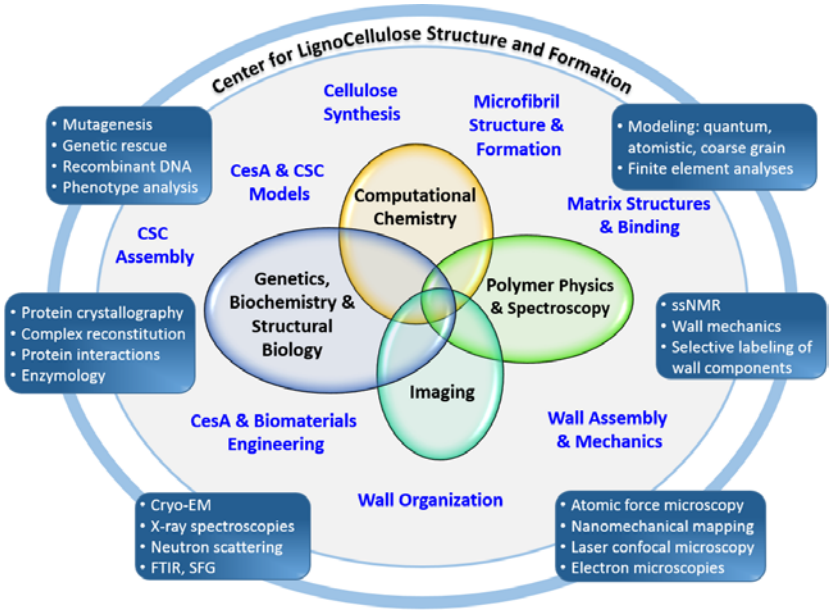
Center for Lignocellulose Structure and Formation (CLSF)
EFRC Director: Daniel J. Cosgrove
Lead Institution: Penn State University
Class: 2009 – 2022

Mission Statement*: To develop a nano- to meso-scale understanding of cellulosic cell walls, the energy-rich structural material in plants, and the physical mechanisms of wall assembly, forming the foundation for new technologies in sustainable energy and novel biomaterials.*

Plant cell walls - also known as cellulosic biomass or lignocellulose - are among the most complex, diverse and useful materials on Earth. These hierarchical structures represent an abundant and renewable source of valuable biomaterials and bioenergy, presenting untapped *transformative opportunities* for engineering them with new properties while simultaneously providing lessons on how to *mimic the nano-scale structure and means of assembly of these complex living materials* for synthesis of man-made materials with specific, tunable properties.

CLSF's research is at the nexus of physics, chemistry and biology and draws on expertise from diverse fields, diagrammed at right. Insights from our research will form the foundation for future efforts to optimize the structures and utility of plant cell walls, which are essential to plant life and comprise a large-scale source of renewable biomaterials and bioenergy.



CLSF goals in the current phase will build upon advances made in the previous funding period to:

1. Combine multiple state-of-the-art methods of electron microscopy with neutron and X-ray scattering, computational modeling and biochemistry to solve the structure and catalytic mechanism of plant cellulose synthases (CesAs) and native cellulose synthesis complexes (CSCs).

