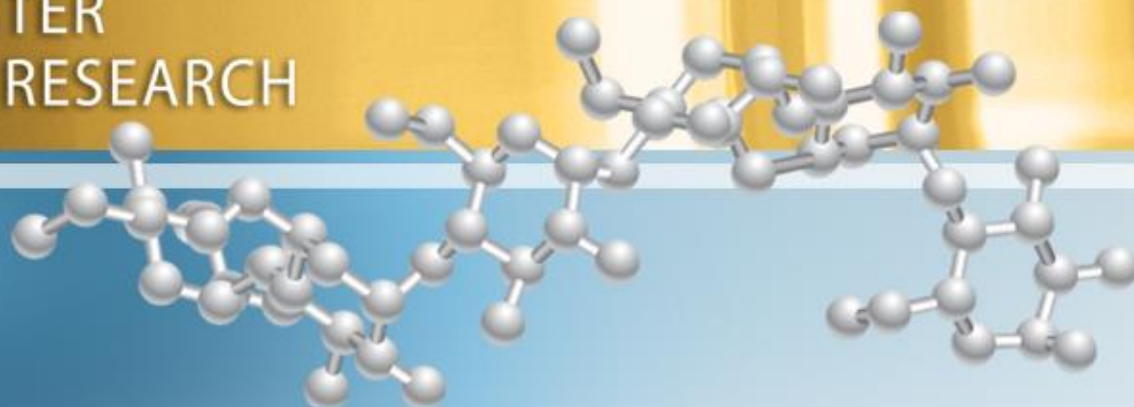


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Dietary fiber polysaccharides as potential prebiotics

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(disclosures – partner in Nutrabiotix, Purdue Research Park; ClostraBio, University of Chicago)

Dietary fiber requirement

- Regulations (FDA) are on:
 - Amount on Nutrition Fact Panel
 - Nutrient claim – e.g. “Good source”
- All fibers are the same
 - But from the health perspective?
 - **Gut bacteria perspective...?**

Original vs. Proposed

Nutrition Facts			
Serving Size 2/3 cup (55g)			
Servings Per Container About 8			
Amount Per Serving			
Calories	230	Calories from Fat 72	
		% Daily Value*	
Total Fat	8g		12%
Saturated Fat 1g			5%
Trans Fat 0g			
Cholesterol	0mg		0%
Sodium	160mg		7%
Total Carbohydrate	37g		12%
Dietary Fiber 4g			16%
Sugars 1g			
Protein	3g		
<hr/>			
Vitamin A			10%
Vitamin C			8%
Calcium			20%
Iron			45%
* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.			
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Nutrition Facts	
8 servings per container	
Serving size	2/3 cup (55g)
Amount per 2/3 cup	
Calories	230
% DV*	
12%	Total Fat 8g
5%	Saturated Fat 1g
	Trans Fat 0g
0%	Cholesterol 0mg
7%	Sodium 160mg
12%	Total Carbs 37g
14%	Dietary Fiber 4g
	Sugars 1g
	Added Sugars 0g
	Protein 3g
<hr/>	
10%	Vitamin D 2mcg
20%	Calcium 260mg
45%	Iron 8 mg
5%	Potassium 235mg
* Footnote on Daily Values (DV) and calories reference to be inserted here.	

Fiber-based strategy of how to make changes in the gut microbiota community

- Bacteria in the gut community can be promoted with specific carbohydrate substrates - examples
 - GOS's synthesized by β -galactosidases using reverse kinetics promoted parent *Bifidobacterium bifidum* and *Lactobacillus reuteri* (Tzortzis et al. 2003, Tzortzis et al. 2005)
 - Flint and colleagues, approaches to promote butyrate-producing bacteria of the *Clostridium* clusters XIVa and IV
- Working Hypothesis: specific carbohydrate/dietary fiber structures exist that align with bacteria strains, and more broadly with groups, that allow them to compete and be promoted; and can be used to make predicted changes within gut bacterial communities
- Dietary fiber = carbohydrates (+ lignin); hundreds of different kinds and perhaps thousands of different “discrete structures”

What are the Rules of Engagement?

Thinking a different way

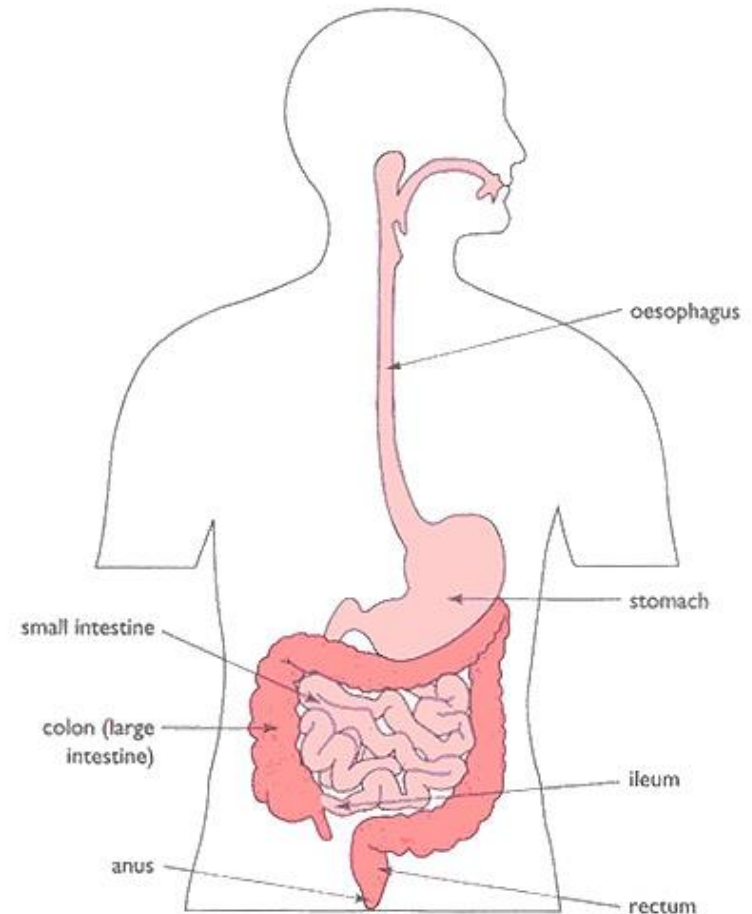
- Instead of testing dietary fibers for their function:
 - Understand desirable microbiota individual strain or group requirements
 - Align polysaccharides/oligosaccharides (chemical structure/physical forms) for their promotion
- Same for pairing carbohydrate structures to probiotics – identifying substrates that strains can compete well on
 - Even for bacteria that ferment the same fiber, it's about who competes best for it

