

# DNA Helicases: Unlocking New Frontiers in Genome Stability and Disease Intervention

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## DESCRIPTION

DNA helicases are essential molecular machines that perform a wide range of tasks in the cell. They are responsible for unwinding the DNA double helix, a process crucial for copying the genome, fixing damaged DNA, exchanging genetic material, and making RNA from DNA. Their ability to separate the two strands of DNA with high accuracy keeps the genome stable and prevents mutations. Despite their importance, scientists still don't fully understand all the ways these enzymes work or how they are controlled inside the cell.

Many believe that DNA helicases deserve more focus in research. While they are often recognized for their role in helping DNA replication at the replication fork, recent studies show they do much more. These enzymes act as guardians of the cell's genetic material, preventing errors that could lead to diseases. When helicase genes mutate, they can cause serious health problems such as Bloom syndrome, Werner syndrome, and Fanconi anemia. All of these conditions involve unstable chromosomes and a higher risk of cancer. This makes it clear that helicases are not just helpers in copying DNA they are key protectors of the entire genome.

With new tools such as advanced imaging and structural analysis, researchers have uncovered many details about how helicases move along DNA and work together with other proteins. Techniques like cryo-electron microscopy (cryo-EM) allow scientists to see these enzymes in action at very high resolution. Single-molecule studies show how helicases change shape and position as they unwind DNA strands. Even with these discoveries, turning this knowledge into medicine has been slow. Creating drugs that specifically target helicases could open new ways to treat cancer. For example, some chemicals could block helicase activity in cancer cells, making existing treatments more effective.

In recent years, scientists have also found that some helicases do more than just unwind DNA. They can help remove RNA-DNA hybrids called R-loops, structures that can block proper gene

activity. Certain helicases can also resolve G-quadruplexes-twisted DNA structures that can threaten genome stability. Others are involved in maintaining the ends of chromosomes, known as telomeres. These alternative functions show that helicases are involved in many parts of genome regulation. Problems with these roles can lead to aging, cancer, or genetic diseases. This raises new questions: How do helicases decide which task to do? How do they fit into the bigger picture of cell health?

As medicine becomes more precise, understanding all of the different types of helicases and their variants becomes more important. New tools like high-resolution live-cell imaging and CRISPR gene editing help researchers study these enzymes in detail. These methods can reveal how helicases behave in living cells and how changes in their DNA sequence affect their function. Better understanding of these proteins could lead to new treatments for genetic disorders, age-related illnesses, and cancers.

Bringing together experts from different fields is key. Structural biologists, geneticists, and drug developers can work as a team to find new ways to target helicases. Developing small molecules that can turn off or modulate these enzymes might provide a way to repair damaged DNA more effectively or prevent harmful mutations. Such drugs could be used alongside existing therapies, making cancer treatments more successful and less toxic.

In summary, DNA helicases are much more than simple unwinding enzymes. They are complex players in many processes that keep our genomes healthy. They help repair DNA, regulate gene activity, and maintain chromosome ends. Elevated research efforts could unlock many new medical options. By understanding how these enzymes work and how they sometimes fail, scientists can create targeted therapies for a variety of diseases. This field offers promising opportunities to protect human health and better treat many genetic and age-related conditions.

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