

# Functional Foods – linking nutrients to disease.

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University of Auckland  
New Zealand



**LIGGINS INSTITUTE**  
**THE UNIVERSITY OF AUCKLAND**  
**NEW ZEALAND**

Te Whare Wānanga o Tāmaki Makaurau

# Functional/Dysfunctional

- Will the real functional food stand up?
- Dysfunctional food
  - Too much, too often
- Fats - form, function and physiology
- Sweetness and light
- The ORIGINAL SUPERFOODS
- Antioxidants – yes/no
- Why eat rabbit food?

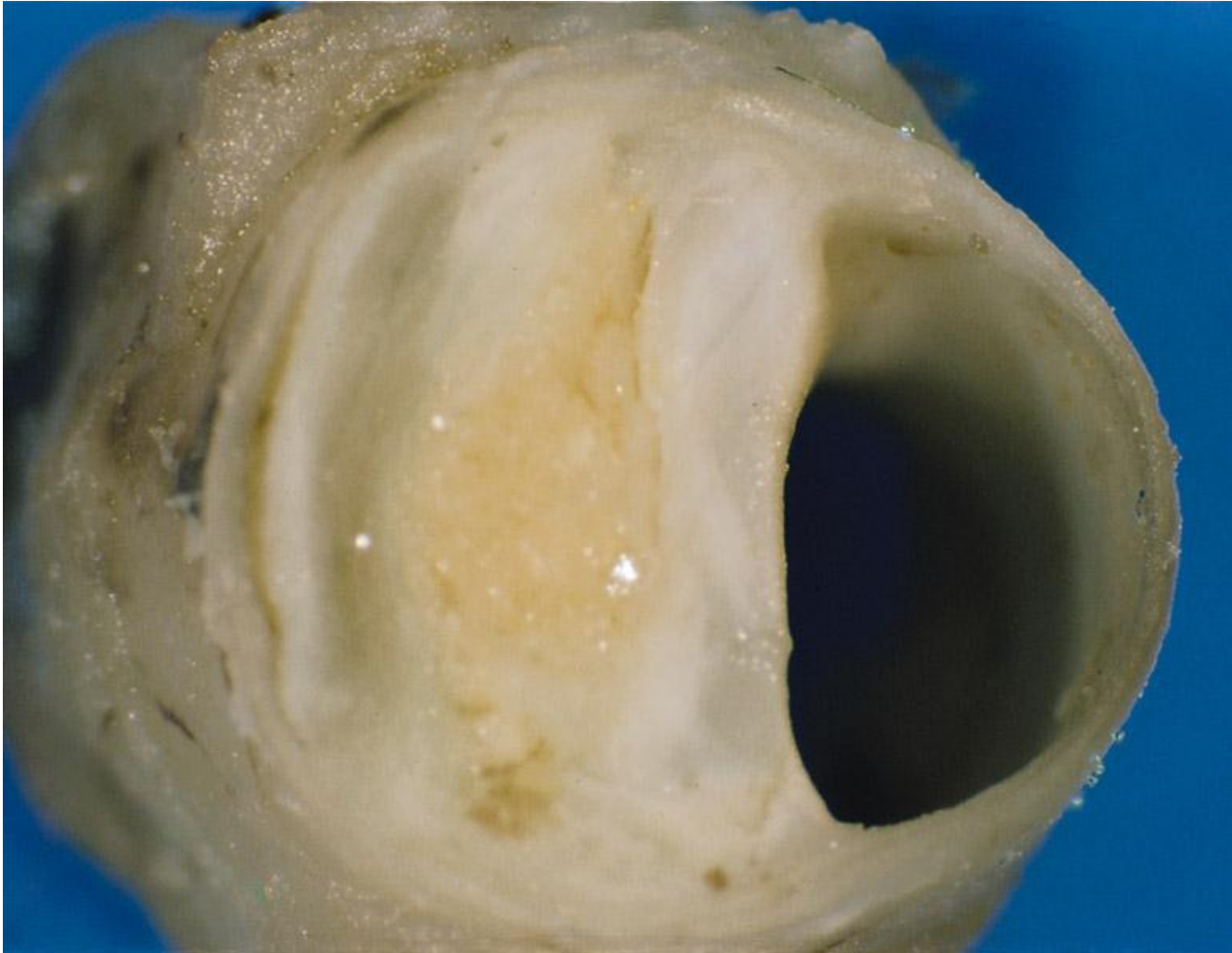


# Superfoods

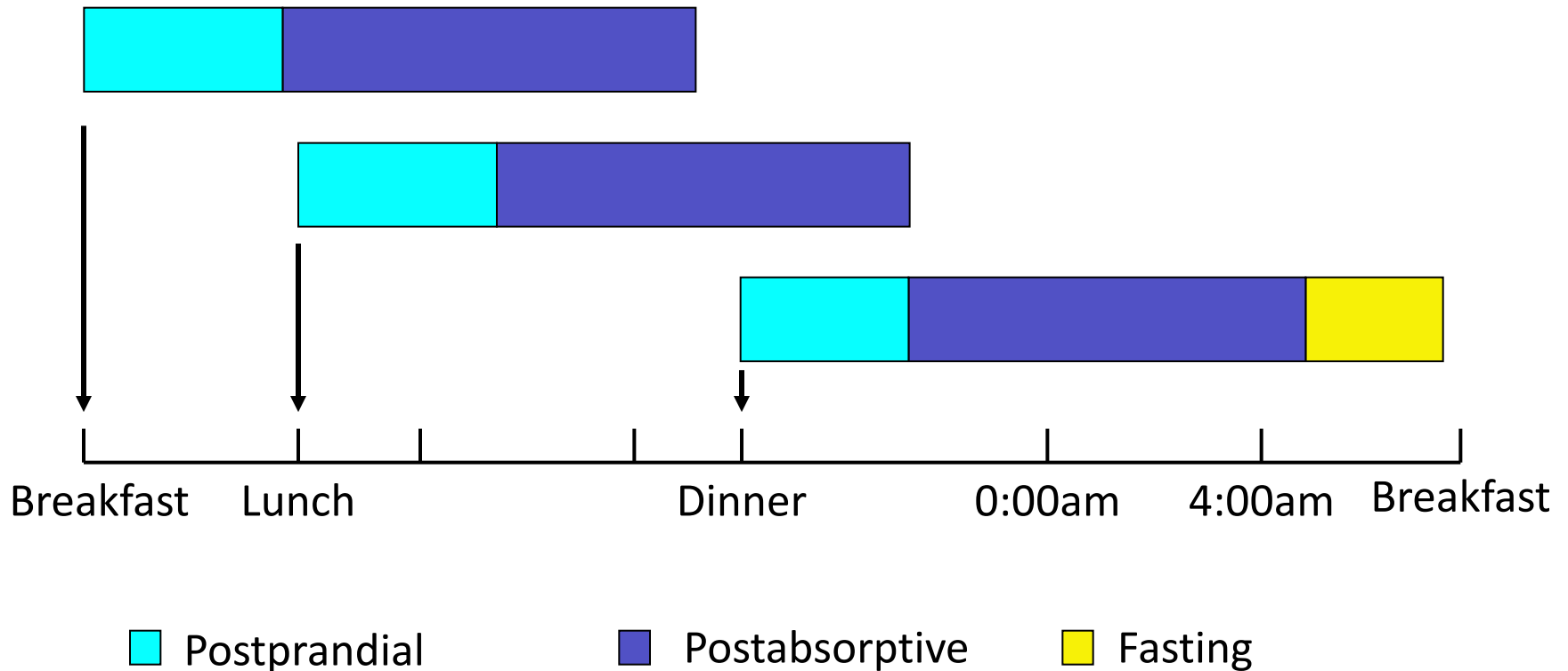
1972



# Atherosclerosis

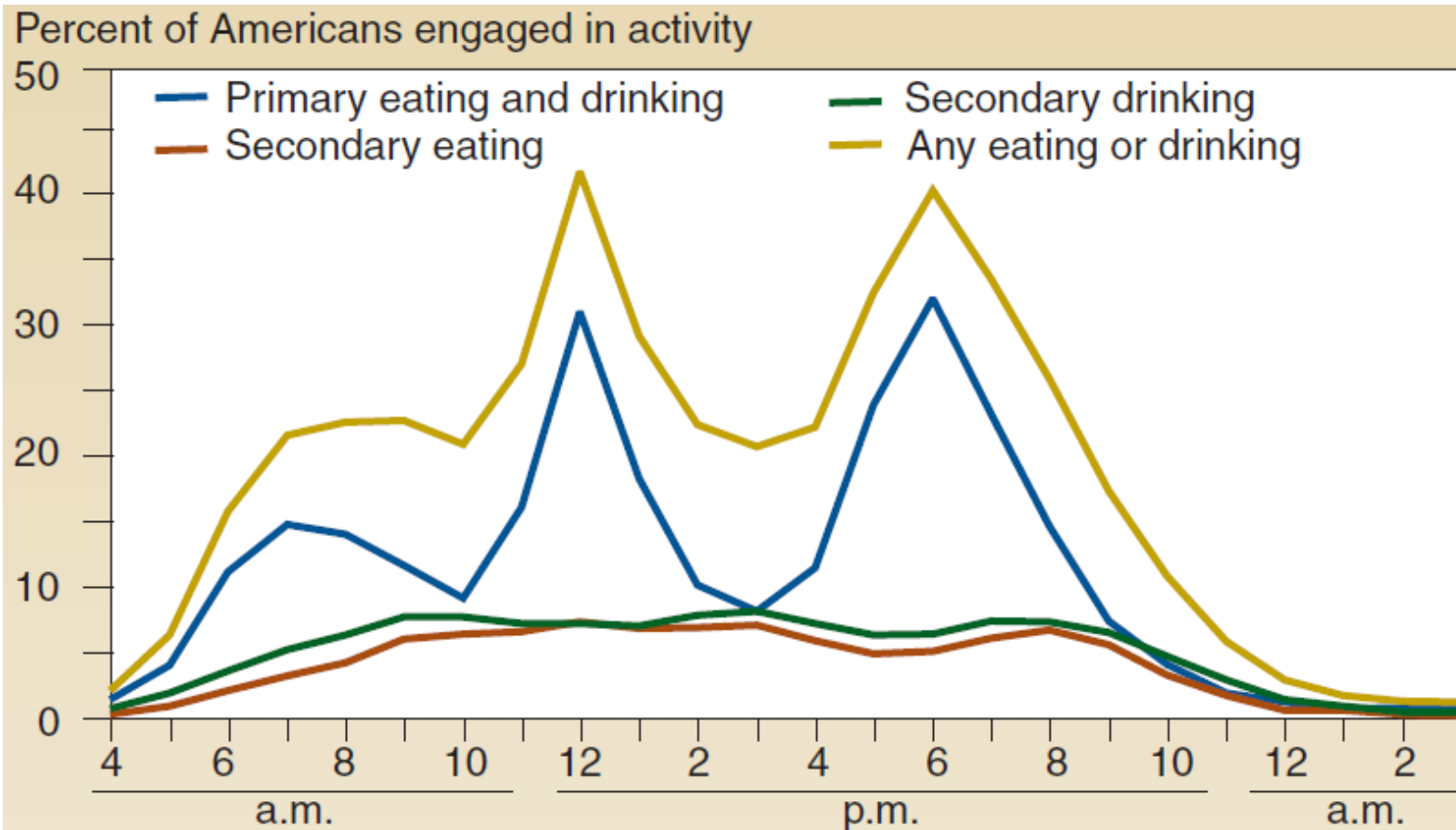