Of course, it's complicated...

- Bacteria send out bacteriocins to kill each other
- Bacteria share genes and shed genes
- Cross-feeding – primary and secondary degraders
- People have different gut bacterial communities
- Yet, there is a good reason to focus on food carbohydrates – *as bacteria evolved under very high selective pressure to access food*

Colon microbiota

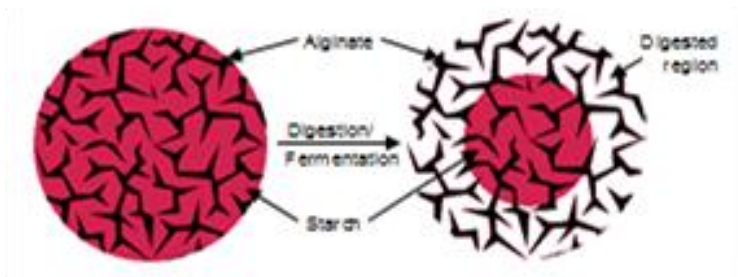
- Let's start w/ 1 microbe
 - Genes encode a set of enzymes/binding proteins to digest specific structures
- 2 microbes (competition)
 - How do they compete for substrate
 - Specificity of fiber structure
 - Hierarchical preference
- Microbial community
 - Multiple factors



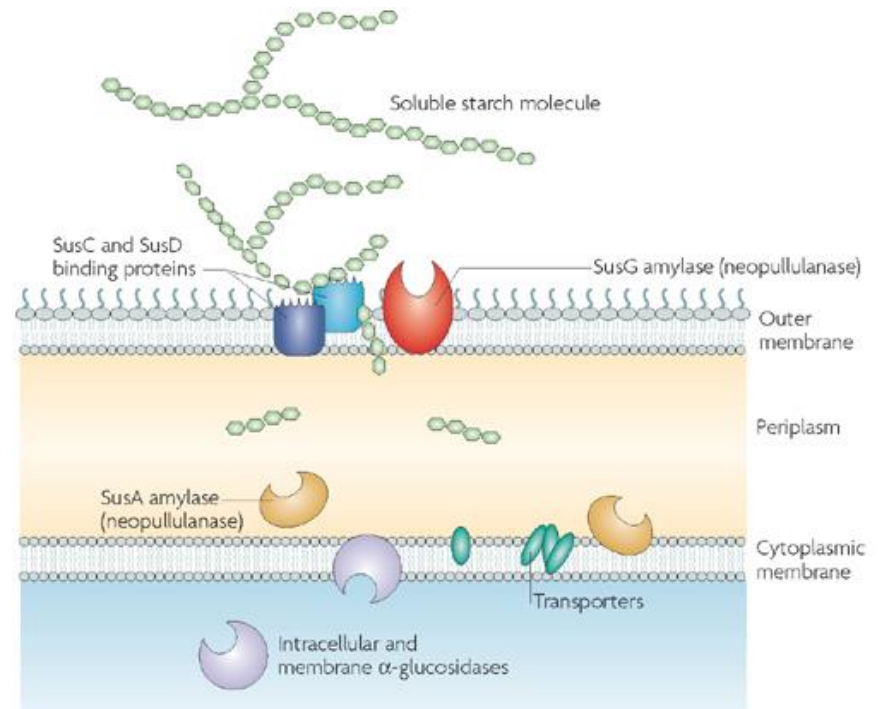
Some simple ideas

- Look at the machinery that different bacteria have to get at CHOs
 - Some have to physically bind to substrate (e.g., gram (-) bacteria, *Bacteroides*)
 - Some have long appendages (cellulosomes) with enzymes attached to “reach in” and get CHOs (e.g. *Clostridia*, *Ruminococcus*)
 - Some have ports that directly take in oligosaccharides (e.g. some *Bifidobacteria*)

