning in what was really a very original hypothesis, implicated circadian rhythms in the time measurement in photoperiodism. By means of the diurnal oscillations (the physiological clock) the cell is brought alternately into two period parts with properties differing both quantitatively and qualitatively. Each of these parts lasts approximately eleven to thirteen hours. The basic importance of this oscillation lay in the fact that the cell is thus brought to certain extreme physiological states. Various physiological functions are possible only when these extremes are reached. One of these extreme states is characterized by high synthetic capacities and the other by a high catabolic capacity. Bünning also very lucidly explained that photoperiodic regulation of a biological process is linked with time measurement. Organisms have an inherited time scale at their disposal. Day after day, throughout the year, they compare the scale with the actual length of day or night. As soon as the day or night exceeds this inherited scale then a physiological response ensues. This is what we call a photoperiodic reaction, and the inherited time scale is known as the critical day length.

²[Schwemmler \(1990\)](#); only those passages given, which were not already in the article on page 40 (Engelmann)

There was some controversy for a while over whether photoperiodic time measurement is made by the principle of an hourglass or by a process of oscillation. The hourglass model gradually found less and less support since the internal time scale or the critical day length ticking off time was found to be practically independent of temperature with Q_{10} values in the range of 0.9 and 1.1. The hourglass model, on the other hand, could not accommodate similar temperature independence.

It is now not only safe but gracious to speak of Bünning's pioneering role in having made chronobiology, a frontier area in biological sciences. But Bünning's contributions on biological rhythms, strangely enough, did not find much resonance even in Germany (Chandrashekar, 1995).

Here Shekar tells the Könitz story (see the text on page 93), Bünning's memberships in various academies, his honorary doctorates, and his retirement. He also mentions his post doc work in Tübingen and how close he came to Bünning during this time. He was also asked to stand in for Colin S. Pittendrigh, who was indisposed, and deliver an in memoriam lecture on Bünning at the Gordon research Conference on Chronobiology in the autumn of 1991 at Irsee in Bavaria in Germany. He felt very honored and privileged for it.

8.4 Yoshio Masuda: Remembering Professor Bünning

The great plant physiologist Professor Erwin Bünning, renowned for his studies on “the physiological clock”, passed away on October 4, 1990 in Tübingen, Germany. He had been a member of our Society, JSPP (Japanese Society for Plant Physiologists) until 1987, when he became ill, and has been an honorary member of the Botanical Society of Japan.

Professor Bünning has been an inspiration to many JSPP members. The current President of the JSPP, Professor Masashi Tazawa, once spent two years at the Botanical Institute, Tübingen, and studied the rhythmic movements of plants under Professor Bünning. I also had the pleasure of being very close to Professor and Mrs. Bünning, and together with many other JSPP members, grieve at the loss of Professor Bünning.

I met Professor Bünning for the last time in the summer of 1985 when I attended a conference held in Heidelberg. My wife and I took this opportunity to make a short visit with Professor Bünning and Mrs. Bünning in Tübingen. When we left Tübingen from the Hauptbahnhof, they waved their hands and said “*Auf Wiedersehen*”. I am very sad not to have another chance to “wiedersehen” (see you again).

Professor Bünning was born on January, 23, 1906 in Hamburg. He finished Gymnasium there, then went to University Berlin, studying botany under Professor Kniep, and obtained a doctoral degree in 1929. ...

(here follows the scientific Curriculum vitae of Bünning and his publications)

...

It was spring 1962, when I first met Professor Bünning. Professor Tazawa, who had studied under him is a good friend of mine, and thus I decided to try to visit Professor Bünning in Tübingen while I was working in Sweden. I was not

8.4 Yoshio Masuda: Remembering Professor Bünning

quite sure if such a great plant physiologist would spare time to see me, young at that time, but anyway I arrived at the Hauptbahnhof of Tübingen. I went to the tourist information office on the bridge over the River Neckar in order to reserve a room at a guest house, then telephoned Professor Bünning. He answered and said “*Wait there until someone from my Institute comes to pick you up*”. In a short while a lady secretary came to me. She canceled the reservation of the room and arranged a room at the guest house in the Institute. In the evening of that day, I was invited Professor Bünning’s house in Waldhäuserstrasse and met Mrs. Bünning, Eleonore, and their second son Otto (their first son Klaus was killed in an accident in the Alps in 1957).

The next day I met several people at the Institute, including W. Haupt who showed me his phytochrome experiments on the movement of chloroplasts. I had a wonderful time discussing many things. And Professor Bünning even drove me around in his Volkswagen Beetle, showing me the beautiful city of Tübingen, starting from the Rathaus. In the afternoon, one of the people at the institute took me to the Schloss (castle) which was connected with Hoppe-Seyler. During my stay in Tübingen, everyone mentioned that they had a good time with Professor Tazawa when he was there, drinking a lot of wine because he liked it very much. Thus, I was given an extraordinary warm welcome by Professor Bünning and his people in the Institute.

I do not really remember how many times I visited Tübingen to see Professor and Mrs. Bünning. They came to Japan in 1978, invited by Professor Tazawa and supported by the JSPS. They met many botanists in Japan, and many JSPS-members may remember their visit. Professor Bünning gave me a copy of his latest book “*Wilhelm Pfeffer*”. He wanted to visit the Institute of Agricultural Biology in Kurashiki, because he wanted to visit the “*Pfeffers library*”, and Ehime University to see the late Professor Joji Ashida, who was my teacher at Kyoto University and the first president of the JSPP. Professor Ashida was rector of Ehime University at that time. Professor Bünning also wanted to see Professor Masami Suda who was Dean of the Medical School at Ehime in order to discuss the biological clock. I was with him and Eleonore for several days, visiting those places, and Professor Ichitaro Harada of Hokkaido University joined us. We first went to Kurashiki after Professor Bünning had given a lecture at Kyoto University.

