

Nanotechnology in Food: Lessons from the Industrialization and Enrichment of Bread

Me



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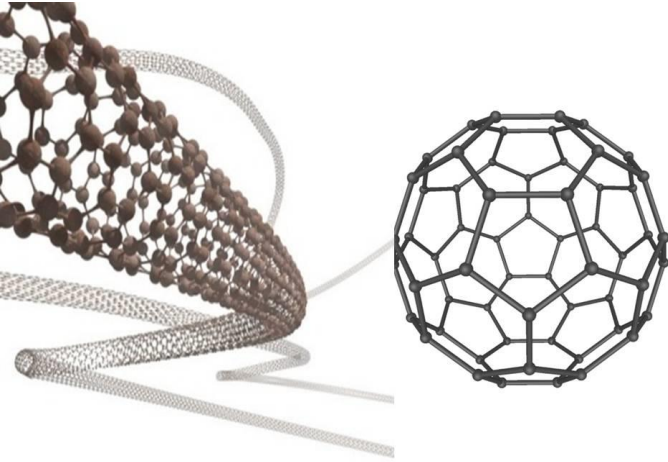
Faculty Advisor



Patrick McCray
History Professor

PROJECT FUNDED BY: THE NATIONAL SCIENCE FOUNDATION

What is Nanotechnology?



- Materials with at least one dimension on the nano-scale (1-100nm)
- Center for Nanotechnology in Society
 - Study the social effects of nanotechnology
 - IRG-1: Applied History of nanotechnology



Nanotechnology in Food



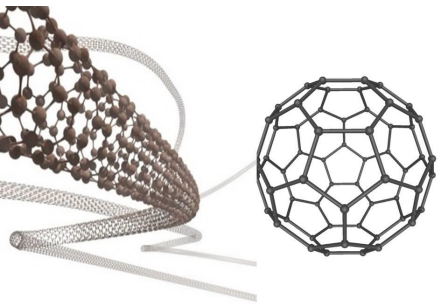
- Titanium Dioxide Nanoparticles found in common food products

– Alex Weir et. al., Titanium Dioxide Nanoparticles in Food and Personal Care Products, Environ. Sci. Technol. 2012, 46, 2242-2250

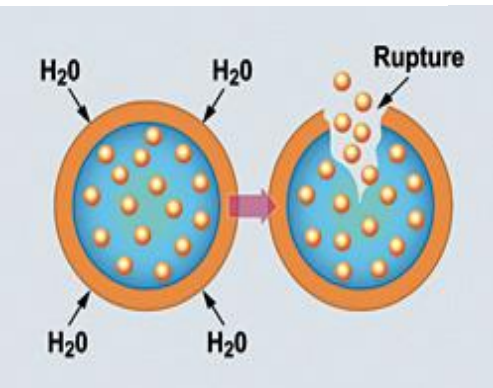
- Used to change food's color, smell, flavor, and texture
- Used to introduce antibacterial properties to foods
- Nanotech is being used in bread



Research Questions & Argument



- How did nanotechnology come to be used as a tech solution in bread?



- How is nanotechnology being used in food today?



- How does the history of bread help us to understand the implications of nano in food?

History of White Bread



- **Problem: White Flour Expensive**
- Considered a status symbol (pre-19th Century)
- Expensive and time intensive to produce

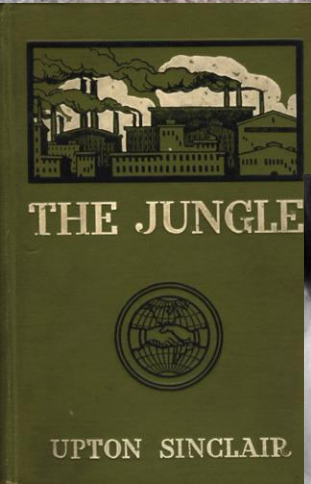
http://www.123rf.com/photo_16037016_white-flour-with-wooden-scoop.html



- **Tech Fix: Alum (19th Century)**
 - Aluminum Sulfate
 - Added to flour
 - Cheap whitener

New Problem: Outcry Against Alum and other Adulterated Foods

- Negative Health Effects of Alum
 - Rickets and Neurodegenerative Disorders during 19th Century
- Upton Sinclair, The Jungle (1905)
- Pure Food and Drug Act of 1906



- Public Fear of “Unsanitary” Bread

Tech Fix: Mechanical Flour Processing (early 20th century)

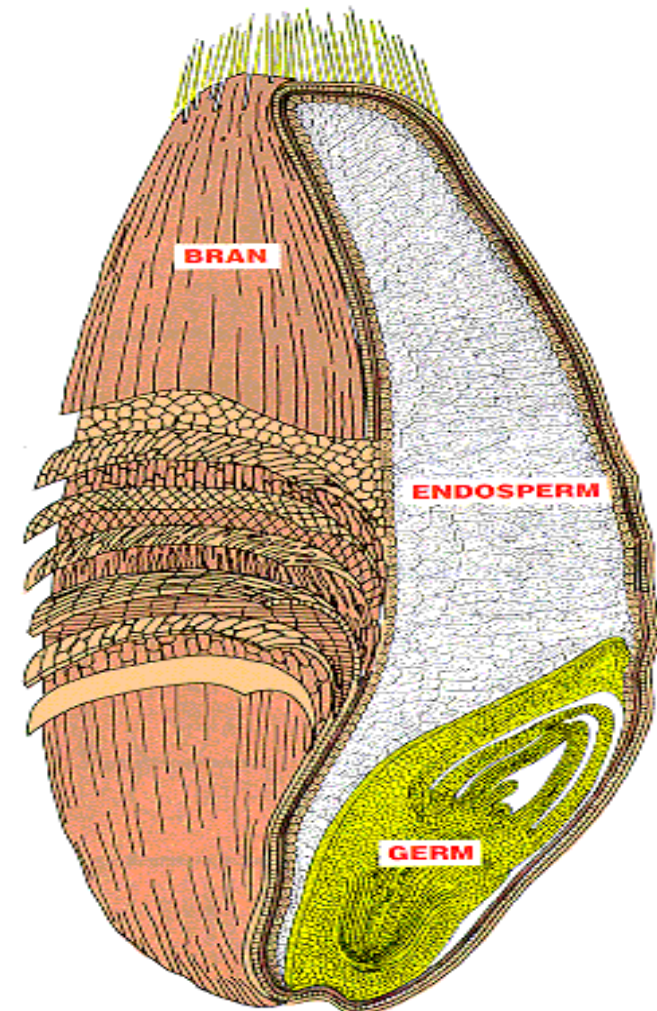


- Steel Roller Milling
 - Removed Germ and Bran
 - Responsible for Brown Color of Bread
- Chemical Bleaching
 - Further Whitened Flour
 - Chlorine Dioxide, Nitrogen Dioxide, Organic Peroxides



