Bioencapsulation

ABE 304
Spring 2018

Bioencapsulation

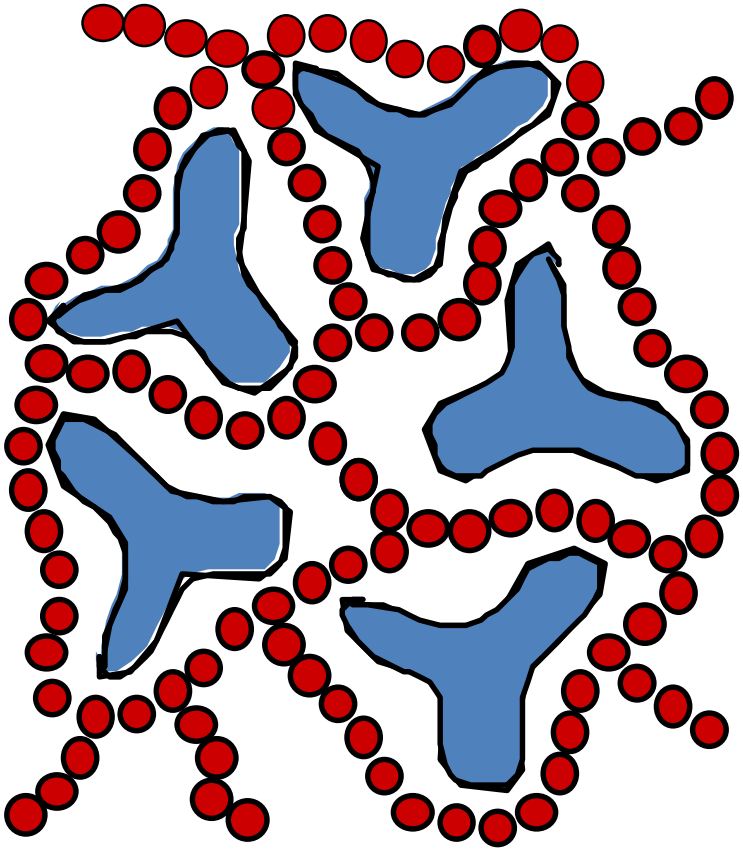
Encapsulation (physical or chemical, trapping or immobilization) of Biological Entities (proteins, DNA, viral particles, cells)

Wide range of applications

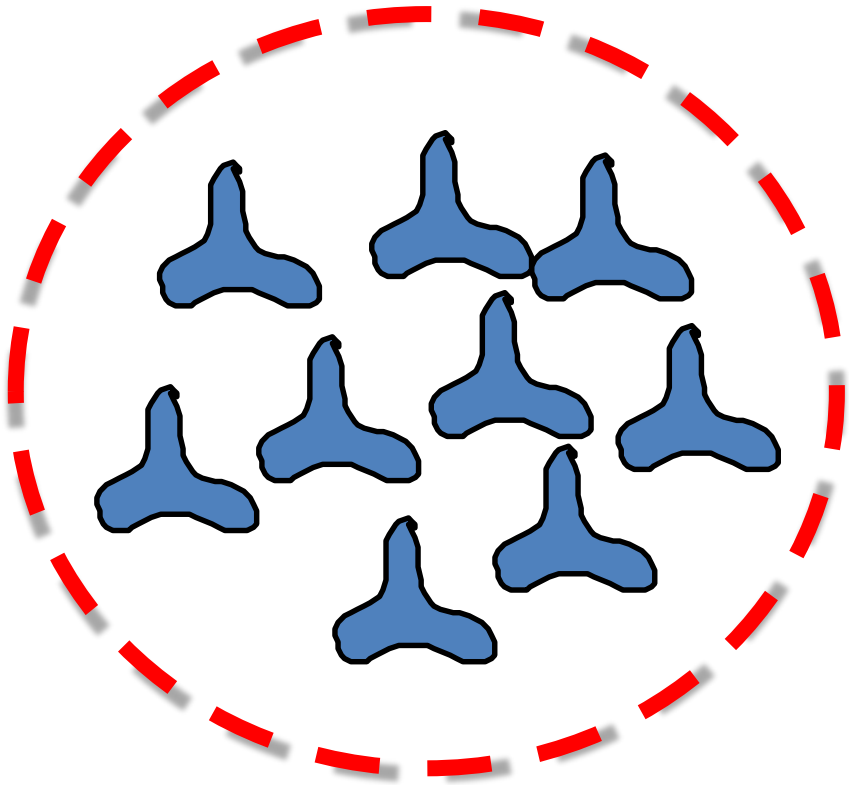
- Food – Ingredient integration, Nutraceuticals (e.g. Probiotics)
- Biotechnology - Biocatalysis, bioreactors, biosensors
- Pharmaceutical – Drug or cell delivery
- Medical – Tissue Engineering, Cell Transplantation
- Agriculture – Feed and Ag chemicals

