

The woods & the fields are a table always spread.

- Henry David Thoreau





“Let food be thy medicine  
and medicine be thy food”  
– Hippocrates

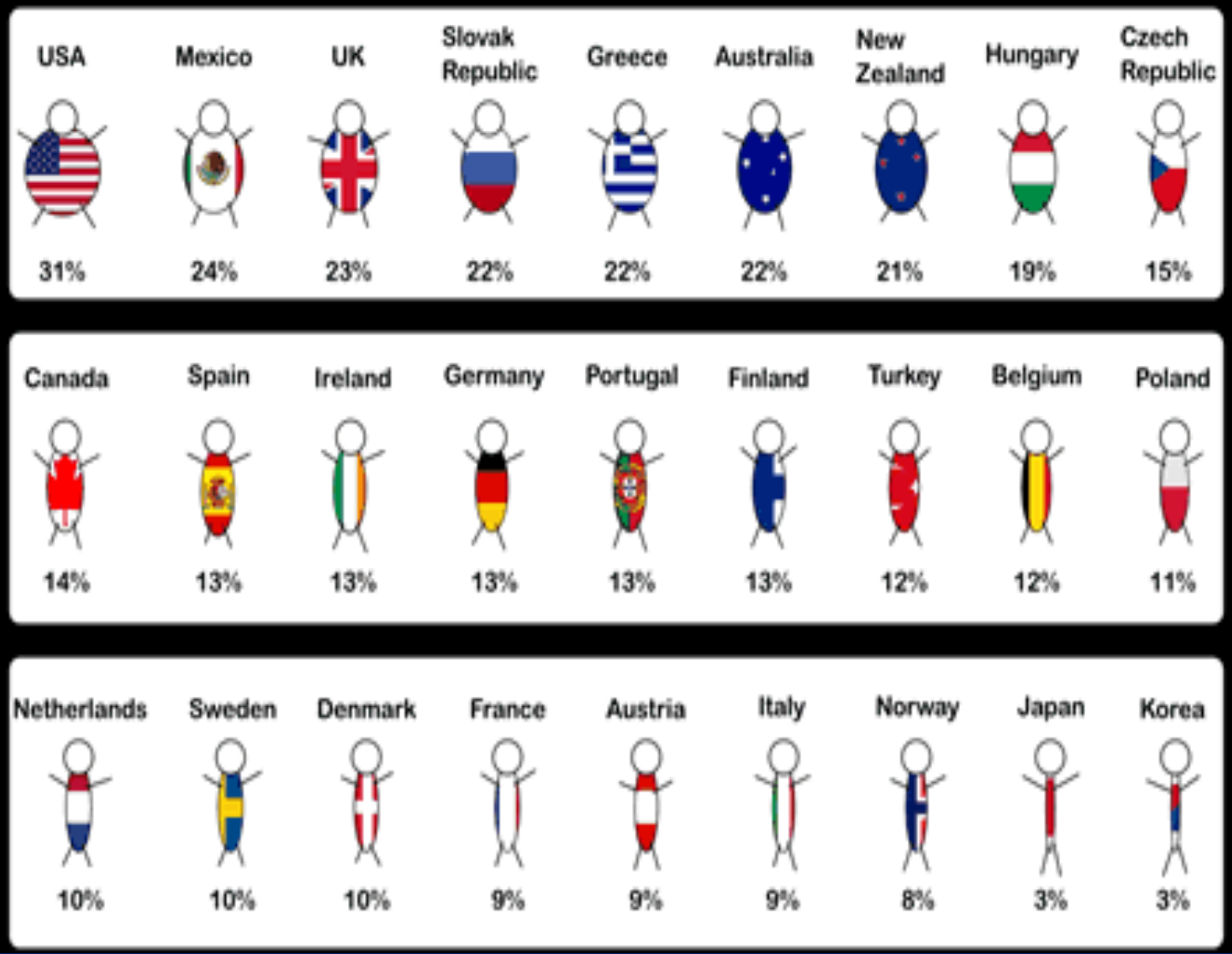
PALEO SPIRIT.COM

**IF FOOD IS OUR MEDICINE,  
SHOULDN'T WE ALL BE A LOT HEALTHIER?**



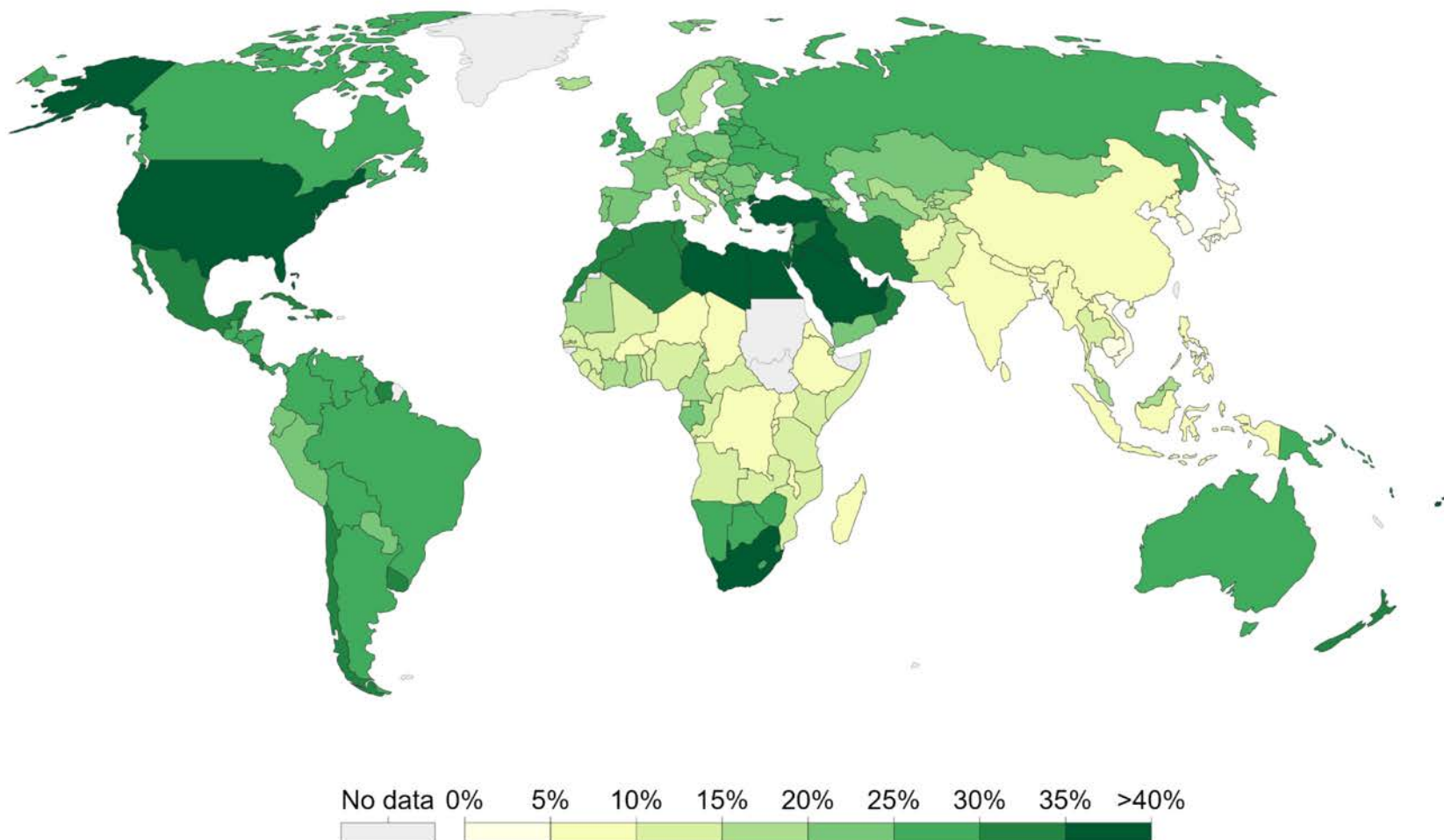
Mary Ann Lila, North Carolina State University, North Carolina Research Campus

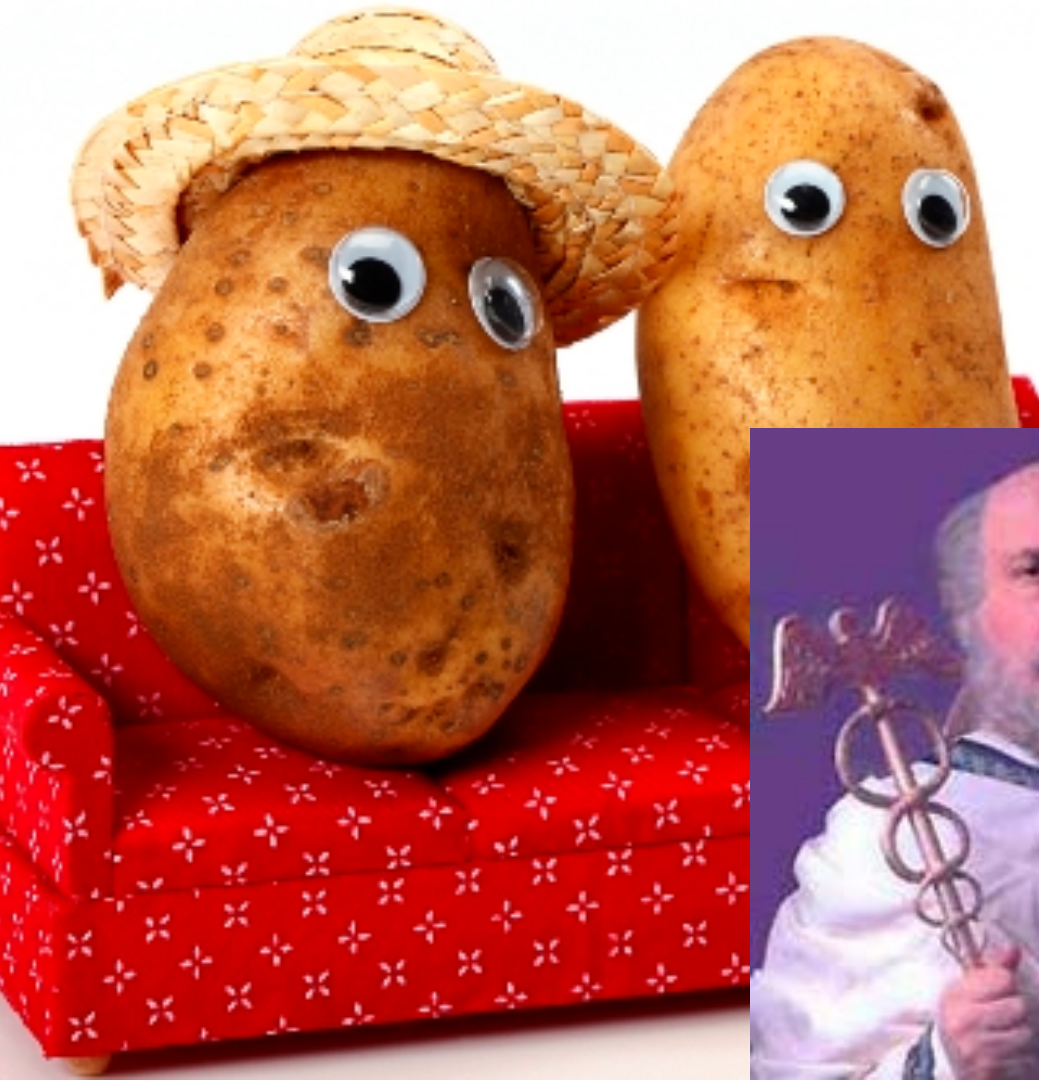
**OBESITY:** The percentage of the population older than 15 with a body-mass index greater than 30.



