otters apparently weep for emotional reasons as do we, so too do Indian elephants. Elephants like whales have, however, reduced their lachrymal gland and increased the Harderian gland contribution to tears. Mrs Morgan is willing to accept elephants as fellow travellers to the water and back, on this and other grounds, but until we are more confident about the functions of copious tear production it seems best to be cautious.

However the fossil record will doubtless have the final say, and it is becoming yearly more complete. Mrs Morgan re-publishes the suggestion of another supporter of the Hardy hypothesis, L.P. La Lumiere. He believes that the aquatic phase was experienced during early Pliocene times on the coast of the Red Sea. At a time of presumed deforestation, changes in land

and water levels providentially provided an island refuge. La Lumiere offers precise predictions of where the missing links will be found.

This book is written for a lay public and is too brief, and too superficial, to satisfy a serious critic. The bibliography, for example, fails to include many of the authorities referred to in the text. The book is also marred by occasional carelessness — I had to read one passage several times to extract from it a meaning *other* than that women and sirens were alone in having two pectoral mammary glands. But the writing is lively and enthusiastic and it will surely engage the interest of those for whom it was written. □

D.R. Newth was formerly Regius Professor of Zoology in the University of Glasgow.

A cycle ride to Stockholm

M.F. Perutz

Reminiscences and Reflections. By Hans Krebs in collaboration with Anne Martin. Pp.250. ISBN 0-19-854702-1. (Oxford University Press: 1982.) £12.50, \$19.95.

ON 14 December 1932 the dean of the medical faculty of the University of Freiburg, Professor E. Rehn, reported to the Ministry of Education,

As an assistant physician Dr Krebs has shown not only outstanding scientific ability, but also unusual human qualities. His . . . paper on the synthesis of urea in the animal body . . . will be regarded as one of the classics of medical research.

Four months later, shortly after Hitler seized power, this same dean sent him a "Notification of Immediate Removal from Office", obediently implementing the Minister's orders against members of the Jewish race.

Krebs kept several such letters and also various press cuttings from those days and had them reproduced as facsimiles in his book. There is the "Manifesto Against the UN-German Spirit" published by the Freiburg Student Union and posted in the University: "Our most dangerous adversary is the Jew and he who serves him. The Jew can think only as a Jew. If he writes German he lies. The German who writes German, but thinks un-German is a traitor . . .". The Rector of the University, von Möllendorf, ordered the posters to be removed, whereupon the Minister replaced him by the existentialist philosopher Martin Heidegger who endorsed them and proclaimed, "German students! . . . Your existence must not be ruled by learned axioms and ideas . . . Only the Führer himself constitutes today's and tomorrow's reality and law. Daily and hourly must you fortify your faithful

obedience . . .". Most of Krebs's colleagues acquiesced, but one Dr Arthur Jores dared send his and Krebs's former Jewish chief, by then in New York, a reprint with a personal dedication. The envelope was opened by a Nazi colleague who denounced him. Jores was dismissed from his post, publicly branded as an enemy of his country and, in due course, imprisoned.

Despite these harrowing experiences and the extermination of 20 of his relatives Krebs does not follow the example of Einstein who refused ever to set foot in Germany again, but declares in the book that "to be anti-German seems to me just as bad as being anti-semitic". After the War he therefore persuaded the Biochemical Society to re-establish contact with Germany by inviting several known anti-Nazis to the First International Congress of Biochemistry at Cambridge.

Krebs's discovery of the ornithine cycle of urea synthesis had caught the eye of F. Gowland Hopkins, then Professor of Biochemistry at Cambridge and President of the Royal Society. When he heard of Krebs's dismissal, he immediately invited him to Cambridge. The Rockefeller Foundation which had already supported Krebs's research at Freiburg, provided the money, and continued to support his research for the next 30 years. Krebs was deeply touched by the warmth of his reception at the Biochemistry Department at Cambridge and by the generous hospitality and friendliness of English people generally. His book is permeated by affection for England, which he epitomizes by Carl Zuckmayer's, another refugee's, saying that "home is not where a man is born but where he wants to die".

How Prussian Krebs remained all the same! He writes,

. . . I expected a lot from my associates — hard disciplined work and the ability to accept my criticisms . . . I have tried to be fair, honest and helpful, and not to demand more of others than I do of myself . . . We criticised each other ruthlessly — we knew it was done honestly, in good faith and in a spirit of helpfulness.

