This research plan will develop metal-based catalysts to transform inert greenhouse gases, i.e. carbon monoxide and carbon dioxide, into fuels.

**Motivation**
- Recycle combustion waste products, CO$_2$ and CO.
- Develop the fundamental understanding of how to regenerate fuels from these waste products.
- Turn our everyday linear vicious use of hydrocarbons into a cycle, where the end products, CO$_2$ and CO, are treated chemically and used again as the fuels they once were.

**Project Description**
- Synthesize novel metal-based catalysts with potential to enforce the chemical regeneration of fuels starting from CO$_2$/CO.

**Context**
- Currently this transformation is known to occur in copper metal surfaces, shown below.$^1$
- In copper surfaces, products such as ethanol (the holy grail end product) have been observed.
- There are no homogeneous systems to carry out this transformation. Thus, much of the fundamental steps en route to fuels remain unknown.

**Project Deliverables**
- This research plan will deliver a family of catalysts with the appropriate geometry to test the reduction of CO$_2$/CO into short hydrocarbons.
- This funding will allow us to investigate an unexplored landscape of polynuclear copper homogeneous catalysis.
- Data collected throughout the upcoming year will serve as the basis to a major NSF and/or DOE grant application.

**Potential Impact**
- Success of this research will provide a guideline to develop catalytic systems to reintroduce carbon-based waste products into our energy-thirsty society.
- These catalysts promise to unveil the chemical steps to guide society to sustainability.

**References and Acknowledgements**