# How we spend our day....



Monier L. Eur. J. Clin. Invest. 30(suppl 2): 3-11, 2000

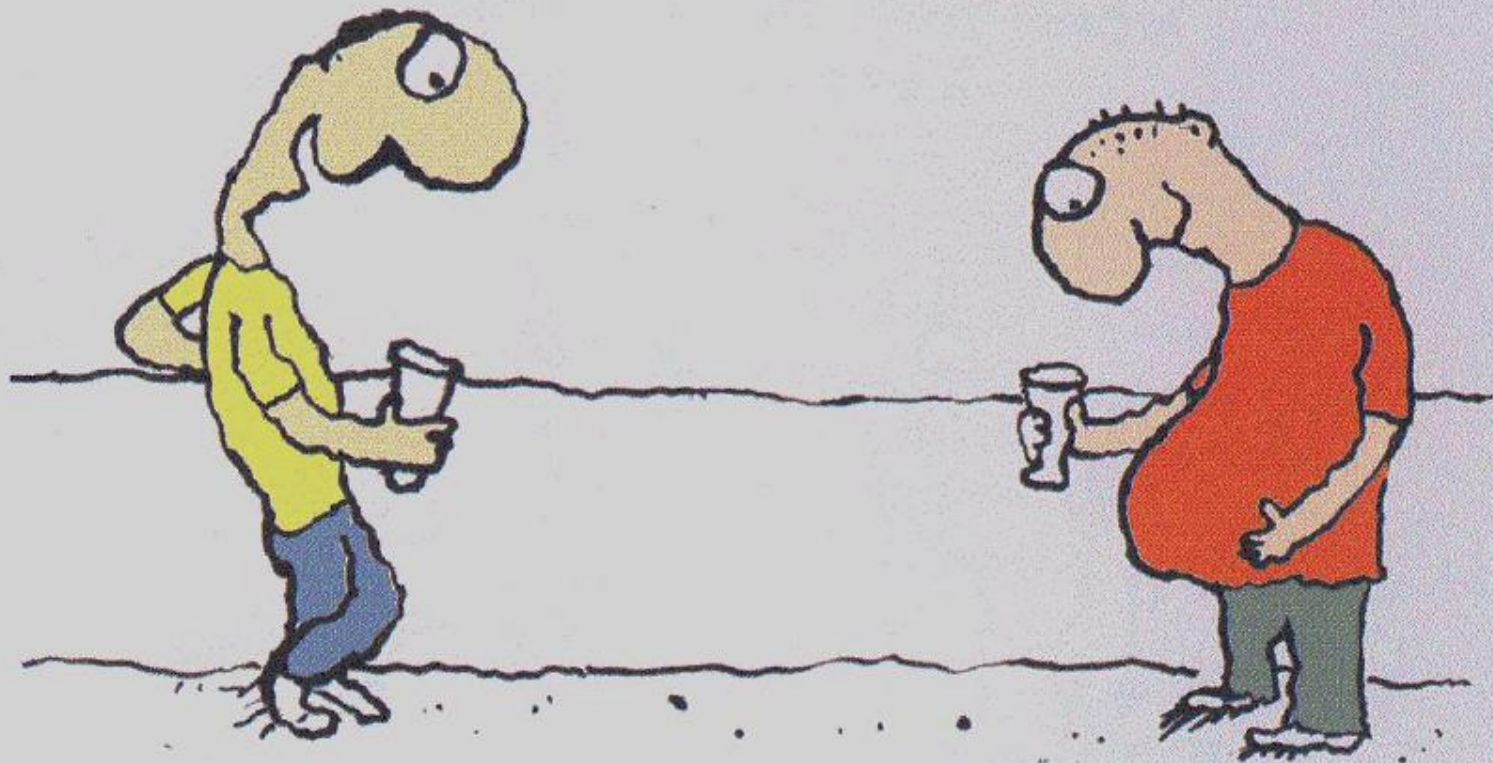
# We eat...often



Note: Data include civilian population age 15 and over.