Few Englishmen would write such solemn stuff about themselves. I cannot imagine Francis Crick declaring in his memoirs that he demolished my cherished 1949 model of haemoglobin, "honestly, in good faith and in a spirit of helpfulness", rather than admitting to a certain mischievous satisfaction at the dastardly deed.

For people who complain that money for research has become hard to come by, Krebs's early career makes salutary reading. His father, a doctor in Hildesheim, had to support him throughout his medical studies. After graduating Krebs wanted to do research, but paid research posts were rare, never advertised and obtainable only by what used to be known in my native Vienna as *Protektion*, which signified a mix of sycophancy, nepotism and the old boy network. Eventually Krebs found an unpaid post at the Third Medical Clinic in Berlin where another biochemist who later made his name, Bruno Mendel, became one of his colleagues. One night the Mendels were invited to the Einsteins when Otto Warburg was among the guests. When Warburg told Mendel that he was looking for a collaborator, Mendel recommended Krebs and also raised the money privately to pay him a modest salary. Krebs regards his four years with Warburg as formative for his career and expresses the greatest admiration for Warburg's scientific genius, regardless of his despotic, egotistical and sometimes malicious behaviour, his lack of confidence in Krebs's own talent and his refusal to help him find a university post where Krebs would have to attach himself "to some old ass of a professor". Only in medicine would Krebs be able to make a living, Warburg told him. Warburg demanded of his staff that they work punctually from eight to six, six days a week, a precept which Krebs himself seems to have followed for much of his life. At 11 o'clock on the Monday morning after reading of Warburg's Draconian regime, I walked into my own biochemistry laboratory to find that only one of my three collaborators had arrived yet. "The other two were still working when I left at midnight", the first reported. This convinced me again that the free coming and going of Cambridge is more conducive to dedicated research than the iron discipline of old Berlin.

Krebs made his first great discovery, the ornithine cycle of urea synthesis, in 1931 and 1932. He used the tissue slice and manometric techniques which Warburg had taught him; another decisive factor was his own invention of the Krebs-Ringer

solution. I found it exciting to read of his groping in the dark, methodically testing all conceivable intermediates until he discovered that "one molecule of ornithine could bring about the formation of more than twenty molecules of urea, provided that ammonia was present". From that moment the tracing of the other intermediates followed logical steps. It was the first biological process in which the intermediates were found to play a purely catalytic role. Krebs made this fundamental discovery while in charge of a medical ward with over 40 beds, which makes his feat even more remarkable.

Krebs's unravelling of the citric acid cycle in 1937 was to win him even greater fame, but his letter to *Nature* announcing it was rejected by the editor, Sir Richard Gregory, who at that time took it upon himself to judge the scientific worth of most of the communications sent to him. (It is not known whether Krebs's paper was refereed, but that seems unlikely — Ed.)

Objections were raised at first against both the cycles. Those against the ornithine cycle were later found to be based either on wrong experiments or incorrect interpretation, while those against the precise chemistry of the citric acid cycle seemed fundamental. Biochemists argued that radioactively labelled CO_2 introduced into the cycle should become randomly distributed among the two carboxyl groups of α -ketoglutaric acid, an intermediate two steps after citric acid, because an enzyme would not be able to distinguish between the two symmetry-related carboxyl groups of citric acid. In fact, only the carboxyl nearest to the keto group of α -ketoglutaric acid was found to be labelled; hence, it was concluded, citric acid could not be an intermediate in the Krebs cycle. That was in 1941. I would have been desperate if an apparently valid objection had been made to my most fundamental discovery in which I could detect no flaw, but Krebs writes as though it had never cost him any sleep. Was he really so placid that he did not continuously turn over in his mind all conceivable explanations of the paradox, or did the sunshine of his later glory dissolve the memory of the seven clouded years that were to elapse before A. Ogston, in a brief and classic note to *Nature*, pointed out the fallacy in the objection: a symmetric molecule attaching itself to an enzyme at three points may give rise to only one of two possible asymmetrical reaction products. This was the birth of the concept of prochirality.

The glory was first heralded in October 1952 by eager journalists who told Krebs that he would shortly be awarded the Nobel Prize, but the rumours proved false and S.W. Waksman received it instead. Krebs relates proudly that the rumours left him and his wife unruffled. But did they really? Nine years later similar rumours about John Kendrew and me were floating

around our laboratory. We doubted them until my secretary rushed in, flourishing two telegrams, one addressed to Kendrew and the other to me. This was it. When we had eagerly torn them open we found them to be from the Pontifical Academy in Rome, enquiring how many reprints we wanted of the papers we had read there the previous autumn. We also pretended to a stoic calm. Unruffled or not, Krebs did receive the Prize the following year.