Resistant starch: physical type can drive groups containing butyrogenic bacteria

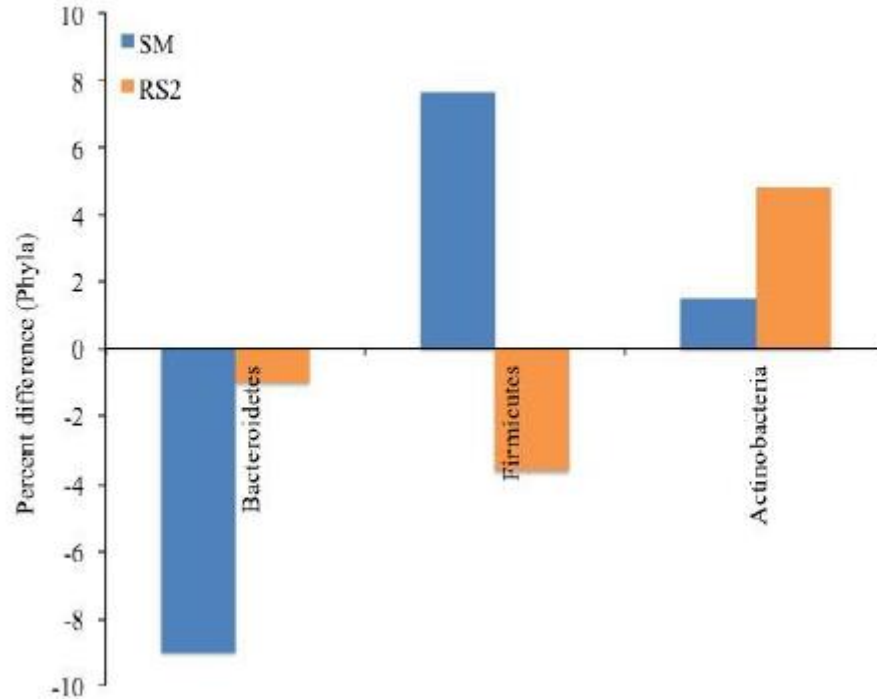


Starch-entrapped microspheres



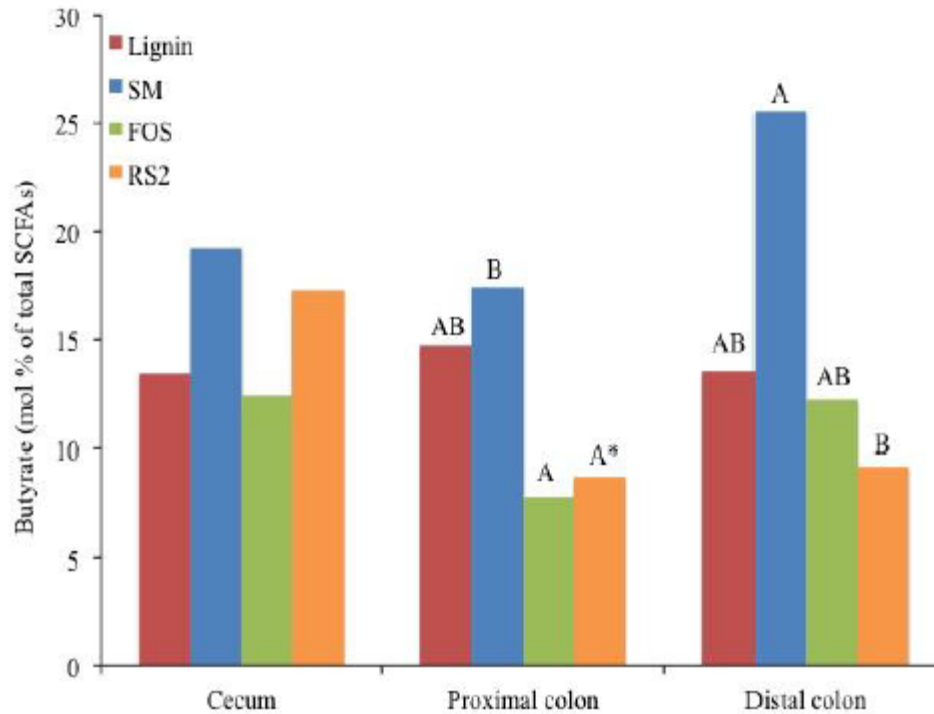
Nature Reviews | Microbiology

Accessibility drives microbiota changes



Mouse study – 2 types resistant starch

Physically accessible and inaccessible

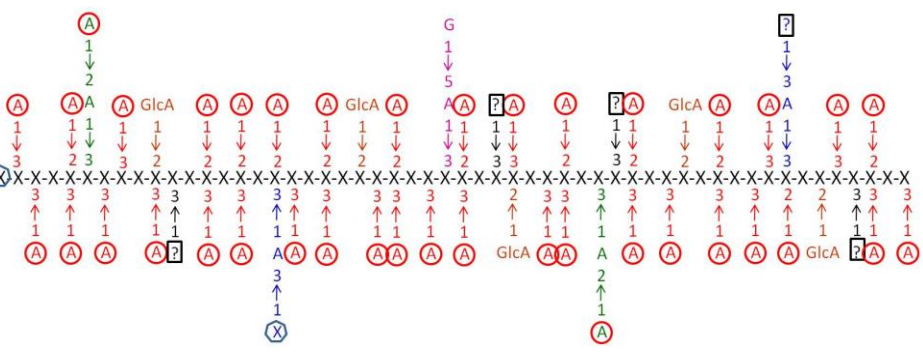


Discrete fiber structures that favor individual bacteria growth

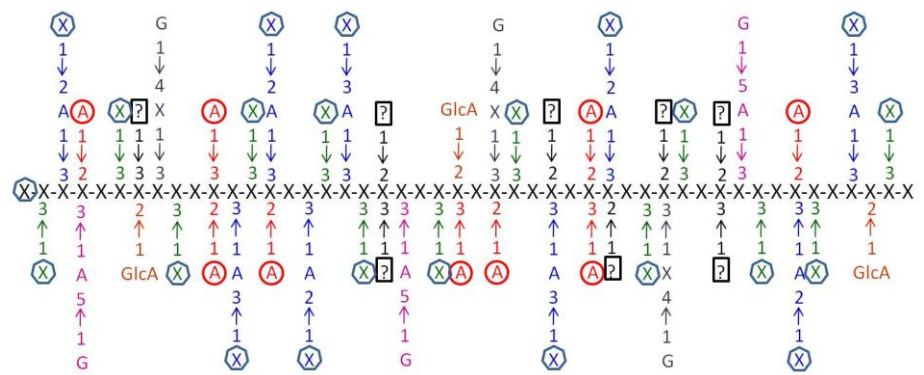
A model fiber – arabinoxylans

Use of arabinoxylans as a model to study structure-bacterial function relationships

