The power behind insect flight: Researchers reveal key kinetic component

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Researchers from Rensselaer Polytechnic Institute and the University of Vermont have discovered a key molecular mechanism that allows tiny flies and other "no-see-ums" to whirl their wings at a dizzying rate of up to 1,000 times per second. The findings are being reported in the Oct. 30-Nov. 3 online early edition of the *Proceedings of the National Academy of Sciences* (PNAS).

"We have determined important details of the biochemical reaction by which the fastest known muscle type -- insect flight muscle -- powers flight," said Douglas Swank, assistant professor of biology at Rensselaer and lead author of the PNAS paper.

The findings will help scientists gain a better understanding of how chemical energy is converted into muscle movements, such as human heart muscle pumping blood. The research also could lead to novel insights into heart disease, and might ultimately serve in the development of gene therapies targeted toward correcting mutations in proteins that detrimentally alter the speed at which heart muscle fibers contract.

Since insects have been remarkably successful in adapting to a great range of physical and biological environments, in large part due to their ability to fly, the research also will interest scientists studying the evolution of flight, Swank noted.

The research is focused on a key component of muscle called myosin, the protein that powers muscle cell contraction. Swank's team focused its efforts on the fruit fly and asked a basic question: Why are fast muscles fast and slow ones slow? The researchers discovered that the reaction mechanism in insect flight muscle on the molecular level is different from how slower muscle types work.

"Most research has focused on slower muscle fibers in larger animals," Swank said. "By investigating extreme examples, e.g. the fastest known muscle type, the mechanisms that differentiate fast and slow muscle fiber types are more readily apparent."

In general, myosin breaks down adenosine triphosphate (ATP), the chemical fuel consumed by muscles, and converts it into force and motion. To do this, myosin splits ATP into two compounds, adenine diphosphate (ADP) and phosphate. Each compound is released from myosin at different rates. In slow-muscle contraction, ADP release is the slowest step of the reaction, but in the fastest muscle fibers, Swank's team has discovered that phosphate release is the slowest step of the reaction.

This finding is significant because the overall chemical reaction rate is set by the slowest step of the reaction. "What we have found is that in the fastest muscle type, ADP release has been sped up to the point where phosphate release is the primary rate-limiting step that determines how fast a muscle can contract," Swank said.

The next step, according to the researchers, is to experiment with other fast muscle types, such as the rattlesnake shaker muscle and fast mammalian muscle fibers. "By broadening our research, we will be able to determine if the phosphate release rate contributes to setting muscle speed in fast muscle types from other species," according to Swank.

Source: Rensselaer Polytechnic Institute