



Nonionizing radiation protection

Second edition

Edited by

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Copenhagen, Denmark*

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Preface to the second edition

This book represents a major milestone in the history of nonionizing radiation (NIR) protection both within and outside the WHO European Region. When the first edition was published in 1982 after several years of work, it was the first comprehensive publication in this field. The book has become a bestseller and has been sold worldwide. It has also served as a text for training at institutes of higher education and for special courses.

Since the completion of the first edition, much new research has been performed and experience gained in the field of NIR protection, particularly with respect to radiofrequency radiation and electric and magnetic fields. Consequently, it has become necessary and appropriate to update and/or revise various chapters; and Chapters 4 and 5 were rewritten anew. To accomplish this task in as short a time as possible, the WHO collaborating centre at the Bureau of Radiation and Medical Devices, Environmental Health Directorate, Health and Welfare Canada, Ottawa was requested to join the project. For the eagerness, cooperation and efforts of Deirdre A. Benwell-Morison, Head of Section, and the staff of the Non-ionizing Radiation Section at Health and Welfare Canada, I wish to extend my special thanks. While much work has been contributed by a number of people, the design, implementation and coordination of the work in putting this book together has represented a special effort by the unit on Control of Environmental Health Hazards of the Regional Office for several years. Major credit must be given to the unit chief, Michael J. Suess, without whose leadership this work would never have been possible.

The strengthening of this scientific field comes at a particularly opportune point in health development in Europe. With the adoption in 1984 by all the European Member States of WHO of the new European health for all policy and its 38 targets, very important new roles and tasks will fall on the shoulders of the health professions, including the radiation health personnel. The development at national level of methodologies and health criteria for the assessment of NIR data in relation to control and protection procedures; the advancement of adequate control measures, and their introduction and maintenance; and the training and utilization of sufficient numbers of competent personnel for all aspects of NIR protection will present many challenges in the

years ahead. Consequently, I hope that the second edition of this book will be received as favourably as the first, and will continue to serve a useful purpose in furthering understanding of this still rather new field.

J.E. Asvall
WHO Regional Director for Europe

Preface to the first edition

As human populations multiply and industrialization increases and diversifies new hazards arise, some of which have become more and more critical. To limit and, as far as possible, reverse this trend, the WHO Regional Office for Europe mounted an intensive intercountry programme during the period 1969–1979, which has culminated in the successful completion of many projects in different sectors.

One of the newer environmental hazards is nonionizing radiation (NIR), which may lead to adverse effects on human health. Exposure to NIR extends from occupational health right into the field of public health. When considering exposure limits and setting up control programmes, the heterogeneity of the population to be protected has to be kept in mind. Possible genetic and carcinogenic effects, as well as effects on development, have all to be carefully considered and are of prime importance in protecting the public. Therefore, one of the major efforts within the radiation sector of the programme during these years was directed towards the development of this book, which I now introduce with pleasure to a broad professional audience. This publication represents the results of the collaborative effort of over 200 experts from 20 countries, to whom we are indebted not only for their professional competence but for their deep dedication. With equal satisfaction, I wish to commend the work of the WHO staff directly responsible for this activity. The financial assistance of the United Nations Environment Programme in the project on NIR protection, and in the publication of this book, is greatly appreciated.

Protection against exposure to NIR is a subject of increasing concern to European countries, but is also of growing importance to those in other parts of the world. I hope that this work will be of practical value to the many scientists, engineers, physicians and community leaders concerned with and responsible for protection against NIR and human health.

Leo A. Kaprio
WHO Regional Director for Europe

Dedication

This book is dedicated to the memory of Mr Frank Harlen, Principal Scientific Officer, National Radiological Protection Board, United Kingdom, who collapsed and died on 16 January 1987 aged only 60 years.

Frank was not only a good and helpful colleague, but also a friend. He became involved in the NIR activities of the WHO Regional Office for Europe (which eventually led to the first edition of this book) when participating in the first working group on nonionizing radiation (NIR) in October 1974, in Dublin, and three subsequent working groups in 1978. He also took part in a number of activities of WHO headquarters in Geneva, concerned with the preparation of Environmental Health Criteria publications on NIR subjects. Frank again demonstrated great ability in the latest working group in October 1985, in Ann Arbor, MI, USA, which reviewed the whole NIR subject and approved the changes that led to the present revised edition. In his humble and quiet way he succeeded in resolving many issues and gaining the support of his colleagues.

