MOLECULAR BIOMIMETICS: GENOME-BASED MATERIALS AND SYSTEMS FOR TECHNOLOGY AND MEDICINE

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Statement of Purpose: Physical and chemical functions of organisms are carried out by a large number of proteins through predictable and self-sustaining interactions. In Nature, biomolecule-material interaction is accomplished via molecular specificity and high efficiency leading to the formation and self-assembly of controlled functional constructs, structures, tissues, and systems at all scales of dimensional hierarchy. Through evolution, Mother Nature developed molecular recognition via successive cycles of mutation and selection towards specific probe-target interactions. With the recent developments of nanoscale engineering in physical sciences, and the advances in molecular biology, we are now able to combine genetic tools with synthetic nanoscale constructs, and create a hybrid methodology. The overarching goal in *molecular biomimetics* is to use genetically engineered peptides and designer functional proteins as fundamental building blocks in synthesis, assembly, and fabrication of material systems for technology and medicine.

Methods: In this approach, we use biology as a guide utilizing and adapting bioschemes including combinatorial biology, post-selection genetic engineering, bioinformatics, and modeling (e.g., molecular dynamics) to select and tailor short (7-60 amino acids) peptides with specific binding to and assembly on functional solid materials. Molecular binding, recognition and assembly are studied using surface plasmon resonance spectroscopy, quartz crystal microbalance, atomic force microscopy, ss-NMR, and CD, among others. Based on the fundamental principles of genome-based design, molecular recognition, and self-assembly, we can now engineer peptides for inorganics and synthetic functional molecules as nucleators, catalyzers, growth modifiers, molecular linkers and erector sets, fundamental utilities for nano- and nanobio-technology.

Results: We will review the latest developments from our collaborative research group in this rapidly developing polydisciplinary field focusing on: i. Fundamental issues in genetic design, molecular recognition, and assembly of peptides, their material-specificity, kinetics and thermodynamics of binding, and supramolecular assembly; ii. Biosynthesis and fabrication capabilities of peptides in synthesizing and morphogenizing nanomaterials (metals, oxides, and semiconductors); and iii. Practical implementation of short peptides as molecular erectors, linkers, and assemblers towards molecular and nano-imaging, sensing (diagnostics), and regenerative medicine.

Conclusions: Genetically engineered peptides for inorganics (GEPI) are now a novel class of short peptides that can be selected with specific affinity to inorganic materials and solid substrates, post-selection engineered to have enhanced molecular recognition, and genetically fused to have biofuntionality with other peptides, proteins and enzymes to form functional molecular constructs as a utility in bionanotechnology, nanotechnology and medicine. The research is supported by USA-ARO-DURINT, NSF-MRSEC, and NIH programs.

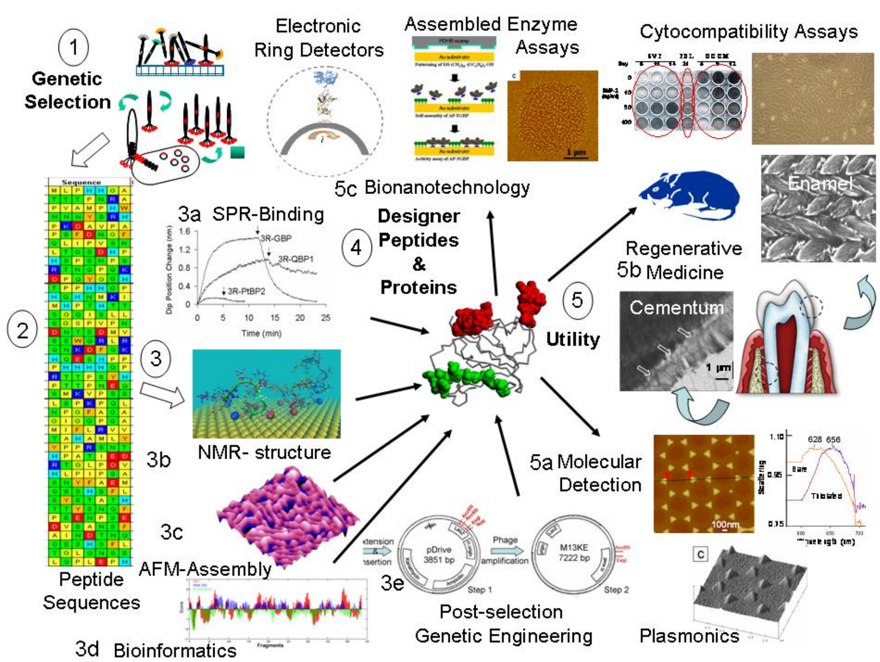

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Figure 1 – Major research and applications steps in molecular biomimetics that include selection, molecular characterization, and novel design of peptides and their utility in bionanotechnology and medicine.