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BIOLOGICAL
HANDBOOKS

Environmental Biology



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B. L. Chen

Environmental Biology

COMPILED AND EDITED BY

Philip L. Altman and Dorothy S. Dittmer

PREPARED UNDER THE AUSPICES OF THE Committee on Biological Handbooks

Federation of American Societies for Experimental Biology

BETHESDA, MARYLAND

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FOREWORD

A living entity, be it virus, tree or man, is being influenced constantly by its environment. The contact can be with liquid ocean, lake and river; gaseous atmosphere; the solid earth, or in more recent experience, space. Each of these is in a state of change and it is the changes which are of such great importance to living things. Environmental biology can, therefore, be interpreted as including a wide variety of external factors which are broadly categorized in the table of contents. One of the limitations imposed on a data book will be the exclusion of those conditions or changes for which insufficient scientific data have been collected. Other environmental conditions which have been excluded are those that are rare, catastrophic or extremely pathologic and thus not within the limitations of normal biological experience. In contrast, changes which have occurred in the environment due to products produced by mankind in the course of development of urbanization and industry have been included, because they are now a definite part of the environment. Not only man, but other flying, walking, crawling and swimming creatures as well as growing plants must live, grow and reproduce in this changing milieu of earth, air and water.

This volume is one of a series of handbooks prepared for use by specialists and published by the Federation of American Societies for Experimental Biology (FASEB). FASEB also has published *Blood and Other Body Fluids*--1961; *Growth Including Reproduction and Morphological Development*--1962; and the *Biological Data Book*--1964. The last named is derived in part from the series of specialized handbooks and is designed for use by persons at all levels of biological study. Earlier volumes in this series were prepared under the auspices of the National Academy of Sciences - National Research Council Committee; the first of these appeared in 1952.

Responsibility for general guidance and for selection of fields to be covered by the data books rests with the Committee on Biological Handbooks. In order to have the knowledge of experts available, a special Advisory Committee is chosen for each book planned. To help select the Advisory Committee an

exploratory committee of zoologists met 19 October 1962. They were: Loren D. Carlson, Hallowell Davis, David B. Dill, J. W. Heim, Arthur W. Martin and Ray G. Daggs. An exploratory committee of botanists met 18 February 1963 and included Paul J. Kramer, the late Paul C. Marth, and Russell B. Stevens. The Federation is grateful to them for their help.

The Advisory Committee meets as often as is necessary in order to determine what should be included and what should be excluded from the volume. On the basis of their extensive research and teaching experience, committee members make suggestions as to authorities in particular fields who should be asked to contribute their services in the preparation of a table or part of a table. Original tables may be sent in by one or more contributors. When necessary, these are integrated by the staff and sent to two or more reviewers for critical evaluation. With the aid of Committee and Advisory Committee members, the staff have been able to obtain remarkable cooperation in this and in previous volumes. The staff compile the data into tables that conform to our standards, and after review they compose and edit these. Because of the nature of the study it has been found more efficient to have composition, editing, indexing, and preparation of camera-ready copy done entirely within the office of Biological Handbooks.

The Committee on Biological Handbooks acknowledges with thanks the contributions made by 450 botanists, zoologists and basic medical research scientists who have contributed so generously with their time and advice. The Committee also wishes to thank the National Institutes of Health, the National Aeronautics and Space Administration, and the Aerospace Medical Research Laboratories of the United States Air Force for the generous support and cooperation which have made possible the production of this book. Participation in this undertaking was fulfilled under National Institutes of Health Grant No. GM-06553, National Aeronautics and Space Administration Contract No. NASr-238, and Air Force Contract No. AF 33(615)-2252.

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INTRODUCTION

During the past decade, the scientific community has developed an increasing interest in the physiological effects of acceleration and deceleration, atmospheric pollution, circadian rhythms, and other external factors. By November, 1961, this growing interest prompted the Committee on Biological Handbooks to consider the need for a new volume in which effects of the environment were quantified for reference purposes. At the request of the Committee, the feasibility of adding *Environmental Biology* to the series of Biological Handbooks was explored by a group of eminent zoologists and botanists who unhesitatingly recommended preparation of such a compendium. Therefore, in 1963, an advisory committee of experts was formed to assist in outlining the contents for the book, and to suggest contributors of data. Solicitation of material was initiated in 1964, and the overwhelming response by hundreds of outstanding scientists confirmed the appropriateness of presenting, in a single compilation, the pertinent information related to the environment of man and other living organisms.

