

Review

Biological Aging Acceleration Due to Environmental Exposures: An Exciting New Direction in Toxicogenomics Research

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Abstract: Biological clock technologies are designed to assess the acceleration of biological age (B-age) in diverse cell types, offering a distinctive opportunity in toxicogenomic research to explore the impact of environmental stressors, social challenges, and unhealthy lifestyles on health impairment. These clocks also play a role in identifying factors that can hinder aging and promote a healthy lifestyle. Over the past decade, researchers in epigenetics have developed testing methods that predict the chronological and biological age of organisms. These methods rely on assessing DNA methylation (DNAm) levels at specific CpG sites, RNA levels, and various biomolecules across multiple cell types, tissues, and entire organisms. Commonly known as “biological clocks” (B-clocks), these estimators hold promise for gaining deeper insights into the pathways contributing to the development of age-related disorders. They also provide a foundation for devising biomedical or social interventions to prevent, reverse, or mitigate these disorders. This review article provides a concise overview of various epigenetic clocks and explores their susceptibility to environmental stressors.

Keywords: biological clocks; epigenetic clocks; toxicology; toxicogenomics; DNA methylation



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1. Introduction

Everyone ages, but biologically not at the same pace. Aging is quantified based on two parameters—chronological age (C-age) is the amount of time that has elapsed from birth to a given date, and biological age (B-age) is the measure of the apparent age of an organ or tissue based on several factors discussed in this review. Individuals with the same C-age can have different health status, and therefore C-age offers limited information regarding the biological pathways underlying aging [1]. That led to the development of the concept of “biological age” which can accurately reflect phenotypic characteristics such as “functional frailty” and molecular level markers such as DNAm [2–5]. Over the past decade, aging has become a critical public health concern because of several socio-economic implications [6]. The unprecedented increase in world’s aging population will continue to rise globally in the next few decades and by 2050, the number of people aged 60 and older would reach 21% [7]. This varies from 9.3% in Africa (low) to 36.5% in Japan (high) and 21.4% in the USA in 2050 [8]. After adolescent growth and development, there is a progressive decline in tissue and organ function along with an exponential rise in mortality rates, doubling roughly every 7–8 years after puberty [9]. The prevalence of significant chronic conditions, such as cardiovascular disease, cancer, diabetes, and Alzheimer’s disease, increases exponentially as individuals age [6]. This is primarily caused by a progressive gradual accumulation

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Review of Biological Research in Aging Morton Rothstein, 1985-08 Annual Review of Gerontology and Geriatrics, Volume 10, 1990 Vincent J. Cristofalo, PhD, 1990-11-15 This volume presents a clear concise overview of the current state of knowledge about the biology of aging serving as both an invaluable graduate level text and a key reference for practicing professionals Over a dozen distinguished contributors probe the latest developments in our knowledge of why people age and how the process works These authoritative chapters are not just written for biologists but for gerontologists in general Marks the tenth anniversary of the Annual Review of Gerontology and Geriatrics Handbook of the Biology of Aging Edward L. Schneider, John W. Rowe, 2013-10-22 Handbook of The Biology of Aging Third Edition provides a general overview to a wide scientific audience of some of the most important topics in biomedical gerontology The book discusses methodologies for biological aging studies and on animal models Protein modifications with aging special senses circadian rhythms and the adrenocortical axis are tacked in the book as well Gerontologists psychologists health care professionals and graduate students will find the book useful **Non-Mammalian Models for Research on Aging** F. A. Lints, 1985-11-26 *The Membrane Hypothesis of Aging* Imre Zs.-Nagy, 1994-07-12 The Membrane Hypothesis of Aging offers the most comprehensive multidisciplinary description of the cell maturation and aging process The membrane hypothesis of aging MHA described in this book is based on the actual multidisciplinary knowledge of cell morphology physiology and biochemistry The solid basis of known facts explains the destructive progressive intrinsic and universal character of the aging process The book interprets other aging theories including free radical theory of aging dysdifferentiation hypothesis of aging and cancer and the accumulation theories It presents important issues for future research The book also outlines the possibilities of an efficient preventive anti aging drug design and presents the first promising results of such research activity

Annual Review of Gerontology and Geriatrics, Volume 15, 1995 , 1995-11-16 Proper nutrition weight and exercise have all been strongly linked to improved health and longevity among the elderly This timely volume presents the latest medical research on nutrition and its impact on healthy aging in a variety of older populations and in a range of care settings Topics include the diagnosis and management of protein undernutrition psychological and social factors in weight loss the effects of vitamins and exercise on aging and more This volume will appeal to geriatricians geriatric researchers and academics as well as to other health professionals concerned with nutrition and the elderly **Aging, Sex, and DNA Repair** Bozzano G Luisa, 2012-12-02 Why organisms age and why sexual reproduction exists are major unsolved problems in biology This book provides an integrated explanation of aging and sex based on current knowledge of DNA damage and repair Discusses the universality of the problem of DNA damage Describes aging as a consequence of accumulated DNA damage Considers meiosis as an adaptation for DNA repair Discusses mating in eukaryotes as an adaptation for masking mutation **Annual Review of Gerontology and Geriatrics, Volume 34, 2014** Richard Sprott, 2014-03-20 Enormous

advances in our knowledge of genetic contributions to aging and disease and in our understanding of the potential for manipulation of the aging process have taken place during the past 20 years This is the first volume in decades to consolidate this research in one place It provides a broad and current overview of the most promising advances in genetic research on aging current understanding of genetic contributions to the basic processes of aging and age related disease The Review focuses on the aging process from lower organisms to man and is organized in ascending order of biological complexity starting with stem cells and progressing through worms flies mice and humans Where relevant the Review also includes information about yeasts and non human primates The research presented in the Review uses a species comparative approach that makes finding cross species similarities gene conservation and differences gene differentiation apparent This approach reflects the way in which the field is organized making it highly useful for investigators who want quick access and a concise summary of a particular topic Key Features Provides state of the art information about promising advances in genetic research on aging Comprises the first comprehensive volume regarding genetic research about aging in decades Authored by leading scholars in the field Disseminates enormous advances in our understanding of the aging process