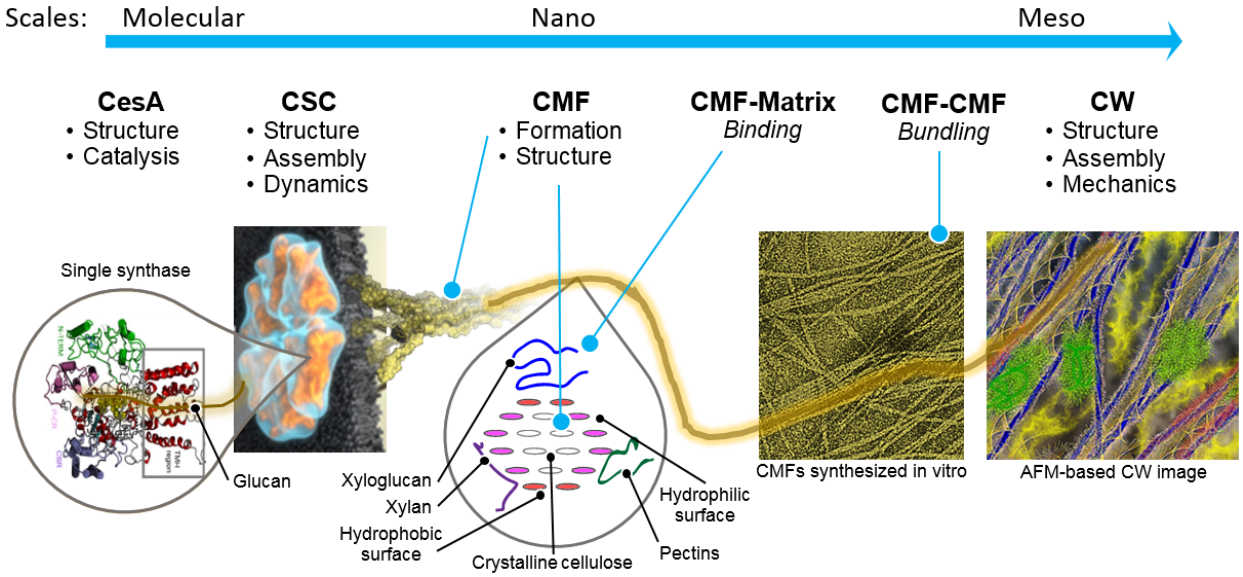
2. Manipulate active CesA assemblies *in vitro* and *in vivo* to learn how artificial and native CSCs are assembled and how cellulose microfibril structure depends on CSC structure. We will use these new experimental platforms to test computational models of CSC and cellulose microfibril assembly.

3. Develop new experimental and quantitative methods for assessing cellulose microfibril organization in cell walls and use them to uncover the physical mechanism(s) of microfibril bundling.

4. Extend newly-developed methods and results by CLSF to analyze the physical basis of microfibril-matrix interactions in cell walls with different matrix polymers and study the structural, physical and mechanical consequences of altering these interactions in primary and secondary cell walls.

5. Develop new biological systems (such as the growing Arabidopsis inflorescence stem and xylem-transdifferentiation in transgenic seedlings) to study the processes of microfibril bundling, primary cell wall assembly and maturation, and secondary cell wall formation.

These topics are linked to one another as illustrated graphically below:



Above: Research questions addressed by CLSF include the structure and kinetics of cellulose synthase (CesA); the structure and activity of the cellulose synthesis complex (CSC); cellulose microfibril (CMF) structure and CMF interactions with water, matrix polysaccharides and lignin.

These goals involve new teaming arrangements and development of novel approaches, experimental platforms and advanced instrumentation. The five goals will synergistically produce new insights for potential means to achieve control of man-made materials and for ways to tune cell walls for specific properties in the materials and energy fields. Overall success with even a subset of these goals will enable a quantum leap in understanding how plants assemble these complex hierarchical structures.

Center for Lignocellulose Structure and Formation (CLSF)	
Penn State University	Charles Anderson, Daniel Cosgrove, Enrique Gomez, Ester Gomez, Ying Gu, Seong Kim, Tracy Nixon, Ming Tien
Oak Ridge National Laboratory	Hugh O'Neill
North Carolina State University	Candace Haigler, Yaroslova Yingling
Massachusetts Institute of Technology	Mei Hong
University of Virginia	Jochen Zimmer
University of Rhode Island	Alison Roberts
University of Texas at El Paso	James Kubicki
University of Cambridge	Paul Dupree
Louisiana State University	Tuo Wang

Contact: Daniel Cosgrove, Director, dcosgrove@psu.edu
(814) 863-3892, www.lignocellulose.org