Bioencapsulation

Two most common Bioencapsulation format:

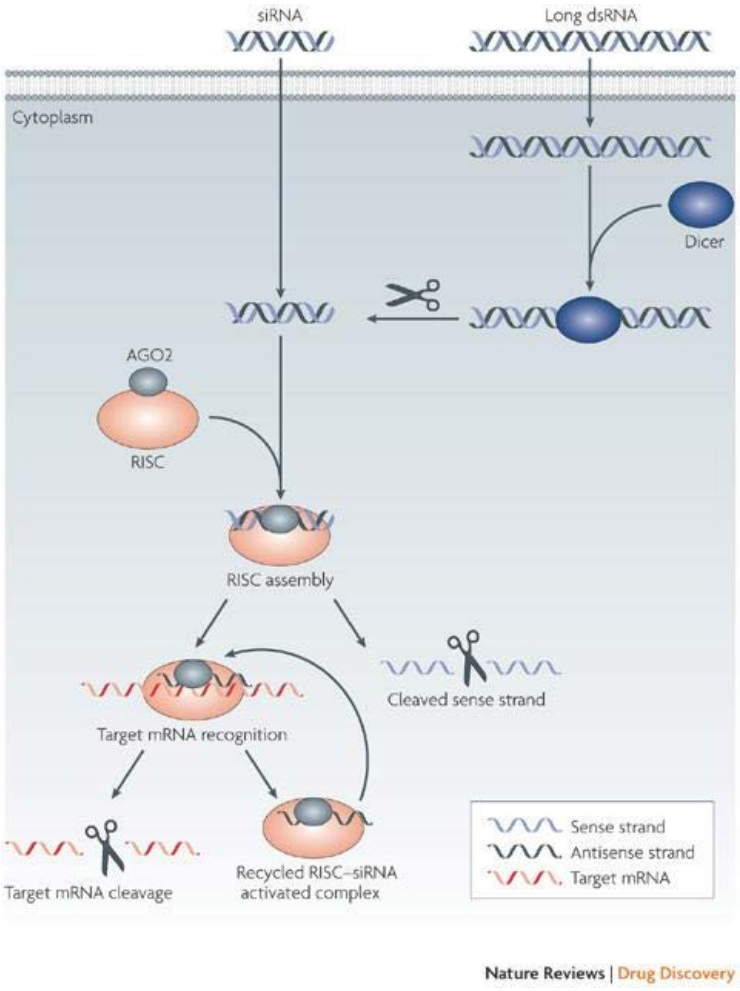


Encapsulated Within a Matrix



Encapsulated within a Membrane

Application: DNA or siRNA Delivery



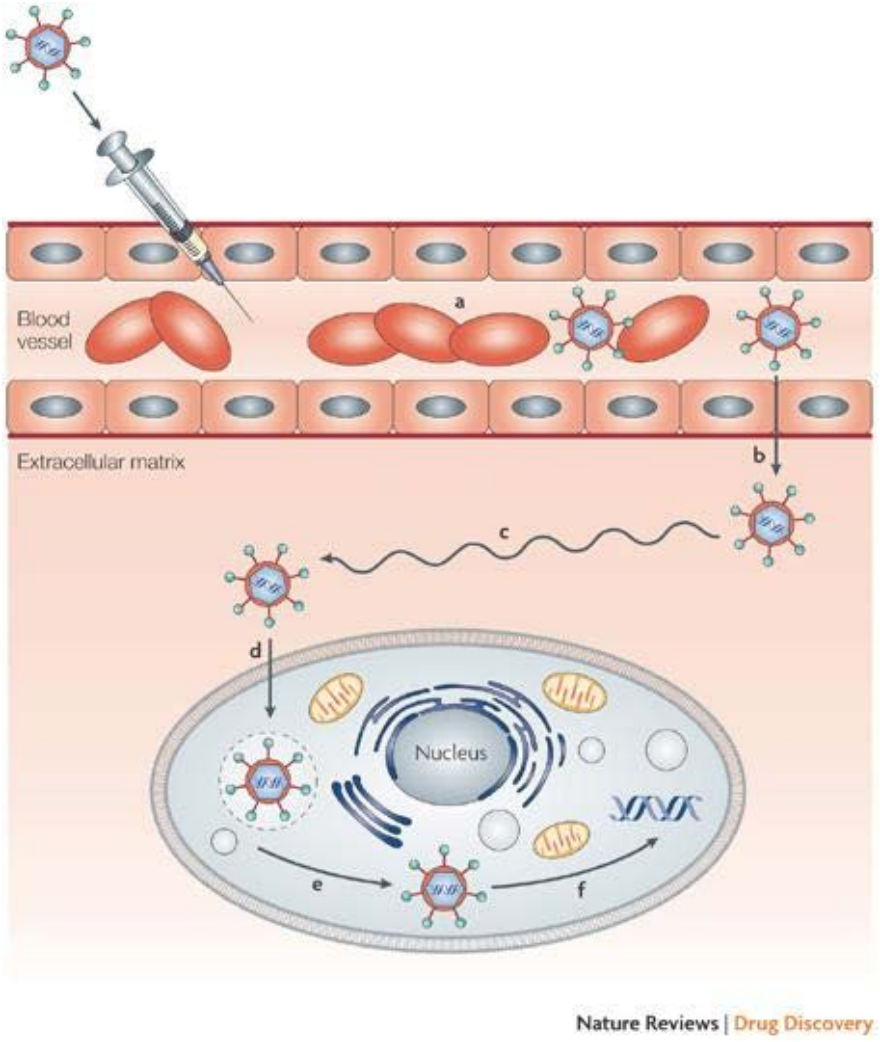
siRNA: small fragment of interfering RNA that is able to cleave specific pieces of mRNA in a eukaryotic cell thereby knocking down or silencing that gene.

Fairly recent discovery. Fire and Mello Awarded Nobel Prize in 2006 for RNA interference
http://www.nobelprize.org/nobel_prizes/medicine/laureates/2006/

Huge Potential for Silencing Genes in Humans to treat disease, but must deliver the siRNA

Reference: Whitehead, Langer, Anderson.
Knocking down barriers: advances in siRNA delivery
Nature Reviews Drug Discovery 8, 129-138 (February 2009) | doi:10.1038/nrd2742

Application: DNA or siRNA Delivery



An injected nanoparticle must:

a) avoid filtration, phagocytosis and degradation in the bloodstream
b) be transported across the vascular endothelial barrier
c) diffuse through the extracellular matrix
d) be taken up into the cell
e) escape the endosome
f) unpackage and release the siRNA to the RNA interference (RNAi) machinery