In Kurashiki, visiting the Pfeffers library, Professor Bünning slowly picked up several books, turning over the pages, standing for a long time in front of the bookshelves. I could imagine his feeling when he first entered the Library and saw Pfeffers books, particularly the two volumes of notebooks for the second edition of “*Pflanzenphysiologie*”, where Pfeffer had made a lot of handwritten notes on the pages.

When Professor Toshio Kawasaki of the Institute was showing us around the city of Kurashiki, Mrs. Bünning suddenly shouted “*This is Jena*”. It was a small coffee house named Jena. Mrs. Bünning found it quickly because “*Jena*” was the place where they married when Professor Bünning was an assistant to Professor Otto Renner.

Professor Kawasaki took us also to the mount Washiu. It happened to be the day when the construction of the huge Seto Ohashi Bridge over the Inland sea

was to start and there were a lot of TV-Cameras. The bridge is now complete, and I cannot help remember that day with Professor and Mrs. Bünning whenever I see the bridge.

During the time Professor Bünning was occupied with academic activities in Kyoto and Osaka, Mrs. Bünning came to our house and visited places such as the Expo Park together with my wife. In the evening we had a pleasant time at our house with Professor Bünning and Tazawa.

Several years later when we went to Tübingen, Professor Bünning showed us around the new Institute and the Botanical Garden in “*Auf der Morgenstelle*” and said “*I seldom come to this garden except when I have visitors*”. On the day we left Tübingen, I was supposed to give a seminar at the Botanisches Institut, Goethe Universität in Frankfurt a. M. in the afternoon. I was planning to go to the airport in Stuttgart to fly to Frankfurt in the morning. Professor Bünning drove us in a “*Golf*” not the Beetle from Tübingen to the airport, although he said that it is was not recommended to fly from Stuttgart to Frankfurt. Just as he had said, our flight was canceled due to dense fog and Lufthansa arranged a bus to drive us to Frankfurt airport. Professor and Mrs. Bünning waved to us, saying “*You must take trains next time. Auf Wiedersehen.*”

As many members of our society know, Professor Bünning was a real humanist who loved science and his colleagues, regardless of their nationality or age. He and Mrs. Bünning really loved Japan and their Japanese friends.

We have lost a great botanist. The passing away of Professor Bünning is a great loss not only to the field of plant sciences in Germany and Japan but of the whole world.³

8.5 Yoshio Masuda: Visiting the grave of Professor Bünning

... On December 1, 1990 I went to the Friedhof (graveyard) ... in Tübingen with Mrs. Bünning, Professor Achim Hager and my wife The day was rather cold and the streets were partly frozen and somewhat covered with snow due to the snowfall on the day before.

The grave still had a simple wooden cross with the name of Klaus, who had been killed by an accident in the Alps in 1958, and Erwin. We put in front of the grave a “Kranz (bouquet)”, which Professor Hager had prepared for us, and a pack of Japanese Sake which Professor Bünning liked, as requested by Professor Tazawa. Mrs. Bünning said, “*Erwin should be most pleased*”. We prayed for Professor Bünning in front of the grave.

On the way back we were invited to the Bünning and Mrs. Bünning kindly served us tea and cakes. She showed us many photo albums from their visit to Japan in 1978. She repeatedly said to us how much Professor Bünning loved Japan and Japanese people and how much he wished to return to Japan. I then gave her a gift from our colleagues in Japan: M. Furuya, I. Harada, N.

³1961 Ph.D. Kyoto University, 1953 Ass.Prof. Ehime Univ., 1957 Ass.Prof. Osaka City Univ., 1965 Assoc. Prof. Osaka City Univ., 1971 Prof. Osaka City Univ. 1991, Prof. Emeritus Osaka City Univ.

8.6 Masashi Tazawa: Commemoration of Professor Bünning

Kamiya, A. Takimoto, M. Tazawa and Y. Masuda. It was a Kiyomizu plate with a Sho-zui pattern. On the backside Professor Tazawa had written the following:

*In thankful commemoration of our venerated teacher and friend
Professor Dr. Erwin Bünning.
Kyoto, October 1990⁴*

Mrs. Bünning was most pleased to receive the gift, and the next day when we saw her again, she asked me to convey this letter of her appreciation to those, who offered her the gift:

December 1990

*Dear friends in Japan:
Today Prof. Masuda brought me a wonderful present. I am happy,
that you don't forget my dear husband, your friend Erwin Bünning.
He loved Japan and Japanese people. In the hospital, when he was
very ill, he said: "I want to visit Japan once more". It was impossible
to do. He passed away, and we miss him not only in Germany. I
am happy, that Prof. and Mrs. Masuda visited his grave, and every
day I look to the wonderful present and know: "He is not forgotten."
My best wishes and greetings to you all.
Yours thankful
Eleonore Bünning*

On the day we visited the cemetery, we were all invited to Professor Hagers house for dinner. However, Mrs. Bünning did not accept because she had a stomach-ache. The next day Professor and Mrs. Hager invited us again for lunch and Mrs. Bünning joined us. She looked much better, driving to the house in the Volkswagen Golf by herself at the age of 82. We all had a good time together, talking about the late Professor Bünning, while dining on Weisswurst⁵ and other German cuisine. We were happy to see that Mrs. Bünning looked rather healthy, much healthier than we had seen her at the time that Professor Bünning was ill. Professor Hager said that she had much been very busy after Erwin's death, but was mentally and physically of very strong person.