Most of the tables, graphs, and diagrams (totaling 190) were contributed especially for this handbook, and were prepared from the scientists' own collections of data and from the current literature. For the convenience of the user, the tables have been arranged in 10 sections according to major environmental factors. Contents of the volume have been authenticated by 450 leading investigators in the fields of botany, zoology, and medicine. The review process to which the data have been subjected was designed to eliminate, insofar as possible, unacceptable material and errors of transcription.

An explanatory headnote, serving as an introduction to the subject matter, may precede a table. More frequently, tables are prefaced by a short headnote containing such important information as units of measurement, abbreviations, definitions, and estimate of the range of variation. To interpret the data, it is essential to read the related headnote.

The main conventions used throughout this handbook have been adapted from the second edition of the *Style Manual for Biological Journals*, published in 1964 for the Conference of Biological Editors by the American Institute of Biological Sciences. Terminology has been checked against *Webster's Third New International Dictionary*, published in 1961 by G. & C. Merriam Company.

Appended to the tables are the names of the contributors, and a list of the literature citations arranged in alphabetical sequence. The reference abbreviations conform, insofar as possible, to the 1961 *Chemical Abstracts List of Periodicals*, and the 1962-1965 supplements thereto, published by the American Chemical Society.

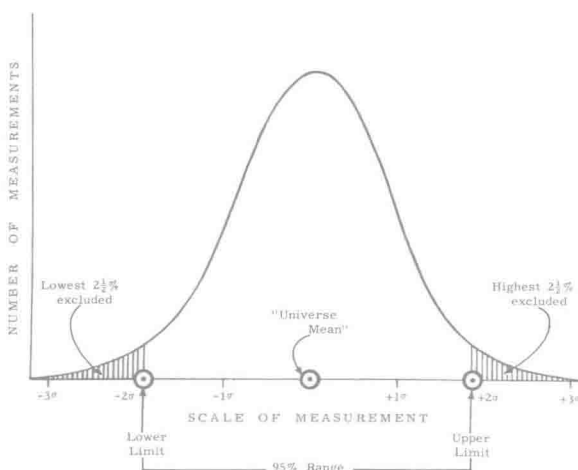
The table of contents should be used in conjunction with the index: the table of contents to determine the scope of the data for the major environmental factors, and the index to locate data for effects on the organism and its functions. To facilitate identification, the index

includes the taxonomic orders for animals, and the families for plants; two appendixes provide cross-reference to scientific and common names.

.....

Values are generally presented as either the mean plus and minus the standard deviation, or the mean and the lower and upper limit of the range of individual values about the mean. The several methods used to estimate the range--depending on the information available--are designated by the letters "a, b, c, or d" to identify the type of range in descending order of accuracy.

"a"--When the group of values is relatively large, a 95% range is derived by curve fitting. A recognized type of normal frequency curve is fitted to a group of measured values, and the extreme 2.5% of the area under the curve at each end is excluded (*see illustration*).



"b"--When the group of values is too small for curve fitting, as is usually the case, a 95% range is estimated by a simple statistical calculation. Assuming a normal symmetrical distribution, the standard deviation is multiplied by a factor of 2, then subtracted from and added to the mean to give the lower and upper range limits.

"c"--A less dependable, but commonly applied, procedure takes as range limits the lowest value and the highest value of the reported sample group of measurements. It underestimates the 95% range for small samples and overestimates for larger sample sizes, but where there is marked asymmetry in the position of the mean within the sample range, this method may be used in preference to the preceding one.

"d"--Another estimate of the lower and upper limits of the range of variation is based on the judgment of an individual experienced in measuring the quantity in question. The trustworthiness of such limits should not be underestimated.

ABBREVIATIONS AND SYMBOLS

Measurements

yr = year
mo = month
wk = week
hr = hour
min = minute
sec = second
msec = millisecond

ht = height
mi = mile
ft = foot
in. = inch
m = meter
km = kilometer
dm = decimeter
cm = centimeter
mm = millimeter
 μ = micron
nm = nanometer
Å = Ångström unit

wt = weight
lb = pound
oz = ounce
g = gram
kg = kilogram
mg = milligram
 μ g = microgram
 μ g = micromicrogram
mEq = milliequivalent
M = mole
mM = millimole
 μ M = micromole

