Role of LPS Heterogeneity on Adhesion of Gram-negative Bacteria

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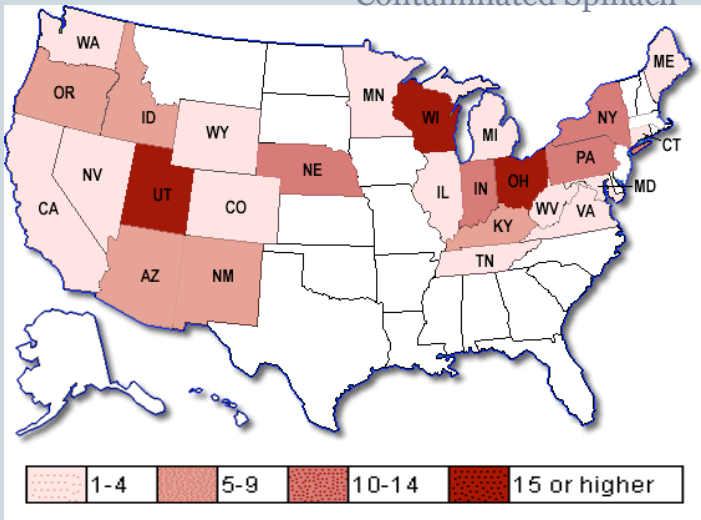
E. coli O157:H7

- September 2006 E. coli O157:H7 Outbreak
- Economic Cost > $74 million
- > 100 Infected

Number of People Infected by Contaminated Spinach



Nov. 5 2007 – Canadian Beef Restricted to the United States Over Testing for E. coli O157:H7
Nov. 3 2007 – Cargill Recalls 1 million lbs of beef
Nov. 1 2007 – General Mills Recalls 414,000 frozen pizzas
Nov-Dec 2006 – Taco Bell Restaurants

Center for Disease Control and Prevention
E. coli O157:H7 Outbreak Case Counts by State

Lipopolysaccharide and O-antigen for Gram-negative bacteria

LPS

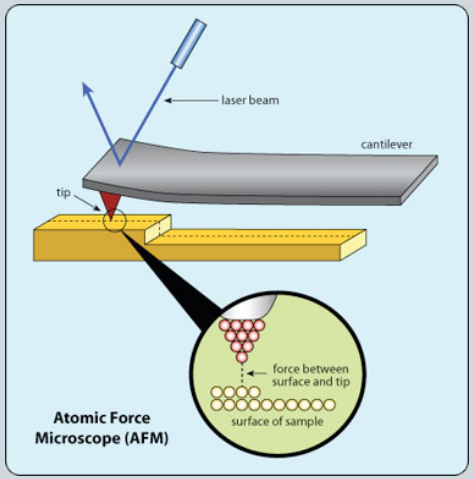
- Immunodominant antigen
- Located in the outer portion of the outer membrane
- Composed of:
  - Lipid A (responsible for initiation of inflammatory response)
  - Core oligosaccharide (critical for entry into cells during infection)
  - O-antigen

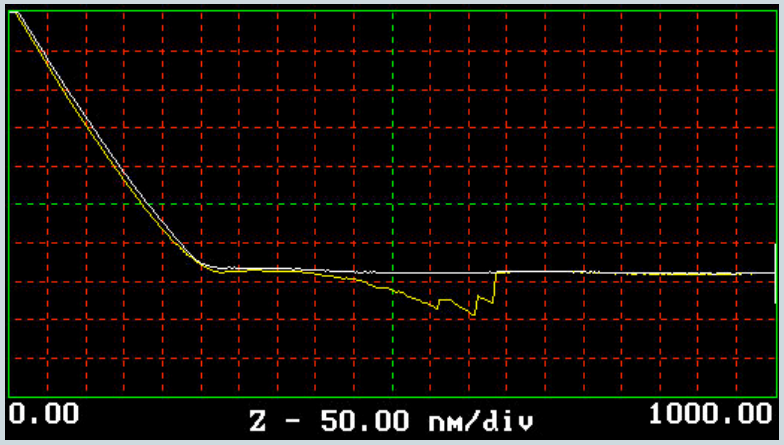
O-antigen

- Related to virulence
- Composed of repeating saccharide units, extends out from the cell to interact with environment
- Not essential for viability of organism