Frank's scientific knowledge, his unwavering objectivity and integrity, and the warmth and humour of his manner will be remembered by all those who knew him, and he will be missed by all of us.

Michael J. Suess

Note on Terminology

The policy of the World Health Organization in respect of terminology is to follow the official recommendations of authoritative international bodies such as the International Union of Pure and Applied Physics (IUPAP), the International Commission on Illumination (CIE) and the International Organization for Standardization (ISO). Every effort has been made in this publication to comply with such recommendations.

Nearly all international scientific bodies have now recommended the use of the SI units (*Système international d'unités*) developed by the Conférence générale des poids et mesures (CGPM)^a and the use of these units was endorsed by the Thirtieth World Health Assembly in May 1977. Only SI units are used in this publication.

In the establishment of scientifically acceptable protection standards, both for workers and for the public, the first requirement is that internationally acceptable units for use in measurements must be available. The introduction of SI units means that this requirement has now largely been satisfied.

^a An authoritative account of the SI system entitled *The SI for the health professions* has been prepared by the World Health Organization. Copies may be obtained through the sales agents listed at the back of this book, or direct from the Distribution and Sales Service, World Health Organization, 1211 Geneva 27, Switzerland.

Introduction to the second edition

M.J. Suess

The first edition of this book, which was finally published in 1982 after a great deal of work, was received very enthusiastically if one is to judge from the demand for copies and the many letters received from both colleagues and strangers. A French translation, the preparation of which had begun even before the English version appeared, was published in 1985 by the Regional Office, and a Chinese translation followed in 1986. It took the People's Medical Publishing House in Beijing only one year from the time of receiving permission to translate until publication, for which they should be specially commended.

The Introduction to the first edition of this book refers to a survey of NIR-related national legislation and institutions and to the subsequent issuing of the results. Consequently, with very important support from the WHO collaborating centre at the Bureau of Radiation and Medical Devices, Environmental Health Directorate, Health and Welfare Canada, Ottawa, the first edition of a directory was issued in 1986.^a It is intended that the directory will be updated and improved every few years. Since 1982, WHO headquarters has continued work on books in the Environmental Health Criteria series dealing with NIR. Following the four titles published up to 1982 (No. 14, 16, 22 and 23) another, on extremely low frequency fields (No. 35), was published in 1984 and a sixth, on magnetic fields (No. 69), in 1987.

Scientific and technical developments in the NIR field have continued apace, particularly with respect to lasers, microwave radiation, magnetic fields and ultrasound. While these developments have not necessarily had any new or unknown effect on the health of workers and the public, a new examination of the health-related issues was considered warranted and timely. Consequently, a quick survey among experts revealed that Chapters 4 and 5 in particular would require a new approach (and new titles) while all the other chapters except Chapter 7 would need some revision and updating.

^a Suess, M.J. & Benwell, D.A., ed. *Institutions and legislation concerned with nonionizing radiation health-related research and protection — a directory*. Copenhagen, WHO Regional Office for Europe, 1986.

Table 1. Ranges of frequency, wavelength and energy for some types of electromagnetic radiation^a

| Type of radiation | Frequency range | Wavelength range | Energy range per photon |
|--|---------------------------------|--------------------------|-------------------------|
| Ionizing | > 3 000 THz | < 100 nm | > 12.40 eV |
| Ultraviolet (UV) (nonionizing part) | 3 000— 750 THz | 100 — 400 nm | 12.40— 3.10 eV |
| extreme (vacuum) | 3×10^5 to 30 000—1 580 | 1 to 10 — 190 | 1 240 to 124 — 6.53 |
| far | 1 580—1 000 | 190 — 300 | 6.53— 4.13 |
| near | 1 000— 750 | 300 — 400 | 4.13— 3.10 |
| UV-C ^b | 3 000—1 070 | 100 — 280 | 12.40— 4.43 |
| UV-B ^b | 1 070— 952 | 280 — 315 | 4.43— 3.94 |
| UV-A ^b ("black light") | 952— 750 | 315 — 400 | 3.94— 3.10 |
| Visible radiation (light) ^c | 750— 385 THz | 400 — 780 nm | 3.10— 1.59 eV |
| Infrared (IR) | 385— 0.3 THz | 0.78—1 000 μm | 1 590 — 1.24 meV |
| IR-A ^b | 385— 214 | 0.78— 1.4 | 1 590 —886 |
| IR-B ^b | 214— 100 | 1.4 — 3 | 886 —413 |
| IR-C ^b | 100— 0.3 | 3 —1 000 | 413 — 1.24 |
| near | 385— 100 | 0.78— 3 | 1 590 —413 |
| middle | 100— 10 | 3 — 30 | 413 — 41.3 |
| far | 10— 0.3 | 30 —1 000 | 41.3 — 1.24 |
| <i>Lasers</i> | 1 500— 15 | 0.2 — 20 | 6 200 — 62 |
| Class 1 — non-risk laser devices | | | |
| Class 2 — low-risk, low-power laser devices | | | |
| Class 3a — low-risk, medium-power laser devices | | | |
| Class 3b — moderate-risk, medium-power laser devices | | | |
| Class 4 — high-risk, high-power laser devices | | | |