L = liter
ml = milliliter
 μ l = microliter
% = parts per hundred
‰ = parts per thousand
ppm = parts per million
vol = volume

cgs = centimeter-gram-second
mks = meter-kilogram-second
Mc = megacycle
kc = kilocycle
rpm = revolutions per minute
mph = miles per hour
G = acceleration due to gravity
atm = atmosphere

ft-c = footcandle
db = decibel
j = joule
w = watt
mw = milliwatt
 μ w = microwatt
mho = conductance unit (reciprocal of resistance in ohms)
mmho = millimho
kv = kilovolt
kvp = kilovolt peak
Mev = million electron volts
 μ c = microcurie
r = roentgen

RH = relative humidity
temp = temperature
°C = degrees centigrade
°F = degrees Fahrenheit
°K = degrees Kelvin
cal = calorie
kcal = kilocalorie

no. = number
sq = square
' = minute or foot
" = second or inch
 $\pm$ = plus or minus
min. = minimum
max. = maximum
avg = average
 $\sim$ = equivalent to [unless otherwise specified]
 $\approx$ = is similar to
 $\equiv$ = is congruent to
vs = versus
> = greater than
< = less than
 $\nlessgtr$, $\leq$, or $\geq$ = not greater than
 $\nlessgtr$, $\geq$, or $\leq$ = not less than
ca. or approx = approximately

Biological and Chemical Specifications

σ = male
 $\varnothing$ = female
sp. = species [singular]
spp. = species [plural]
Hb = hemoglobin
RBC = red blood cell (erythrocyte)
WBC = white blood cell (leukocyte)
CNS = central nervous system
BMR = basal metabolic rate
ECG = electrocardiogram
EEG = electroencephalogram
ip = intraperitoneal
iv = intravenous
I.U. = international unit
R.U. = rat unit
conc = concentration
LD₅₀ (or LC₅₀) = lethal dose (or concentration) for 50% of inoculated group

DNA = deoxyribonucleic acid
RNA = ribonucleic acid
NADP = nicotinamide adenine dinucleotide phosphate
M = molar
N = normal, or *nitro*
n = normal
m = *meta*
o = *ortho*
p = *para*
D = *dextro*
L = *levo*
STP = standard temperature and pressure
BTSP = body temperature and pressure, saturated with water vapor

CONTENTS

INTRODUCTION	xix
------------------------	-----

ABBREVIATIONS AND SYMBOLS	xxi
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I. TEMPERATURE

1. Temperature Characteristics: Homoiothermic Animals	1
2. Responses to Changes in Ambient Temperature: Man and Domestic Animals	2
3. Brief Exposure to Low Ambient Temperature: Man	3
4. Hypothermia	4
Part I. Physiological Variables: Mammals	4
Part II. Stroke Volume and Cardiac Output: Man, Dog, and Rat	6
Part III. Heart Rate: Vertebrates	7
5. Nervous System and Temperature: Man and Other Animals	11
6. Heat Production and Temperature	12
Part I. Skin Temperature: Man	12
Part II. Ambient Temperature: Rodents and Reptiles	12
7. Metabolism and Temperature: Hibernating Mammals and Birds	12
8. Oxygen Consumption and Temperature: Nonhibernating Mammals	14
9. Oxygen Consumption and Ambient Temperature	16
Part I. Lower Chordates and Other Metazoa	16
Part II. Flatworms and Protozoa	19
10. Respiration Rates and Temperature	20
Part I. Bacteria and Fungi	20
Part II. Lichens, Algae, and Bryophytes	21
Part III. Vascular Plants	23
11. Growth and Temperature	29
Part I. Body Weight: Mouse	29
Part II. Body Weight: Rat	29
Part III. Organ Weight: Rat	29
Part IV. Body Weight: Chick	30
12. Hatching Time and Temperature	30
Part I. Amphibians and Bony Fishes	30
Part II. Ticks and Insects	33
13. Optimum Temperature for Growth: Rickettsia and Bacteria	36
14. Optimum Temperature for Growth: Fungi	39
Part I. Animal Pathogens and Related Saprobes	39
Part II. Plant Pathogens and Related Soil Fungi	42
15. Optimum Temperature for Flowering: Bulbous Plants	45
16. Vernalization Requirement for Flowering: Angiosperms	46
17. Sex Expression and Temperature: Angiosperms	53
18. Life Span and Temperature: Seeds	54
19. Cell Division and Temperature: Tissue Culture	55
20. Adaptation to Temperature	56
Part I. Mammals and Birds	56
Part II. Reptiles, Amphibians, and Fishes	58
Part III. Invertebrates	59
21. Resistance to Frost and Heat: Angiosperms	60
22. Local Cold Injury: Man, Rabbit, and Rat	61
23. Tolerance to Temperature Extremes: Animals	62
Part I. Mammals	62
Part II. Birds	67
Part III. Reptiles and Amphibians	68
Part IV. Fishes	73
Part V. Aquatic Invertebrates	81
24. Tolerance to Temperature Extremes: Plants	87
Part I. Maximum: Lichens	87
Part II. Minimum and Maximum: Algae	87
Part III. Minimum and Maximum: Mosses	90
Part IV. Minimum and Maximum: Vascular Plants Other Than Fruit and Vegetable Crops	91
Part V. Minimum: Fruit and Vegetable Crops	96
25. Lethal Temperatures	100
Part I. Insects	100
Part II. Parasitic Helminths and Protozoa	102
26. Thermal Death: Rickettsia and Bacteria	103
Part I. Animal Pathogens	103
Part II. Plant Pathogens	107