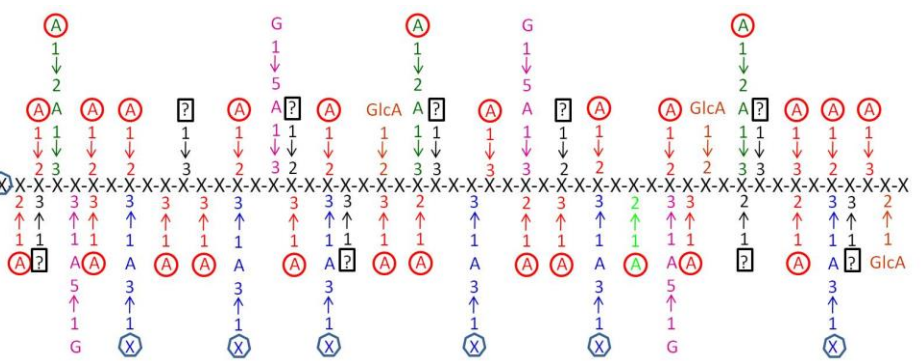
Sorghum



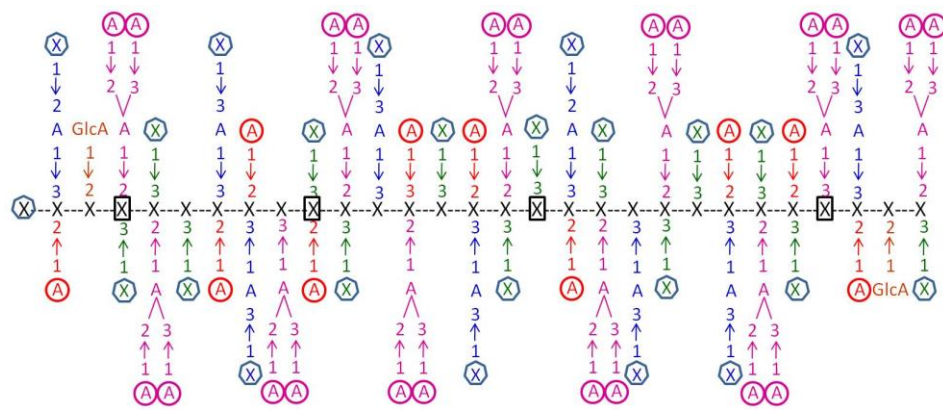
Corn Hydrolyzate



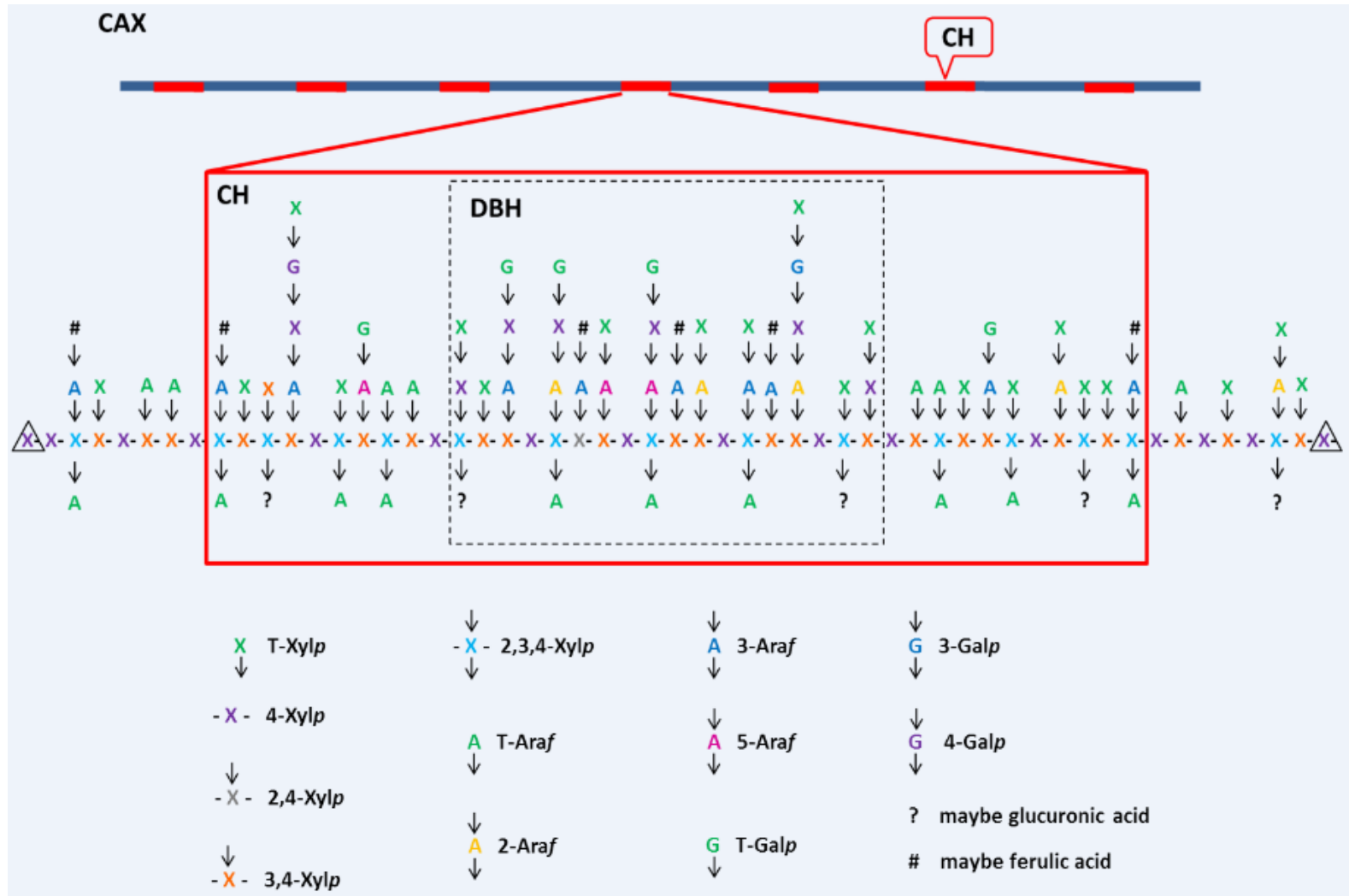
Rice Hydrolyzate



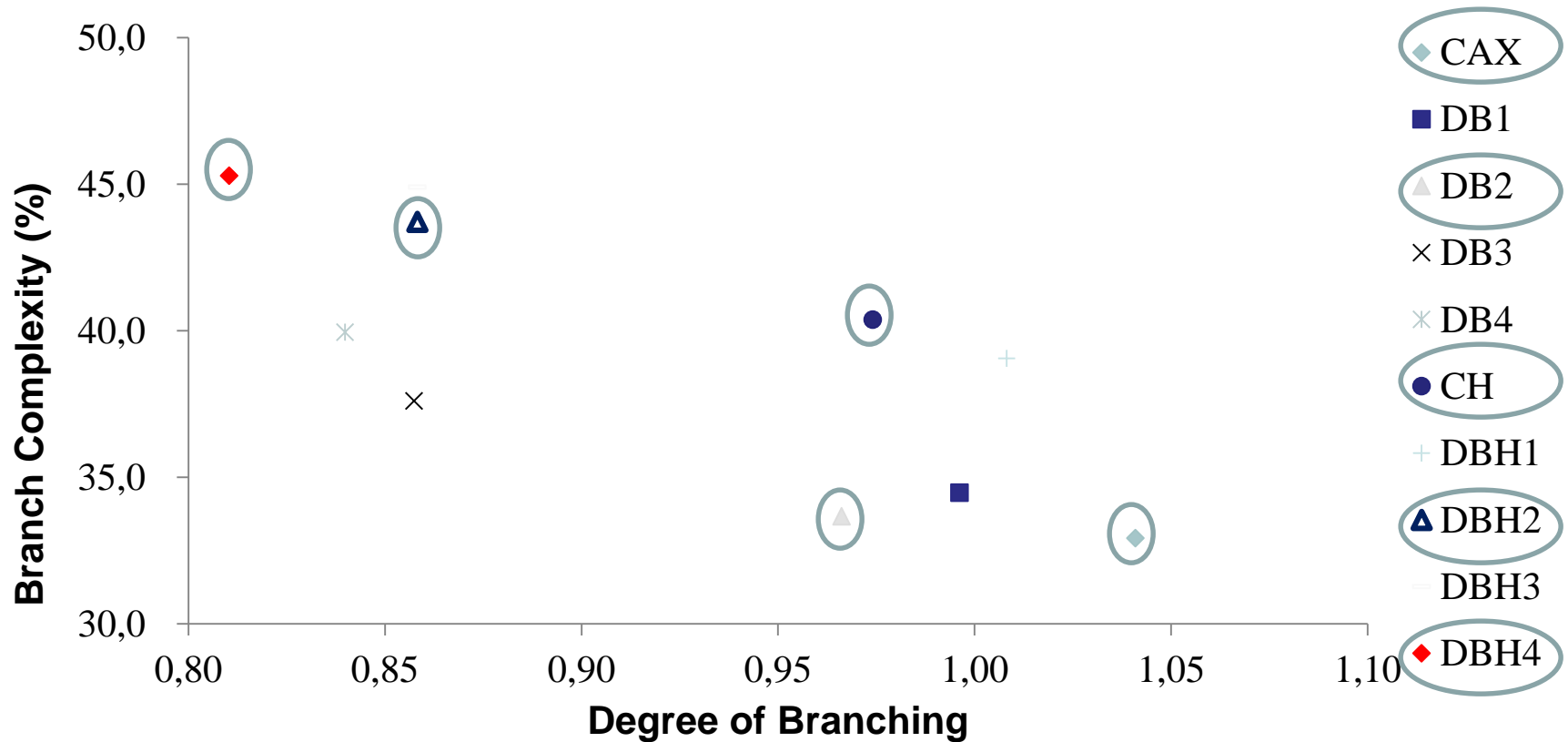
Wheat Fraction



Structural Model for the Multiple Layers of Corn AX