| Radiofrequency (RF) | 300 GHz— | 0.1 MHz | 1 mm—3 000 m | 1 240 μ eV— | 0.41 neV |
|--------------------------------|-------------------|--------------------|--------------|-----------------|---------------|
| extremely high frequency (EHF) | 300— 30— 3— | 30 GHz 3 0.3 | 1 — 10 mm | 1 240 | —124 μ eV |
| super-high frequency (SHF) | | | | | |
| ultra-high frequency (UHF) | | | | | |
| } "Microwaves" (MW) | | | | | |
| very high frequency (VHF) | 300— | 30 MHz | 1 — 10 m | 1 240 | —124 neV |
| high frequency (HF) | 30— | 3 | 10 — 100 | 124 | — 12.4 |
| medium frequency (MF) | 3— | 0.3 | 100 —1 000 | 12.4 | — 1.24 |
| ----- | | | | | |
| Low frequency (LF) | 300— | 30 kHz | 1 — 10 km | 1 240 | —124 peV |
| Very low frequency (VLF) | 30— | 3 | 10 — 100 | 124 | — 12.4 |
| — | 3— | 0.3 | 100 —1 000 | 12.4 | — 1.24 |
| ----- | | | | | |
| Extremely low frequency (ELF) | <0.3 kHz | | > 1 000 km | < 1.24 peV | |

^a The limits shown are those of some of the more commonly used conventions. When conversion between columns is involved, the numbers have generally been rounded up or down to the third digit.

^b Radiation bands of biological significance designated by the International Commission on Illumination (CIE) (Chapter 3, reference 17).

^c The limits for the human eye vary among individuals between about 380–400 nm and 750–780 nm.

The revision process was begun in 1985 and was undertaken by the original and/or new authors. The newly drafted texts were circulated to reviewers for comments, and then submitted to a group of experts for discussion and finalization. Chapters 1–3 and Chapters 4 and 5 were discussed in plenary and by two subgroups, respectively, of the Working Group that met in October 1985 in Ann Arbor, MI, USA. Chapter 6, on ultrasound, had already been discussed by a third subgroup, which had met in September 1985 in Erice, Sicily, immediately following the sixth Course on Advances in Biological Effects and Dosimetry of Ultrasound of the International School of Radiation Damage and Protection at the Ettore Majorana Centre for Scientific Culture (see Annex 2). The chapters were then revised by the various contributors in accordance with the decisions of the Working Group, recirculated to the Working Group participants for final examination and comments, corrected, and then submitted for final thorough WHO editing.

The Working Group also reviewed new developments in the different NIR spectra ranges and discussed their present or potential impact on human health. The relevant conclusions and recommendations have been added at the end of each chapter. Table 1, which was first published in the Introduction to the first edition, was also re-examined during the meeting in Ann Arbor, and a revised version is presented on pp. 2 & 3.

For the benefit of new readers, the Glossary to the first edition has been reproduced in this edition with minimum change. It is, however, the intention to enlarge the Glossary significantly with the support of the WHO collaborating centre at Health and Welfare Canada, and then to publish it as a separate entity.

Special reference should be made to the essential contribution of the scientific, technical and secretarial staff of the NIR Section, Bureau of Radiation and Medical Devices, Environmental Health Directorate, Health and Welfare Canada, Ottawa in its capacity as a WHO collaborating centre, and its tireless efforts without which the preparation of this revised edition could not have been successfully undertaken. Deirdre Benwell-Morison, in her capacity as Head of the NIR Section, provided effective leadership and served as the major driving force in carrying the complex coordination of this project to a successful conclusion. She also took full command, both scientifically and administratively, of the organization and proceedings of the subgroup on ultrasound, meeting in Italy. Maria Stuchly contributed extensively from her vast scientific knowledge, and spared no effort in assembling all the necessary ingredients for the newly written Chapters 4 and 5. Yvon Deslauriers effectively served as the third member of the Canadian scientific team by providing the link in Chapters 1, 2 and 3.