I wish for the peaceful rest of Professor Bünning's soul for the good health of Mrs. Bünning ...⁶

8.6 Masashi Tazawa: Commemoration of Professor Bünning

Professor Erwin Bünning, member of the Japanese Society for Plant Physiologists and honorary member of the Botanical Society of Japan, died on October, 1990. As he was born on January 23 in 1906, he was 84 years old. In his contribution to a symposium in Blaubeuren in 1987 in memory of Wilhelm Pfeffer (Bünning, 1988) Bünning stated:

⁴in the text it was written in German

⁵Bavarian veal sausage

⁶Masuda (1991); Yoshio Masuda was president of JSPP

8 Obituaries

“Pfeffer was particularly fortunate to have been born at an opportune time. Had he been born earlier, he would have been considered as one of those ‘Destroyers of Natural Sciences’ along with Bacon, Newton, and other founders of modern Natural Sciences, by philosophers such as Friedrich Wilhelm Schelling (who was so appreciated in Tübingen)”.

Pfeffer was the scientist Bünning looked to with deep respect and who served as a model figure, as can be seen from the title he selected for the prefatory chapter of *Annual Review of Plant Physiology* (Bünning, 1977b): *“Fifty years of research in the wake of Wilhelm Pfeffer”*. He stated at the end of this paper:

“I would not like to see the old type of plant physiologist fully disappear. But we do lack (in this country) enough scientists belonging to the new type. This is not only because leading biochemists and geneticists had to leave Germany during Hitler’s time. It had already begun by neglecting Pfeffer’s warning not to separate botany from the other fields of natural science. The new plant physiologist is actually what he should be in the present situation of biology: Not primarily botanist or zoologist, but rather a chemist or physicist who succeeds in recognizing the physical and chemical complexity of those special natural structures which we call organisms. Most of the earlier chemists and physicists did not realize this.”

Pfeffer was a pioneer who tried to understand the phenomena of life via molecular physiology based on physics and chemistry, while severely rejecting the vitalism that was still a strong current at that time. His work included the discovery of osmotic pressure, the prophecy of the existence of the plasma membrane, the discovery of bacterial chemotaxis, the examination of adaptive enzymes, and the demonstration of endogenous rhythms (circadian rhythm) using a self constructed climate chamber equipped with a switch mechanisms controlling light and dark. All of his work was related to areas important to modern biology. We can understand his greatness from the excellent book *“Wilhelm Pfeffer”* written by Bünning in 1975.

Was Bünning himself born at a suitable time? His ancestors were farmers in Schleswig-Holstein for several centuries. His father was a school teacher and a good teacher for Bünning too. When I visited Bünning in 1987, he showed me a voluminous book on physics and chemistry and told me, *“My father gave me this book when I was a schoolboy, and I studied science with the help of this book. The book was so excellent, that my studies of physics and chemistry at university was very easy. I treasure this book even now”*. Bünning attended primary school from 1912 to 1916 and then visited a gymnasium in Hamburg, finishing with the Abitur (the final examination before entering university) in 1925. That school seems to have traditionally promoted the spirit of freedom and self-induced studies. Bünning later studied at the Universities of Berlin and Göttingen, but he was always proud of his native place, the Hanseatic city of Hamburg.

Bünning loved freedom very much and hated and rejected the Nazi fascism. In his letter to me dated August 11, 1988, which included his brief autobiography written by my request, he wrote: *“I was banished from Jena by the Nazi students, since I stated my opinion against Hitler”* (He was an assistant of Prof. Otto Renner in Jena since 1930). He moved to Königsberg in 1935, and then he went to Indonesia (Java and Sumatra) for a research expedition from 1938 to 1939,

8.6 Masashi Tazawa: Commemoration of Professor Bünning

the results of which were published in the books [Bünning \(1949\)](#) and [Bünning \(1956b\)](#). When he returned to Germany, he was immediately called to war, and was in the army for 6 years as a soldier, refusing continuously to become an officer.

During his two years of study at the University of Berlin, he was much fascinated by the thigmonasty of the flowers of *Sparmannia africana* and became devoted to Pfeffers works and ideas, as stated in [Bünning \(1977b\)](#). . . .