27. Thermal Death: Nonpathogenic Bacteria	109
Part I. D Values	109
Part II. Minutes to Kill	113
Part III. Percent Destruction of Population	117
28. Thermal Death: Fungi	118
Part I. Animal Pathogens	118
Part II. Plant Pathogens	119
Part III. Saprophytes	119
29. Thermal Inactivation: Animal Viruses	121
30. Survival Time and Thermal Inactivation: Plant Viruses	123

II. RADIANT ENERGY

31. Responses to Radio-Frequency Radiation	131
32. Visible Light and Vision: Man	138
Part I. Photometric and Radiometric Concepts	138
Part II. Conversion Factors for Photometric Units	139
Part III. Colorimetric and Photometric Specification of Stimuli	139
Part IV. Visual Performance	141
33. Light Intensity and Rate of Photosynthesis	142
34. Responses to Visible Light: Plants	143
Part I. Artificial Light	143
Part II. Natural Light	147
35. Spectral Distribution of Light Affecting Growth and Development: Angiosperms	147
Part I. Phytochrome Response (Low-Energy Red and Far-Red Reversible Reaction)	147
Part II. Prolonged Irradiation with High-Intensity Light	151
36. Responses to Polarized Light: Animals	155
Part I. Polarotaxis: Arthropods and Mollusks	155
Part II. Electrophysiology: Arthropods	161
Part III. Miscellaneous Effects: Man, Arthropods, and Mollusks	162
37. Responses to Polarized Light: Plants	164
38. Maximum Permissible Occupational Exposure to Ionizing Radiation: Man	165
Part I. Dose-Equivalent to Body Organs	165
Part II. Type of Radiation	165
Part III. Internal Concentration of Radionuclides	166
39. Genetic Effects of Ionizing Radiation: Mammals Other Than Man	175
Part I. Population Fitness: Mouse	175
Part II. Dominant Prenatal Effects	176
Part III. Dominant Postnatal Effects	177
Part IV. Quantitative Traits	179
Part V. Nonvisible Recessive Lethals	179
Part VI. Specific Locus Mutation Rate for Recessive Visible Genes: Mouse	180
40. Sensitivity to Ionizing Radiation: Major Ecosystems and Dominant Plant Species	181
41. Sensitivity to Ionizing Radiation: Dormant Seeds	183

III. SOUND, VIBRATION, AND IMPACT

42. Audible Sound Pressure Levels: Man	191
Part I. Thresholds of Minimum Audibility: Otologically Normal Ears	191
Part II. Thresholds of Minimum Audibility: Audiometric Systems	195
Part III. Thresholds of Maximum Audibility	195
43. Exposure to Noise: Mammals and Roaches	196
44. Physical Acoustic Properties: Mammalian Tissues	197
45. Tissue Changes in Central Nervous System After Exposure to Ultrasound: Cat	198
Part I. Small Lesions in White Matter	199
Part II. Small Lesions in Gray Matter	202
46. Relationship of Lesion Size in Central Nervous System to Ultrasonic Dosage: Cat [<i>graphs</i>]	205
47. Relationship of Ultrasonic Lesion Size in Brain to Temperature, Tissue Composition, and Blood Flow: Cat and Dog	207
48. Peripheral Nerve Conduction and Ultrasound: Mammals [<i>graph</i>]	207
49. Ultrasonic Destruction and Injury: Cells and Microorganisms	208
Part I. Cell Size and Relative Fragility	208
Part II. Cell Size and Optimum Destructive Frequency	208
Part III. Destruction Times	209
Part IV. Destruction (at 9 kc) Related to pH and Temperature	209
Part V. Injury Related to Position in Ultrasonic Field	210
50. Responses to Ultrasound: Plants	210
Part I. Quantitative Measurements	210
Part II. Qualitative Measurements	216
51. Reactions to Mechanical Vibrations: Man [<i>graphs</i>]	217
52. Blast Effects in Air: Mammals Other Than Man	221
53. Blast Effects Underwater: Man and Other Mammals	225