The WHO collaborating centre at the Center for Devices and Radiological Health, Food and Drug Administration, Rockville, MD, USA played an important role in organizing the Working Group in the United States. Moris Shore of the Center, who strongly supported the preparation of both the first and the second editions, again demonstrated, as Chairman of the Working Group in Ann Arbor, his special talent in channelling the many views of the various experts in the direction of one successful finale.

All the participants in the meetings in Erice and Ann Arbor deserve great praise and appreciation for their efforts and contributions. But special mention should be made of the contributors who rewrote, or updated and revised, and corrected many times the chapters of this edition. Four invited participants whose contributions were expected to be of particular importance were, unfortunately, unable to attend at the last moment. Two of these, Sol Michaelson and Rudolf Hauf, the authors of Chapters 4 and 5 of the first edition respectively, could not attend because of illness. They did, however, extensively review the new draft Chapters 4 and 5 both before and after the meeting, and provided useful comments.

Professors Martino Grandolfo and A. Rindi deserve much appreciation for their courtesy, and for arranging the excellent free facilities which were provided for the subgroup meeting at the Ettore Majorana Centre in Erice. Similarly, credit goes to Nancy D. D'Angelo and Vivian H. Green of the University of Michigan for their excellent administrative support and arrangements. Their special attention to the comfort of the participants and to social events contributed greatly to the warm and pleasant atmosphere during the meeting on the University campus in Ann Arbor.

Finally, mention should be made of one staff member of the WHO Regional Office for Europe in Copenhagen who was very active and supportive in the production and distribution of the first edition of this book. In his latest capacity as Publications Promotion Officer, he was expected to be involved again in promoting the distribution of this second edition. Unfortunately this dear colleague — Martin Jones — passed away on 10 December 1986 at the age of 48, after a short but unsuccessful struggle against cancer. May this book be a tribute to his memory also.

Introduction to the first edition

M.J. Suess

In recent years there has been an increase in the development and use of equipment that produces nonionizing radiant energy, and the question has been raised as to whether adequate measures are being taken to guard the user and the general public from its possible adverse effects. In contrast to ionizing radiation, radiation of longer wavelengths is intrinsically less energetic and usually interacts with human tissue primarily by generating heat. For want of a better collective term, “nonionizing radiation” (NIR) is used to encompass this group of electromagnetic radiations and also ultrasound. Nonionizing radiation pervades the entire environment but, except for the narrow spectrum of visible radiation, it is unperceived by any of the human senses unless its intensity becomes so great that it is felt as heat. Differences in wavelength, even within a single type of radiation, are particularly important when evaluating hazards from exposure to NIR. The ability of the radiation to penetrate into the human body and the sites of absorption will depend on this characteristic and will differ from one type of radiation to another.

In developed countries there has been a remarkable growth in the number of processes and devices that utilize or emit NIR. They find an ever increasing use in industry, engineering, telecommunications, medicine, research, education and the home. This gives rise to a number of questions. How serious are the problems linked with NIR, what are their dimensions, and what acute and chronic effects on the human body are involved? Is there sufficient knowledge of occupational risks and public health hazards? How can exposure be reduced? Are national protection standards adequate and, if not, how can better regulations be drafted and enforced to reduce exposure? Because of the rapidly developing technology and the associated health implications, there is a need to develop international cooperation in the use of NIR and measures to prevent overexposure. Moreover, governments will be expected to intensify the establishment of rules and regulations and means of enforcing them.

The NIR part of the electromagnetic spectrum is divided into five regions (Table 1).^a No exact ranges for these regions can be defined, and those given

^a Table 1 has been revised, and now appears in the Introduction to the second edition on pp. 2 & 3.

in Table 1 are only approximations. In some cases, and for various reasons, different international bodies have developed and agreed on slightly different ranges, depending on the purpose of the definition. This is similarly true for some of the working groups involved in the preparation of this book.

Ultraviolet (UV) radiation has been used extensively for sterilizing equipment and air, and in different types of medical apparatus. In recent years industrial use of UV sources has greatly increased, and a certain risk still exists for workers from open UV sources. Damage is confined to the eye and the skin, but there is a certain long-term risk of skin cancer. The largest exposed group comprises those who spend a great deal of time in the sun, and attention should be drawn to protective measures. As far as human cancer is concerned, little quantitative knowledge of dose-effect relationships and latency periods is available. Ultraviolet lamps for private use are widely distributed among the public and should be supplied with appropriate warnings.