After nearly 20 happy years and the founding of a flourishing school of biochemistry at Sheffield, Krebs became

Scherzo metabolico cantabile

Thomas A. Scott

The Biochemists' Songbook. By Harold Baum. Pp.62. Pbk ISBN 0-08-027370-X. (Pergamon: 1982.) £2.45, \$4.95.

How refreshing, in the 1980s, to find a professor of biochemistry writing, not a solemn research text, but humorous biochemical verses. Thirteen important topics of biochemistry have been rendered by Professor Baum into light-hearted songs and set to appropriate popular tunes with piano accompaniment. The biochemical accuracy of the outrageous doggerel can be checked at a glance, because each song appears with the conventional scheme or account.

According to the author, all the songs were written while travelling on the top deck of a No. 22 bus; this I do not believe. He also points out that they are intended for communal singing, ideally with a blood alcohol level of 35 mg per cent; this I do believe. Some of the scansion is tortuous and not always immediately obvious. While the alcohol will not make them any easier, it will stop you worrying whether you get them right.

Perhaps the greatest challenge is in the first verse of "Protein Biosynthesis":

*Introns and exons, changes post-transcriptional, and all
Glycosylations, don't alter such basics at all*

to the tune of My Bonny Lies Over the Ocean. In contrast other compositions have a reassuring and earthy quality, for instance:

*If you gobble tagliatelli,
Chicken soup with vermicelli,
You'll acquire a sagging belly —*

are the opening lines of "Fatty Acid Biosynthesis" set to Men of Harlech.

Surprisingly, the author has failed to exploit the rousing coda of Macnamara's Band in "The Pentose Phosphate Shunt". Admittedly, this loud and rasping interlude is normally left to the trombones, but it is tailor-made for Professor Baum's particular style of ethanolic chorus; in the second edition perhaps? Also, these days, when so many bar pianists are over forty, and all the young wags play the guitar, this already excellent songbook might be made more usable by the younger generation by the inclusion of harmony frets or chord names for each tune.

The Biochemists' Songbook is dedicated jointly to Sir Hans Krebs on his eightieth birthday and to the author's wife. Sir Hans has also contributed a foreword, and there is a certain poignancy in the publication of the *Songbook* so shortly after his death. His cycle is set to Waltzing Matilda, and this year the International Congress of Biochemistry will be held in Australia, where it is no novelty, indeed it is a long established tradition, to sing this tune communally and with a blood alcohol level rather in excess of that recommended by Professor Baum.

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Professor of Biochemistry at Oxford and stayed there until his death last November. I was surprised by his statement that Oxford had remained in the forefront of learning for 600 years. Had he never read Edward Gibbons's description of its decline into sloth in the eighteenth century when dons could not even be bothered to teach their students? The picture of Oxford University in Krebs's own time conjured up in the book is of a citadel of unjust privileges jealously guarded by the Party members. Krebs got himself elected to the Central Committee by the under-

privileged Solidarity of Active Researchers, but all his brave attempts to reform The System were defeated by the strength and cunning of the Old Guard, who even went so far as to refuse money offered by the University Grants Committee for the creation of additional science professorships, lest this should lead to the appointment of more Dissidents and Enemies of the Party like Krebs. Despite these rebuffs, Krebs describes his life at Oxford as a happy and successful one. Asked once for a guiding motto, Krebs replied "Never put off till tomorrow what you can do today", which sounds like one of those recipes for virtue Victorian children were made to embroider and hang over their beds. The King of France says it less prosaically in *All's Well that Ends Well*:

Let's take the instant by the forward top;
For we are old, and on our quick'st decrees,
The inaudible and noiseless foot of time
Steals ere we can effect them.

Krebs emerges from this book as a dynamic scientist and an engaging, warm-hearted individual utterly devoted to his research and teaching. He quotes Noel Coward's saying that "work is fun, there is no fun like work". I agree. □

M.F. Perutz is a Member of the Medical Research Council Laboratory of Molecular Biology, Cambridge. With John Kendrew he was winner of the Nobel Prize for Chemistry in 1962.

AN ENUMERATION OF THE FLOWERING PLANTS OF NEPAL

Vol.1 Gymnospermae & Monocotyledones.
H. Hara, W.T. Stearn & L.H.J. Williams.
June 1978. **£22.50**

Vol.2 Dicotyledones I.
H. Hara & L.H.J. Williams.
June 1979. **£22.50**

Vol.3 Dicotyledones II.
H. Hara, A.O. Chater & L.H.J. Williams.
May 1982. **£32.00**

The publication of the third volume completes this joint project of the British Museum (Natural History) and the University of Tokyo. It is based on the extensive botanical exploration of Nepal by British and Japanese scientists during the last 25 years.

