



WORLD HEALTH ORGANIZATION
INTERNATIONAL AGENCY FOR RESEARCH ON CANCER

IARC Handbooks of Cancer Prevention

Volume 5

Sunscreens

This publication represents the views and expert opinions
of an IARC Working Group on the
Evaluation of Cancer-preventive Agents,
which met in Lyon,

11–18 April 2000

2001

Published by the International Agency for Research on Cancer,
150 cours Albert Thomas, F-69372 Lyon cedex 08, France

© International Agency for Research on Cancer, 2001

Distributed by Oxford University Press, Walton Street, Oxford, OX2 6DP, UK (Fax: +44 1865 267782) and in the USA by
Oxford University Press, 2001 Evans Road, Carey, NC 27513, USA (Fax: +1 919 677 1303).

All IARC publications can also be ordered directly from IARC*Press*
(Fax: +33 4 72 73 83 02; E-mail: press@iarc.fr).

Publications of the World Health Organization enjoy copyright protection in
accordance with the provisions of Protocol 2 of the Universal Copyright Convention.
All rights reserved.

The designations used and the presentation of the material in this publication do not imply the
expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization
concerning the legal status of any country, territory, city, or area or of its authorities,
or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply
that they are endorsed or recommended by the World Health Organization in preference to others
of a similar nature that are not mentioned. Errors and omissions excepted,
the names of proprietary products are distinguished by initial capital letters.

The authors alone are responsible for the views expressed in this publication.

The International Agency for Research on Cancer welcomes requests for permission to
reproduce or translate its publications, in part or in full. Applications and enquiries should be addressed
to the Editorial & Publications Service, International Agency for Research on Cancer,
which will be glad to provide the latest information on any changes made to the text, plans for new
editions, and reprints and translations already available.

IARC Library Cataloguing in Publication Data

Sunscreens/

IARC Working Group on the Evaluation of
Cancer Preventive Agents (2001 : Lyon, France)

(IARC handbooks of cancer prevention ; 5)

1. Sunscreening agents – congresses. I. IARC Working Group on the Evaluation of Cancer Preventive Agents II Series

ISBN 92 832 3005 1
ISSN 1027-5622

(NLM Classification: W1)

Printed in France

International Agency For Research On Cancer

The International Agency for Research on Cancer (IARC) was established in 1965 by the World Health Assembly, as an independently financed organization within the framework of the World Health Organization. The headquarters of the Agency are in Lyon, France.

The Agency conducts a programme of research concentrating particularly on the epidemiology of cancer and the study of potential carcinogens in the human environment. Its field studies are supplemented by biological and chemical research carried out in the Agency's laboratories in Lyon and, through collaborative research agreements, in national research institutions in many countries. The Agency also conducts a programme for the education and training of personnel for cancer research.

The publications of the Agency contribute to the dissemination of authoritative information on different aspects of cancer research. A complete list is printed at the back of this book. Information about IARC publications, and how to order them, is also available via the Internet at: <http://www.iarc.fr/>

Note to the Reader

Anyone who is aware of published data that may influence any consideration in these *Handbooks* is encouraged to make the information available to the Unit of Chemoprevention, International Agency for Research on Cancer, 150 Cours Albert Thomas, 69372 Lyon Cedex 08, France

Although all efforts are made to prepare the *Handbooks* as accurately as possible, mistakes may occur. Readers are requested to communicate any errors to the Unit of Chemoprevention, so that corrections can be reported in future volumes.

Acknowledgements

The Foundation for Promotion of Cancer Research, Japan, is gratefully acknowledged for its generous support to the meeting of the Working Group and the production of this volume of the *IARC Handbooks of Cancer Prevention*.

List of Participants

H.N. Ananthaswamy

Department of Immunology
The University of Texas
M.D. Anderson Cancer Center
1515 Holcombe Boulevard
Box 178
Houston, TX 77030
USA

C. Arlett

MRC Cell Mutation Unit
University of Sussex
Falmer
Brighton, BN1 9RR
United Kingdom

B.K. Armstrong (Chairman)

Cancer Research and Registers
Division
New South Wales Cancer Council
PO Box 572
Kings Cross
1340 Sydney
Australia

P. Autier

European Institute of Oncology
Division of Epidemiology &
Biostatistics
Via Ripamonti 435
20141 Milan
Italy

J.A. Crowell

Chemoprevention Branch
Division of Cancer Prevention and
Control
National Institutes of Health
National Cancer Institute
Bethesda, MD 20892
USA

F.R. de Gruijl

Dermatology
University Hospital Utrecht
G02 124
PO Box 85500
3508 GA Utrecht
The Netherlands

B.L. Diffey

Regional Medical Physics Department
Newcastle General Hospital
Newcastle NE4 6BE
UK

J.-F. Doré (Vice-Chairman)

INSERM U453
Biologie des Gènes Suppresseurs de
Tumeurs
Bâtiment Le Cheney
Centre Léon Bérard
28, rue Laënnec
69373 Lyon Cedex 08
France