Source: Bureau of Labor Statistics 2006 American Time Use Survey and ERS 2006 Eating & Health Module.

That's quite an explosive  
suicide belt you've got  
there, Craig.

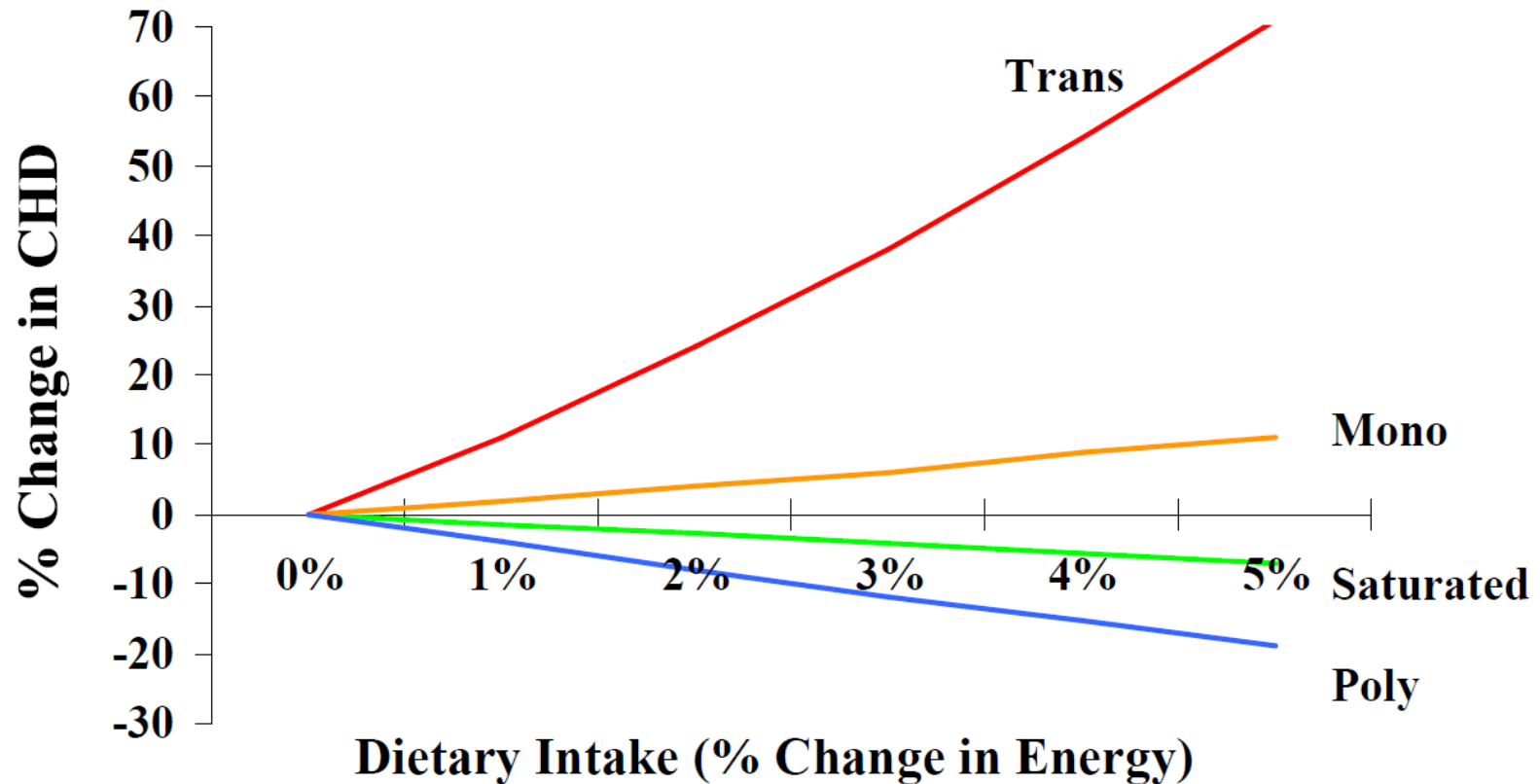


Leunig

# The emerging role of Inflammation



# Dietary Fats and CHD



Based on a meta-analysis of 4 prospective cohort studies (for TFA) and a pooled analysis of 11 prospective cohort studies (for SFA, MUFA, and PUFA).