Exposure to infrared (IR) radiation can occur in almost any industry from direct IR sources as well as from other heat sources, and the risks under certain working conditions are well known. Still unanswered is the question of whether IR radiation has produced lenticular cataract. In any case, the presence of well developed temperature sensors in the skin around the eye provides a good biological warning system.

Risks from the use of lasers should receive more attention because of the rapid development of these instruments and their increased use for both military and nonmilitary applications. The emitted light can damage the eye and the skin, and under certain conditions perhaps also internal tissues. The difficulty in evaluating the risks from lasers is due partly to the difficulty of extrapolating the results of animal experiments to man.

Microwave (MW) and radiofrequency (RF) radiation are recognized as the types of NIR that present the greatest perceived risk. The expansion in the use of MW in the communications field and of MW ovens, if appropriate safety devices are not present in such ovens, presents a possible public health hazard.

Some questions have been raised with respect to possible adverse effects of electric and magnetic fields, particularly those at low frequencies, in connection with high-voltage lines. However, no effects due to occupational exposure have been reported, nor are there any indications of injuries to human organs. At present, there is still a dearth of information, and there is a need for better experimentation and more objective and relevant observations.

The versatility of ultrasound has led to its widespread employment in industry, medicine and science for measurement, scanning and control applications, and for thermally modifying material. Ultrasound is relatively safe because of its inability to pass an air-water interface. Whether potential adverse effects exist from immersion of hands in ultrasonic cleaning baths is not known. It has been claimed that chromosome aberrations can be produced by ultrasound radiation, but the evidence tends to be negative. So far, no major adverse effects have been recognized following diagnostic exposure of children *in utero*, and there is general agreement that the risk is much less than from X-ray examinations.

The World Health Organization has always recognized that the protection of the environment is an integral part of protecting the health of the people who live in it. Conscious of the seriousness of the issue, the WHO Regional Committee for Europe decided in 1969 to adopt a comprehensive long-term programme on environmental health and pollution control, including NIR protection. The main aim of the programme was to develop management guides and decision aids for use by government administrations, executive agencies, scientific institutions and individual specialists concerned with the quality of the environment and the protection of public health.

Development of the NIR protection sector of the programme began with a working group which was held in The Hague in November 1971 to consider the health effects of ionizing and nonionizing radiation. This meeting could perhaps be considered the beginning of international activities on NIR protection. The working group reviewed the existing situation with regard to the use of NIR and concluded that although the existing codes and guidelines were sufficient to prevent injury, it was doubtful whether they would be adequate in the future in view of the expected growth in the use of all types of NIR. The group went on to make a number of specific recommendations with respect to surveys in the field of health protection, dissemination of information, and the preparation of codes of practice. The major project that followed this meeting consisted of a series of activities which have led to the publication of this book.

This book is the culmination of a decade of concerted effort by over 200 scientists from 20 countries in Europe, North America and Asia. Five scientific groups, each addressing the subject matter of one or two chapters, met at various times to review draft chapters and to recommend ways and means of finalizing them. Drafts went through several reviews before and after the group meetings, followed by revisions and final editing. The purpose of this book is to provide practical information on health aspects of exposure to NIR energies. Descriptions are given of the physical characteristics, biophysical principles and biological effects of exposure to these energies. Public and occupational health implications and protective measures against the hazards of exposure are also described. Existing standards for general public and occupational exposures are described to inform the reader about the maximum permissible exposure levels, or threshold limit values, at present accepted in various countries. The book is intended to provide information and recommendations that will assist in setting up NIR control programmes and establishing a unified system for the recording and evaluation of results. It is also designed to serve as a technical guide for scientists, engineers and medical personnel active in the field of NIR protection and control. Evidence is presented on possible adverse health effects of NIR, so that where appropriate standards and legislation may be enacted to protect health. Although the book was originally planned by the Regional Office for use in European countries, it should be of value to countries in other parts of the world and to the other international organizations concerned. Moreover, it should provide NIR specialists everywhere with helpful information based on up-to-date international practice.

