

REVIEW

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History and evolution of cytogenetics

Malcolm A. Ferguson-Smith

Abstract

The events that have led to the development of cytogenetics as a specialty within the life sciences are described, with special attention to the early history of human cytogenetics. Improvements in the resolution of chromosome analysis has followed closely the introduction of innovative technology. The review provides a brief account of the structure of somatic and meiotic chromosomes, stressing the high conservation of structure in plants and animals, with emphasis on aspects that require further research. The future of molecular cytogenetics is likely to depend on a better knowledge of chromosome structure and function.

Introduction

Our specialty was pioneered by scientists who developed the compound microscope to study the cellular organisation of the living world. While comparative anatomists had known for centuries that all animals share physical features that suggest a common structure among creatures both living and revealed in fossils, the cytologists of the 19th century found that this concept extended to a cellular organisation present in all plants and animals. Variations in morphology within species, and to a greater extent between species, led Linnaeus and other taxonomists to classify all organisms in terms of genealogies with species, families and orders depending on their similarities, starting with individuals capable of reproduction that defined a species. The stage was set for ideas about the transmutability of species, the heritability of physical traits and Darwin's theory of the origin of species [1].

The mechanisms of transmission of both discontinuous and continuous characteristics across the generations were unknown before Mendel's laws were explained at the turn of the 20th Century by the behavior of chromosomes in germ cells [2,3]. Stains used by pathologists to identify bacteria also served to identify chromosomes. Proof of the chromosomal theory of inheritance was a decisive event in biology that turned cytologists into cytogeneticists. Morgan, Sturtevant, Bridges and Muller constructed the first genetic linkage maps from recombination studies in crosses made in the fruit fly and from cytological preparations of its polytene salivary gland chromosomes [4–6]. Cyril Darlington pioneered plant cytogenetics in 1920–30

and made important advances in our understanding of mechanisms of chiasma formation and the behavior of sex chromosomes in meiosis [7]. These studies reaffirmed that chromosome structure and behavior in somatic and germ cell divisions were common to all plants and animals.

In 1944 it was realized that genetic transformation in bacteria was due to DNA and not protein and that DNA was the molecule responsible for heredity in genes and chromosomes [8]. The molecular structure of DNA became a key question. Chargaff showed in 1950 that, in DNA, the amount of adenine is equal to the amount of thymine and that the amount of guanine is equal to the amount of cytosine [9]. This was the important clue to the structure of the DNA double helix modeled by Watson and Crick in 1953, and based on the X-ray diffraction studies of Rosalind Franklin [10]. Some eight years later it was discovered that triplets of the base pairs specified each amino acid in the polypeptide chain of each protein [11,12]. The sequence of base pairs in DNA/RNA is thus the universal genetic code in all forms of life that descended from a common progenitor 4.5 billion years ago. Phylogenomic studies using chromosome painting confirms the high conservation of DNA between even distantly related species [13].

Chromosome structure

Since the genetic code was deciphered much has been learnt about the chromosome structure shared by all organisms from yeast to human. Much more remains to be discovered. One of the purposes of this review is to encourage research into chromosome structure as this could help advance molecular cytogenetics. The following is a

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Cytogenetics And Evolution

**All India Seminar on the Cytogenetics
in Evolution and Improvement of
Plants (1972 ; Kashmir)**

Cytogenetics And Evolution:

Cytogenetics, Evolution and Biostatistics RS Shukla | PS Chandel, 2010 For Degree level Students Amphibian Cytogenetics and Evolution David M. Green, Stanley K. Sessions, 2012-12-02 This book appears at a time when molecular cytogenetics is positioned to make a significant impact upon evolutionary studies enabling problems of chromosomal structure and change to be critically assessed It is an up to date and comprehensive survey of the cytogenetics of a major class of animals including all three amphibian orders with chapters authored by international leaders in the field Amphibian Cytogenetics and Evolution will be of interest to classical and molecular cytogeneticists systematicists evolutionary biologists herpetologists and anyone using amphibians in genetic research Offers the only current and comprehensive survey of amphibian cytogenetics Gives authoritative and in depth coverage of topics of present interest Reviews general cytogenetic topics Presents new insights into evolutionary changes in chromosome structure and amphibian phylogeny and relationships including Phylogenetic analysis of chromosome data Current techniques of cytogenetic analysis Examination of all three amphibian orders **Cytogenetics and Evolution** Ujjwala Deshmukh, 2003 **Cytogenetics, Evolution, Biostatistics and Plant Breeding** Shukla R.S. & Chandel P.S., 2004-09 Cytology Genetics Evolution Biostatistics and Plant Breeding for B Sc M Sc Students *Advancing Frontiers in Cytogenetics in Evolution and Improvement of Plants* All India Seminar on the Cytogenetics in Evolution and Improvement of Plants (1972 ; Kashmir), 1975 Advancing Frontiers in Cytogenetics in Evolution & Improvement of Plants Premnath Kachroo, 1974 Cytogenetics, Evolution and Plant Breeding R. S. Shukla, P. S. Chandel, 2001-01-01 The Biology of Plethodontid Salamanders Richard C. Bruce, Robert G. Jaeger, Lynne D. Houck, 2012-12-06 The fourth Conference on the Biology of Plethodontid Salamanders was held at The Mountain in Highlands North Carolina on June 12 14 1998 Hosted by the Highlands Biological Station and sponsored by the Highlands Biological Foundation Inc the conference afforded a state of the art overview of these animals as evidenced by the contents of the present volume and the credentials of the contributors In the following pages the reader will find the best current understanding of many aspects of plethodontid salamander evolution systematics development morphology life history ecology and field methodology While the contents of this book consist of chapters developed from selected conference papers their excellence is representative of the high overall quality of the conference presentations The Highlands Biological Station is located on the Highlands Plateau in the southern Blue Ridge Mountains As these mountains are a present center of plethodontid diversity and are considered by some to be the center of origin of the group the Highlands Biological Station has historically been important in the study of these animals A list of visitors to the Station for the last 70 years would include a who's who of twentieth century North American herpetologists The location and amenities of the Highlands Biological Station are unique Within the city limits of Highlands at an elevation of nearly 1200 meters the Station includes modern research laboratories administrative offices library facilities as well as dormitory and living facilities *Plant Cytogenetics,*

Breeding and Evolution Bentlee Salinas, 2018-12-21 There are about 300 315 thousand species of plants of which the great majority some 260 290 thousand are seed plants Green plants provide a substantial proportion of the world's molecular oxygen and are the basis of most of Earth's Ecologies especially on land Plants that produce grains fruits and vegetables form humankind's basic foodstuffs and have been domesticated for millennia Plants play many roles in culture They are used as ornaments and until recently and in great variety they have served as the source of most medicines and drugs The scientific study of plants is known as botany a branch of biology Plant Cytogenetics Breeding and Evolution Plant Cytogenetics comprises a topic of broad interest and increasing importance in plant science In keeping with the exciting advances in plant genetics and genomics we believe that a comprehensive and up to date reference on Plant Cytogenetics would be of great interest and value for researchers instructors and students with interests in genetics plant biology and plant genomics

Cancer Cytogenetics Sverre Heim, Felix Mitelman, 2011-09-20 Cancer Cytogenetics 3rd Edition offers a comprehensive expanded and up to date review of recent dramatic advances in this area and incorporates a vast amount of new data from the latest basic and clinical investigations Edited by two leading experts and now involving a new panel of international experts the book offers an authoritative description of neoplastic processes at the chromosomal level of genomic organization Researchers in cytogenetics medical and molecular genetics cellular and molecular biology cancer research clinical oncology and hematology will find this reference both thorough and authoritative

First colloquium on plant cytogenetics and evolution, 1984

Cytogenetics, Plant Breeding and Evolution Umakant Sinha, Sunita Sinha, 1985

Advances in Genetics E. W. Caspari, Milislav Demerec, 1976 ADVANCES IN GENETICS VOLUME 18