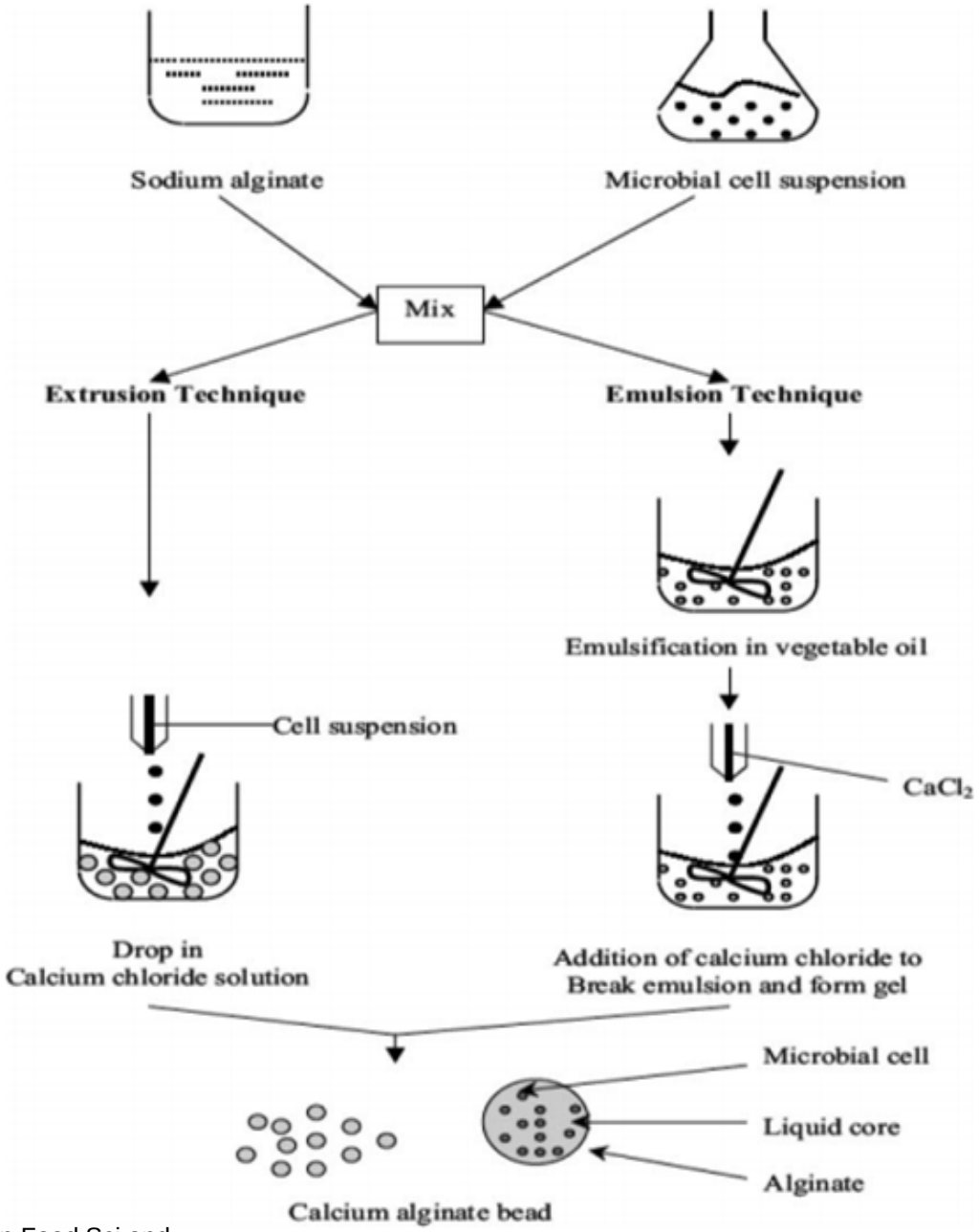
Naked siRNA won't make it!
Need delivery vehicle

Reference: Whitehead, Langer, Anderson.
Knocking down barriers: advances in siRNA delivery
Nature Reviews Drug Discovery 8, 129-138 (February 2009) | doi:10.1038/nrd2742

Probiotic Microencapsulation: Techniques

Common methods of encapsulating bacteria:

- Extrusion
  - Higher biocompatibility and low cell loss
  - Difficult for scale-up due to extrusion principles
- Emulsion
  - Smaller bead size produced and can be scaled-up
  - Higher cost and lower number of viable bacteria in final product
  - Suspended in vegetable oil before beading