Bünning studied at Göttingen in the winter term of 1927 and the summer term of 1928. He mentioned in a special lecture in December 1986 (published in [Bünning \(1987\)](#)), when the University of Göttingen awarded an honorary doctoral degree, that many prominent scholars were at this university at that time, such as J. Franck (physics, awarded the Nobel prize in 1925), A. Windaus (chemistry, awarded the Nobel prize in 1928), A. Kuhn (zoology), W. Heisenberg (physics, awarded the Nobel prize in 1932), P. Jordan (physics), O. Hahn (chemistry and physics, awarded the Nobel prize in 1944), and M. Delbrück (physics and biology, awarded the Nobel prize in 1966) etc. By the way, these scholars received their doctoral degrees at the ages of 24, 23, 23, 22, 24 and 22. Göttingen at that time was the Mecca of natural sciences. It is easy to understand, that Bünning was attracted by that atmosphere. In a letter to me dated December 15, 1986, Bünning remarked on this special lecture in Göttingen: “*The main purpose of the lecture is to attack the bureaucratism of universities in the present time*”. Perhaps he intended to suggest, that the universities should not treat the students in a uniform manner but should give able students freedom to go their own way as soon as possible without interference from their teachers. In that lecture he cited another persons words: “*Nothing is more unjust than to treat equally things that are essentially unequal*”. At the end of the letter he referred to the young age at which the above famous scientists received their degrees and said: “*Nowadays most of the students who get doctorates are 30 years old. They are too old to seek quite a new (and crazy) way.*” Also in his special lecture in Göttingen, he, remembering the time of his discovery of the biological clock, states: “*If I were over 30 years, I could not have to develop such a mysterious and metaphysical hypothesis*”.

He returned to Berlin after a short stay in Frankfurt and 3 months in Utrecht with F. W. Went. He got his doctoral degree in 1929 at the age of 23. His doctoral work was published in two papers: *Untersuchungen über die Seismoreaktionen von Staubgefäßen und Narben*⁷ ([Bünning, 1929b](#)) and *Über die thermonastischen und thigmonastischen Blütenbewegungen*⁸ ([Bünning, 1929a](#)).

These papers were completed when he was in his second year of study, and he published at that time five more papers on physiology of stimulus-response, physiology of root growth, electric physiology, and phototropism.

Before receiving his doctoral degree, Bünning experienced an event, which directed him to his later research. He says in his speech (originally in German) in Göttingen: “*Just briefly before finishing the 6th term, Kniep*⁹ *came to me and*

⁷ *Studies of the seismoreactions of stamina and stigma*

⁸ *On thermonastic and thigmonastic petal movements*

⁹ *Hans Kniep, Bünning's doctoral advisor, Professor of plant physiology at the University of Berlin*

showed a letter from the Research Institute for the Physical Basis of Medicine. The institute was looking for two botanists to join a research group to investigate the influence of atmospheric ions on plants. Kniep asked me to apply for it. If I accepted this offer, I had to begin to work there within two weeks. My “yes” came immediately¹⁰. The other botanist was Kurt Stern. He had published already a book on “Electrophysiology of plants” in 1924. In Frankfurt, we investigated how the transpiration and growth of plants were influenced by ion-rich and ion-free air. The result: No effect was found. However, we were able to find the secret of the diurnal leaf movement which had been discussed for a long time and for which several researchers postulated that some “factor X” may operate, probably cosmic rays or electricity of the air. Our result: It was truly the endogenous rhythm (regulated by light-dark change), as several researchers had asserted long before.”

Here I would like to refer the work published in 1930 with Stern (Bünning and Stern, 1929). The paper was summarized as follows: “The leaves of the legume *Phaseolus multiflorus* show a diurnal nyctinastic movement under conditions of continuous darkness and constant temperature. There exists a constant relationship that the interval between the time of the first amounts to 10 to 16 hours. The period length of the rhythm under constant conditions is not 24 hours but 25.4 hours. The phenomenon can be explained by assuming that the nyctinastic movement is an autonomous one which can be regulated by light and temperature. The time for the leaves to take the uppermost or lowest position is determined by the time of setting the plants, at least under our experimental conditions.”

Thus young Bünning at the age of 24, having a crazy idea of a physiological clock, dared to sail into an unknown field of science. He never looked back for the next 60 years until his death.

Referring to the lack of sympathy for this kind of work, he once told me: “When I presented my results on the circadian rhythm of an animal, an aged professor reminded me that this was a botanical meeting.” In the preface of the third edition of his famous book “*The Physiological Clock*” he wrote: “As recently as 15 to 20 years ago, to proclaim the existence of an endogenous diurnal rhythm was regarded even by some well-known biologists, as subscribing to a mystic or metaphysical notion.”

It was his idea of the measurement of day length by a biological clock that made his name immortal. He briefly touched on this in the Göttingen lecture: “When I was reading journals, I encountered the phenomenon of photoperiodism. An idea struck me that the endogenous diurnal rhythm may be a physiological clock, with which, for example, the length of day can be measured. In such a way I came to my publication of the paper in the “*Berichte*”¹¹ of this society, volume 54, 1936 “*Die endogene Tagesrhythmik als Grundlage der photoperiodischen Reaktion*” (Bünning, 1936a). . . .

In shortday plants light in the photophilic phase stimulates flowering while light in the skotophilic phase inhibits flowering. It is well-known that the

¹⁰Note: This yes determined his future work

¹¹Reports

8.6 Masashi Tazawa: Commemoration of Professor Bünning

experimental support for this theory was found by Hamner and coworkers including Takimoto (now professor emeritus of Kyoto University) in the 1960th. Also in 1958, one of Bünning's pupils presented powerful experimental evidence for this theory (Könitz, 1958).