New Problem: Degraded Nutrition

- Bran: Vitamin A, Calcium, Vitamin B₆, Iron, and Fiber
- Germ: B Vitamins, Omega-3s, Omega-6s, Iron, and Vitamin E
- Endosperm: Primarily Starch



World War II

New Problem: Americans Unfit for Service



- Mass Nutrient Deficiencies
 - Americans got more calories from bread than any other food
 - Aaron Borrow-Strain. *White Bread: A Social History of the Store-Bought Loaf*. Boston: Beacon Press. 2012.
 - Malnutrition responsible for 1/3 of all draft rejections
 - W. H. Sebrell, Urgent Problems in Nutrition for National Betterment *American Journal of Public Health and the Nation's Health*. 1942 January; 32(1)15
 - Vitamin Deficiencies: Iron, Thiamin, Niacin, Vitamin A
 - Conditions: Pellagra, Beriberi, Night-blindness, and others

Tech Fix: Enrichment of Bread



wiseGEEK



- United States mandated enrichment tablets (1943)
- Other options were available
 - England Mandated Whole Grain Bread
 - Equally effective

New Problem: After the War



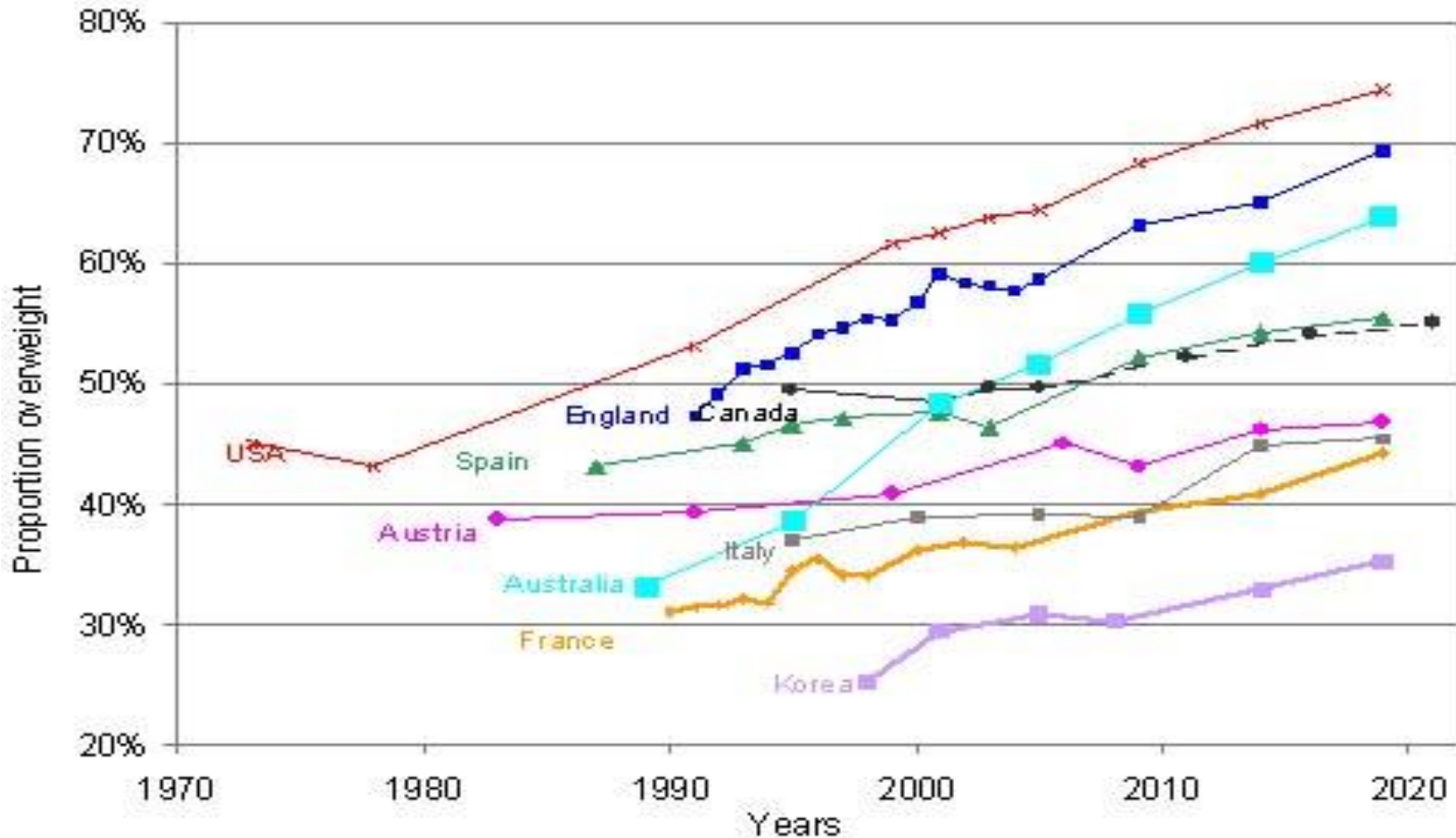
Bread is Enriched with
Vitamins BUT...

- White Bread has a High Glycemic Index
- Consumption of High Glycemic Foods Contributes to Obesity, Heart Disease, and Diabetes



Overweight Rates in Industrialized World

Past and projected future overweight rates in selected O.E.C.D. countries



Overweight and Obesity Statistics

- Approximately 70% of Americans are overweight
 - Weight-control Information Network (branch of NIH)
- Obesity cost the US \$190 Billion dollars in 2005
 - Cawley J, Meyerhoefer C. The medical care costs of obesity: an instrumental variables approach. [J Health Econ.](#) 2012; 31:219-30.
- An estimated 300,000 deaths per year in the US are related to co-morbidities of obesity
 - US Surgeon General <http://www.surgeongeneral.gov/library/calls/obesity/index.html>
- Two most common obesity related killers are...
 - Type 2 Diabetes, and heart disease

New Tech Fix? - Heart Healthy Enrichment with Nanotech



Tip Top Up Nano-Bread



- Uses nano-encapsulation to enrich bread with heart healthy Omega 3s
- No fishy smell or flavor
- Intended to combat heart disease

HOWEVER...



