Dialog between Bioinformatics, Molecular and Structural Biology, and Biochemistry Illuminates the Interaction of Functional Domains in a Multi-Enzyme Complex

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Many cellulolytic microorganisms produce intricate multi-enzyme complexes called cellulosomes that efficiently degrade cellulose - the most abundant organic polymer on Earth. The cellulosomes are composed of a conglomerate of subunits, each of which comprises a set of interacting functional modules. A multi-functional integrating subunit (called scaffoldin) is responsible for organizing the cellulolytic subunits into the multi-enzyme complex. This is accomplished by the interaction of two complementary classes of domain, located on the two separate types of interacting subunits, i.e., a cohesin domain on scaffoldin and a dockerin domain on each enzymatic subunit. The high-affinity cohesin-dockerin interaction defines the cellulosome structure (Fig. 1). The scaffoldin subunit also bears a cellulose-binding domain (CBD) that mediates attachment of the cellulosome to its substrate.

Due to the complexity of this system, progress in this area is dependent on a multidisciplinary approach. Within the past decade, the original contributions of biochemistry to this area have been advanced greatly, first by molecular biology and sequence analysis, and more recently through the benefits of three-dimensional structure determination.

The relevant genes available from sequence databases have been augmented in our lab by sequencing of new cellulosomal genes from other bacteria and by newly emerging genome sequences. Multiple sequence alignment and phylogenetic analysis of the cohesins, dockerins and CBDs have shed light on potentially important residues involved in the functioning of these modules. X-ray and/or NMR structures of recombinant modules provides a structural basis for homology modeling and mapping of the suspected residues. Their involvement in cellulosome function is further examined by site-directed mutagenesis of the desired residues and biochemical analysis of the mutated proteins. Currently, random mutagenesis combined with phage- and cell-display methods

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