Annual Review of Gerontology and Geriatrics, Volume 34, 2014 Richard L. Sprott, Toni C. Antonucci, 2014-03-20 Print CourseSmart **Biomedical Advances in Aging** Allan L. Goldstein, 2012-12-06 The VIIIth Annual International Spring Symposium on Health Sciences held at the George Washington University School of Medicine in Washington D C attracted over three hundred fifty scientists from twenty five countries The leading scientific experts in the field reported on recent biomedical advances in aging They provided an up to date account of the molecular genetic nutritional and immunological mechanisms associated with the aging process and approaches to intervention and treatment of the major disorders associated with the aging process including Alzheimer's disease A unique aspect of this meeting was a concurrent one day hearing of the U S Senate Sub Committee on Aging organized by the Alliance for Aging Research The theme for the hearing was Advances in Aging Research Seven scientists attending our aging symposium were asked to testify They were Drs Carl Cotman University of California Irvine Trudy Bush Johns Hopkins University Takashi Makinodan University of California Los Angeles William Ershler University of Wisconsin Madison Gino Doria ENEA Rome Mr Dan Perry Director of the Alliance for Aging Research and myself **Time: A Bibliographic Guide** Samuel L. Macey, 2018-10-10 Originally published in 1991 A multidisciplinary guide in the form of a bibliography of selected time related books and articles divided into 25 existing academic disciplines and about 100 subdisciplines which have a wide application to time studies *Nonmammalian Animal Models for Biomedical Research* Avril D. Woodhead, 1989-11-30 This book provides essential knowledge and information required to adequately assess useful alternatives from among the lower vertebrates and the invertebrates This volume highlights unfamiliar and underdeveloped organisms that have the potential to become very satisfactory surrogates for biomedical research A practical guide aimed at disseminating information to researchers about new models this work

provides comparative biomedical studies at many levels of the phylogenetic ladder

Routledge Library Editions: Philosophy of Time Various Authors, 2021-03-05 Reissuing five works originally published between 1937 and 1991 this collection contains books addressing the subject of time from a mostly philosophic point of view but also of interest to those in the science and mathematics worlds These texts are brought back into print in this small set of works addressing how we think about time the history of the philosophy of time the measurement of time theories of relativity and discussions of the wider thinking about time and space among other aspects One volume is a thorough bibliography collating references on the subject of time across many disciplines

Genetic Effects on Aging David E. Harrison, 1990-08-09 This volume provides background knowledge useful to those setting out to do genetic studies of aging in mammals and raises vital questions How many genes are important in mammalian aging What are the optimal methods for their study To what degree are patterns of aging and patterns of growth and development part of the same process Do patterns of development predict subsequent patterns of growth and aging Are there a few fundamental aging processes or does every biological system age The rapid rate of progress in this field required a new volume with a new approach based on the combination of classical genetics and the powerful new tools of molecular genetics Although mammalian systems are emphasized representatives of the advanced genetic studies in *Drosophila* and other model systems are included The purpose is to enrich and stimulate genetic studies of mammalian aging by suggesting and evaluating future possibilities

Special Focus on the Biology of Aging Vincent J. Cristofalo, M. Powell Lawton, 2013-12-17 *The Official Anti-Aging Revolution (Volume 2 of 2) (EasyRead Comfort Edition)* ,

Biology of Longevity and Aging Robert Arking, 2019-01-10 An introductory text to the biology of aging and longevity offering a thorough review of the field

Drosophila as a Model Organism for Ageing Studies Frédéric A. Lints, M. Hani Soliman, 2013-11-21 Many books on ageing attempt to cover the whole field of gerontology However since gerontology is now such a diversified and rapidly expanding subject the results of such attempts tend to be either incomprehensible compendia or encyclopedias of disheartening size The present book aims to be both more modest and more ambitious It focuses on a single object *Drosophila* but attempts to offer a synthesis of all the gerontological work that has been done on it It also aims to show the extent to which this work has led to an understanding of the biological phenomena of ageing longevity senescence and death in higher organisms including man Finally it attempts on the basis of current knowledge to mark out the paths that the next generation of researchers will most probably follow *Drosophila* has been used as a model organism to advance our basic knowledge of the fundamentals of genetics and gerontology It may be noted that the pioneering work on the genetics of ageing which used *Drosophila* began very early in this century within the first decade of the rediscovery of Mendel's laws

Guide to Sources for Agricultural and Biological Research J. Richard Blanchard, Lois Farrell, 2023-07-28

Annual Review of Nursing Research, Volume 25, 2007 , 2007-06-11 This 25th anniversary edition of the Annual Review of Nursing Research is focused on nursing science in vulnerable populations Identified as a priority in

the nursing discipline vulnerable populations are discussed in terms of the development of nursing science diverse approaches in building the state of the science research integrating biologic methods in the research and research in reducing health disparities Topics include Measurement issues Prevention of infectious diseases among vulnerable populations Genomics and proteomics methodologies for research Promoting culturally appropriate interventions Community academic research partnerships with vulnerable populations Vulnerable populations in Thailand women living with HIV AIDS As in all volumes of the Annual Reviews leading nurse researchers provide students other researchers and clinicians with the foundations for evidence based practice and further research

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