Glycemic Index:

White Bread (avg.): 75

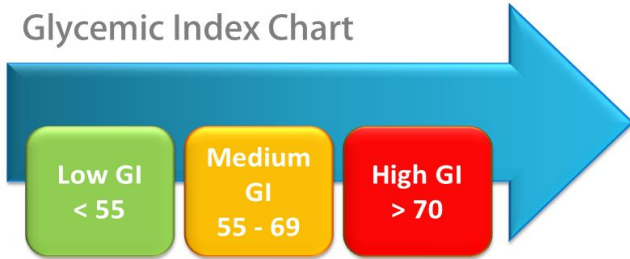
Table Sugar (avg.): 65

“high dietary glycemic load from refined carbohydrates increases the risk of CHD, independent of known coronary disease risk factors”

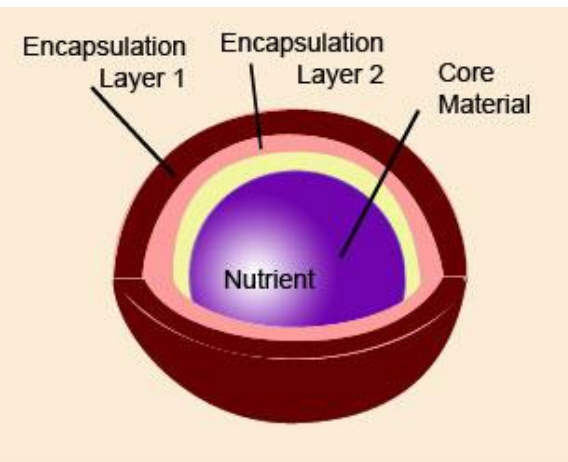
Simin Liu, et. al, A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women, *Am J Clin Nutr* June 2000 vol. 71 no. 6 1455-1461

Problems with Nano-encapsulation Fix

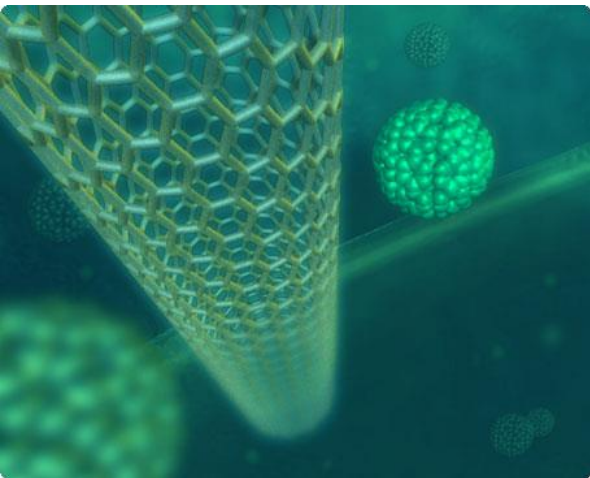
Glycemic Index Chart



- Doesn't Address Essential Problem
 - High in Carbohydrates
 - High Glycemic Index
- Introduces New Risks
 - Oxidation of Fish Oils
 - Toxicology of Encapsulation Materials Has Not been Studied



General Uncertainties of Nano



- Evidence suggests nano behaves differently in biological systems
- Nanotoxicology methods are not currently sufficient to evaluate safety
 - Andrew Maynard, et al, “The New Toxicology of Sophisticated Materials: Nanotoxicology and Beyond,” *Toxicol. Sci.* 120 (2011): S109-S129
- Regulatory bodies lack data for proper health and safety determinations
 - Scientific Opinion of the Scientific Committee on a request from the European Commission on the Potential Risks Arising from Nanoscience and Nanotechnologies on Food and Feed Safety,” *The EFSA Journal* 958 (2009): 1-39.
 - EPA Office of Inspector General, *EPA Needs to Manage Nanomaterial Risks More Effectively*, Report no. 12-P-0162 (Dec. 2011).
 - FDA et al, *Draft Guidance for Industry... on the Safety and Regulatory Status of Food Ingredients* (April 2012)

Current Applications of Nanotech in Food



- Common Food Additive Applications

- TiO₂ Nanoparticles

- Used to Whiten Powdered Sugar
- Found in Powdered Donuts

- Nano-encapsulation

- Tip Top Up Bread

- Other Applications Are Coming Soon...



Conclusions



- Uncertainties surrounding Nano indicate that more research is needed to ensure safety
- The history of bread suggests that Nano in food will create unintended consequences
- Current applications of Nano do not yet justify the risk of uncertainty associated with nanofoods



Is Nanofood Worth The Risk?



Thank You!

This research is based upon work supported by the National Science Foundation under Grant No. SES 0938099. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.



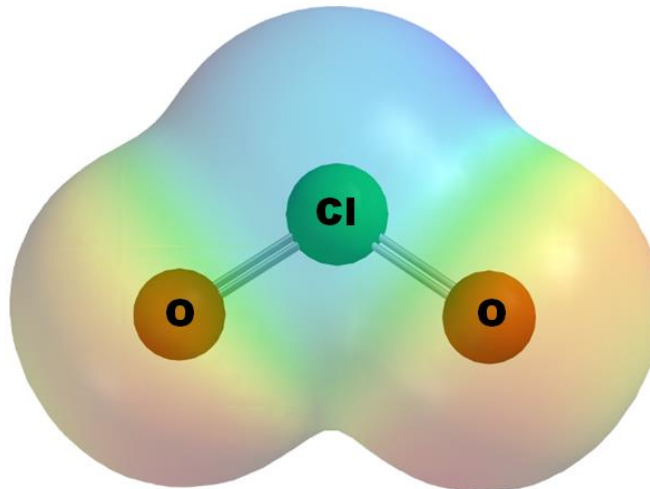
Tip Top Up



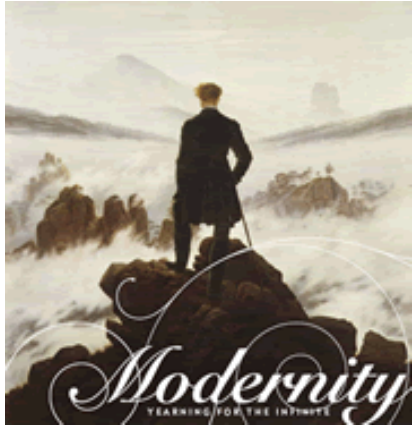
- Uses Nano-encapsulation technology
- To Enrich bread with Omega 3 fatty acids from Fish Oil Source
- Intended to Combat Heart Disease



Case Study: The History of Bread Technology



Why is History Important?



