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The conservation and divergence of telomeric structures, effects, and functions

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Telomeres are specialized eukaryotic structures at the ends of linear chromosomes, recognized for decades as having multiple functions that include the stabilization of chromosome ends, a solution to the end-replication problem, and the rearrangement of meiotic chromosomes [1–4]. More recently, the recognition that telomeres play a critical role in aging and cancer has resulted in a great deal of excitement and research activity on telomere length regulation [5–7].

In most eukaryotes, telomeres consist of a simple repeated sequence, such as the human telomere repeat TTAGGG, and associated proteins. The repeating unit is made de novo by extension of the 3′ G-rich strand by telomerase, a reverse transcriptase with its own RNA template [reviewed in 8]. Recent and significant progress in the identification of telomeric complex proteins has provided the basis for new and revised models depicting functions or structures of telomeres [9–11].

In this series of five reviews, specific structures and functions of telomeres are summarized with emphasis on cross-species comparisons. The first two reviews focus on conserved telomere structures. Wei and Price review the G-strand overhang-binding proteins from different species and discuss the prevalence and significance of the t-loop structures that can be found at the chromosomal termini. Kanoh and Ishikawa review recent findings on the proteins associated with telomeric DNA, with discussion on the different modes, direct verses indirect, by which proteins can be localized to the telomeres.

The last three reviews focus on telomere functions. Perrod and Gasser review the rapidly growing body of data on chromatin dynamics and telomere-associated transcriptional silencing. Telomeric position effects are reviewed in light of other well-characterized locus-specific gene silencing found at centromeres, rDNA, and mating-type loci. Chromatin remodeling proteins at different loci or from different species reveal that some aspects of heterochromatin-mediated silencing are conserved while others are not. Next, Bass reviews the role of telomeres in meiotic chromosome behavior. Meiotic telomeres have been observed to cluster together on the nuclear envelope during meiotic prophase, when homologous chromosomes commence synapsis and recombination. Historical and recent observations on meiotic telomere clustering reveal the ancient and conserved nature of this unique telomere behavior. Evidence from plants, animals, and fungi links microtubules to at least some of these telomere movements. Finally, Biessmann and Mason review what is known about telomerase-independent maintenance of telomeres. Experimentally induced and naturally occurring telomerase-lacking systems provide insight into alternative strategies to maintain chromosomal termini.

In summary, telomere research covers a remarkably broad range of topics from cell division and cancer to transcriptional silencing and meiotic chromosome behavior. As more and more components of the telomeric complexes are identified and characterized, we are slowly but surely beginning to define the factors that may be common to two or more telomere-associated processes. Cross-kingdom comparisons of telomere structures and telomere functions provide important insights into the specialized roles for telomeres in the life cycles of eukaryotic organisms.

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