

**IRRITABILITY, A
PHYSIOLOGICAL ANALYSIS
OF THE GENERAL EFFECT OF
STIMULI IN LIVING SUBSTANCE**

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649016174

Irritability, a physiological analysis of the general effect of stimuli in living substance by Max Verworn

Except for use in any review, the reproduction or utilisation of this work in whole or in part in any form by any electronic, mechanical or other means, now known or hereafter invented, including xerography, photocopying and recording, or in any information storage or retrieval system, is forbidden without the permission of the publisher, Trieste Publishing Pty Ltd, PO Box 1576 Collingwood, Victoria 3066 Australia.

All rights reserved.

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

This book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, re-sold, hired out, or otherwise circulated without the publisher's prior consent in any form or binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

www.triestepublishing.com

MAX VERWORN

**IRRITABILITY, A
PHYSIOLOGICAL ANALYSIS
OF THE GENERAL EFFECT OF
STIMULI IN LIVING SUBSTANCE**

YALE UNIVERSITY
MRS. HEPSA ELY SILLIMAN MEMORIAL LECTURES
—
IRRITABILITY

SILLIMAN MEMORIAL LECTURES
PUBLISHED BY YALE UNIVERSITY PRESS

ELECTRICITY AND MATTER. *By* JOSEPH JOHN THOMSON, D.Sc., F.R.S., F.R.S., F.R.S., *Fellow of Trinity College, Cambridge; Cavendish Professor of Experimental Physics, Cambridge.*
(Fourth printing.) *Price \$1.25 net.*

THE INTEGRATIVE ACTION OF THE NERVOUS SYSTEM. *By* CHARLES S. SHERRINGTON, D.Sc., M.D., DUN. LL.D. TOR., F.R.S., *Holt Professor of Physiology, University of Liverpool.*
(Fourth printing.) *Price \$3.50 net.*

RADIOACTIVE TRANSFORMATIONS. *By* FRANK RUTHERFORD, D.Sc., LL.D., F.R.S., *Macdonald Professor of Physics, McGill University.*
Price \$3.50 net.

EXPERIMENTAL AND THEORETICAL APPLICATIONS OF THERMODYNAMICS TO CHEMISTRY. *By* DR. WALTER NERNST, *Professor and Director of the Institute of Physical Chemistry in the University of Berlin.*
Price \$7.50 net.

PROBLEMS OF GENETICS. *By* WILLIAM BATESON, M.A., F.R.S., *Director of the John Innes Horticultural Institution, Rotham Park, Surrey, England.*
(Second printing.) *Price \$5.00 net.*

STELLAR MOTIONS. *With Special Reference to Motions Determined by Means of the Spectrograph.* *By* WILLIAM WALLACE CAMPBELL, Sc.D., LL.D., *Director of the Lick Observatory, University of California.*
Price \$3.50 net.

THEORIES OF SOLUTIONS. *By* SVANTE ARRHENIUS, Ph.D., Sc.D., M.D., *Director of the Physical-Chemical Department of the Nobel Institute, Stockholm, Sweden.*
(Third printing.) *Price \$2.00 net.*

IRRITABILITY. *A Physiological Analysis of the General Effect of Stimuli on Living Substances.* *By* MAX VERNER, M.D., Ph.D., *Professor of Bonn Physiological Institute.*
(Second printing.) *Price \$5.50 net.*

PROBLEMS OF AMERICAN GEOLOGY. *By* WILLIAM NORTH RICE, FRANK D. ADAMS, ARTHUR F. COLEMAN, CHARLES D. WALCOTT, WALDEMAR LINDBERG, FERDINAND LESLIE RANSOME, AND WILLIAM D. MERRILL.
Price \$5.00 net.

THE PROBLEM OF VOLCANISM. *By* JOSEPH PAXSON IODING, Ph.D., Sc.D.
Price \$5.00 net.

ORGANISM AND ENVIRONMENT AS ILLUSTRATED BY THE PHYSIOLOGY OF BREATHING. *By* JOHN SCOTT HALDANE, M.D., LL.D., F.R.S., *Fellow of New College, Oxford.*
Price \$1.85 net.