- The Fallacy of Modernity
 - Through Science and Technology we can Solve the Essential Problems of Life

<http://news.nd.edu/news/8531-center-for-ethics-and-culture-to-host-conference-on-modernity/>



- History Shows that Technology Creates New Problems
- Is the Present Special?

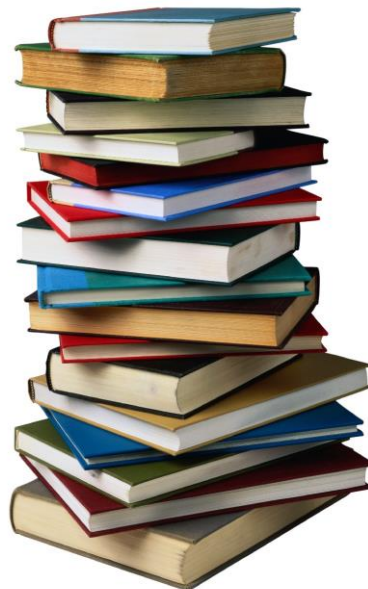
Historical Methodology & Sources

- History is an Empirical Discipline
- Rooted in Primary and Secondary Sources

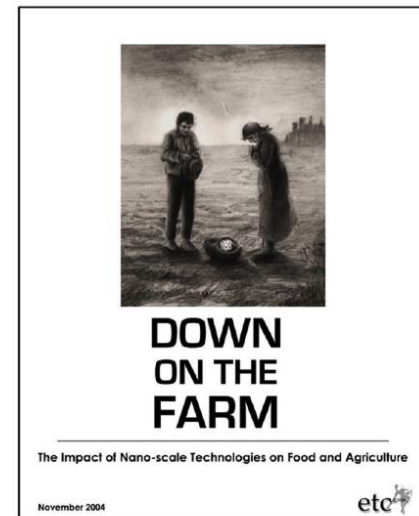
Journal Articles



Books

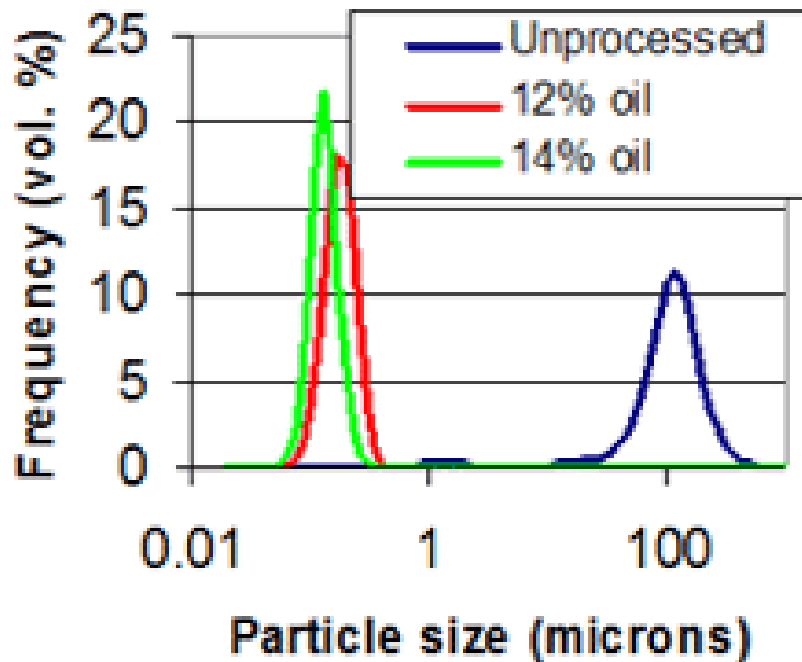


Reports

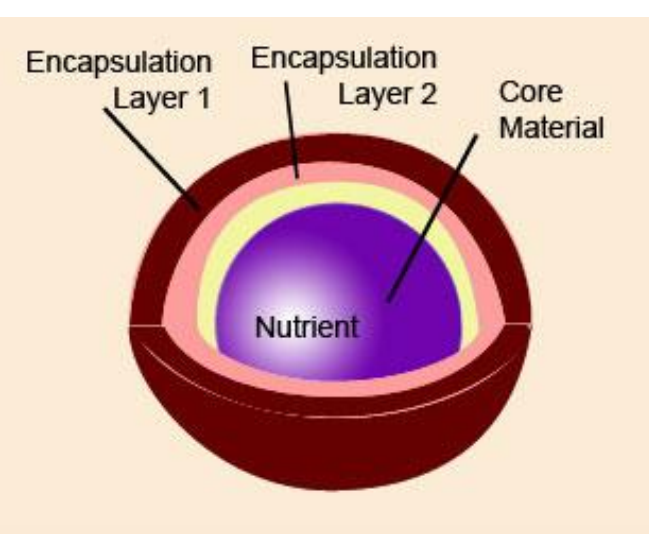


Encapsulation Methods

- High Shear Fluid processors
 - Create Nano-sized capsules



Nano-encapsulation Technology

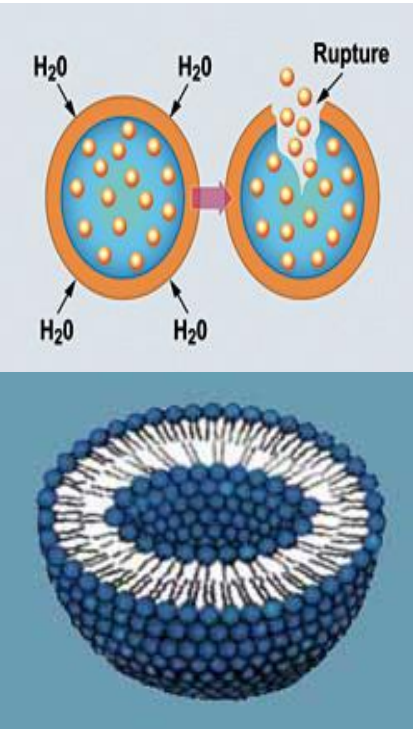


- Each Microcapsule is defined by its core composition, the composition of the capsule, and the encapsulation method
- Many methods
 - Spray Drying, spray-cooling, spray-chilling, air suspension coating, extrusion, centrifugal extrusion, freeze-drying, coacervation, rotational suspension separation, co-crystallization
- Many core compounds
- Many different compounds used in the Capsule layer