# Share of females defined as obese, 2016

The percentage of adult females (aged 18+ years) who are defined as obese. An adult is defined as obese if their body-mass index (BMI) is greater than 30. Body mass index is a person's weight in kilograms (kg) divided by her height in metres squared.





"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health."

Hippocrates

Wild  
Foods

Living off of the  
Land

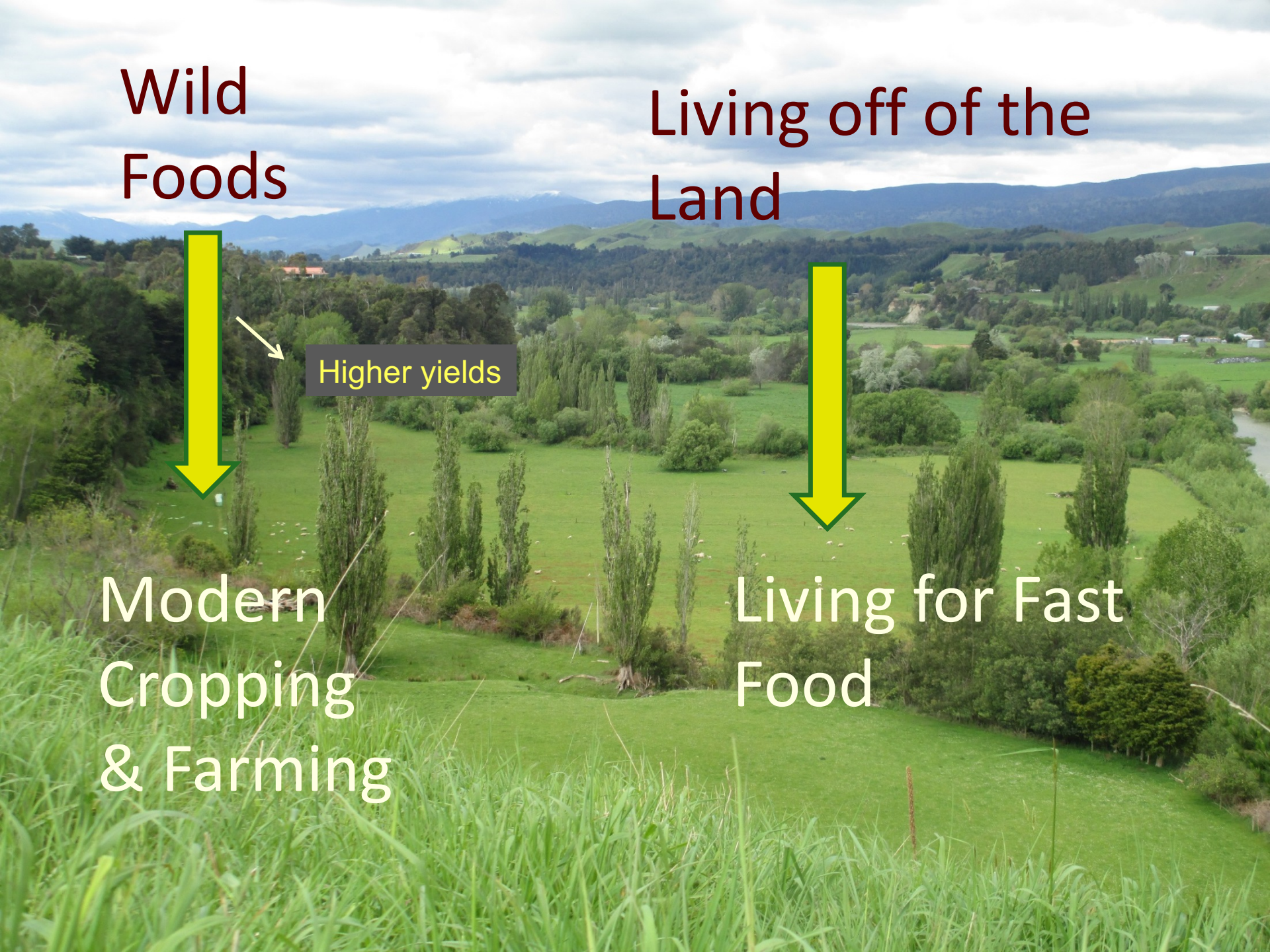


Higher yields



Modern  
Cropping  
& Farming

Living for Fast  
Food





*Planet Alaska*





# PRODUCE



PRODUCE  
Over 150 varieties



5.99  
EA.



BEVER

WINE

PHAR



In cultivation



Wild  
Foods

The Negative Outcomes:

- Reliant on high inputs
- Depleted nutrients
- Depleted/diluted phytoactives



High yields

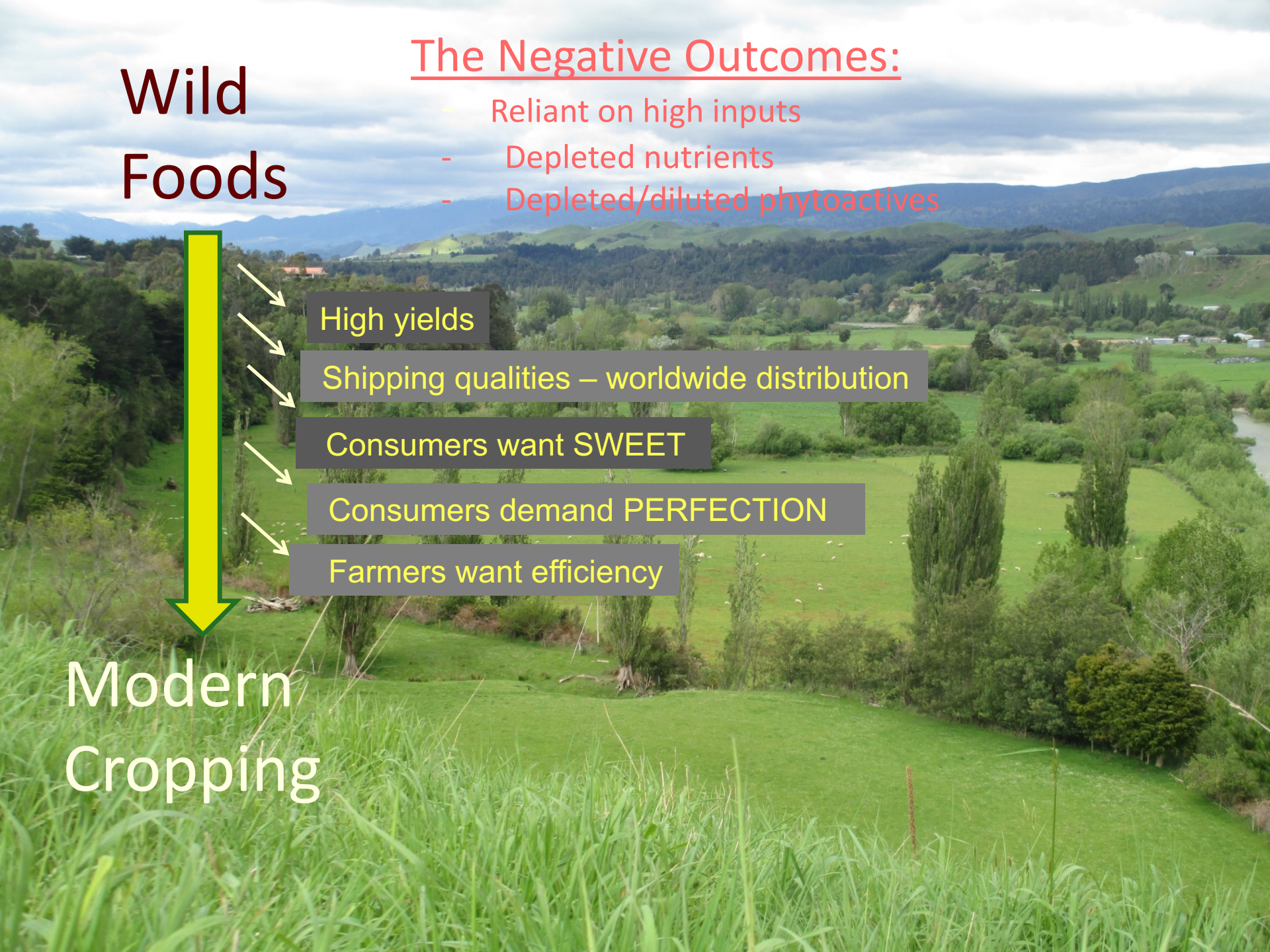
Shipping qualities – worldwide distribution

Consumers want SWEET

Consumers demand PERFECTION

Farmers want efficiency

Modern  
Cropping





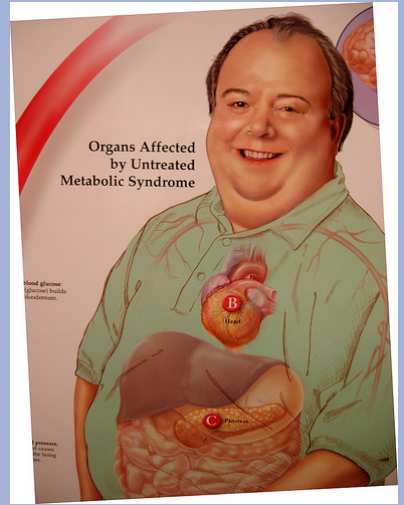
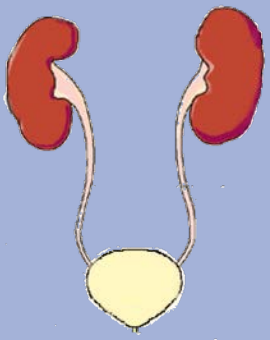
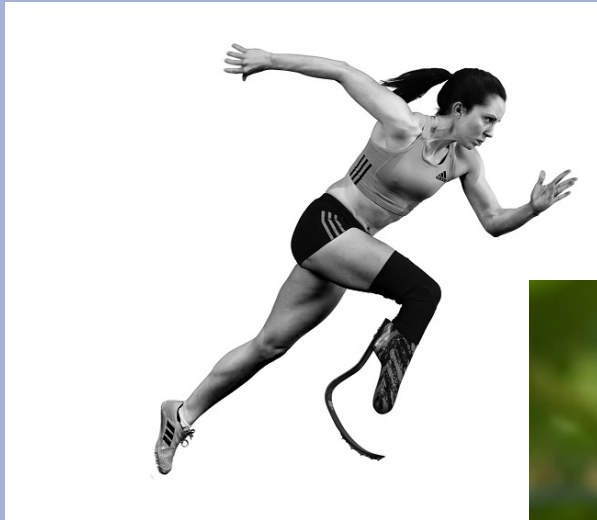