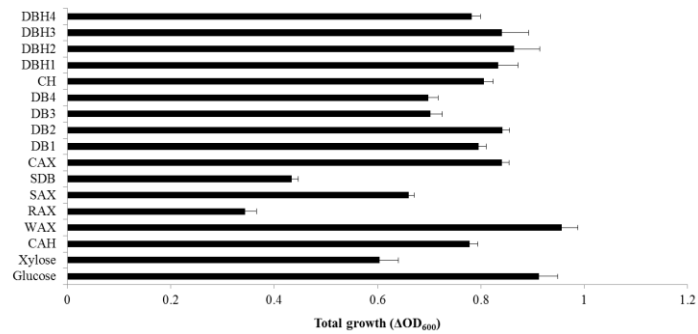


Branch Complexity and Degree of Branching

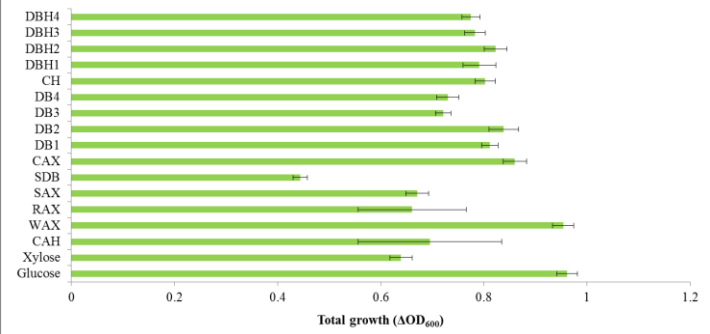


Branch complexity = Sum (terminal Xyl + 2-Ara + 3-Ara + terminal Gal + 5-Ara + 3-Gal + 4-Gal); degree of branching = Sum (mono- + di-*2)-substituted Xyl / Sum (un- + mono- + di-)-substituted Xyl