Riaz & Masud (2012) Crit Rev in Food Sci and Nutrition

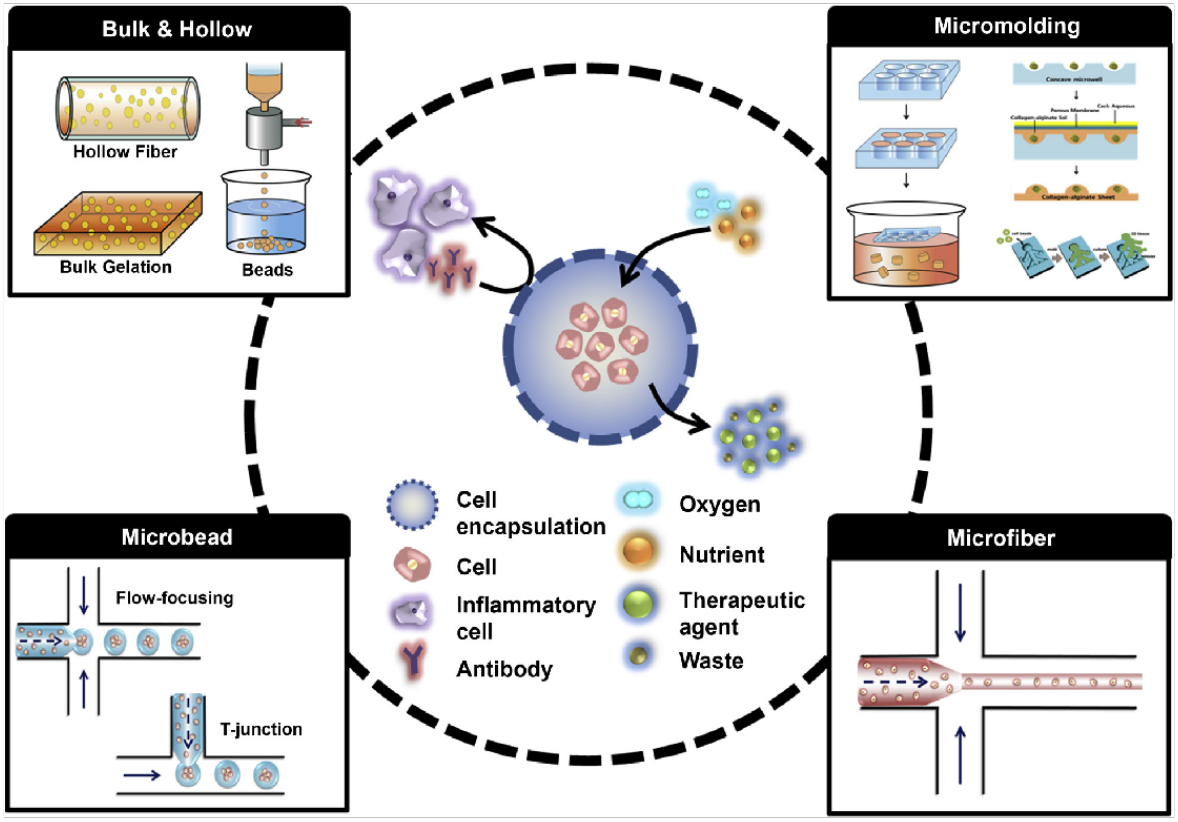
Application: Cell Encapsulation

Purpose:

- immobilize cells
- Protect cells
- Integrate into a device (e.g. biosensor)
  or unit operation (e.g. bioreactor)
- Deliver cells into organism (e.g. human)

Cell Types:

- Prokaryotes (e.g. bacteria)
- Eukaryotes (e.g. mammalian)