OPEN ←  
PUSH  
DOWN  
& TURN  
CLOSE →



# Multiplicity of bioactivities

<http://www.thespoof.com/news/spoof.cfm?headline=s5i82852>





**Grown in 38 states; 10 states account for 98% of the cultivated crop:**

**Michigan, Oregon, Washington, NJ, Indiana, California,  
North Carolina, Florida, Mississippi, Georgia.**

**Globally: New Zealand, Morocco, Germany, UK, Chile, Ecuador, Mexico, France, Switzerland.....**





In  
the  
WILD

What doesn't kill you makes you STRONGER







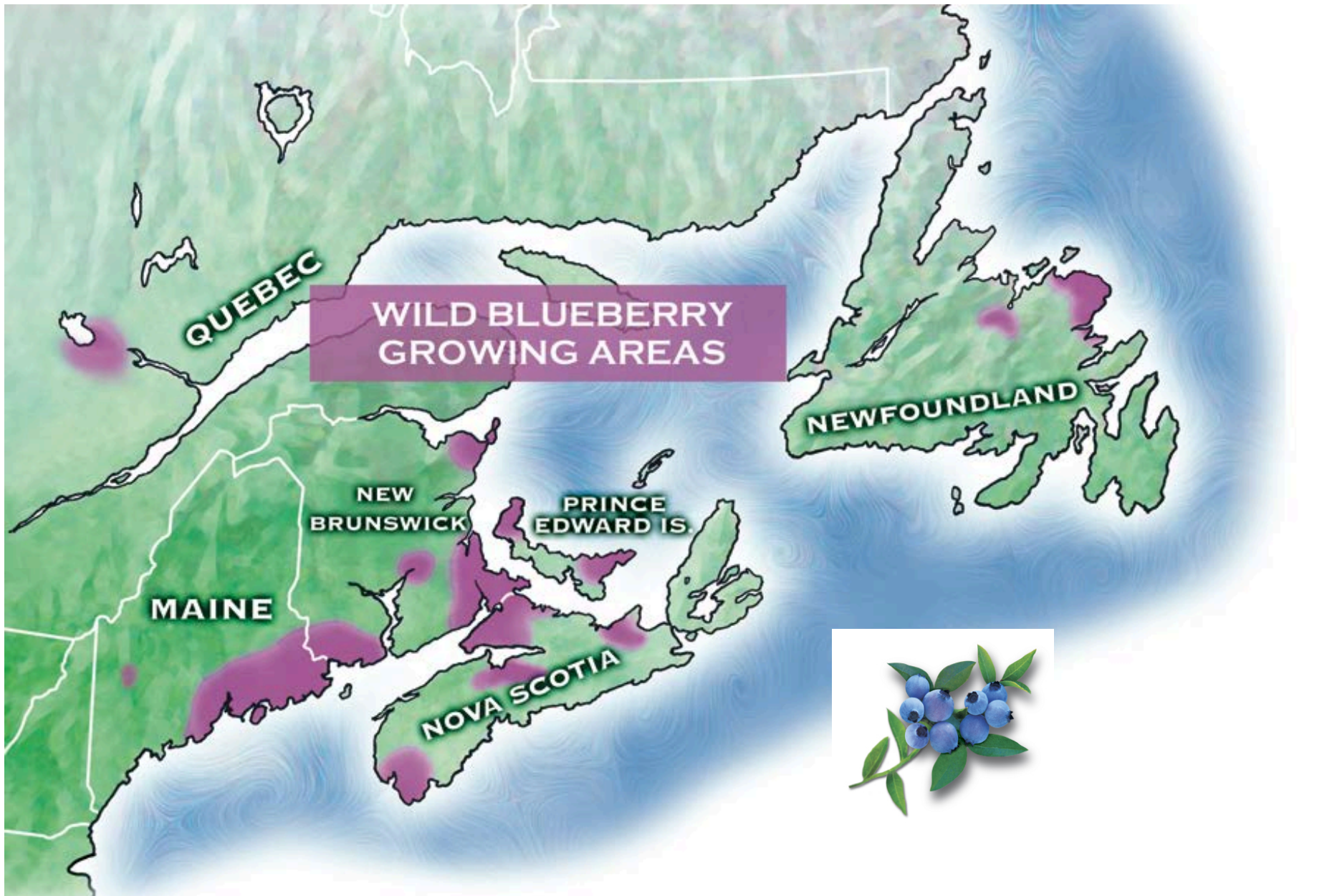




blueberries







# Stressed for Success

**elicitation**



# Blueberry (*Vaccinium* spp.)





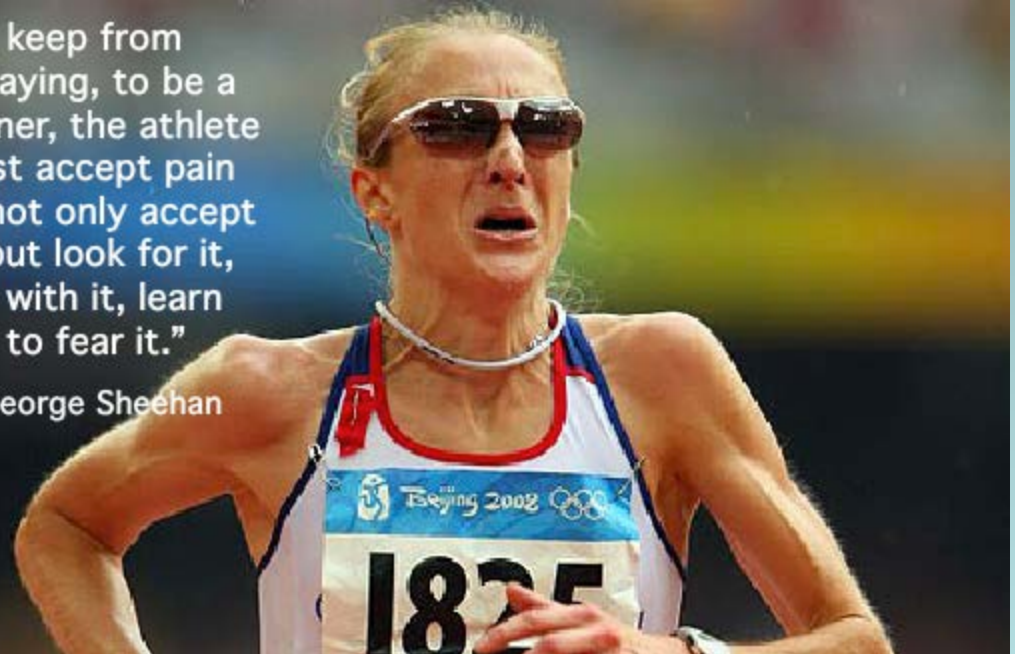


# NO PAIN, NO GAIN



“To keep from decaying, to be a winner, the athlete must accept pain — not only accept it, but look for it, live with it, learn not to fear it.”

— George Sheehan





NO STAIN,  
NO GAIN

16 wk – 2.2#

35 d – 3.7#



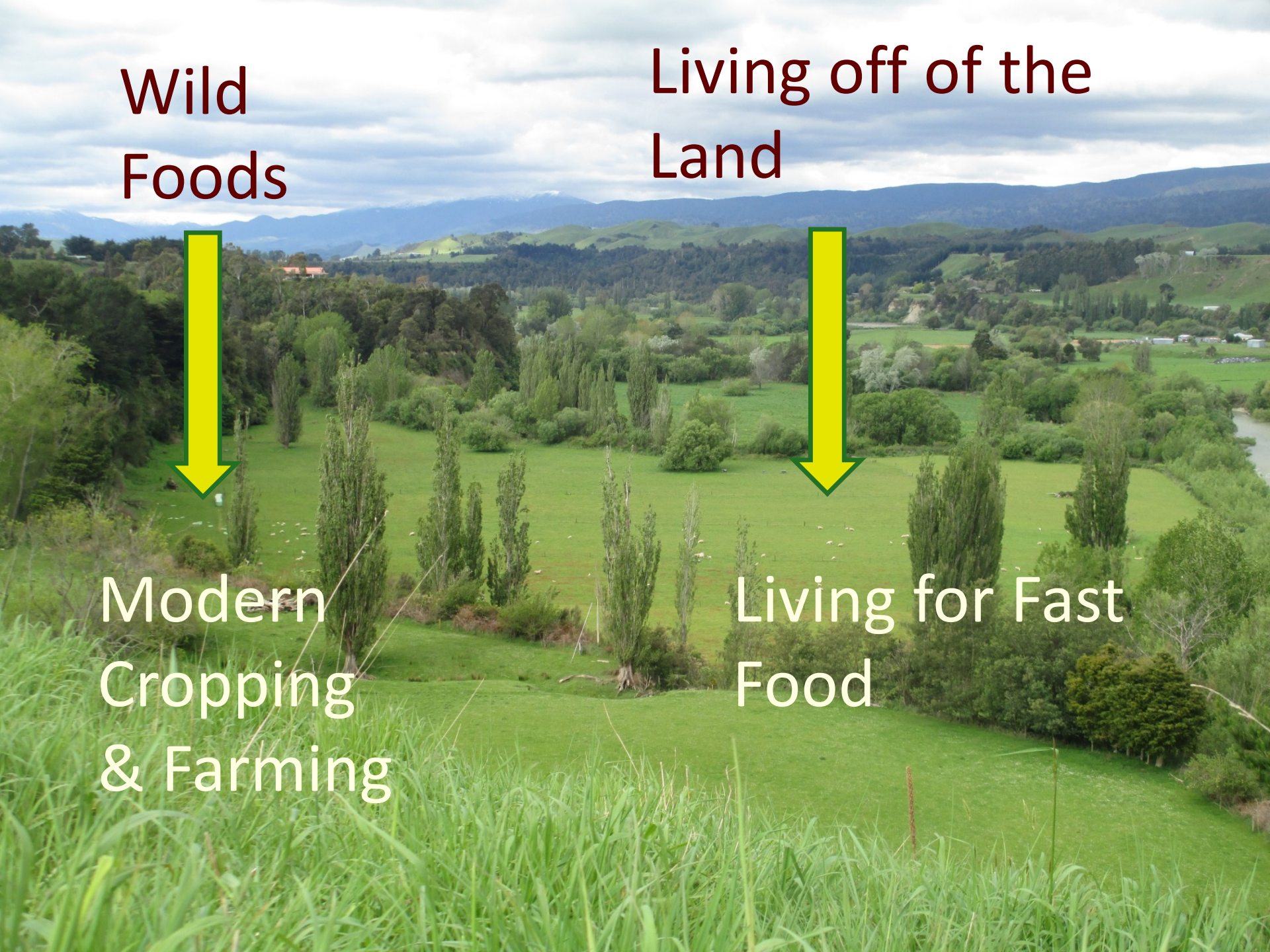
Wild  
Foods

Living off of the  
Land



Modern  
Cropping  
& Farming

Living for Fast  
Food







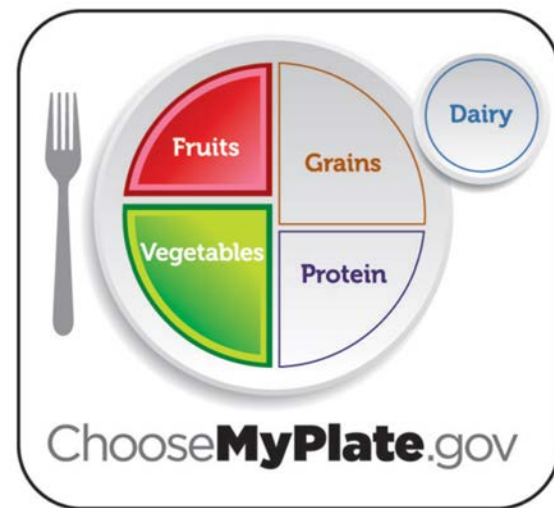
Western Diets, Western (sedentary) Lifestyles



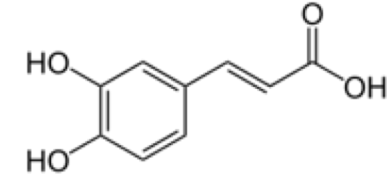
Diet |  
Nutrients  
& phytoactives



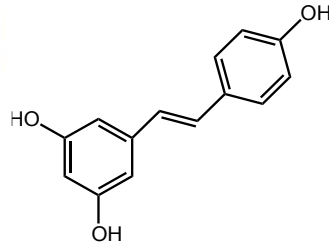
Exercise/  
movement

**Title: Closing the gap in delivery of  
fruit and vegetable benefits****\$2M****Partners:** NCSU PHHI; Dole; GMI; Standard Process, Sensory Spectrum**Problem:** Only 13% of population consumes the  
4.5 Servings recommended by 2015 DGA**Goal:** Develop strategies that close the gap in  
delivery of fruit and vegetable health benefits  
through improvement of nutritional quality and  
effectiveness (bioavailability) of food products.**Genomics → Metabolomics → Bioavailability****Approach:** Expansion of breeding strategies to identify genetic  
factors that control bioavailability of micronutrients/bioactives  
can be leveraged with emerging technologies (ingredients) to  
develop processed products that can improve delivery of fruit  
and vegetable benefits to consumers.

