Design of the insect respiratory system: a test case for symmorphosis

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CONTENTS

Abstract

The idea that animals are designed economically follows the line of reasoning that building and maintaining superfluous structure is energetically expensive, and should therefore be selected against. It was on these foundations that Taylor and Weibel introduced the theory of symmorphosis, which posits no more structure should exist in an animal than is necessary for the structure to fulfil its maximum functional task. In support of the theory, the volume of mitochondria in mammalian muscle appears perfectly matched to the muscle's aerobic capacity. But contrary to the predictions of symmorphosis, the mammalian lung is capable of oxygen delivery rates that exceed the maximum needs of the mitochondria. The purpose of this dissertation is to examine whether the insect respiratory system conforms to the economic principles of symmorphosis, such that the capacity of the tracheal system to deliver oxygen is matched to the aerobic capacity of the mitochondrial sink. The insect respiratory system conveys a number of attributes that make it well suited for such a task. Perhaps the most important of these is the fact that insects achieve the highest mass-specific aerobic metabolic rates of all animals, and in theory, the strong selective forces acting on such a system should push it towards an optimal design. The insect used for this purpose is the migratory locust *Locusta migratoria* where the delivery and consumption of oxygen increases significantly throughout development and also once adults take to the wing.

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