IRRITABILITY

A PHYSIOLOGICAL ANALYSIS OF THE GENERAL
EFFECT OF STIMULI IN LIVING SUBSTANCE

BY

MAX VERWORN, M.D., PH.D.

Professor at Bonn Physiological Institute

WITH DIAGRAMS AND ILLUSTRATIONS



166682.
1-11 35

NEW HAVEN: YALE UNIVERSITY PRESS

LONDON: HUMPHREY MILFORD

OXFORD UNIVERSITY PRESS

MDCCCXIII

COPYRIGHT, 1911
BY YALE UNIVERSITY PRESS

First published, May, 1911
Second printing, November, 1916

OH
345
767

THE SILLIMAN FOUNDATION.

In the year 1883 a legacy of eighty thousand dollars was left to the President and Fellows of Yale College in the city of New Haven, to be held in trust, as a gift from her children, in memory of their beloved and honored mother, Mrs. Hepsa Ely Silliman.

On this foundation Yale College was requested and directed to establish an annual course of lectures designed to illustrate the presence and providence, the wisdom and goodness of God, as manifested in the natural and moral world. These were to be designated as the Mrs. Hepsa Ely Silliman Lectures. It is the belief of the testator that any orderly presentation of the facts of nature or history contributed to the end of this foundation more effectively than any attempt to emphasize the elements of doctrine or creed; and he therefore provided that lectures on dogmatic or polemical theology should be excluded from the scope of this foundation, and that the subjects should be selected rather from the domains of natural science and history, giving special prominence to astronomy, chemistry, geology, and anatomy.

It was further directed that each annual course should be made the basis of a volume to form part of a series constituting a memorial to Mrs. Silliman. The memorial fund came into the possession of the corporation of Yale University in the year 1901; and the present volume constitutes the ninth of the series of memorial lectures.

PREFACE

The lectures on irritability here published were held at the University of Yale in October, 1911. When the authorities of that University honored me by an invitation to give a course of Silliman memorial lectures, I accepted with the more pleasure as it furnished me with the opportunity of summarizing the results of numerous experimental researches carried out with the assistance of my co-workers during the course of more than two decades in the physiological laboratories of Jena, Göttingen and Bonn, to unite therewith the results obtained by other investigators and thus present a uniform exposition of the general effects and laws of stimulation in the living substance. I have long entertained this plan and this for the following reason:

The physiologist, the zoölogist, the botanist, the psychologist, the pathologist, have to deal, day in, day out, with the effects of stimulation on the living substance. No living substance exists without stimulation. In the vital manifestations of all organisms the interplay of the most varied stimuli produces an enormous and manifold variety of effects. Experimental biological science employs artificial stimulation as the most important aid in the methodic production of certain effects of stimulation. The number of researches in which special effects of stimulation are treated is endless. Nevertheless the systematic investigation of the effects of stimulation have, curiously enough, been strangely neglected. Although countless results of individual effects of stimulation have been studied, the attempt has never been made to establish a general physiology of the laws of stimulation and consider it as an independent problem. This circumstance induced me to systematically investigate the general laws of the effect of stimulation. In the fifth and sixth chapters of my book on general physiology the results of these studies are recorded for the first time. Since then, especially during our own researches on the general physiology of the nervous system, a great number

of new facts of importance for the general physiology of the effects of stimulation have been obtained. All these results I have endeavored to combine and elucidate in the following lectures.

The text of the lectures in its present form was written in German in 1911. The English translation was made by my wife, with the help of our friend, Dr. Lodholz of the University of Pennsylvania, who also undertook the reading of the proofs. We wish here to thank him once again and express our deep appreciation of the great sacrifice of time and labor involved in this task. I am likewise much indebted to Dr. Julius Vészi for his assistance unstintingly given, especially in obtaining a number of curves. Finally, I wish to take this opportunity to render warmest thanks to the authorities of Yale University, and especially to President Hadley and Professor Chittenden, as well as to my special colleagues, for the hospitality and cordial reception extended to me in New Haven and for the pleasant hours I was privileged to spend in their midst.

MAX VERWORN.

Bonn.

Physiological Laboratory of the University.