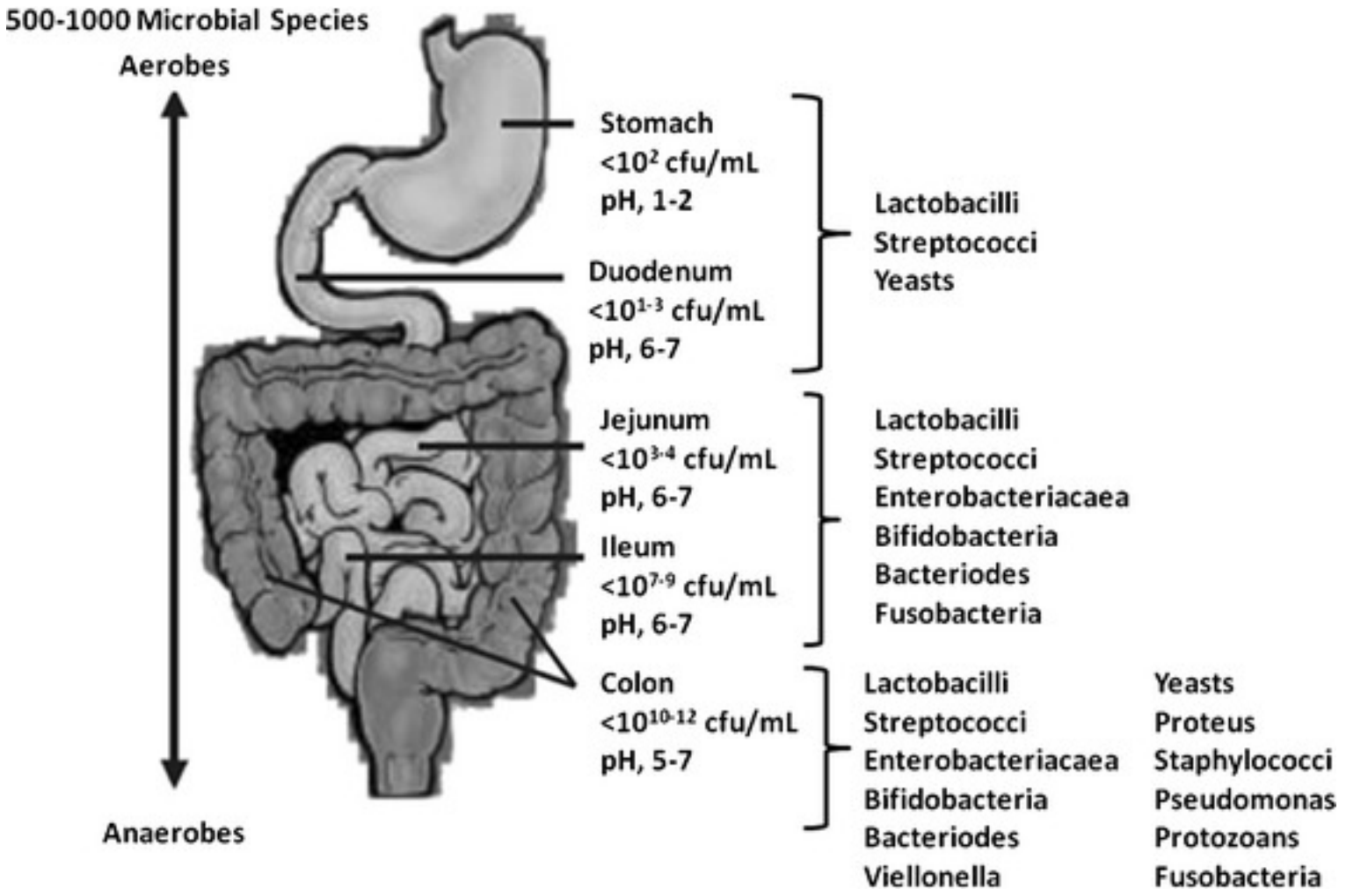


Encapsulation Materials:

- Natural Organic Polymers
  - Alginate
  - Collagen
- Synthetic Polymers
  - polyethylene glycol
- Inorganic Polymers
  - Silica