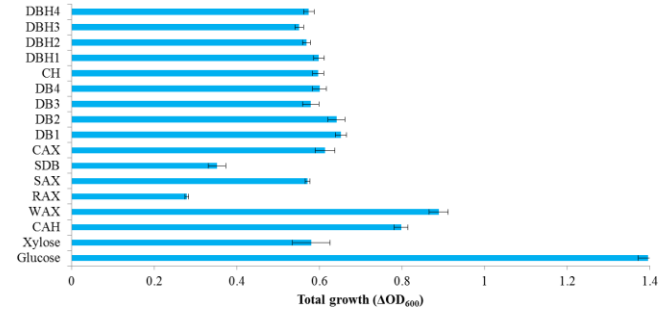
B. cellulosilyticus DSM 14830



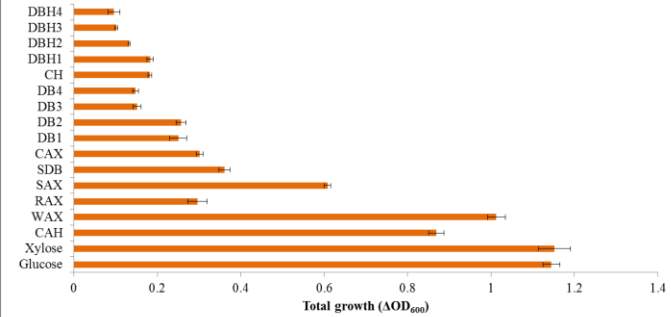
B. cellulosilyticus WH2



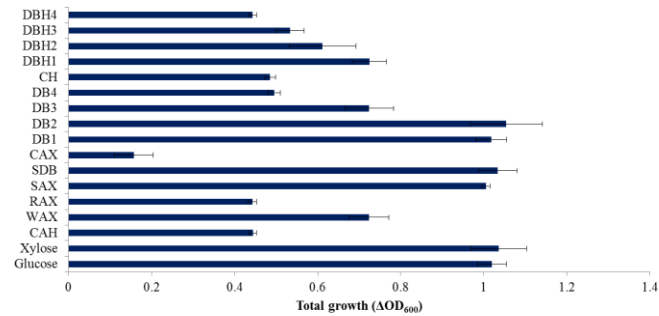
B. ovatus ATCC 8483



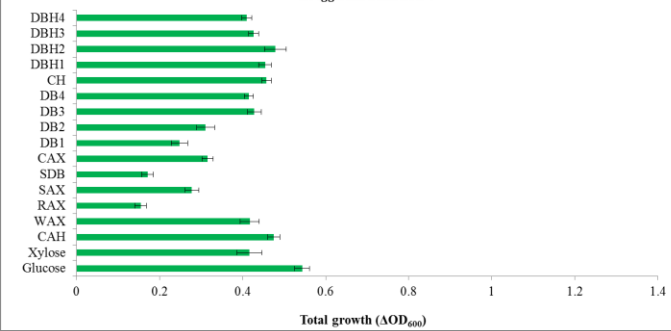
B. ovatus 3-1-23