Microencapsulation

- Most Common Method
 - Spray Drying
- Many Ways to Encapsulate
 - Method is Customized for Core Nutrient being Delivered
 - Materials Used Vary from Nutrient to Nutrient
 - Each Technique Must be Evaluated for Toxicology Separately

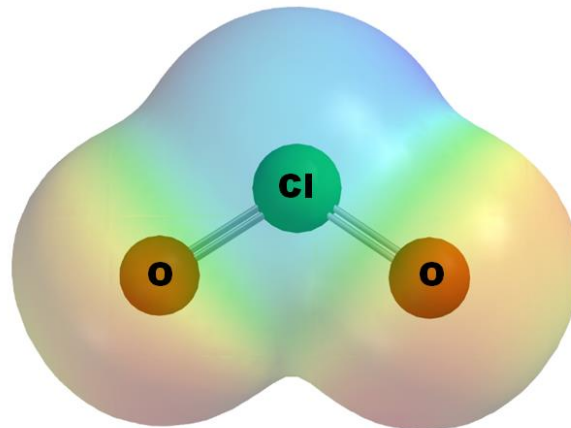
What Problems Could Nanoencapsulation Create?



- Evidence that Nano Behaves Differently in Biological Systems
- Nanotoxicology Methods
 - Characterization Techniques
 - Especially important in Encapsulation
 - Very Few Nanotoxicology Studies in General

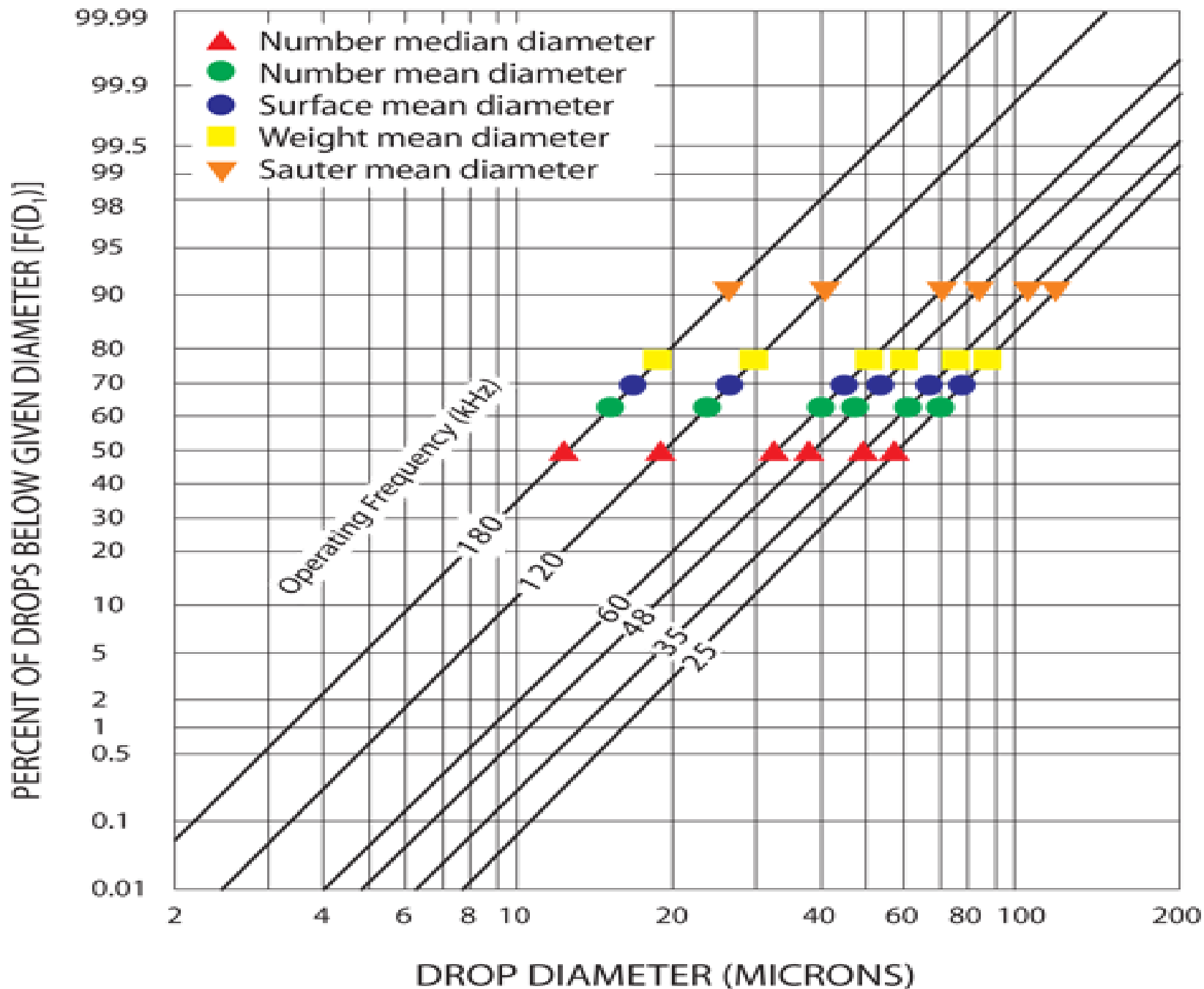
Fundamental Insight

- History of Bread Technology has a Predictable Pattern
 - Problem/Solution/New problem
 - Tech Solutions to Problems Often Create New Problems with Unintended Consequences