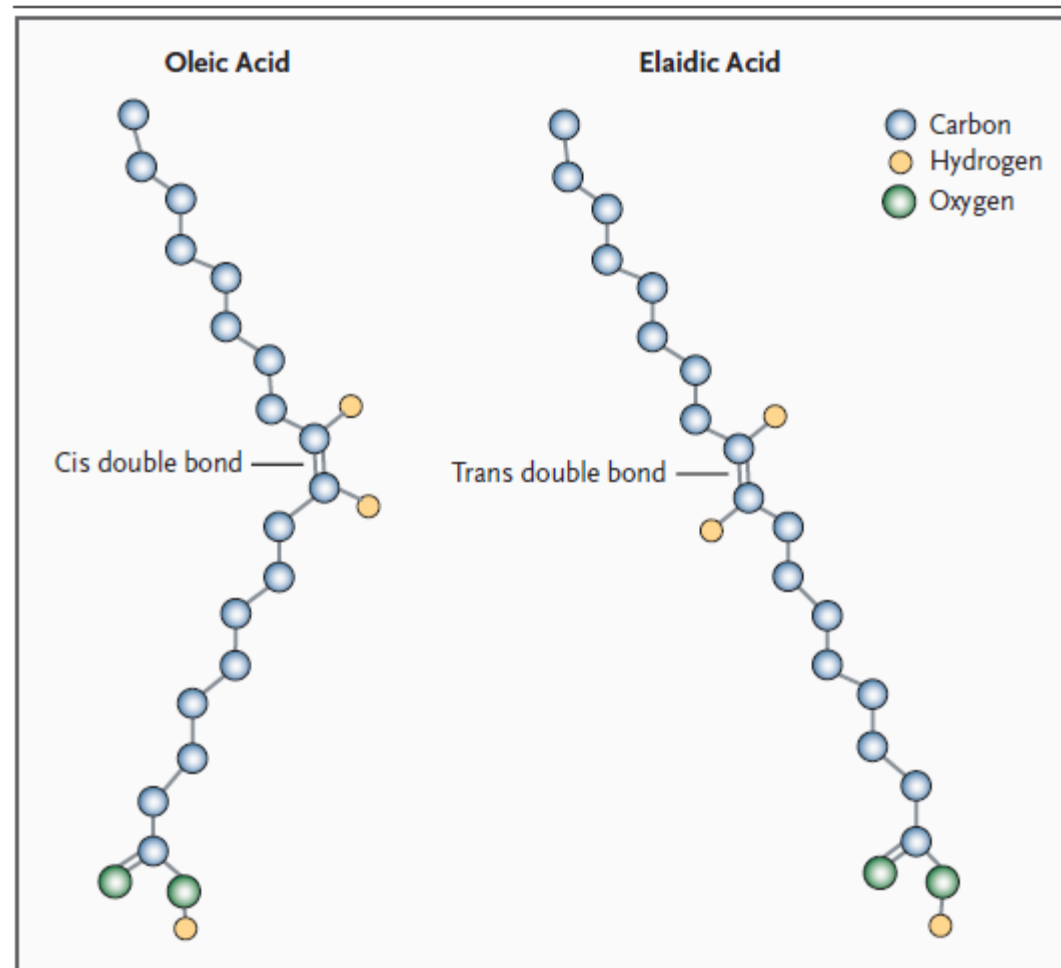
**To make it tasty.....**



# ***Trans – Fatty