To shed some light on this situation around 1958, I would like to cite part of a laudation given by one of Bünning's pupils, Hans Mohr (professor of Freiburg University) on the occasion of receiving the honorary doctoral degree from the University of Göttingen in 1958 (Mohr, 1987). *“found in a short-day plant Chenopodium amaranticolor that far-red light given in the light period inhibits the flowering and that this inhibitory effect can be reversed by red light. In the dark period is situation is quite the reverse: red light inhibits the flowering and far-red light reverses the inhibitory effect. From these results Könitz rightly drew the conclusion, that active phytochrome (Pfr) in the photophilic phase of the endogenous rhythm stimulates flowering or is rather essential for the flowering, while the same Pfr in the skotophilic phase of the rhythm inhibits the flowering.”* “As we followed embodiment of this work together with him, it was impossible for us to understand why these studies were not accepted by influential specialists, but were regarded instead as a made-up story- fairy tales instead of solid science.” Mohr adds: *“Könitz has long been reinstated. His spectacular findings in those days were re-found repeatedly by other scientists who had learned to experiment as clean and devotedly as he did.”*

The following sentence of Mohr arouses my sympathy. *“Bünning, in response to these matters, behaved with a restrained attitude. With his clear arguments and noble diction he was always trying to persuade those who challenged him with dispute. His calm attitude against the scientific opponents irritated often the pupils who were not accustomed to the Hanseatic modesty. But at least, we were much impressed by his attitude and learned how to behave in such a situation.”*

I would like to tell you a story which might be correlated with this Hanseatic attitude. One day when Bünning visited Japan from end of September to the end of October 1978, he said to me: *“I can tell you a story which shows the temper of a Hamburger. Hamburg is a city with many canals. Two friends meet every morning on the bridge of such a canal, but they simply look on the surface of the water all day long leaning their elbows on the bridge girder. The conversation between them is only “good morning” and “see you tomorrow”. One day one of them brought his nephew along and introduces him to his friend. All three looked on the water as the couple usually did. Suddenly the silence was broken by the youngest: “Look! There is a drowned body!”. In the evening when they parted, the other one whispered: “Your young man speaks too much. Don't bring him along tomorrow.”*

Bünning did not like formalities. On January 23, 1986, the University of Tübingen celebrated his 80th birthday (he was once the president). I was invited by the Biological Institute to give a lecture that afternoon with two other speakers, Prof. Mohr and Prof. Wilkins. In the morning I arrived at the Bünning's to join them for the drive to the Neue Aula where the celebration ceremony was to take place. In an exception to his usual style of dress, he was wearing a suit with a necktie. Noticing that the collar of his coat was standing

and necktie was not correctly positioned, Mrs. Bünning told him: “*Mr. Tazawa dresses neatly, but you!*”. She then put the collar down and straightened the tie. At that time the age of retirement of an ordinary in Germany was 68. But he intended to retire at the age of 65. He wished to be free from the troublesome administrative work as chairman of the Institute. I think that Bünning was a bit of a misanthrope, in a sense that he did not like to handle complex human relations. In the fifties when I was in Tübingen, he went to Lapland every summer for an excursions with students. In the midst of uninhabited Great Mother Nature he enjoyed freedom and recovered his spirits.

In the summer of 1957 Bünning together with his wife, was again in Lapland. During his absence we were invited by Miss Frau Kaut, his technical assistant and had onion cakes and enjoyed a conversation with wine. The weather was bad, with a gale outside. The radio news reported that a German party of two climbers had met with disaster on the south wall of Marmolada in the Dolomite Alps. The secretary, Mrs. Rätze knew that the oldest son of Bünning, Klaus, who was studying physics at the University of Tübingen, had gone to Tirol for climbing with his friend. We hoped that the accident did not involve Klaus’ party, but unfortunately it did. It took a long time for the Bünning to receive the terrible news in Lapland. Even now I remember Bünning tightly holding onto his wife who collapsed with grief. That image often recurs to me. One day during tea time a student asked him, what he would like to study if he were reborn. He answered: “*Biology is too complex. Perhaps physics*”. Probably he had expected much from Klaus. Klaus was a tall young man of calm manner. Bünning did not show his depression but the shock must have been great and deep.

Pfeffer had also lost his oldest son. This was in the first World War, several weeks before its end. The 73 year old Pfeffer was struck with this grief and the difficult postwar life. He died about one year later. I cite the following sentence from the English translation of Bünning’s book “*Wilhelm Pfeffer*” (by grandson Helmut William Pfeffer, Carleton University Press, Ottawa):

“Since he was inclined to brood, he unfortunately did not have the ability to accept old age with a happy and cheerful resignation. With advancing age, he dreaded the idea of leaving the site place of his lifes work and his lovely home (as director of the botanical gardens and the Department of Botany he had the use of a large residence in the botanical institute). For a man still young in spirit and intent on devoting his thoughts to scientific problems, the idea of physical frailty and of dependence on others was most frightening.” Bünning seemed to have similar troubles.

In 1978 Bünning together with his wife came to Japan on invitation of the Japanese Society for the Promotion of Science and stayed for a month. They enjoyed Japan very much including the meeting with Professor Hiroshi Tamiya, an old friend since their young years. Bünning was 72 years old but still his passion for science was intense. He gave lectures at the annual meeting of botanists held in the Chiba University and at many universities, and had eager discussions with many Japanese scientists. He enjoy the sake (rice wine) and food. In 1986, on his 80th birthday, Bünning looked very well, but was suffering from prostate carcinoma and had an operation in the same year. When I met

8.7 Wolfgang Engelmann: Talk at the Marburg Meeting 1991

him in the summer of 1987, he could not walk for long distances. On our parting he said: *“I can not bring you to the station, but my wife will do so”*. Shaking his hand I said *“Auf Wiedersehen”*. He replied *“it may be difficult”*. He suffered from insomnia. Wine was a sleeping drug for him. In his later life he complained of his situation which lacked social activities. It was Mrs. Bünning who cheered up her pessimistic husband. Early in 1988 he underwent another operation and his physical activities were restrained.