Chromosome Engineering in Plants P.K. Gupta, T. Tsuchiya, 2012-12-02 This two volume work surveys the entire range of general aspects of chromosome research in plants The first volume covers cytogenetics of cereals and millets with more than one chapter being devoted to the same crop to give a detailed treatment to an up to date status of chromosome research This second volume deals with cytogenetics of plant materials including legumes vegetable and oil crops sugar crops forage crops fibre crops medicinal crops and ornamentals The book will be useful both as a reference work and a teaching aid to satisfy a wide range of workers Every chapter has been written by an expert who has been involved in chromosome research on a particular plant material for many years so that the treatment is authoritative and up to date in most cases

Wheat Evolution and Domestication Moshe Feldman, Avraham A. Levy, 2023-10-03 This open access book covers a century of research on wheat genetics and evolution starting with the discovery in 1918 of the accurate number of chromosomes in wheat We re evaluate classical studies that are pillars of the current knowledge considering recent genomic data in the wheat group comprising 31 species from the genera *Amblyopyrum* *Aegilops* *Triticum* and other more distant relatives For these species we describe morphology ecogeographical distribution phylogeny as well as cytogenetic and genomic features For crops we also address evolution under human selection namely pre domestication cultivation and domestication We re examine the genetic and archeological

evidence of where when and how domestication occurred We discuss unique aspects of genome evolution and maintenance under polyploidization in natural and synthetic allopolyploids of the wheat group Finally we propose some thoughts on the future prospects of wheat improvement As such it can be of great interest to wheat researchers and breeders as well as to plant scientists and students interested in plant genetics evolution domestication and polyploidy *Cytogenetics and evolution* Mohan P. Arora, Gurdarshan Singh Sandhu, 1982 **Evolution and Speciation** William R. Atchley, David S. Woodruff, 1981-05-29 This 1981 collection focuses on a wide range of topics in the general field of evolutionary biology The authors have all been associated with Professor M J D White who was the world authority on chromosomal evolution and speciation to whom this volume was presented on his seventieth birthday *Cytogenetics and Evolution* R. S. Shukla, P. S. Chandel, 1977 *Animal Cytology and Evolution* Michael James Denham White, 1973-06-28 Chromosomes as supermolecular systems The mitotic mechanism in evolution Endomitosis and endopolyploidy Giant chromosomes the polytene type Giant chromosomes the lampbrush type The mechanism of meiosis Chromosomes rearrangements occurrence and mechanisms Chromosomal polymorphism in natural populations Supernumerary chromosomes Chromosomal rearrangements and speciation evolution of the meiotic mechanism The evolution of aberrant genetic systems The cytology of interspecific hybrid The evolution of sex determination Haplodiploidy Thelytoky *Reviews in Plant Cytogenetics* Maria J. Puertas, Tomás Naranjo, 2008 Chromosomes represent the main focus of cytogenetics One of the main challenges of modern day cytogenetics is to unravel the relation between the genomic content and architecture of chromosomes and their genetic function Plant species have provided an important contribution to the knowledge of chromosome evolution and those with large chromosomes have often been used in the study of chromosome behavior The rapid development of molecular tools in the last few years has greatly furthered advances in elucidating the organization behavior and evolution of chromosomes This special issue of Cytogenetic and Genome Research presents an excellent compilation of current research in plant cytogenetics In a series of review articles experts in the field explain and discuss the organization of chromosomes and the impact of new technologies the organization and evolution of sex chromosomes and B chromosomes recent advances in meiosis and different aspects of chromosome evolution and plant breeding Providing an excellent update this book is recommended to researchers teachers and students in genetics plant biology and agronomy

Cytogenetics And Evolution: Bestsellers in 2023 The year 2023 has witnessed a noteworthy surge in literary brilliance, with numerous engrossing novels captivating the hearts of readers worldwide. Lets delve into the realm of popular books, exploring the fascinating narratives that have captivated audiences this year. Cytogenetics And Evolution : Colleen Hoover's "It Ends with Us" This touching tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can succeed. Uncover the Best : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids compelling storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Cytogenetics And Evolution : Delia Owens "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens crafts a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of compelling stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is an exceptional and suspenseful novel that will keep you speculating until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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