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Professors, parasites and public health

Anthony C. Allison

New Guinea Tapeworms and Jewish Grandmothers: Tales of Parasites and People. By Robert S. Desowitz. Pp.224. ISBN 0-393-01474-6. (W.W. Norton:1981.) \$12.95, £8.75.

DURING the period following the Second World War, a few pioneers of a particular type flourished. They were motivated by curiosity about medical problems in primitive societies, the people themselves and how social organization affects health. In an era of liberal funding they were able to spend a great deal of time travelling to New Guinea, South-East Asia, the Australian outback, East and West Africa and other appealing places, collecting thousands of samples of blood, brains and other materials. For some time they were regarded as amusing, if somewhat irresponsible, amateurs, who should settle down and do serious research in Bethesda or London. But they enjoyed themselves, satisfied their curiosity and carried out research of real quality, sometimes solving problems that had for decades defied frontal attack in the United States and Western Europe.

Carleton Gajdusek transmitted kuru, a degenerative disease of the central nervous system, from cannibals of the New Guinea highlands to chimpanzees. His energy and vision played a large part in development of the concept of slow viruses. Baruch Blumberg found that certain sera of North Americans who had received blood transfusions precipitated a component in the sera of some Australian aborigines. Out of this seemingly trivial observation came the identification of hepatitis B virus and the development of a test that has nearly eliminated post-transfusion hepatitis in the United States and Western Europe. Both of these developments won Nobel prizes. Following Denis Burkitt's observations on the prevalence of a particular type of lymphoma in Uganda and other East African countries, Tony Epstein identified in the lymphoma cells the herpesvirus that bears his name. This was found to transform human lymphocytes, to cause infectious mononucleosis and to be associated with a type of cancer of the nasopharynx common in parts of East Africa and China. It is the first likely candidate for a human cancer-inducing virus. The identification of the single amino-acid substitution in sickle-cell haemoglobin, and the demonstration that this gene confers resistance to malaria, were notable contributions to molecular and population genetics.

Included in this group of individualists is Bob Desowitz. After an orthodox training in tropical medicine, he worked on sleeping sickness in Nigeria and on various parasitic diseases in Singapore. He then became Professor of Tropical Medicine in Hawaii,

and has travelled as a consultant for the World Health Organization and national governments to New Guinea, Indonesia, Burma and other places. This is a life that many might envy, and its highlights are recounted in this book of essays. Although the title might seem flippant, the book is instructive and entertaining.

Desowitz has a clear and readable prose style. Most medical students and biologists are bored by the life cycles of parasites. It helps to know that the fish tapeworm *Diphyllobothrium latum* was introduced into the fish of the lake region of Minnesota and Wisconsin by Scandinavian fishermen and was not killed during the delicate cooking of gefilte fish by New York grandmothers. The book is packed with easily assimilated information about parasites. Desowitz is an amusing raconteur and enjoys the detective side of public health, such as finding that a common brain infection among the Ekari of New Guinea was cysticercosis (tapeworm disease) transmitted by pigs given to the people by President Suharto of Indonesia to sweeten the military occupation.

The two central themes of the book are, first, that man-made ecological-environmental changes have been responsible for perpetuating and intensifying the majority of infectious diseases; and, second, that ultimately effective control of these infections will follow widespread use of the time-honoured, sensible approach of environmental sanitation.

Each of these assertions is open to debate. It is true that building the Aswan high dam in Egypt increased the already high risk of developing schistosomiasis in Egypt, but that has to be balanced against the manifest advantages of building such a dam. Whenever such enterprises are contemplated, the environmental health implications should be considered by international experts convened by the World Health Organization and the Food and Agriculture Organization. Determined efforts should be made to prevent such health problems; this would be a useful way to use international aid funds, which are often squandered.

Does control of disease necessarily require the time-honoured, sensible approach of environmental sanitation? Nobody would argue against sanitation. But with labour and fossil fuel costs escalating, there is no realistic prospect of eliminating malaria from Africa by ditches and drains or tsetse flies by scrub clearance. Despite 30 years of the Chinese "People's War against the Snail" and Chairman Mao's poem "Farewell to the God of Plague", schistosomiasis still exists in China.

It is more realistic to employ whatever