Ultrasonic Spray Nozzles

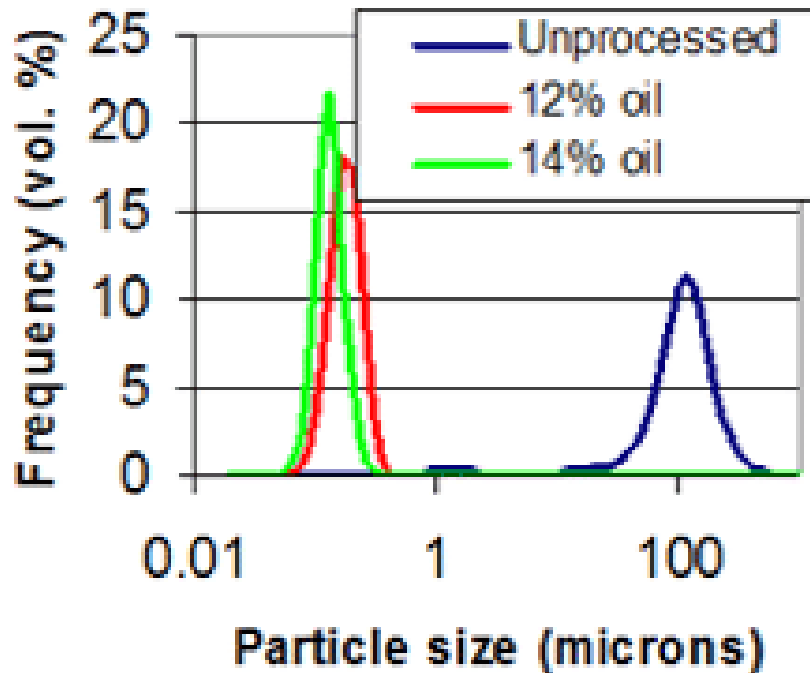
- Used to create microcapsules



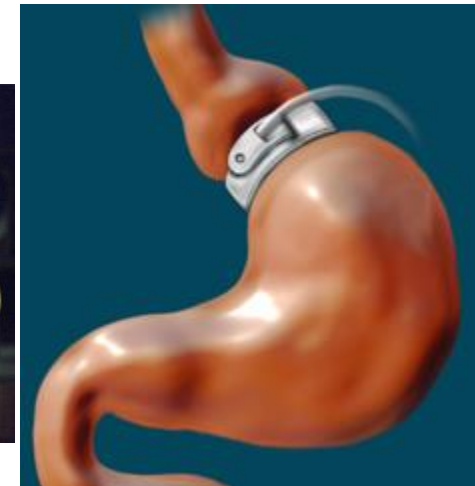
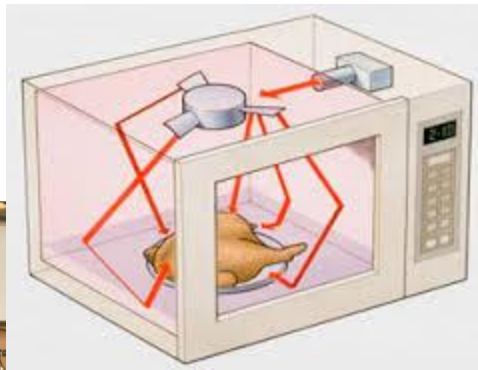
Note: Data compiled for water. Other materials may give different results.

