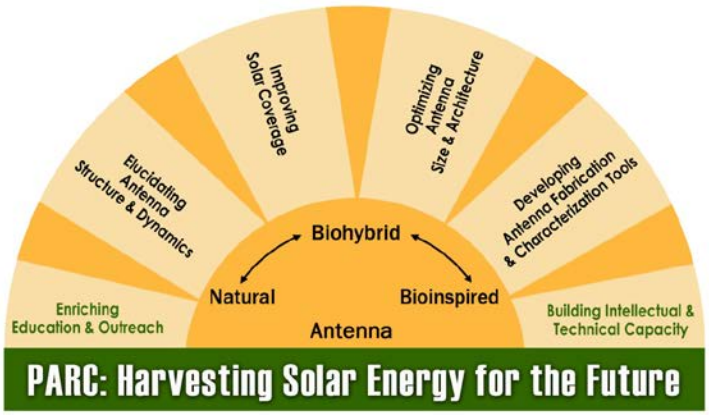
Photosynthetic Antenna Research Center (PARC)
EFRC Director: Robert E. Blankenship
Lead Institution: Washington University in St. Louis

Mission Statement*: To maximize photosynthetic antenna efficiency in living organisms and to fabricate robust micron-scale biohybrid light-harvesting systems to drive chemical processes or generate photocurrent.*

Scientific Themes. Through basic scientific research, PARC seeks to understand the principles of light-harvesting and energy funneling as applied to three programmatic themes:

1. *Natural Antennas*: Structure and Efficiency
2. *Biohybrid Antennas*: Organization and Implementation
3. *Bioinspired Antennas*: Design and Characterization



Unifying Research Activities. The three scientific themes are connected by the idea that enhancements of photo-synthetic light harvesting and the design of the biohybid and bioinspired antenna will draw upon the lessons learned from natural systems. The thematic activities are joined by interrelated research threads, including to:

- Elucidate antenna structure and dynamics
- Improve solar coverage
- Optimize antenna size and architecture
- Develop antenna fabrication and characterization tools

Global Impact. All of the PARC activities have the broader goals to:

- Enrich education and outreach
- Build intellectual and technical capacity

Specific Objectives for Theme 1: Natural Antennas: Structure and Efficiency
PARC seeks to understand the structure and function of the wide variety of natural photosynthetic antenna systems, including their efficiency, mechanism of action, regulation, assembly and repair. Emphasis will be placed on developing new and modified antennas using molecular and synthetic biology, such as increasing photosynthetic efficiency by reducing light saturation effects and expanding the spectral ranges of radiation that can be used for energy storage. The specific objectives are to:

- Determine structures of native and modified antenna systems and correlate with function.
- Understand subcellular organization of antenna systems in different photosynthetic organisms.
- Examine physiological consequences of modified/alternate antenna in diverse organisms.

The overall aim is to determine and manipulate the antenna size and composition to maximize photosynthetic efficiency in any such organism.

Specific Objectives for Theme 2: Biohybrid Antennas: Organization and Implementation
PARC will develop the new research area of "bottom-up" fabrication of biohybrid antenna architectures, in which natural light-harvesting (LH) components (e.g., complexes or peptides) are coupled with

synthetic components (e.g., substrates or chromophores) . Emphasis will be placed on attachment chemistry, substrate properties, assembly, stability and function. The specific objectives are to:

- Pattern single and multicomponent arrays of bacterial photosynthetic light harvesting complexes on surfaces in various geometries to promote directed energy migration and trapping
- Fabricate biohybrid antenna consisting of peptide analogos of photosynthetic light harvesting complexes coupled with tunable synthetic chromophores to enhance solar coverage.
- Employ genetically and chemically modified biohybrid constructs along with far-and near-field fluorescence microscopy for spectroscopic readout.

The overall aim is to design biohybrid architectures for energy collection and storage.

Specific Objectives for Theme 3: Bioinspired Antennas: Design and Characterization
PARC will draw upon knowledge of native and synthetic antennas to assemble light harvesting arrays for integration into target solar-conversion systems. The aim is fabrication of assemblies that absorb 90% of incident photons over a specified portion of the visible and near-infrared regions and deliver the energy to a target site(s) with a quantum yield of 80% or greater. The specific objectives are to:

- Develop self-assembled macromolecular arrays based on tunable synthetic pigments alone, or incorporated into designer maquette polypeptides.
- Extend the functionality of the arrays to include sites of energy trapping and photochemistry.
- Control mesoscale of constructs using lithographic approaches.

The overall aim is the assembly of micron-scale arrays for efficient solar light harvesting, energy transfer and trapping that can be used to generate chemical fuels or photocurrent.

The synergy among PARCs principal investigators listed below is extended by 17 Research Affiliates, 5 Scientific Advisory Committee members, 11 research/technical associates, 32 postdoctoral associates, 28 graduate students, 4 undergraduate students, and 5 administrative personnel.

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