54. Whole Body Tolerance to Impact	228
Part I. Effects of Position: Man	228
Part II. Effects of Seat Belts: Man	229
Part III. Effects of Orientation: Man	229
Part IV. Injurious Deceleration: Chimpanzee	230
55. Physiological Effects of Impact: Man and Other Mammals	231

IV. ACCELERATION AND GRAVITY

56. Equivalent Terminology for Body Acceleration	243
57. Tolerance to Prolonged Acceleration: Man	244
58. Rotatory Stimulation of the Semicircular Canals: Man	246
59. Visual Reactions to Acceleration: Man	248
Part I. Positive G	248
Part II. Negative G	248
60. Auditory Reaction to Acceleration: Man	248
61. Electroencephalographic Recording During Acceleration: Man, Cat, and Monkey	249
62. Circulatory and Respiratory Effects of Acceleration: Mammals	250
63. Physiological Effects of Acceleration and Exercise: Man	255
Part I. Pulmonary Compliance During Positive G and Transverse G	255
Part II. Ventilation During Forward Acceleration	255
Part III. Changes in the Cardiovascular System During Positive G	256
Part IV. Changes in Circulation Due To Posture and Exercise [<i>graph</i>]	257
Part V. Changes in Blood Oxygen Levels, Cardiac Output, and Stroke Volume Due To Posture and Exercise	258
Part VI. Blood Volume and G Tolerance After Rest and After Exercise	258
64. Growth Retardation Due To Acceleration: <i>Escherichia coli</i>	259
65. Devices for Protection Against Positive (Long Axis) Acceleration	259
66. Pilot Performance During Acceleration [<i>graphs</i>]	261
67. Nomogram Relating Linear Velocity, Acceleration, Time for and Diameter of a 360° Turn	264
68. Physiological Effects of Weightlessness: Vertebrates	264
69. Tolerance to Simple Tumbling: Man [<i>graphs</i>]	267
70. Tolerance to Constant Rate of Tumbling in a Decaying G Field: Man [<i>graph</i>]	268

V. ATMOSPHERE AND POLLUTANTS

71. Characteristics and Composition of the Atmosphere	269
Part I. Regional Temperatures	269
Part II. Chemical Composition	269
72. Chemistry of Air Pollutants	270
Part I. Classification	270
Part II. Products	270
73. Emission of Air Pollutants	271
Part I. Motor Vehicles and Gasoline Evaporation	271
Part II. Open Burning, Incineration, and Combustion	272
74. Air Pollutants Measured for Various Periods of Time	273
75. Air Pollutants Sampled in Continuous Monitoring Program	274
76. Urban and Nonurban Distribution of Suspended Particulate Air Pollutants	275
77. Respiratory Effects of Acute and Chronic Exposure to Air Pollutants: Man and Other Mammals	276
Part I. Substances That Mainly Affect Conducting Airways	276
Part II. Substances That Mainly Affect Alveoli and Lung Tissue	281
Part III. Plant Dusts	284
78. Physiological Changes and Mortality Resulting from Inhalation of Air Pollutants: Mammals and Birds	286
79. Susceptibility to Air Pollutants: Spermatophytes	310
Part I. Ammonia, Chlorine, Nitrogen Dioxide, and Peroxyacetyl Nitrate	310
Part II. Ethylene	312
Part III. Fluoride	312
Part IV. Ozone	313
Part V. Sulfur Dioxide	315
80. Air Dispersion of Small Organisms	316
Part I. Bacteria and Fungi	316
Part II. Pollen and Seeds: Spermatophytes	318
81. Biological Effects of Gaseous Ions	320
82. Spacecraft Atmospheres	325
Part I. Gas Pressures	325
Part II. Contaminants	326
83. Tolerance to Oxygen Pressures in Spacecraft Atmospheres: Man	327
84. Chemical Constituents of Nuclear Submarine Atmospheres	327
Part I. Quantitatively Identified	327
Part II. Qualitatively Identified	328
85. Blood Values After Prolonged Exposure to a Nuclear Submarine Atmosphere: Man	329