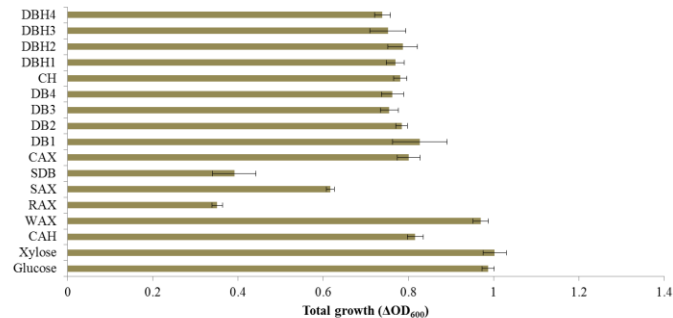
B. ovatus D2



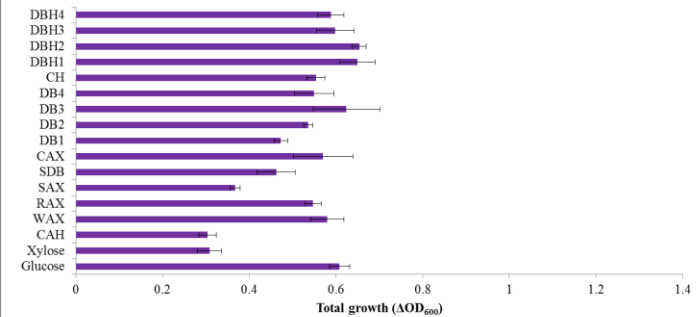
B. eggerthii DSM 20697

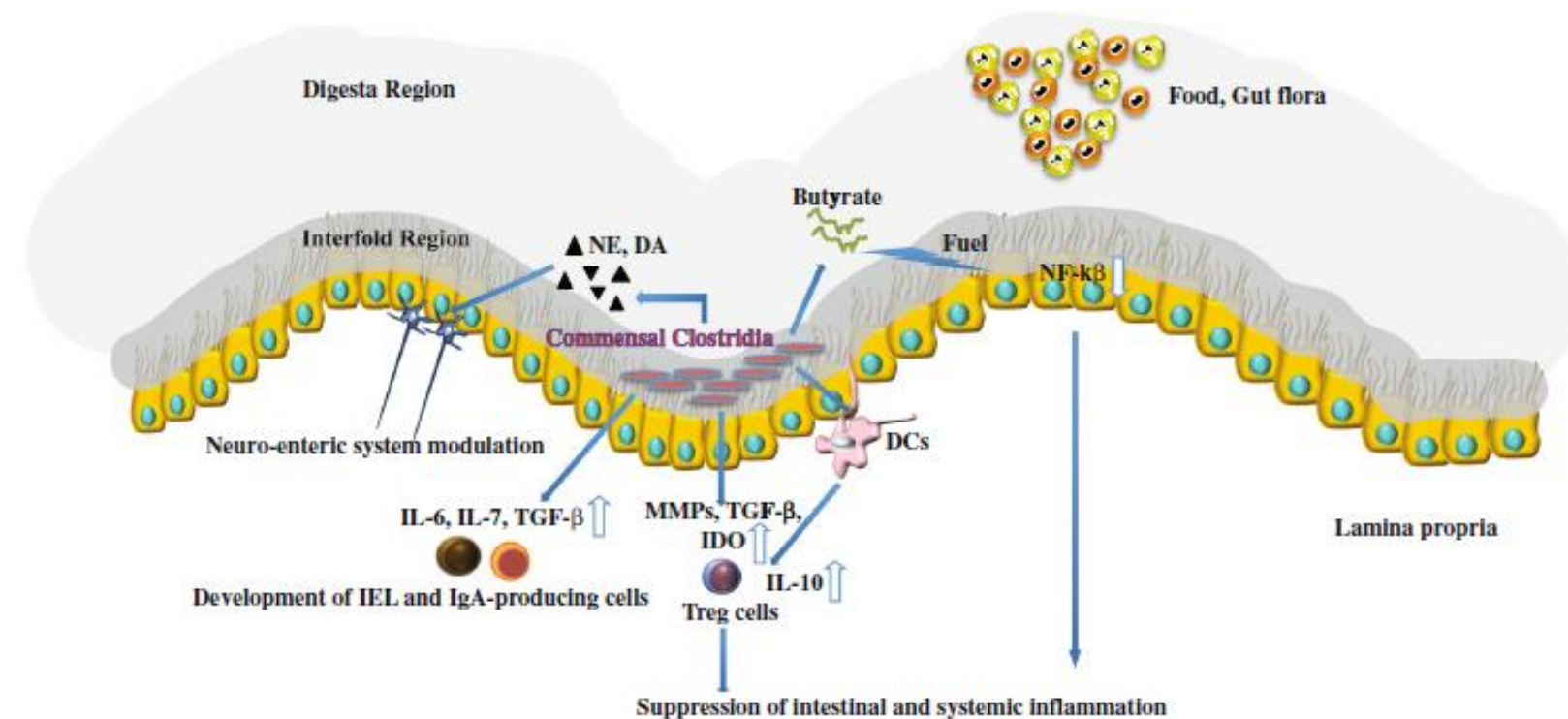


B. xylanisolvens XB1A

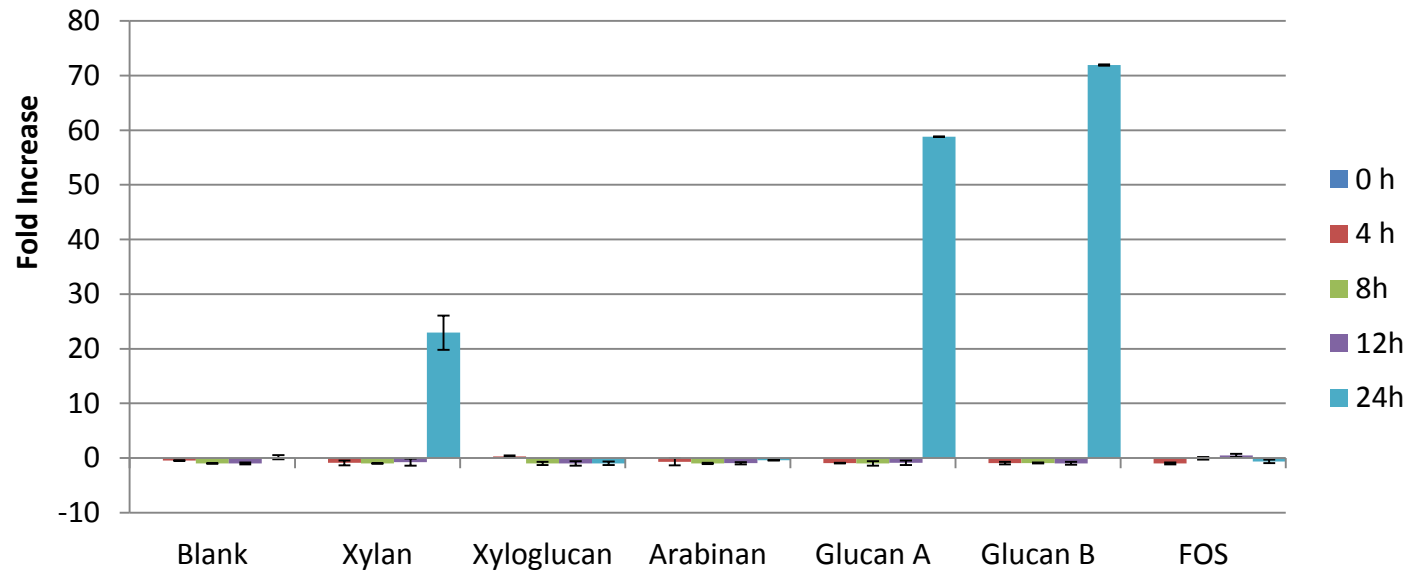
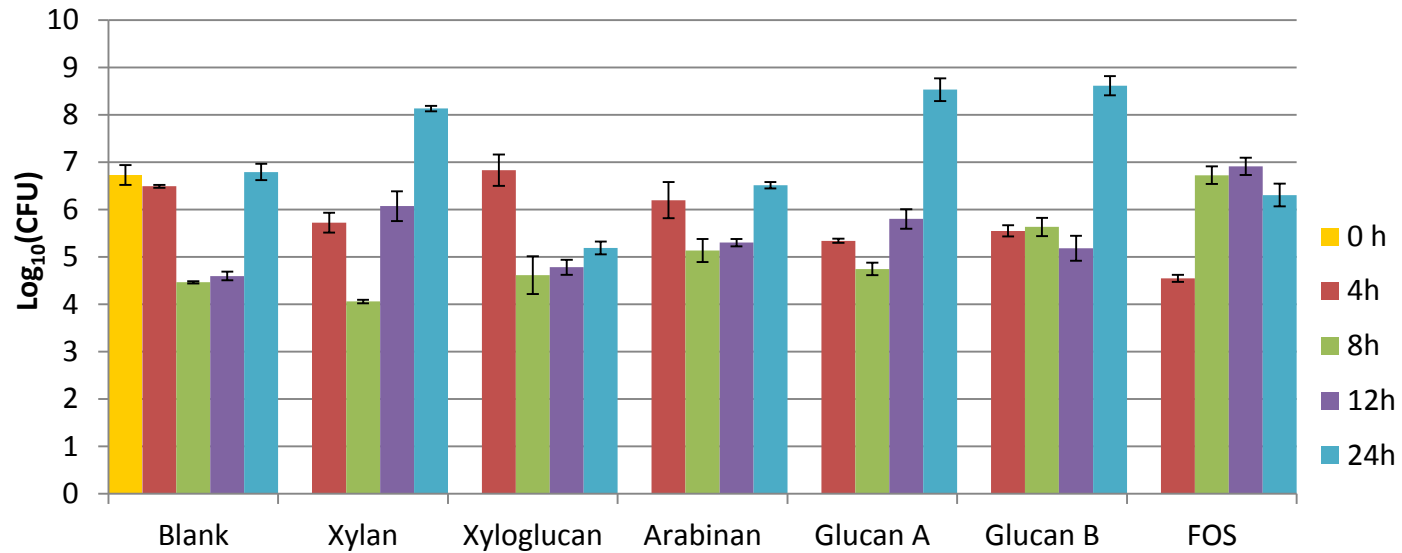


