CLEMSON
School of MATHEMATICAL AND STATISTICAL SCIENCES

January 24, 2020

To Whom It May Concern

It is my great pleasure to write this letter in strong support of **Carson Wood**'s nomination for an undergraduate award. I have known him since January 2019, when he started working on a research project with me. At that time, he was still a freshman only beginning his second semester. This year Carson's been selected to be one of the students nominated for the Goldwater Scholarship and below is the recommendation letter I wrote in support of his nomination.

Please let me know if I can be of any further assistance.

Sincerely,

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Svetlana Poznanovic
Associate Professor

To the Goldwater Foundation:

It is my great pleasure to write this letter in strong support of **Carson Wood**'s nomination for the Goldwater Scholarship. I have known him since the beginning of this year, when he started working with me on a research project.

My research is in combinatorics and mathematical biology. I apply mathematical tools to model and study the formation of the RNA structure and understand the limitations of the current methods used for structure prediction. RNA structure prediction is an important problem in bioinformatics as the structure of many RNAs is now known to be related to their function. With my collaborators, we developed a way to calculate polytopes for RNA sequences which enable us to understand the branching structure imposed by the thermodynamic model. We had an idea of how to use these polytopes to understand the limitations of how much the prediction can be improved by changing the branching parameters in the model. A little over a year ago, I sent out an email to the math majors advertising this research opportunity. Carson contacted me and, after talking to me about the goals of the project, decided to work with me.

Last spring, Carson registered for an Undergraduate Research course with me. I was happy to recruit a student to work on the project but wasn't overly optimistic that we will get fast results. He was an excellent student in his classes and an honors student but, after all, he had only one semester of experience at college. Based on my previous experience with mentoring undergraduate and graduate research, at this point I was hoping for the best but preparing for medium.

It turns out I was incredibly fortunate to recruit Carson for this project! The first task I gave him was to implement a branch-and-bound algorithm in order to search for a region in the parameter space that contains the parameters that would improve the RNA structure prediction. Very quickly, Carson understood the polytopes, their structure, implemented the algorithm, and started running the code on our data set. Unfortunately, it turned out that the complexity of the calculations was too high. The initial results showed that the bounding part of the algorithm was not very effective in pruning out the regions and the code ran for a week, eventually taking up too much memory. I suggested that instead of processing the sequences sequentially, we should do binary merges. Since the merges could be done in parallel, we thought this could give us the speed up we needed.

Carson went off to figure out how to do the binary merges, but he wasn't entirely happy about the situation. He was looking ahead and knew that our plan for the next step was to use this code to analyze a more complex data set and, if it is so slow at the beginning, it will surely be a problem later.

Next week, I received an email from him saying that he found a solution and said he'd explain the details at our next weekly meeting. To be honest, part of me was happy to hear some hope, but another part of me thought there might be a mistake in his reasoning. The next meeting was all about hashing out all the details in the new way he found to prune the regions, making sure there was no mistake. And it was all correct! Carson had understood the details of the problem so well, that he realized that there were probably a lot of regions that were unnecessarily considered in our original version and that there was a faster way to discard them and reduce the complexity of the calculations. Off he went to implement his idea.

The new algorithm that Carson proposed included preprocessing the data to generate more information about the regions that can be used to obtain better bounds in the bounding stage. But as he was implementing it, he realized that he could add another initial step to prune some of the regions in the initial stage, which would help the calculations later. At the next meeting he already gave me some preliminary results to support this suggestion. Ultimately, after the two new modifications Carson introduced, the code that used to run for a week without any results now returns results within hours. Thanks to this work now we know how limited the possibility of improvement is in predicting the branching in certain classes of RNAs based on the current model.

This academic year Carson has been working as a research assistant to finish this project and we are working on gathering all the necessary data and writing a paper that will be submitted for publication in a strong bioinformatics journal. Carson has absolutely been instrumental in pushing the project forward with his ideas and fast implementation. The conversations with him every week have been such a pleasure. One can clearly see how much he is taking ownership of the project (this I find is rare with graduate students and very unusual with undergrads), and how

invested he is in moving it forward. In the meantime, he is already thinking about the next project and suggesting ways to proceed.

Among the undergraduate students I have mentored, I would put Carson at the level of Martin Copenhaver, an undergraduate student I worked with when I was a postdoc at Georgia Tech 2011-2012. Martin got his PhD in operations research from MIT last year and is now an operations research scientist at the Massachusetts General Hospital. With the level of initiative Carson has already displayed, the way he already asks research questions, and the perseverance to work towards a goal despite obstacles, I have no doubt that he will be successful in his plans to pursue a PhD in mathematics and be a productive researcher. I give him my strongest recommendation for this scholarship.

Sincerely,

Svetlana Poznanovic
Associate Professor