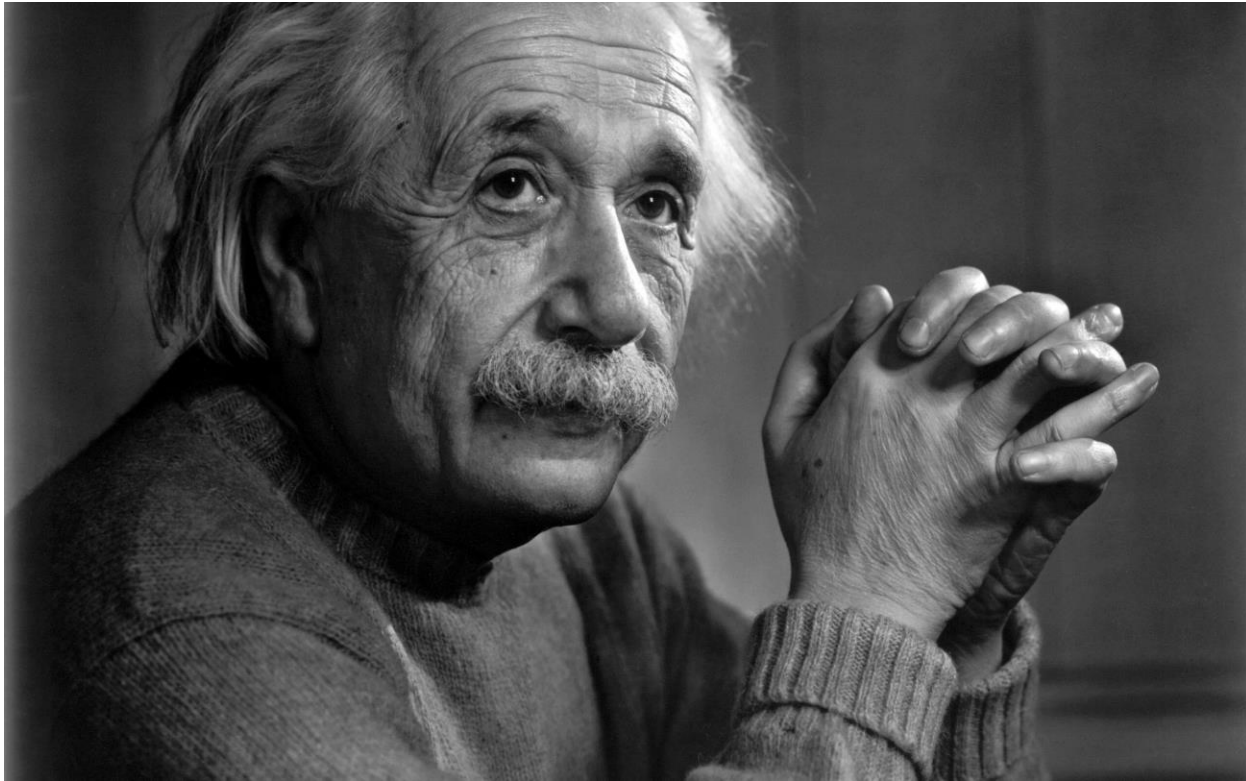
Microfluidizer processors

- Used to Make Nanocapsules



The Tech Fix



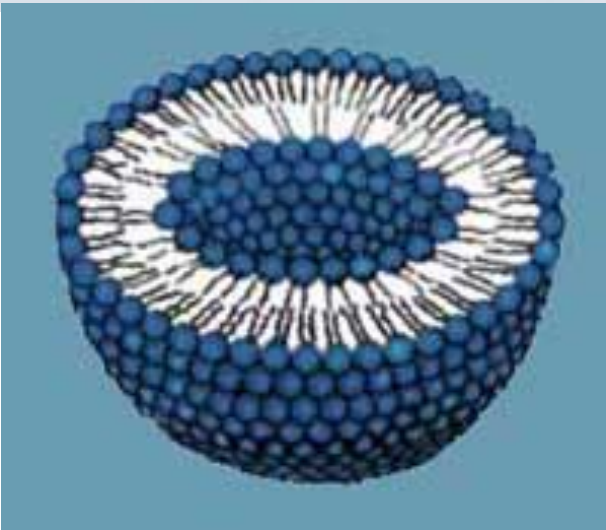
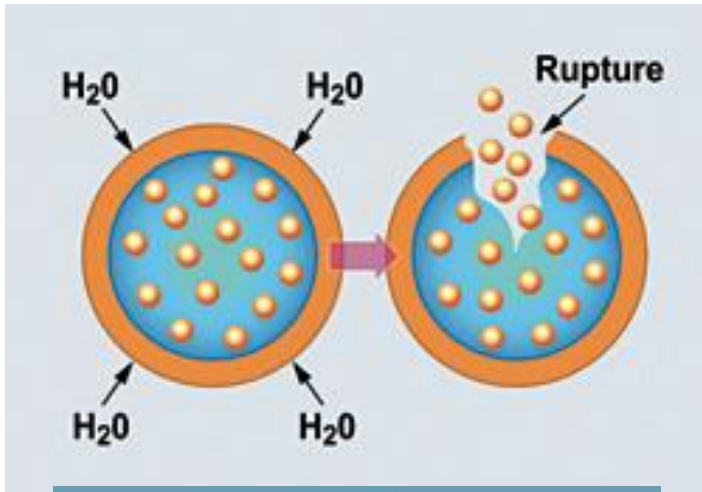


<http://quotes.lifehack.org/albert-einstein/Albert-Einstein-Miracle/>

“We cannot solve our problems with the same thinking we used when we created them”

Tip Top Up Bread

- Nanoencapsulation Technology
- Used to Enrich Bread with Heart Healthy Omega 3 Fish Oils
- High Sugar Content: Contributes to Heart Disease



Demand for Sanitary Bread



- White Flour
 - “Clean” Bread was White Bread
 - White Bread used White Flour
 - White Flour is Still Expensive
 - Alum was not considered Safe



Chemical Bleaching



- Steel Roll Milling Product not quite White
- No Time for Natural Aging
- Chemical Bleaching
 - Chlorine Dioxide, Nitrogen Dioxide, Organic Peroxides



BMI

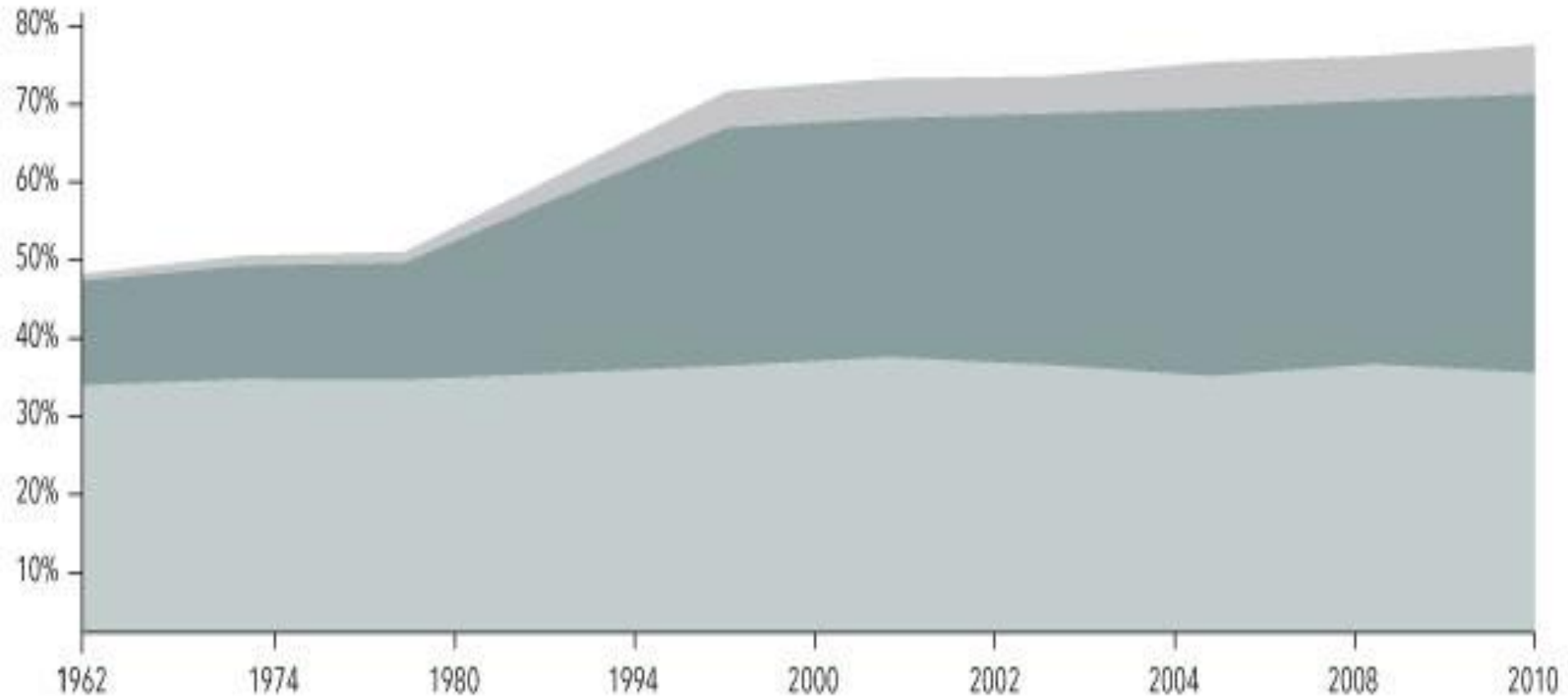
- BMI is used to determine weight status
 - An adult who has a BMI between 25 and 29.9 is considered overweight.
 - An adult who has a BMI of 30 or higher is considered obese.

$$\text{BMI} = \frac{\text{mass}(\text{kg})}{(\text{height}(\text{m}))^2} = \frac{\text{mass}(\text{lb})}{(\text{height}(\text{in}))^2} \times 703$$

Overweight Statistics

- According to a Study Titled *Overweight and Obesity Statistics* funded by
 - U.S. Department of Health and Human Services
 - National Institute of Health
- “More than two-thirds (68.8 percent) of adults are considered to be overweight or obese.”
- <http://www.win.niddk.nih.gov/statistics/#b>

Overweight Statistics



Obesity in America

Weight-control Information Network (WIN)

The Weight-control Information Network (WIN) is an information service of the [National Institute of Diabetes and Digestive and Kidney Diseases](#) (NIDDK), part of the [National Institutes of Health](#) (NIH). Established in 1994, WIN provides the general public, health professionals, and the media with up-to-date, science-based information on obesity, weight control, physical activity, and related nutritional issues. WIN also developed [Sisters Together: Move More, Eat Better](#), a national program to encourage black women to maintain a healthy weight by becoming more physically active and eating healthier foods.