Needless to say, Bünning is one of the greatest plant physiologists of the century. Ritchie R. Ward in his book *“The living clocks”* (Ward, 1971) refers to Bünning's work and states as follows:

“Throughout his years at Tübingen Bünning has continued his research, broadening and deepening biologies understanding of photoperiodism. He has long since attained the stature of a world authority, and as the acknowledged father of the clock concept he is invited to tell of his latest thinking at every conference and symposium in the field. At the Cold Spring Harbor Symposium on Biological Clocks in 1960 he gave the opening keynote address, and at the 1969 International Symposium on Biochronometry sponsored by the National Academy of Science, National Research Council and N.A.S.A., he presented a paper entitled “The importance of circadian leaf movements for the precision of photoperiodic time measurement.” The second edition of his definitive monograph on the circadian clock was published in 1963 and translated into English a year later. Whether he suspects it or not, there is a growing feeling among biologists that if anyone in the rhythm field should ever receive a Nobel price, that price should go to Erwin Bünning.”

In August 1989 I visited him in the Institut für Tropenkrankheiten. He was very much pleased with my visit. He lay mostly in bed but sat on a chair during meal. He enjoyed a glass of wine that his wife brought. I can never forget his saying: *“Japan is a very interesting country. I will visit Japan again.”*

His last letter in his own hand composed of 5 lines was a letter of thanks for my congratulations on his 83rd birthday. The last three lines:

*Japan und Deutschland waren ja wissenschaftlich immer eng verbunden. So soll es bleiben.
(Japan and Germany in science have been tightly bound to each other.
This should continue.*

May Erwin Bünning sleep peacefully together with his beloved son on the hill of Tübingen from where the plateau of the Schwäbische Alb seen over the town that he so deeply loved.¹²

8.7 Wolfgang Engelmann: Talk at the Marburg Meeting of the International Society for Chronobiology 1991

Prof. Bünning passed away on the 4th of October, 1990. We lost an eminent scientist, an excellent teacher and tutor, and a person with high qualities.

¹²I am deeply indebted to Prof. Dr. Wolfgang Engelmann of the University of Tübingen for his critical reading of the manuscript and to Ms. J. Noguchi for her correction of my English

His **scientific work** was characterized by his broad interest in various disciplines in biology; in some new fields he was a pioneer. He was at this time one of the most prominent and internationally best known plant physiologists of the German-speaking countries. He raised up a generation of biologists, and I was lucky to belong to his scientific sons. Bünning's scientific strongholds were based on his curiosity, his huge knowledge, and his intuition for the essential. He worked hard, but economic, his experiments were simple and straight forward, and he argued clear and convincing. His constructive criticism helped him, us and others, to find the weak points in our conclusions. He brought things to a point: *"Everything worth to say can be expressed briefly"* or, as we students used to say, *"short and Bünning"*¹³.

Bünning was an **excellent teacher**, as attested by his *"Tübinger Schule"*. He was restrained in praise and critique. He came seldom to us students, but there were no official consultation hours: He was always open for us. Under his guidance we learned to work scientifically independent with much freedom, to follow our own ideas. This was especially true for his assistances. Students, who asked him for a diploma- or PhD work were often shocked, how briefly he introduced them into the problem. Professor Haupt remembers, how Bünning proposed to E. W. Bauer: *"You could heat up the dry seeds to 110°C and check the germination. Perhaps something interesting happens"*. No mentioning of methods, perhaps one or two references. But in this way we found our own way, asked colleagues for help and offered them our help, we were stimulated to fruitful discussions, and there was no negative competition.

Bünning possessed **high human qualities**. He was helpful and reliable, fair, unselfish, moderate and liberal. Thus his name was only added to a publication, if he was involved with own work. His tuition fees he divided equally between his assistants.

That is the *"endogenous"* part. But in the same way as a clock needs external synchronizers, energy and proper conditions, Bünning needed also sources of recreation. Lapland was one of it, from where he got new energy. Here he structured his thoughts and planned future work. A further source of his vigor was his family and his wife. She gave him *"flank protection"* and a home.

¹³in German: kurz und Bündig, referring to the saying *kurz und bündig*. See section 8.1

9 Bünning-Stories

Here some Bünning-stories; it is a pity, that we did not start earlier to collect *the many “sayings”* of Bünning.

9.1 Bettina Brommer: Erwin Bünning and the Internet

One can still learn from Erwin Bünning: If you enter in *Google* “Bünning”, you will find 99 500 hits. The second one is on Erwin Bünning, a wanted hit. The search for “Erwin Bünning” in *Google* leads to 565 hits.

Looking at the first: The Internet lexicon *Wikipedia* tells for instance, that Erwin Bünning was born in Hamburg and died *in Hungary*. The second source, a medical lexicon, claims the same . . . The third hit is *the Tübingen Studium generale lecture* of this term. The fourth hit, the *Munzinger archive*, tells the correct places. Hit 5 to 8 offer antiquarian books of E. Bünning. Hit 9 is the *Tagblattnote* of January 7 on Erwin Bünning and Georg Melchers in the newspaper.