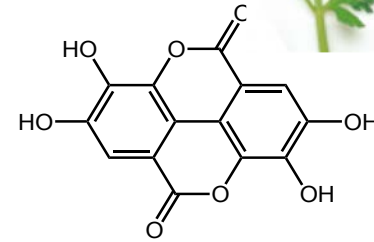
# *Polyphenols are key phytoactive components of fruits and vegetables and have been linked to health outcomes*



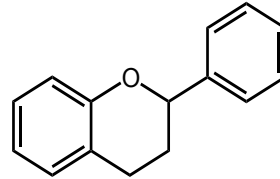
**Phenolic Acids**



**Stilbenes**



**Ellagic Acid**



**Flavonoids**



## *Prevention of Chronic Disease and Promotion of Health*



**Heart Health**



**Brain Health**



**Cancer Prevention**



**GI Health**

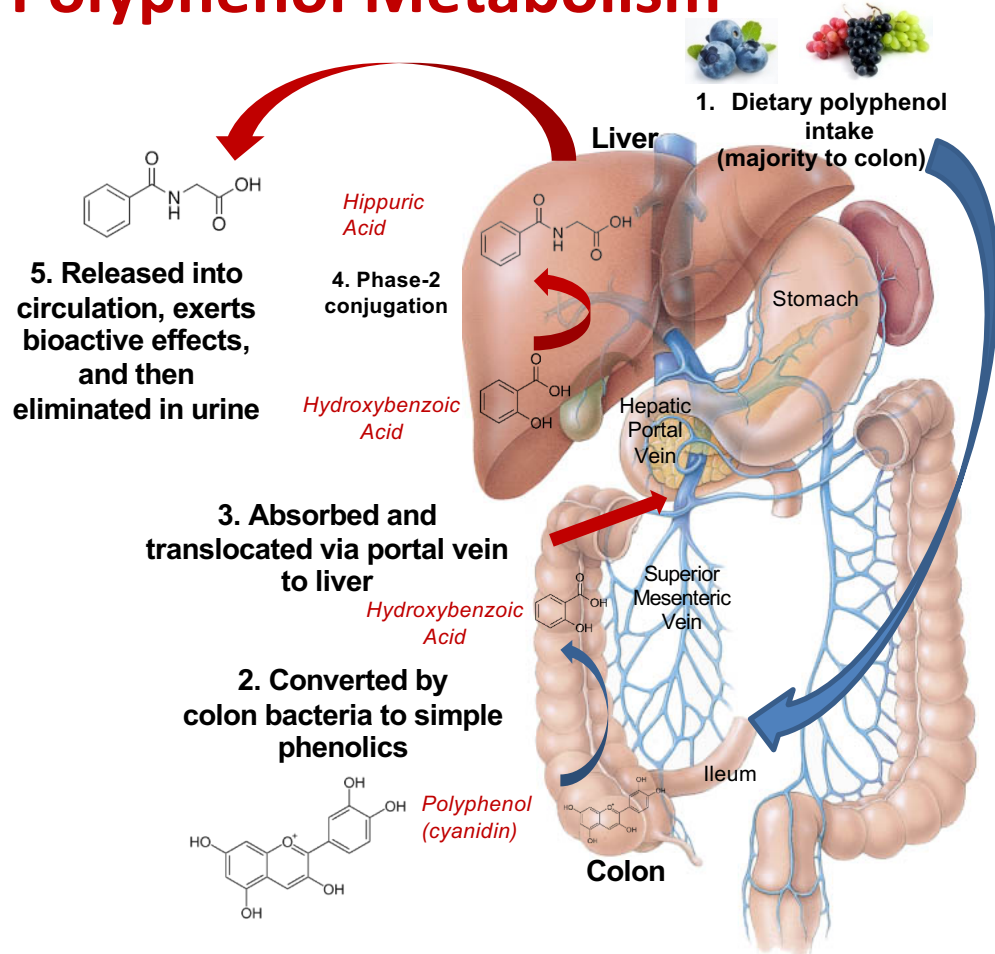


**Obesity**



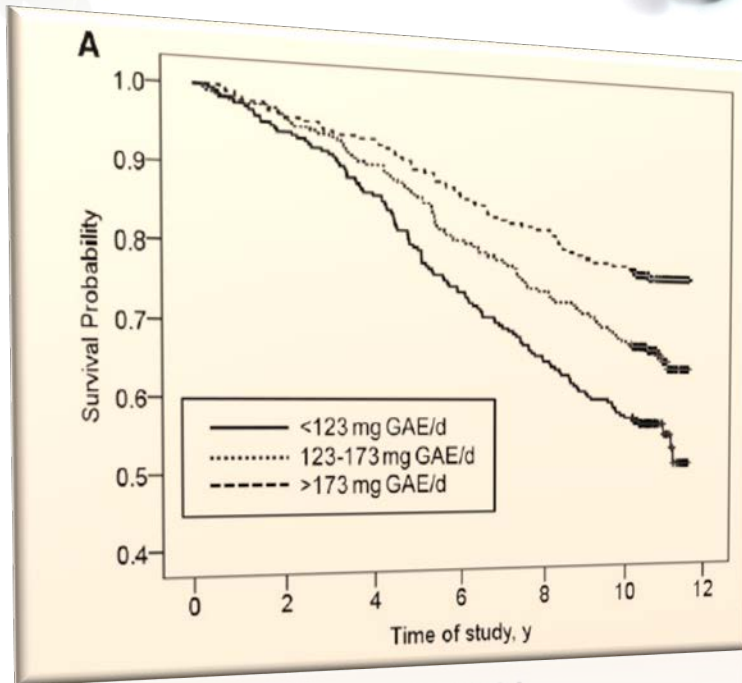
**Diabetes**

# Polyphenol Metabolism



Sources: Nieman DC. *Nutrients*. 2017 May 18;9(5); *Nutrients* 2016, 8, 636.

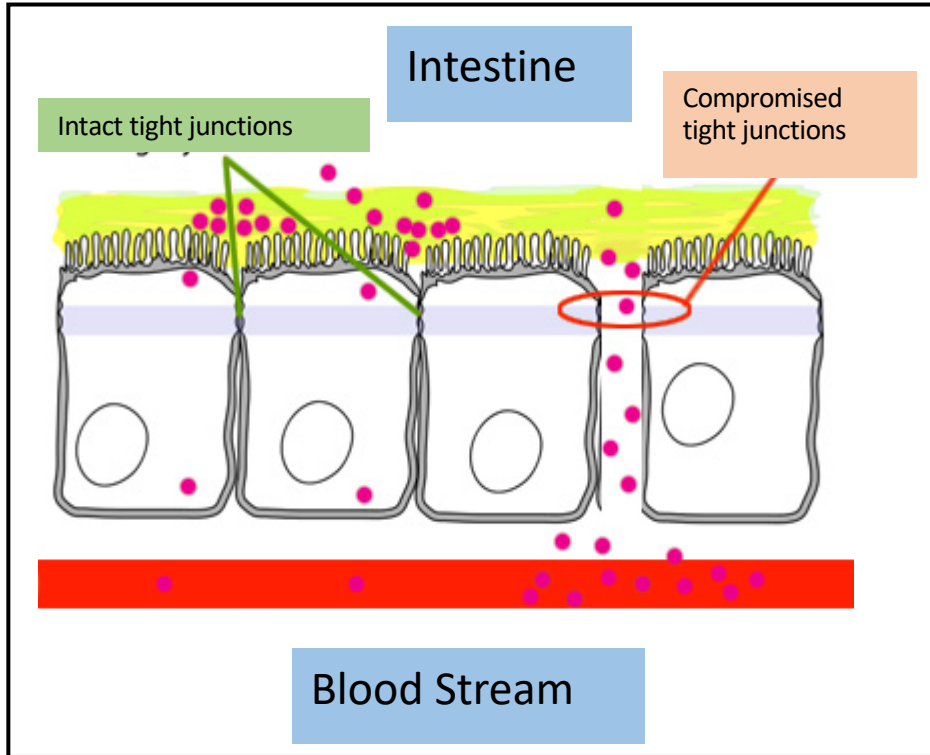
- Most ingested polyphenols reach the colon.
- Microbial degradation transforms into simple phenols (and improve colon health and microbiome).
- Phenols can be reabsorbed into the portal vein (augmented with exercise), and undergo phase II biotransformation in the liver.
- Then enter the blood and exert beneficial effects.
- Finally excreted in the urine.



**High urine phenolic content reflects high diet intake of polyphenols, and is linked to 30% lower mortality. *J Nutr* 143: 1445–1450, 2013.**