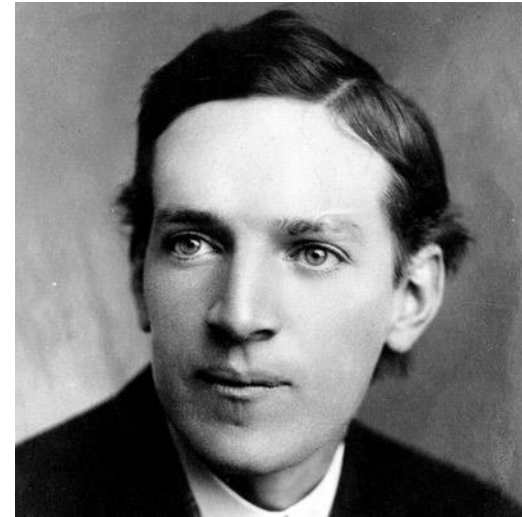
Source: <http://win.niddk.nih.gov/about/index.htm>

Image Sources

- Slide 1
 - Picture of Me
 - Picture of Roger
 - Picture of Patrick
- Slide 2
 - Picture of Einstein: <http://quotes.lifehack.org/albert-einstein/Albert-Einstein-Miracle/>
- Slide 3
 - Question Mark: http://en.wikipedia.org/wiki/File:Question_mark_%28black_on_white%29.png
 - Phones: <http://www.busyevent.com/making-a-technology-decision-for-your-event-at-the-last-minute-9-things-to-consider/>
 - Sick Child: <http://www.multiplemayhemamma.com/wp-content/uploads/2012/03/sickchild.jpg>
 - Pill: <http://www.flight001.com/big-pill-1.html>
 - Stressed Mother: <http://www.njfamily.com/NJ-Family/December-2011/Whats-for-Dinner/>
 - Microwave:
 - Lap Band: http://en.wikipedia.org/wiki/Adjustable_gastric_band
- Slide 4
- Slide 5
- Slide 6
- Slide 7

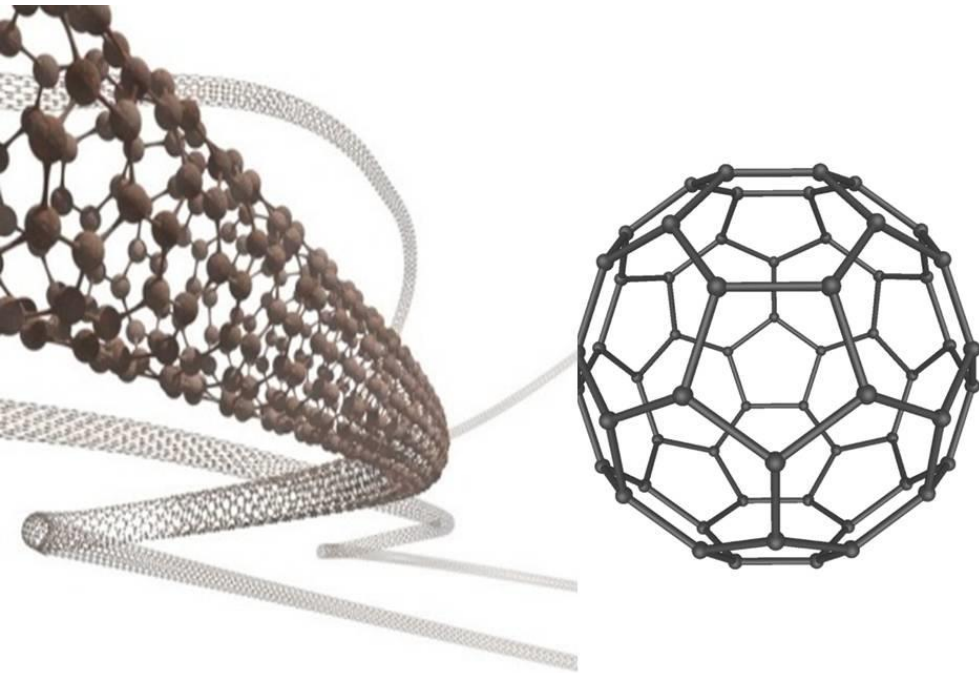
Food Adulteration

- Upton Sinclair (1905)
 - *The Jungle*
- Exposed Adulteration in Meatpacking Industry



- Provided motivation for Food Safety Legislation
- Strengthened “Food Purity” Movement

My Project: Nanotechnology and Food



<http://diamondenv.wordpress.com/2010/05/19/bohs-conference-nanotechnology/>

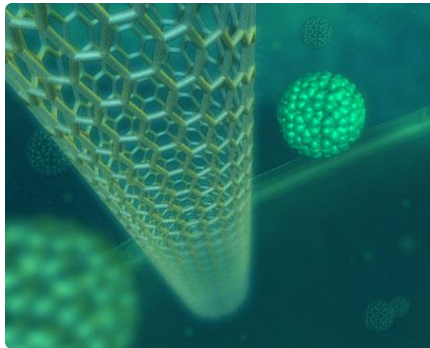
http://www.123rf.com/photo_9230337_close-up-on-traditional-bread.html

My Research: Nanotechnology and Food

- Project Description: Study Nanotechnology in Food from a historical perspective



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<http://farewelletter.blogspot.com/2010/08/chia-seeds.html>

<http://www.celsias.com/article/nanotechnology-our-food/>



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http://www.constructiondigital.com/green_building/epsi-owns-first-lead-certified-food-factory-in-ca