**Introduction**

Oxidative stress, characterized by an imbalance between reactive oxygen species (ROS) production and antioxidant defense mechanisms, presents a significant threat to cellular integrity, impacting macromolecules such as DNA, proteins, and lipids. Catalase, an essential antioxidant enzyme, plays a pivotal role in cellular defense by converting hydrogen peroxide, a reactive oxidant, into water and oxygen. This enzymatic activity is particularly critical in organisms exposed to environmental stressors, which may exacerbate ROS production and necessitate robust antioxidant responses. In *Drosophila melanogaster*, a model organism frequently utilized for oxidative stress research, catalase activity is influenced by both genetic variation and environmental factors, providing a powerful framework for investigating the adaptive mechanisms underlying oxidative stress resilience.

The genetic basis of oxidative stress response in *Drosophila* is well-documented. For instance, Weber et al. (2012) identified single nucleotide polymorphisms associated with oxidative stress resistance, underscoring the complexity of genetic contributions to antioxidant defense. Additionally, Guio et al. (2016) demonstrated that the insertion of the Bari-Jheh transposable element enhances oxidative stress resistance by upregulating genes involved in antioxidant pathways. These findings suggest that genetic variation can significantly modulate catalase activity, shaping an organism's ability to counteract oxidative damage.

Environmental stressors further modulate the oxidative response. Habib et al. (2021) found that oxidative stress intensifies under hypoxic conditions followed by reperfusion, highlighting the importance of catalase in maintaining cellular homeostasis in fluctuating oxygen environments. Similarly, Pickering et al. (2013) emphasized the role of catalase and other enzymes in mitigating ROS accumulation, particularly under conditions of acute stress. Moreover, Zhang et al. (2016) reported that combined exposure to thermal stress and electromagnetic fields in *Drosophila* heightened oxidative responses, suggesting that environmental factors can interact to amplify ROS levels and necessitate enhanced antioxidant defenses.

**Experimental Questions and Hypothesis**

This study addresses two primary questions: (1) How does catalase activity vary across genotypes and life stages in *Drosophila melanogaster*? and (2) How does heat shock influence catalase activity within these populations? Based on prior evidence, we hypothesize that catalase activity will be most pronounced in heat-shocked adults, as adult flies are likely to exhibit heightened enzymatic responses to oxidative stress. This prediction aligns with existing literature indicating that mature life stages often demonstrate more robust physiological adaptations to environmental stressors (Habib et al., 2021; Zhang et al., 2016).

**Methods and Expected Findings**

To test this hypothesis, catalase activity will be measured across various *Drosophila* genotypes and life stages under heat shock conditions. Using a spectrophotometric assay, catalase levels will be quantified to assess differences across experimental groups. We anticipate elevated catalase activity in heat-shocked adult flies, particularly among genotypes previously associated with increased oxidative resilience. This study aims to clarify the roles of genetic and environmental factors in oxidative stress resilience in *Drosophila melanogaster*, contributing to a broader understanding of the adaptive mechanisms that underlie antioxidant responses.