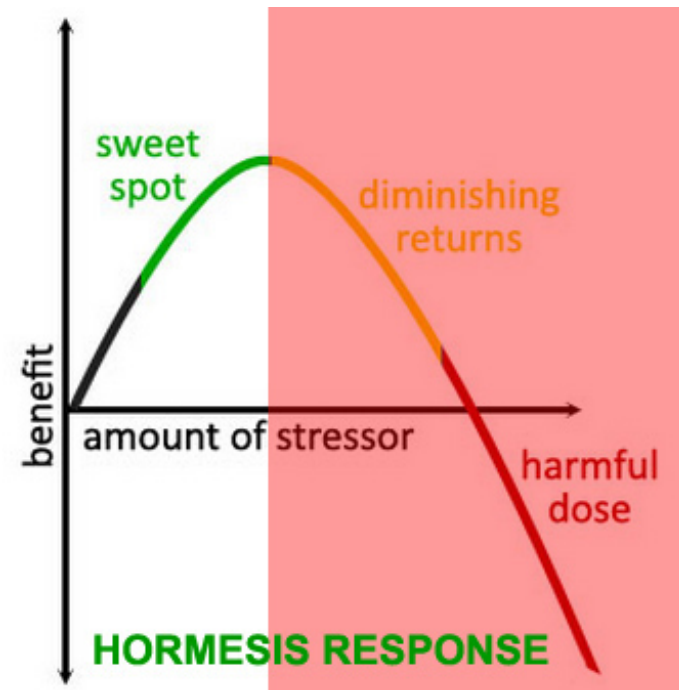


# Intestinal Permeability

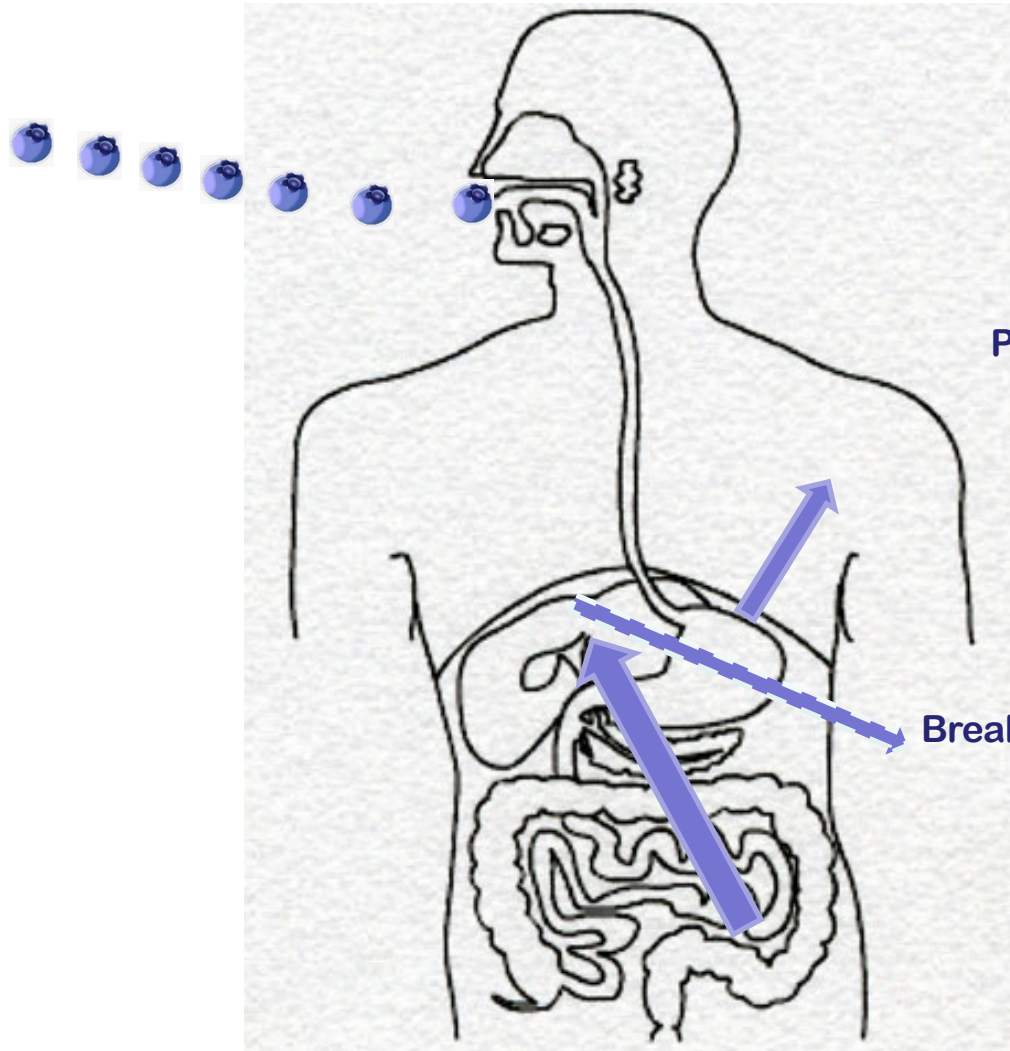


- Symptom of several disorders
  - Celiac's, Crohn's, Obesity, IBS
- Common after strenuous exercise
  - Chronic vs Intermittant
  - Hormesis Effect

- Tight junctions between epithelial cells form a barrier between the gut and the bloodstream
- Regulates nutrient absorption, prevents antigens, toxins and microorganisms from entering the bloodstream







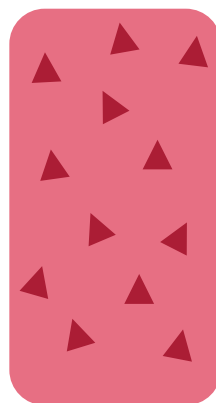
Parent compounds (polyphenolics, flavonoids)

Breakdown metabolites (bioactive phenolic acids)

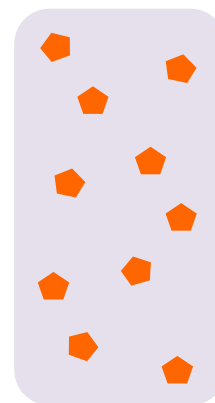
# Protein-Polyphenol Colloidal Aggregate Particles for Delivery of Fruit and Vegetable Phytoactives in Consumer Products



Juice/Pomace



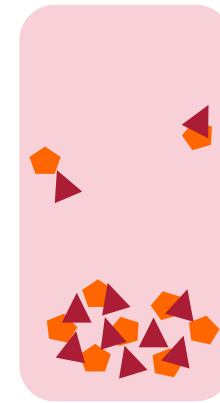
Food proteins



+

=

Adjust to pH 4.5  
Centrifuge



**Polyphenols:** cranberry, blackcurrant, and muscadine

**Protein:** WPI, SPI, hemp, rice, other

## Outcomes:

- Formation of versatile colloidal aggregates
- Concentrate, stabilize and protect polyphenols and proteins = **HEALTH functionality**
- Attenuate protein reactivity and stabilize food structures = **STRUCTURAL functionality**
- Modulate food protein allergenicity

**FUNCTIONALITY** IN TERMS OF **HEALTH & TEXTURE, TASTE, STABILITY**

Prebiotics – foods that selectively stimulate growth/activity of commensal bacteria in the colon/GIT

Probiotics – live microorganisms

Synbiotics – foods that combine prebiotics and probiotics



**Blackcurrant Anthocyanins Attenuate Weight Gain and Improve Glucose Metabolism in Diet-Induced Obese Mice with Intact, but Not Disrupted, Gut Microbiome**

Debora Esposito, Thanakorn Damsud, Mickey Wilson, Mary H. Grace,  
Renee Strauch, Xu Li, Mary Ann Lila, and Slavko Komarnytsky

*J. Agric. Food Chem.*, Just Accepted Manuscript • DOI: 10.1021/acs.jafc.5b00963 • Publication Date (Web): 12 Jun 2015

Downloaded from <http://pubs.acs.org> on June 15, 2015



## Blackcurrants

40% anthocyanins

    cyanidin-3-rutinoside 42%

    delphinidin-3-rutinoside 41%

    cyanidin-3-glucoside 5%

    delphinidin-3-glucoside 11%

10% flavonols (myricetin,  
kaempferol, quercetin)

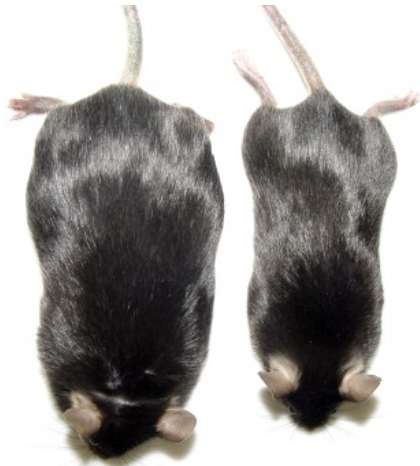
40% organic acids (citric acid, etc)

# Blackcurrant Anthocyanins Attenuate Weight Gain and Improve Glucose Metabolism in Diet-Induced Obese Mice with Intact, but Not Disrupted, Gut Microbiome

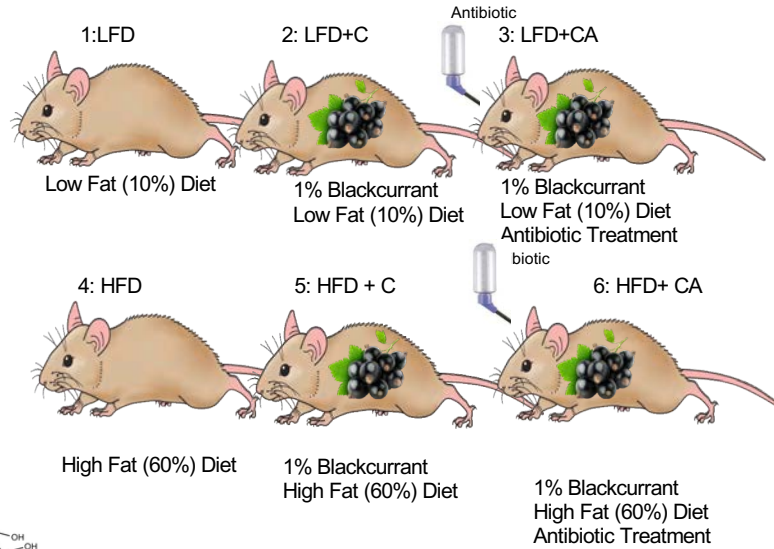
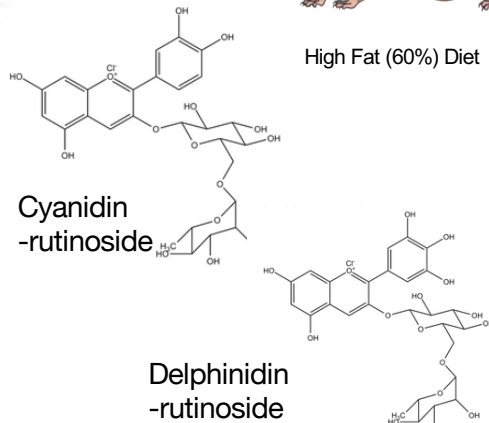
Debora Esposito, Thanakorn Damsud, Mickey Wilson, Mary H. Grace,