Since the statement “died in Debrecen” in *Wikipedia* and HYPERLINK <http://www.kliniken.de> was wrong, a note went to *Wikipedia* with the request for correction (which one could have done also by one self). Now the data there are correct. Of all available Email addresses for the medicine lexicon the proposal for correction were returned without commentary. *Wikipedia* as well as the medicine lexicon got the data from I. Jahn: *History of biology* (3rd edition 1998). Conclusion: You can’t trust the Internet sources, nor the printed in books.

Searching in *Google-pictures* for Erwin Bünning resulted in a card index note of the University library Innsbruck and the illustration of the book cover of the biography of Erwin Bünning. Erwin Bünning and Amazon, the Internet book shop with antiquarian, resulted in a meadow flower book of 1955. Bünning searched in *Google Scholar* (with hits sorted according to the importance) lead to 567 hits, the first and second are Erwin Bünning: *The physiological clock* (1973), cited 125 times, and the article of 1936 in *Berichte der Deutschen Botanischen Gesellschaft*, cited 75 times. Both articles are cited also for 2004, 2003 and 2002 (and of course earlier). If one searches more detailed for *E. Bünning*, one finds 519 hits of the mentioned 567, all of which pertain to Erwin Bünning . . . That means: without measuring impact factors it is obvious by the citations: *E. B. was and is important*.

Konstanz, January 2006

9.2 Vera Hemleben: “Botanisches Institut”

Impression on an afternoon of the New Years Eve in the botany institute,
December 31st, 1961

*Bohnen gegossen,
Algen gepflegt,
Eier gezählt . . .
Ja, was denn noch?
Natürlich, im Keller
da laufen die Schaben,
auch sie wollen sich laben
auf goldenem Teller.
Und weiter, welch Ton?
Ein Knuspern und Knaspern,
es raspelt an Blättern . . .
Richtig, die Raupen,
sie hatten ja schon den Salat bekommen.*

-

*Stimmt es, wir sind in Botanischen Hallen?
Kann das denn den Zoologen gefallen?¹*

1

*Beans watered,
Algae cared,
eggs counted . . .
Well, what else?
Of course, in the cellar
there run the roaches,
they too want some food
on golden plates.
And further, which sound?
A tasting and cracking,
it rattles on leaves . . .
indeed, the canker,
but they got the salad already.*

-

*Is it true, we are in botanical halls?
Can this appeal to the zoologists?*

9.3 Dietrich Gradmann

Bünning was not the direct advisor of the PhD work of Gradmann, but felt responsible for him and asked frequently how his work proceeded. Often, when Gradmann came to the institute in the morning, notes of Bünning with literature hints were on his desk².

9.4 Claus Schilde

Bünning did not like too much medical students. Claus Schilde mentioned the “*Urinkränzchen*” (gathering of the natural science club, which hold meetings in the former physiology -nowadays the Kupferbau), where often modern findings of the biosciences were presented. In the first row were the Ordinaries seated. Once the problem of the training of medical students was discussed. Since Bünning was member of the science committee, he was invited. Bünning proposed, to donate the doctoral degree to the medical scientists at their state examination, since it is anyway more or less a designation of their profession. A physician complained, that there exists no journal, which prints the PhD work of medical students and proposed, to launch a special journal for this purpose. Bünning's answer: *Herr colleague, you do realize, that the level of this journal will be far below the one of “Jugend forscht”*³.

Claus Schilde together with Klaus Brinkmann and Frau Haarer (the bride-elect of Bünning's son Klaus, who lost his life during a hike in the mountains) joined Bünning at his first winter tour in Lapland. They were supposed to be picked up by a Swede, who lived during the winter in the Mudus hut and had to watch, that no fish were caught in ice wholes. He was, however, not there when they arrived. They started therefore and came across a ski track which was occasionally joined by a dogs track, which disappeared again. Later the riddle was solved, when the Swede, who laid the track, caught up from behind. He had a little dog with him, which hitched a ride on the ski, but fell down occasionally and had to run for getting his ride. The Swede used leathern loafers with a long tip in his cross-country skier, which were fastened with a simple strap. In the hut he read a book in German about the hunt of Friedrich the Stauffer. Claus Schilde called him the *Waldschratt*, and this name fell later back upon Claus: He was called *the Schratt* by his friends.

One night somebody went outside the hut and noticed polar lights. He informed the other, which were excited, and also Bünning (*Herr Professor, there is a polar light*), who had a quick look from the door, but retracted immediately in his sleeping bag with the remark, “*ja, ja, thats what I wanted to show you also*”. One should know, that Bünning was during the war stationed at the scouts in Norway for listening to the radio communication of the Allied and to analyze them. He was therefore well acquainted with aurora borealis.

Bünning had a high esteem for the Chinese. Claus Schilde knew that and brought him a Mao-Bible from East Berlin. Bünning graped in his table drawer,

²Bünning did the same also with other candidates in the institute! Engelmann

³corresponds to “science fair”

9 Bünning-Stories

took one out and remarked: “*ja, ja, nice, nice, but I have it already*”. Bünning: “*Will we reach the Middle ages, before the Chinese will conquer us*”. Bünning liked also to tell the story of the students in Tübingen, sitting at the road, reading Goethe and having a tin bowl alongside, in which the Chinese, who traveled with an Europe bus through the country, threw occasionally a coin.

9.5 Marianne Hetzer

has sent on December 26, 2005 copies of pictures of a winter Lapland excursion (Topic: “*Suffering in Lapland*”) and a promotion party in the old botany building. Furthermore a sketch “*tract: The institution alarm clock*”. It was written 1964 by Irmela Brinkmann.