B. intestinalis DSM 17393

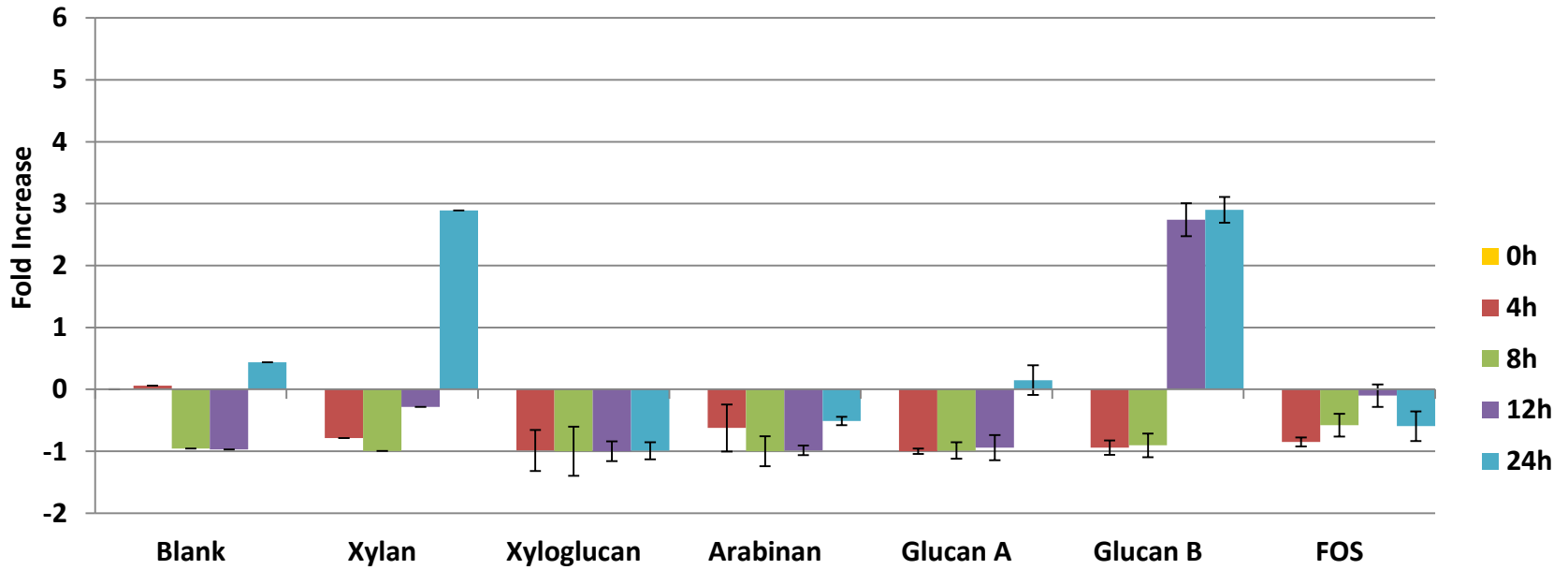




Clostridium Cluster XIVa



Roseburia spp.– Relative Abundance



Is it possible to align fibers to bacteria?

- Different ***discrete structures*** may provide special competitive niches for different gut bacterial strains
- Perhaps every bacteria or bacterial group has specific fiber structure(s) that can favor their growth in the competitive environment of the colon

QUESTIONS?