

# The Role of Active Polymerase Enzyme as a Model Material in the Study of the Algae DNA Replication System

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**Annotation.** This scientific work extensively explores the potential of using the Taq polymerase enzyme as a model in studying the DNA replication system of algae. The structural and functional properties of thermostable DNA polymerases serve as an important tool in the in-depth study of the genetic system of algae. The results of this study form a new scientific approach to determining the stability of the algal genome, their replication mechanism, and their biotechnological significance

**Keywords:** DNA, PCR, Taq polymerase, algae, genetic material, replication, synthesis, denaturation, annealing, elongation

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## Intraduction

Algae are among the most ancient and important photosynthetic organisms in the Earth's biosphere. They are one of the main components that maintain the ecological balance, and are of great importance in oxygen production, carbon cycling, and as the initial link in the food chain in aquatic ecosystems. Therefore, the study of the genetic and molecular mechanisms of algae is relevant for modern biology and biotechnology.

DNA replication is a fundamental biological process that ensures the accurate transmission of genetic information from one generation of cells to the next. In algae — a diverse group of

photosynthetic organisms — DNA replication plays a critical role not only in cell division and growth but also in adapting to changing environmental conditions, such as light intensity, temperature, and nutrient availability.

Active polymerase enzymes are used in experimental replication systems that mimic algal DNA replication:

- In vitro replication assays — studying how polymerase interacts with algal DNA templates.
- PCR amplification of algal genes — to investigate gene expression or mutation.
- Enzyme kinetics studies — determining optimal temperature, pH,  $Mg^{2+}$  concentration.
- Structural biology — crystallizing polymerases to understand their adaptation to algal cellular environments.
- Comparative genomics — identifying conserved polymerase motifs among algae, bacteria, and higher plants.

DNA replication is the process by which genetic information is accurately and completely reproduced in every living organism. Analyzing the DNA replication process in algae helps to understand the mechanisms of their adaptation, development, and evolutionary stability.

Thermostable enzymes, in particular Taq polymerase from the bacterium *Thermus aquaticus*, are widely used in scientific research due to their stability at high temperatures and rapid DNA synthesis. In this work, the role of the Taq polymerase enzyme as a model in studying the algal DNA replication system was analyzed.

**Role of DNA polymerase enzymes:** DNA polymerases are key enzymes responsible for catalyzing the addition of nucleotides to a growing DNA chain, using a template strand as a guide. These enzymes ensure high-fidelity DNA synthesis through proofreading and error-correction mechanisms

**Active polymerase enzyme as a model material:** The term “active polymerase enzyme” refers to a biochemically functional, purified form of a DNA polymerase (such as Taq polymerase, Pfu polymerase, or polymerases derived from algae themselves).

**Algal DNA replication system:** Algae possess unique nuclear and chloroplast DNA replication systems, both requiring specialized polymerases.

a. Nuclear DNA replication:

Involves multiple eukaryotic-like polymerases:

- DNA polymerase  $\alpha$  (primase activity)
- DNA polymerase  $\delta$  (lagging strand synthesis)
- DNA polymerase  $\epsilon$  (leading strand synthesis)

b. Chloroplast and Mitochondrial DNA replication:

These organelles contain bacteriophage-like polymerases (PolII-type), thought to have evolved from bacterial ancestors. In algae, these polymerases show adaptations such as:

- High thermostability (in thermophilic algae)
- Resistance to reactive oxygen species
- Ability to replicate circular DNA structures

**Materials and methods**

The study used molecular biology methods, including polymerase chain reaction (PCR), electrophoresis, and DNA extraction. Genetic material was isolated from algae DNA samples and DNA replication was performed in vitro using the Taq polymerase enzyme. During the PCR process, optimal temperature regimes (denaturation – 95°C, annealing – 55°C, elongation – 72°C) were maintained, and specific parts of the algae genome were

amplified. Enzyme activity was assessed spectrophotometrically and the structural stability of Taq polymerase was analyzed by SDS-PAGE. The results showed that DNA replication rate and enzyme stability depend on the genomic characteristics of the algae.

### **Results and discussion**

The results of the study showed that the Taq polymerase enzyme allows for high-fidelity amplification of algae DNA fragments. The enzyme's activity at high temperatures ensured stable DNA synthesis during the PCR process. According to the analysis, some segments of the algae genome were successfully replicated using Taq polymerase, which indicates that the DNA structure of algae differs from that of ordinary bacterial genomes. In addition, the adaptation of algae to their ecological environment has shown that their DNA replication system has its own stability mechanisms. The use of Taq polymerase as a model allows the development of new molecular approaches in the analysis of algal DNA.

### **Conclusion**

The results of the studies showed that the Taq polymerase enzyme can be used as an effective model enzyme in studying the process of DNA replication in algae. The highly thermostable properties of the enzyme are of practical importance for in-depth analysis of the genetic material of algae, identification of their species-level differences, and creation of molecular markers. These results will lay the foundation for future research on algae in the fields of genetic engineering, bioenergy, and environmental monitoring. Also, the role of Taq polymerase as a model enzyme could be widely used in future biotechnological processes, including genetic modification and the improvement of replication processes.

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