9.6 Gottfried Wiedenmann

Gottfried Wiedenmann is a scientific grandson of Bünning. His brother Reinhard is a colleague of Otto Bünning at a school in Hamburger. He happened to meet by chance on a journey to Sweden Professor Bünning in the train and recognized him, since Otto resembled him and since he knew from Otto the profession of Bünning. Asking him: “*Aren't you Professor Bünning?*” he answered: “*No. But I know him very well*”.

9.7 Wolfgang Engelmann

I remember, that Bünning thought, natural science publications should be printed on a paper, which falls apart after ten years (or was it five?) by itself, since the results by than are anyway outdated.

Bünning's remarks to the space experiments regarding polarity: . . . *Everybody knows, that is already determined. It is as if somebody sends a baby in space and looks, whether the head becomes an ass . . .*

Answer of a medical student to Bünning's examination question, on which bacteria feed: *Och, Herr Professor, they are so small, they don't need anything.*

9.8 Ilse Franklin

Just before Christmas 2005 Ilse Franklin recounted the following anecdotes about her father. Both parents had principally refused to join the NSDAP. Then, during the summer of 1938, father went to Indonesia, remaining there for a year of research. Upon returning home he was recruited as a private and was sent to the front where he had to carry sandbags for some time. Only when the authorities learned that he had mastered the English language did his situation improve. At that time all high school graduates were proficient in Latin and French, but it was rare to find one proficient in English. Ilse's father was given a crash course in radio transmission and then assigned to reconnaissance. He was sent to Norway where he was to monitor the radio transmissions of the Allied

forces. It was during this assignment that he soon realized that the war was drawing to a close.

He had previously arranged with his wife, Ilse's mother, coded messages inserted into his letters to her that indicated when she and the family should leave Strasbourg, where she and the children had been living. The prearranged plan was for them to move to Bad Rippoldsau in the Black Forest. There she improvised living quarters for herself and the family in one room of a mineral water production plant. Meanwhile Ilse's father found himself flying over Northwest Europe as the war came to an end. He was able to parachute out of the plane and landed in a deserted field. Ilse did not remember where this field was. Her father carefully folded the parachute, which he took with him. It later provided a blouse for his wife and a dress for Ilse. He then found a bicycle (a military bicycle?) and cycled direction south. On the border to the French zone he was stopped by a uniformed Frenchman. The first question – “Do you have any identification documents?” – “No, none at all.” The next question – “Do you have any children?” “Yes, three and a fourth is on the way.” “Now I will look in the other direction and you will ride away on your bicycle as fast as you can.” (Her father often told this story and also had written it down in his terse style. Ilse had a copy.) Her father arrived in Bad Rippoldsau wearing an old military sweater. When he saw his children on the street he said to them “I'm your father.” To which Ilse, then seven years old, replied “Well, anyone can say that.” Her father approved, thinking that she would not go along with anybody⁴.

⁴Translated by Richard Franklin, October, 2018

10 Literature

I have compiled Bünning's publications in a file BUENNING.bib and BUENNING.html by using the program JabRef, which is available free of charge from the Internet. Here follows a compilation of the titles of the doctoral theses under Bünning's guidance (section 10.1), and the books of Bünning (section 10.2.10.2).

10.1 Doctoral theses

Doctoral theses of Bünning's PhD students: Itzerott (1936); Drawert (1937); Herdtle (1943); Rotta (1949); Schmidle (1950); Stiefel (1951); Heiligmann (1951); Franck (1951); Enderle (1951); Wenck (1952); Bauer (1952); Zepf (1952); Haupt (1952); Wettstein (1953); Kemmler (1953); Rau (1953); Clauss (1953); Lemppenau (1953); Schwemmle (1953); Biegert (1953); Ziegler (1954); Wemmer (1954); Schneiderhöhn (1954); Hess (1954); Schoser (1955); Thorning (1955); Drumm (1955); Sahmann (1955); Venter (1955); Chaudri (1955); Zain (1955); Speiser-Kraatz (1956); Leinweber (1956); Gössel (1957); Redel (1957); Salim (1957); Kohlbecker (1957); Könitz (1958); Lörcher (1957); Schautz (1957); Maas (1957); Reisener (1958); Kummerow (1958); Jantsch (1958); Kurz (1959); Keller (1959); Wassermann (1960); Krause (1960); Thiele (1960); Engelmann (1960); Karve (1960); Rückebeil (1960); Ruddat (1960); Günther (1960); Landgraf (1961); Todt (1961); Etzold (1961); Kleinert (1961); Müller (1961); Moser (1962); Zimmer (1962); Hörhammer (1962); Wagner (1963); Vielhaben (1963); Baltes (1964); Bühler (1965); Brinkmann (1966); Rentschler (1967); Honegger (1967); Kirschstein (1968); Schnabel (1968); Schilde (1968); Steinheil (1969); Kübler (1969); Gunst (1972); Kruckelmann (1972)

10.2 Book publications of Erwin Bünning

Bünning (1932, 1939, 1945, 1947, 1948, 1953a) (earlier edition 1948), Bünning (1954, 1956b,a,c, 1957b,c, 1958) and translations into Russian (1961), Chinese (1965), Japanese (1977) Korean (1993, Academic press Seoul, by Sang Zin Han), Bünning (1960, 1963, 1967c, 1973, 1975); Bünning (1977, 1983); Bünning (1989).

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