P.D. Forbes

Argus Research Laboratories, Inc.
905 Sheehy Drive
Horsham, PA 19044
USA

A. Fourtanier

Department of Dermato-Biology
L'Oréal-Advanced Research-Life
Sciences Research
Centre Charles Zviak
90 rue du Général Roguet
92583 Clichy Cedex
France

R.P. Gallagher

Cancer Control Research Program
British Columbia Cancer Agency
600 West 10th Avenue
Vancouver, BC, V5Z 4E6
Canada

G.M. Halliday

Department of Medicine (Dermatology)
Royal Prince Alfred Hospital
University of Sydney
Sydney, NSW
Australia

K. Hemminki

Centre for Nutrition and Toxicology
Karolinska Institute
Novum
141 52 Huddinge
Sweden

D.J. Hill

Centre for Behavioural Research in
Cancer
Anti-Cancer Council of Australia
100 Drummond Street
Carlton Victoria 3053
Australia

C. Jansén

Department of Dermatology
Turku University Central Hospital
Kiinamyllynkatu 4-8
20520 Turku
Finland

A. Kawada

Department of Dermatology
Kinki University School of Medicine
377-2 Ohno-Higashi,
Osaka-Sayama
Osaka 589 8511
Japan

A.M. Mommaas

Department of Dermatology and
Center for Electron Microscopy
Leiden University Medical Center
PO Box 9503
2300 RA Leiden
The Netherlands

M.F. Naylor

Department of Dermatology
University of Oklahoma Health
Sciences Center
Oklahoma City,
OK 73190
USA

V.E. Reeve

Department of Veterinary Anatomy
and Pathology
University of Sydney
B14 - McMaster Building, Room 225
Sydney NSW 2006
Australia

J.K. Robinson

Loyola University Chicago
2160 South First Avenue
Room 341
Cardinal Bernardin Cancer Center
Maywood, IL 60153
USA

B.W. Stewart

Cancer Control Program
South Eastern Sydney Area Health
Service
PO Box 88
Randwick NSW 2031
Australia

R.M. Tyrrell

Department of Pharmacy and
Pharmacology
University of Bath (5 West – 2.27)
Claverton Down
Bath, BA2 7AY
United Kingdom

A.R. Young

Department of Photobiology
St. John's Institute of Dermatology
Guy's, King's and St Thomas' School
of Medicine
University of London
London SE1 7EH
United Kingdom

Observer

Dr Romano Mascotto
L'Oréal
6 rue Bertrand Sincholle
92585 Clichy Cedex
France

Secretariat

R. Baan
F. Bianchini
M. Friesen
J. Hall
E. Heseltine
V. Krutovskikh
B. Pignatelli
A.B. Miller
H. Ohshima
C. Partensky
A. Sasco
H. Vainio
J. Wilbourn

Technical assistance

S. Egraz
A. Meneghel
D. Mietton
J. Mitchell
S. Reynaud
J. Thévenoux

Contents

1 Sun, skin and cancer prevention	1	6 Other beneficial effects of sunscreens	125
Sun and skin cancer in humans	1	Prevention of non-carcinogenic dermal effects of the sun	125
Solar radiation of concern and its attenuation	4	Prevention of cumulative effects of exposure to the sun	126
Sunscreens	5	Prevention of UVR-induced stimulation of cutaneous diseases	127
Interaction of solar radiation with biomolecules	7		
Effects of solar radiation other than cancer	11	7 Carcinogenicity	129
Carcinogenicity of ultraviolet radiation in animals	13	Human studies	129
		Experimental models	130
2 Chemical and physical characteristics of sunscreen constituents	17		
Active ingredients	17	8 Toxic effects	133
Historical perspective	17	Toxic and other adverse effects of sunscreens	133
Biological pigments	20	Reproductive and developmental effects	137
Vehicles and formulations	20	Genetic and related effects	137
Additional ingredients	20		
Stability, photostability and reactivity	21	9 Summary of data	141
Analysis, verification and quality control	21	Chemistry, occurrence and human exposure	141
New chemical absorbers	21	Metabolism and kinetics	142
Other properties of sunscreen ingredients	21	Cancer-preventive effects	142
		Other beneficial effects	144
3 Human use of sunscreens	23	Carcinogenic effects	144
Availability	23	Other toxic effects	145
Regulation	23		
Production	23	10 Recommendations	146
Sun exposure and protection	24	Recommendations for research	146
Behavioural considerations in sunscreen use	28	Recommendations for public health action	148
4 Metabolism of sunscreens in various species	63	11 Evaluation	149
Humans	63		
Experimental models	66	References	151
		Appendix 1 Chemical UVR absorbers	175
5 Cancer-preventive effects of sunscreens	69	Appendix 2 Definition of genetic test codes	181
Human studies	69	Glossary	183
Experimental systems	90	Sources of figures	185
Mechanisms of cancer prevention by sunscreens	118	Working Procedures	187