Renee Strauch, Xu Li, Mary Ann Lila, and Slavko Komarnytsky

# Experimental Setup

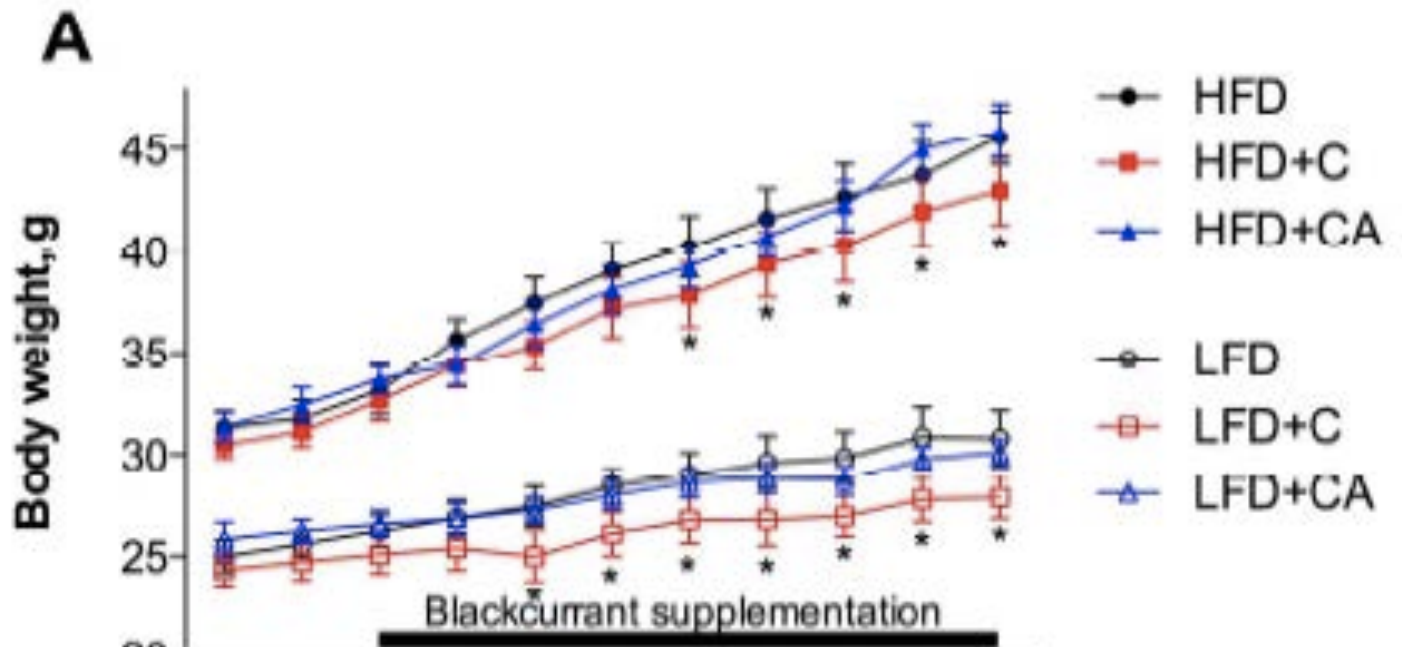


6 Weeks of Low or High Fat Diets



8 Weeks of treatment









Appalachian  
STATE UNIVERSITY



Gut derived  
polyphenolic  
metabolites  
in physically-  
active adults

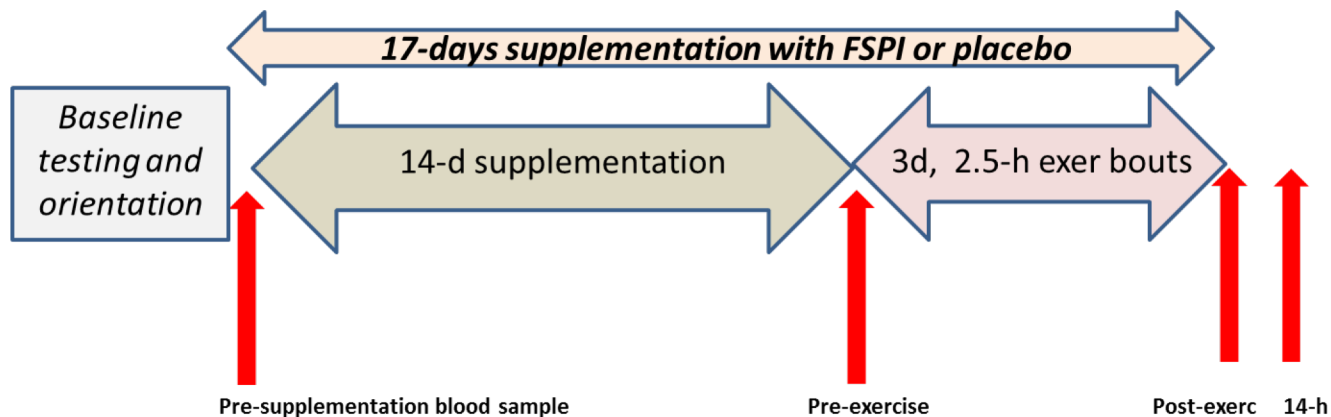






**polyphenol soy protein complex:**  
soy protein isolate matrix (26 g protein/40 g daily serving) sorbed with polyphenols from 3 c fresh blueberries and 12 fl oz. of brewed green tea or 2,136 mg/d gallic acid equivalents.

- ▶ 31 runners were randomized to PSPC (N=16) or placebo (N=15) for 2 weeks, and then completed 3 consecutive days of intense bouts of 2.5 h exercise at 70-75%  $VO_{2max}$ . Blood samples were collected as shown below.





Competitive long-distance runners ran for 2.5 h/d on treadmills at  $\sim 70\% \text{VO}_{2\text{max}}$  for 3 d in a row.

This was an intensified period of exercise for these runners, inducing “overreaching”.

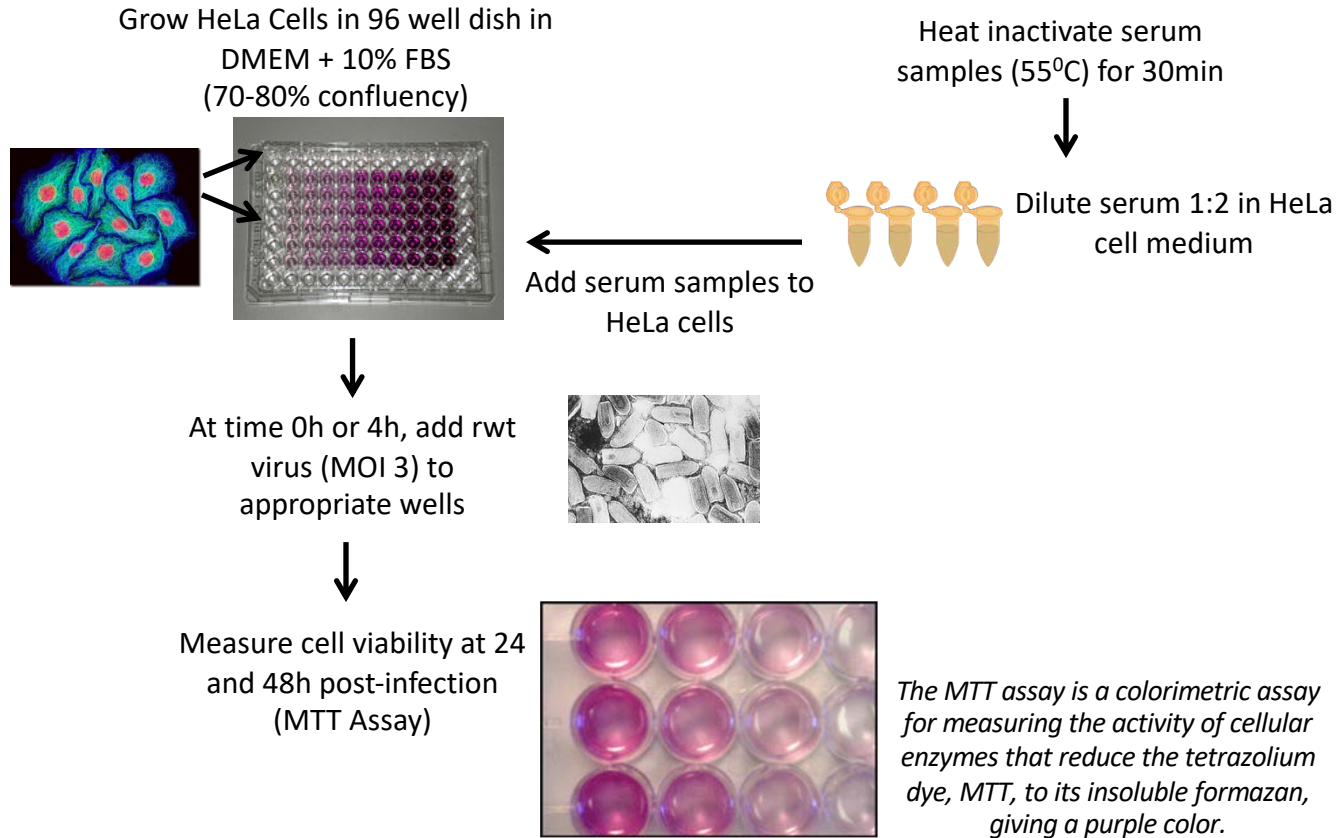
Striking results of polyphenol supplementation:

1. Polyphenolic signature (post-colonic) in serum
2. Enhanced ketogenesis (burning fat post-exercise)

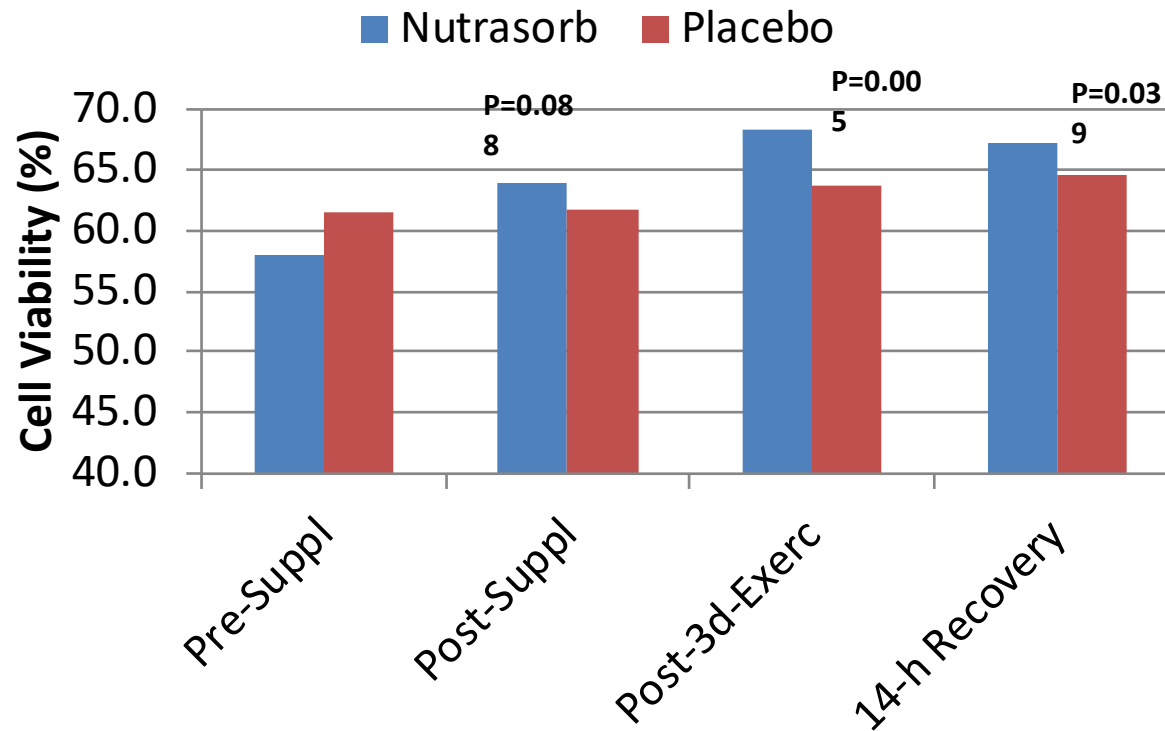




# Serum Antiviral Assay

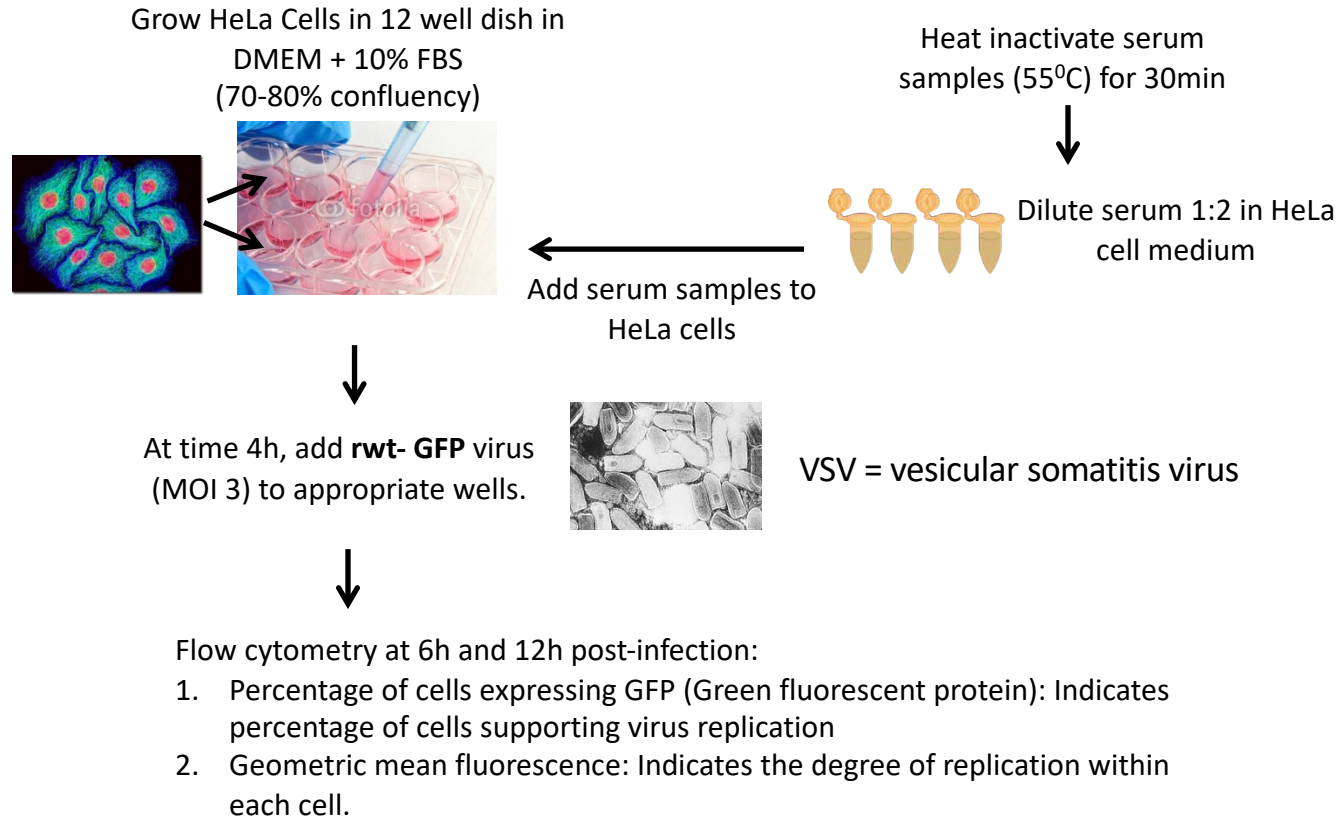


## Cell Viability Serum 4 hr --> Virus Interaction P=0.045; Time P<0.001

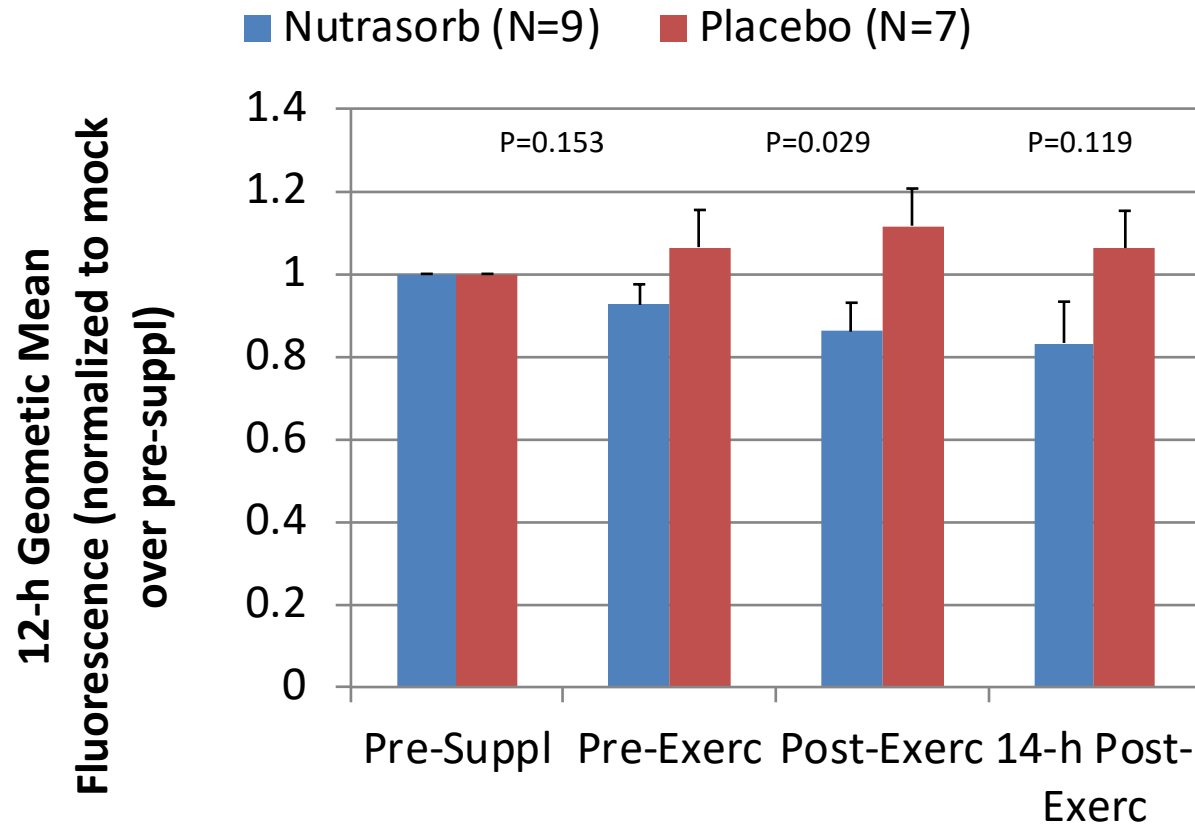


Ahmed et al. 2014. Protective effects of a polyphenol-enriched protein powder on exercise-induced susceptibility to virus infection. *Phytotherapy Research* (2014) 28:1829-1836.

# Virus Replication Assay



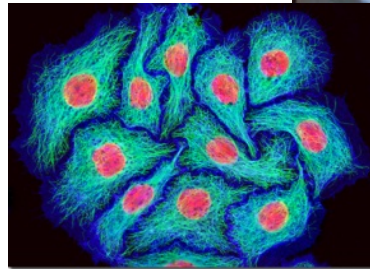
After incubation with serum from subjects for 4 h, samples were infected with rwt-GFP virus for 12 h. Data represent geometric mean fluorescence, and support decreased viral replication in polyphenol treatment samples compared to placebo. (P values represent contrasts at time point).



# Conclusions

- Serum from subjects collected after 3 days of heavy exertion (2.5 h running/day, 70%  $VO_{2max}$ ) compared to pre-exercise encouraged viral replication. (*athletes are vulnerable post exercise*)
- The use of polyphenol-rich supplement vs. placebo for 17 days prior to and during the 3-day exercise period *improved Hela cell viability and attenuated viral replication*

So..... all that we need to do is get people to exercise more, and eat functional foods