Reference: Kang et al, Biomaterials 35 (2014) 2651e2663

Probiotic Delivery to GI Tract

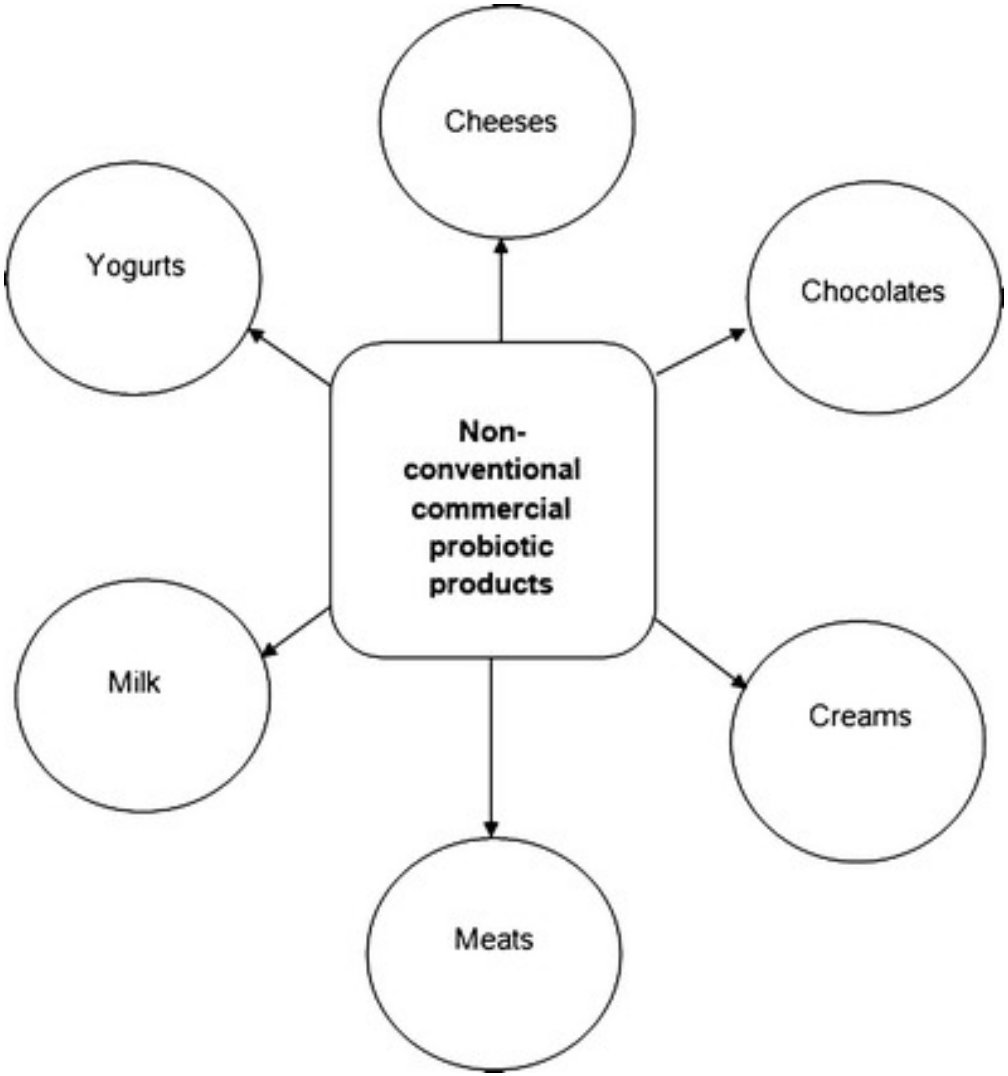


Govander et al 2014

Table I. Comparative Analysis of Probiotic Bacteria Genera and Their Functional Health Benefits

Genus (Probiotic spp. included)	Functional benefit (of genus)	Reference
Lactobacillus	Prevention of vaginosis	
L. acidophilus	Antibiotic-associated diarrhea	(61)
L. fermentum	Infant diarrhea	(62)
L. helveticus	Atopic dermatitis	(62)
L. paracasei	Promotion of vitamin	(62)
L. rhamnosus	production	(63)
L. salivarius	Digestion	(63)
Bifidobacterium	Irritable bowel disease	(62)
B. bifidum	Gut transit time control	(62)
B. breve	Immune support	(63)
B. longum	Antimutagens	(63)
	Anticholesterol agents	(63)
	Digestion	(63)
Enterococci		
E. faecium	Treatment of gastroenteritis and *Salmonella* infections	(49)
Escherichia		
E. coli Nissle 1917	Anti-tumor	(55)
	Vaccine delivery	(51)

Govander et al 2014



Govander et al 2014

Week 1

This lab is designed to allow <u>you</u> to design your own experiment!

- Preliminary tests to allow you to understand the procedure
- From these tests, come up with design of experiment (DOE) to answer the following:

What encapsulation formula/conditions will result in the greatest number of viable *E. coli* cells?

- Must check DOE with TA ***before*** lab ends

Week 2

- Perform DOE from week 1
- Obtain data for analysis
- Write *detailed observations*
- Remember to do data analysis

Prelab

- Group Assignment
  - Due Sunday at 5 PM

- All students must be present for designated lab time for both weeks
- Presentations during dead week
  - –Look at schedule