Work began in 1973, when Professor Michaelson was invited to prepare a document on the potential hazards and safety considerations of human exposure to NIR energies. The first draft was ready in May 1973 and was sent to specialists for review. Moreover, advantage was taken of the International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, held in Warsaw in 1973, to convene a small ad hoc group with the participation of Professors Czerski, Faber, Gordon, Michaelson and Schwan. It was decided to divide the document into two parts: that on MW and RF would be subjected to further revision and review, and a second on lasers would eventually be submitted to a working group on that subject. The final manuscript on MW and RF, following significant and elaborate changes, was ready for final editing in February 1976 and was issued by this Office in 1977. Some of the major contributions to the completeness and accuracy of this version were made by Professors Gordon and Schwan, and Dr Silverman.

However, this document had neither the advantage of being discussed by a working group, nor was it up to date by the time other chapters were completed. An ad hoc meeting in Freiburg in May 1978, attended by Czerski, Harlen, Kossel, Michaelson, Repacholi, Shore and Suess, decided to submit the MW/RF document for further review and revision. Consequently, Professor Michaelson convened a group of experts from Europe and North America for a review meeting, which was held in 1978 at the Bureau of Radiological Health in Washington, DC. This meeting led to a new, rather lengthy and detailed text, but one that was very comprehensive and acceptable to all the points of view represented. The new chapter was revised and corrected, and submitted for final editing in December 1979. Mr Harlen in particular was very helpful in checking the nonbiological sections of the manuscript for adequacy and accuracy.

The Working Group on Health Effects from Lasers, held in Dublin in October 1974, considered the revised working document provided by Professor Michaelson, and the authorship was then enlarged and the material redrafted. After further review and revision, the chapter was submitted for final editing in February 1976 and was issued by this Office in a provisional form in 1977. Mr Sliney and Dr Wolbarsht were particularly instrumental in giving this chapter its present form, while Professor Michaelson was the coordinator of the team and technical editor of the material.

The chapters on UV and IR radiation were both commissioned in 1976. The former was reviewed by correspondence and examined thereafter by a working group in Sofia, in February 1978. After further revision, the chapter was submitted for final editing in January 1979. The draft chapter on IR radiation went through a number of reviews and revisions before submission to the same working group. It was revised, reviewed and corrected thereafter, and submitted for final editing in October 1978.

The chapter on ultrasound was commissioned in 1975 and was passed through a similar process. It was discussed by a working group in London in October 1976, and after further review and corrections, was submitted for final editing in May 1977. A provisional edition of this chapter was issued by this Office that same year.

The two last chapters to be mentioned, which were discussed by the working group in Freiburg in May 1978, are concerned with electric and magnetic fields at low frequencies, and with regulations and enforcement procedures. They were commissioned in 1976, went through a similar review, revision, and correction process, and were submitted for final editing in December and October 1978, respectively.

Some chapters contain conclusions and/or recommendations of various types and purpose. These were agreed on, as were the contents of the chapters themselves, by the participants in the various working groups, and presented by the respective authors in their chapters. It will be obvious, considering the time spent in compiling this work, that some literature references are not as recent as one would wish. However, the reader will appreciate that the objective of this book is not to provide (even if it were possible) an up-to-date literature review. What is important is that the fundamental information contained in this publication is sound and will remain valid for some years. The updating of the material and the references will be dealt with in future revisions.

A great effort has been made to present a uniform text as regards style and terminology. Moreover, the general rule of WHO in its publications is to follow authoritative, internationally approved scientific terms and units, some of which are rather new. A short glossary provides definitions of some essential terms. However, terms in common use in related fields, such as physics, optics, radio-sciences, ionizing radiation and medicine, and their definitions in other glossaries, have been excluded.

This Office has also embarked on a survey of national legislation and regulations, and of institutions and specialists concerned with one or more sectors of the NIR field. The survey is based on replies to two questionnaires received from various governments, and on information from many experts involved in this project. The survey has revealed that only in a relatively small number of countries are there institutions dealing with NIR. In addition to the two countries that have long been involved in this area, namely the United States and the USSR, only about two dozen other countries in the world are known to have institutions that are concerned with the study of NIR, and of these about three quarters are European countries. Since the listing at present is incomplete, and the first attempt will inevitably contain errors and omissions, the results will be issued separately so that it can easily be revised and updated.

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Some of the figures and tables in this book have been reproduced from published works. In all cases this has been acknowledged by means of a suitable reference. The authors and WHO wish to thank the publishers for granting permission for such use to be made of copyright material.

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A revised and updated edition of this book may be prepared in the future and readers are invited to submit comments, corrections and observations, as well as suggestions for additional material, to the World Health Organization, Regional Office for Europe, Scherfigsvej 8, 2100 Copenhagen Ø, Denmark.