Atomic Force Microscopy (AFM)

- Measure molecular interaction forces and captureg high resolution images
- Force and separation data obtained directly
- Data modeled using polymer brush model of Alexander and de Gennes



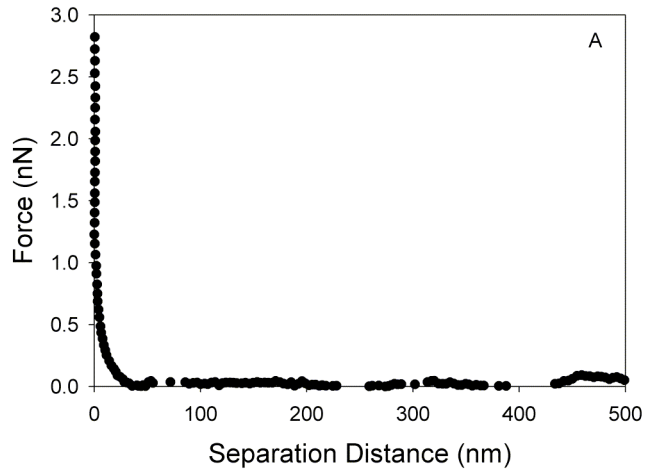


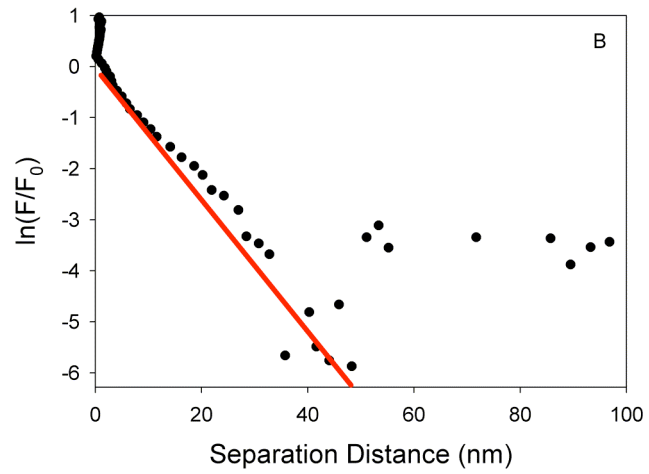
AFM Approach curve on *E. coli*

Fit data with simplified steric model

$\ln (F/F_o) = -(2 \pi / L) \delta$

Where F = force
F_o = force at zero separation
L = brush thickness
δ = tip-sample separation





Strauss, J., Burnham, N.A., and T.A. Camesano. Probing role of LPS O-antigen on *E. coli* adhesion using atomic force microscopy. *Journal of Molecular Recognition,* 2009, 22:347-355.

Steric Modeling Results (Brush Thickness)

Strain	Eqm. Length (nm)	Core Type	F_{adh} (nN)
HB101	**5 ± 3**	**K12**	**0.4 ± 0.1**
K12	**3 ± 2**	**K12**	**0.5 ± 0.2**
ML35	**3 ± 2**	**K12**	**0.7 ± 0.4**
O113:H4	17 ± 10	R3	0.6 ± 0.6
O113:H21	37 ± 9	R1	1.0 ± 0.4
O157:H7	30 ± 13	R3	0.7 ± 0.4
O157:H12	25 ± 9	R2	0.6 ± 0.2
O157:H16	19 ± 6	R2	0.5 ± 0.2

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Conclusions for *E. coli*

- Substantial variations exist in physical properties of molecules, even within same serotype
- LPS length was the best predictor of adhesion forces for strains with O-antigens (no relation for control strains)
- In more recent studies, we have also found that LPS length is a predictor of adhesion with peptides

References for Further Reading:

- Strauss, J., Burnham, N.A., and T.A. Camesano. Probing role of LPS O-antigen on *E. coli* adhesion using atomic force microscopy. *Journal of Molecular Recognition,* 2009, 22:347-355.
- Strauss, J., Kadilak, A., Cronin, C., Mello, C.M, and T. A. Camesano. Binding, inactivation, and adhesion forces between antimicrobial peptide cecropin P1 and pathogenic *E. coli*, *Colloids and Surfaces B: Biointerfaces*, 2010, 75:156-164.