



**CALIFORNIA STATE SCIENCE FAIR  
2017 PROJECT SUMMARY**

<b>Name(s)</b> <b>Vivek Vijayakumar</b>	<b>Project Number</b> <b>J1823</b>
<b>Project Title</b> <b>A Comparison of the Morphology, Mass, and the Expansion Velocities of Planetary Nebulae</b>	
<p style="text-align: center;"><b>Abstract</b></p> <p><b>Objectives/Goals</b> The subject of planetary nebulae is one of which we still have much to learn. This project intended to use the known and acquired details about the morphology, central star mass, and the expansion velocities of specific planetary nebulae to look for correlations between these three characteristics.</p> <p><b>Methods/Materials</b> Images of 10 planetary nebulae taken with an astrophotography setup were combined with current scientific research as well as historical data to meet this end.</p> <p><b>Results</b> No correlations were found between any of the three properties. However, most of the central star masses did stay below 1.44 solar masses, excluding AGB (asymptotic giant branch) stars and binary systems. Most expansion velocities were in the range of 22 to 43 km/s, excluding AGB stars once again.</p> <p><b>Conclusions/Discussion</b> Since no definite correlations are found, it is concluded that the hypothesis is incorrect about the relationships between the morphology, central star mass, and expansion velocities. However, it is also concluded that most planetary nebulae with single white dwarf central stars have masses from 0 to 1.44 solar masses, and expansion velocities ranging from 20 to 45 km/s. This project demonstrates the evolution of planetary nebulae and their progenitors, from red giants to white dwarfs.</p>	
<b>Summary Statement</b> I measured different properties of multiple planetary nebulae and compared them, in order to find correlations, relationships, or oddities among them.	
<b>Help Received</b> Kin Searcy of the San Diego Astronomy Association reviewed some parts of this project, and provided input.	