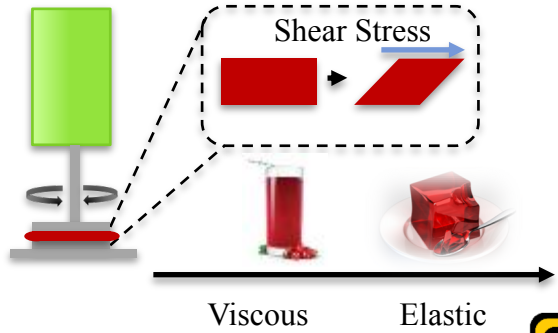




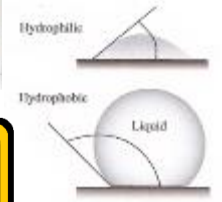
# Plants for Human Health

INSTITUTE

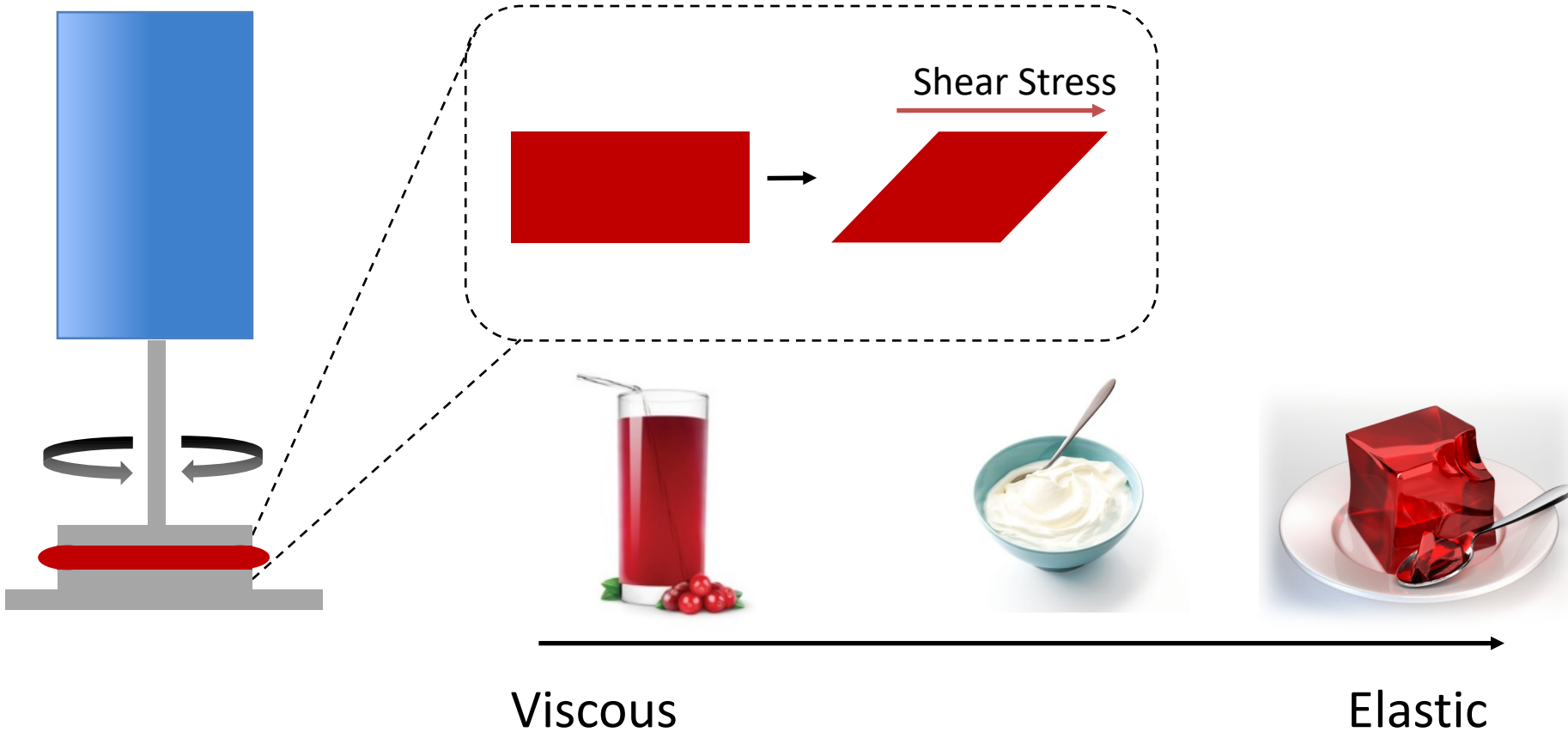
# NOVEL INGREDIENTS



Rheology



# Utilizing creep recovery to determine the viscous and elastic (viscoelastic) properties of bars



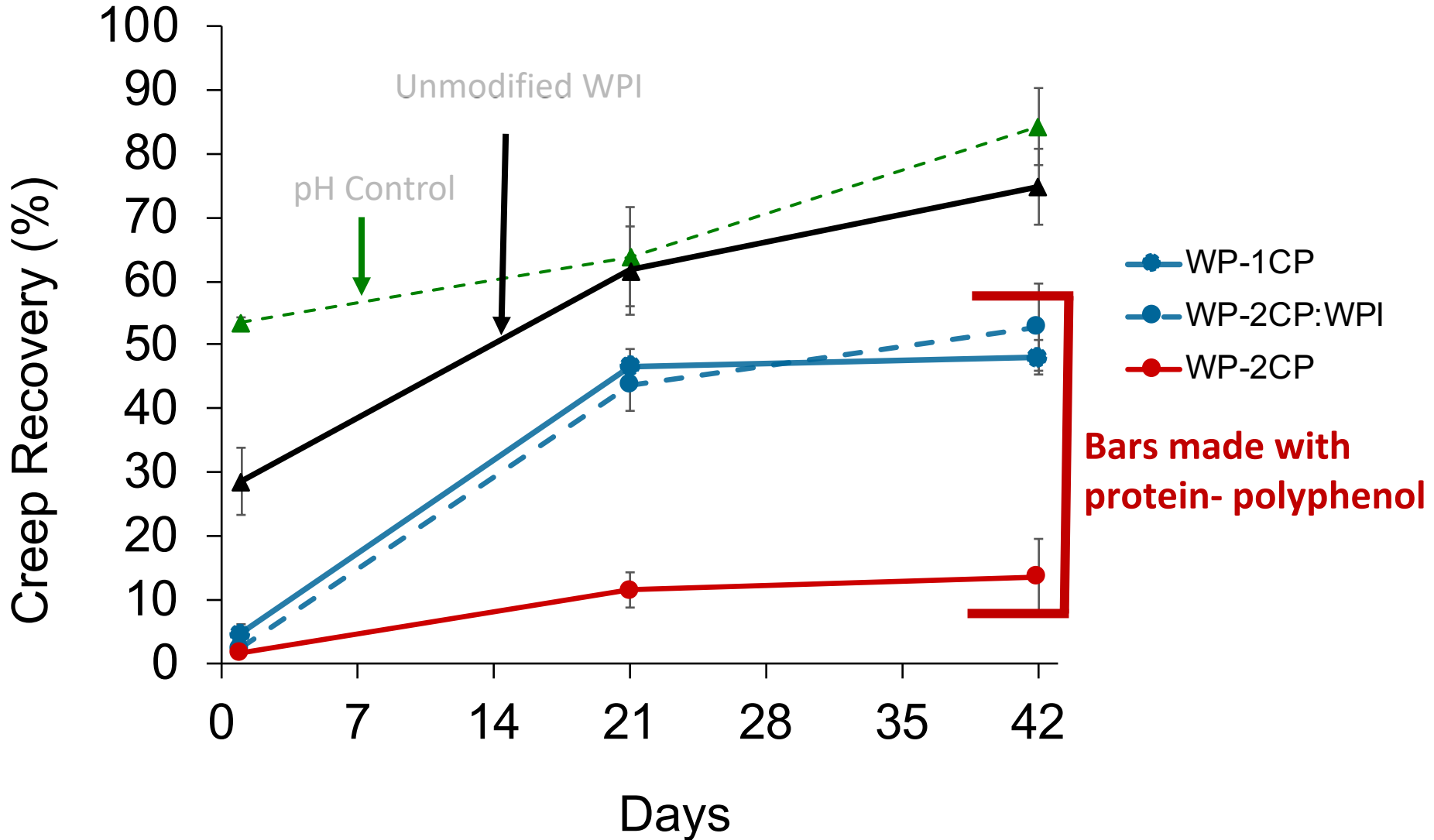
Creep Recovery (%) =  $(J_{max} - J_r) / J_{max} * 100$   
 $J_r = J_{max} - J_{min}$

$J_{max}$  = compliance after 20 sec

$J_{min}$  = minimum compliance post stress release,

$J_r$  = compliance after recovery or the difference between  $J_{max}$  and  $J_{min}$

# Reduction of Bar Hardness with the use of protein polyphenol particles



# Protein-Polyphenol Colloidal Aggregate Particles for Delivery of Fruit and Vegetable Phytoactives in Consumer Products

- Natural association of **proteins** and **polyphenols** can be used to form particles
- Modification of **interaction conditions** will modify particle properties
- Particle properties can be **modified to fit application**

## Beverages

Dry Mixes



RTD



## Cereals & Snacks





**Oral sensitization**

**Absorbed proteins (allergens)**

**Production of allergen-specific IgE**

**IgE binds on mast cells and basophils**

**Allergic reaction**

**Re-exposure to same allergen**

**Cross-linking of allergen (protein) with allergen-specific IgE**

**Release of inflammatory mediators**



!!Epiphany! Could we take advantage of the natural affinity of medium-polarity polyphenols to proteins, in order to mask or modify the allergenic protein epitopes?



# Analysis of Hypoallergenic Egg White-Polyphenol Complexes Using a Neonatal Pig Model of Food Allergy

- Efficacy testing in an *in vivo* system similar to humans

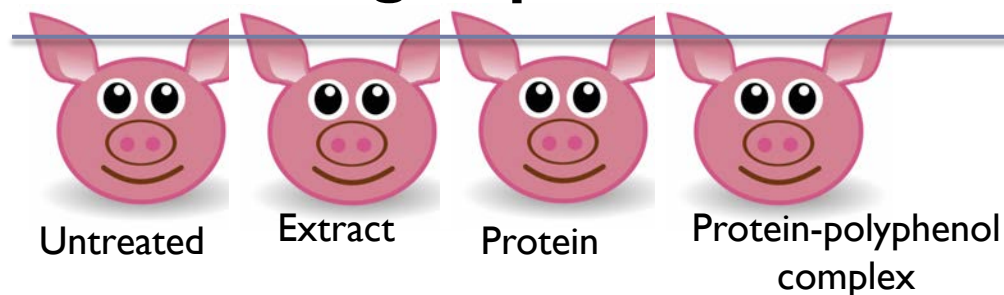
- Takes multiple digestive fluids and enzymes into account
- Takes possible interaction with GI microflora into account
- Similar gastrointestinal tract
- Neonatal pig model mimicked physical and immunologic characteristics of peanut allergy in humans (*Helm et al., 2002*)



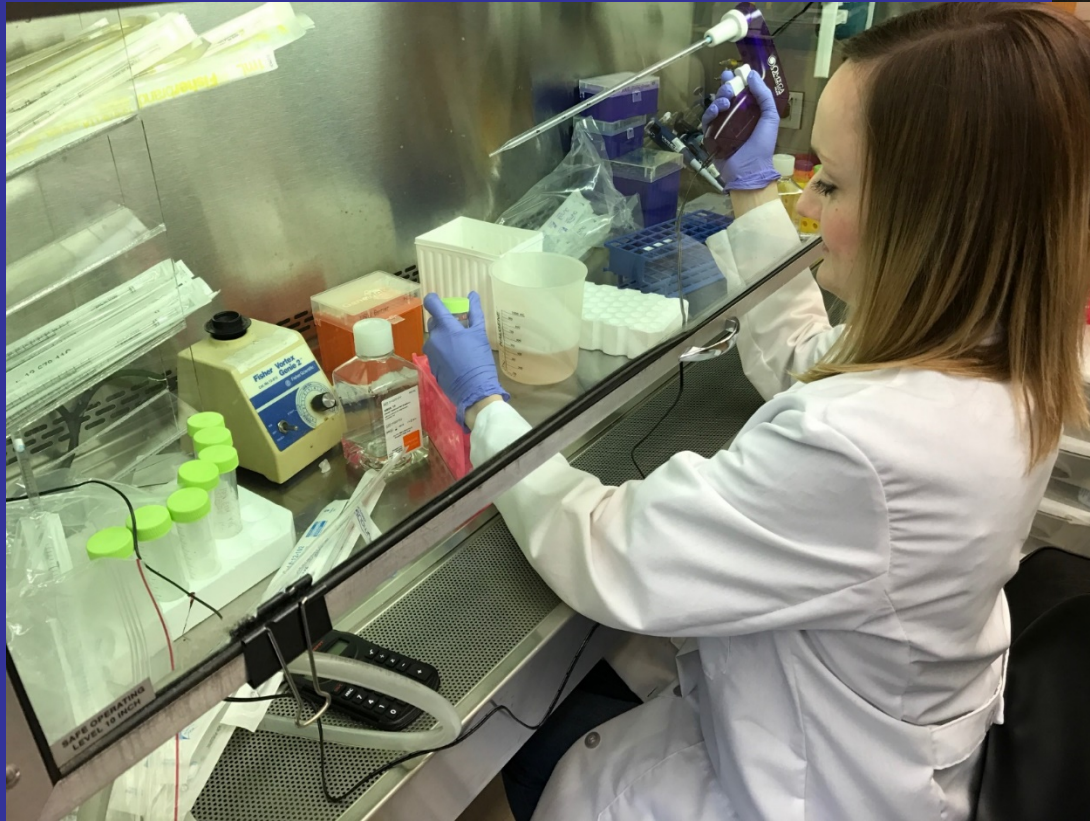
- Sensitization with target protein + cholera toxin
- Skin test
- Bleeding and storage of serum



## 4 groups



# Porcine model of food allergy

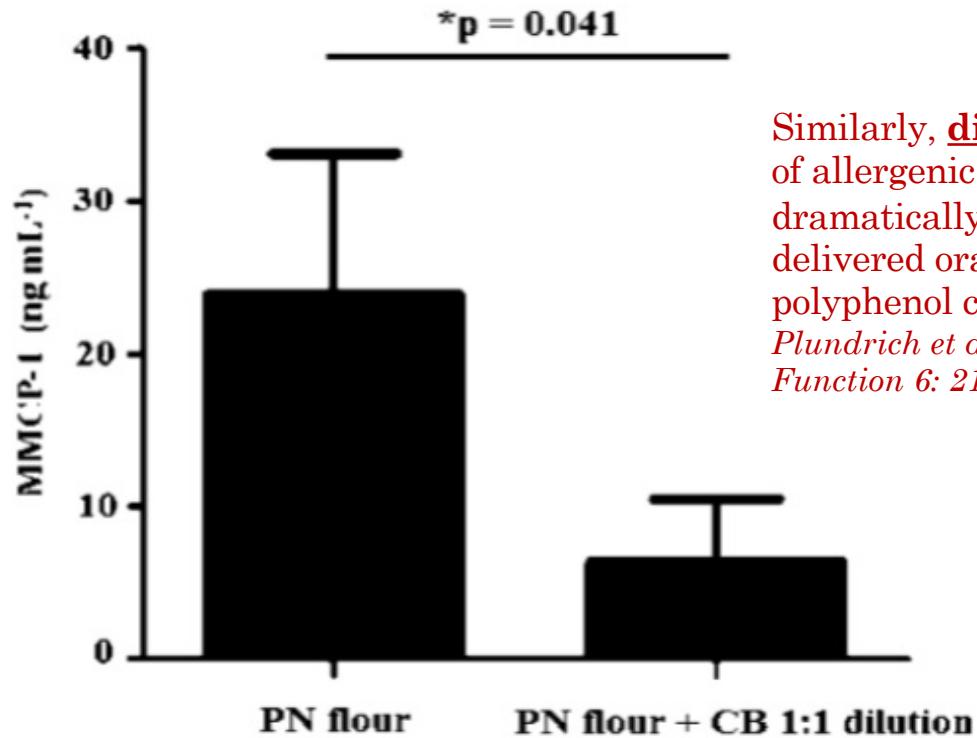


Symptoms: vomiting, diarrhea, skin reactions, and infiltration of eosinophils in the esophagus of egg-allergic pigs



*In vivo*

## Oral food challenge



Similarly, digestive fragments of allergenic proteins were dramatically less reactive when delivered orally as protein-polyphenol colloidal aggregates  
*Plundrich et al., 2015. Food & Function 6: 2145-2154.*

**FOOD AS OUR MEDICINE| APPLICATIONS FOR FOODS THAT DELIVER  
HEALTH PROTECTIVE INGREDIENTS AS WELL AS BIOAVAILABILITY**



Sport &  
Military

**FOOD AS OUR MEDICINE| APPLICATIONS FOR FOODS THAT DELIVER  
*HEALTH PROTECTIVE INGREDIENTS AS WELL AS BIOAVAILABILITY***

The Developing World – Humanitarian Aid



**FOOD AS OUR MEDICINE| APPLICATIONS FOR FOODS THAT DELIVER  
HEALTH PROTECTIVE INGREDIENTS AS WELL AS BIOAVAILABILITY**

.....the American public





1. We are what we eat
2. We must move to get all the benefits from it

Thank you!