Acids***

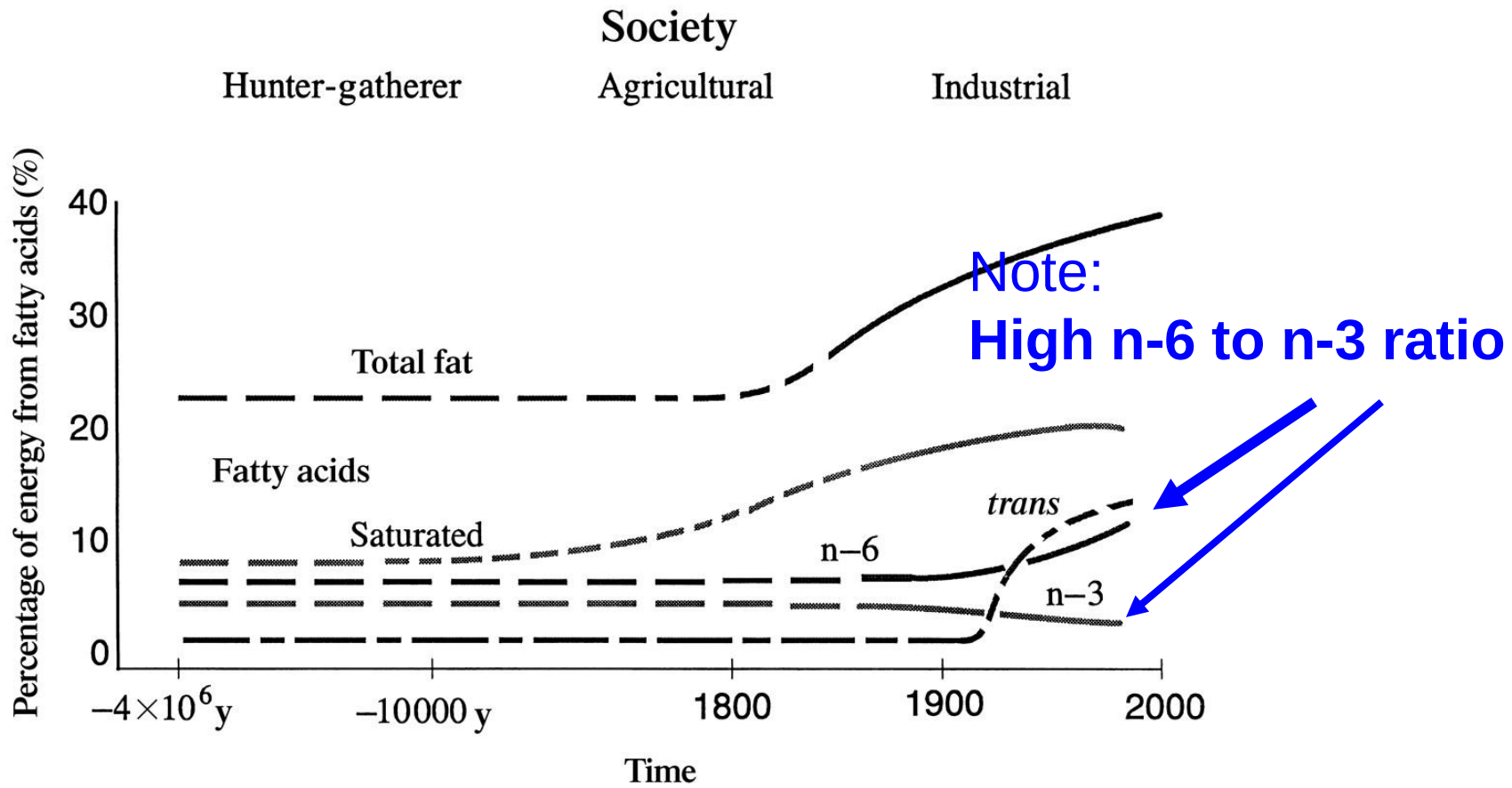


# Industrially generated *trans* FA



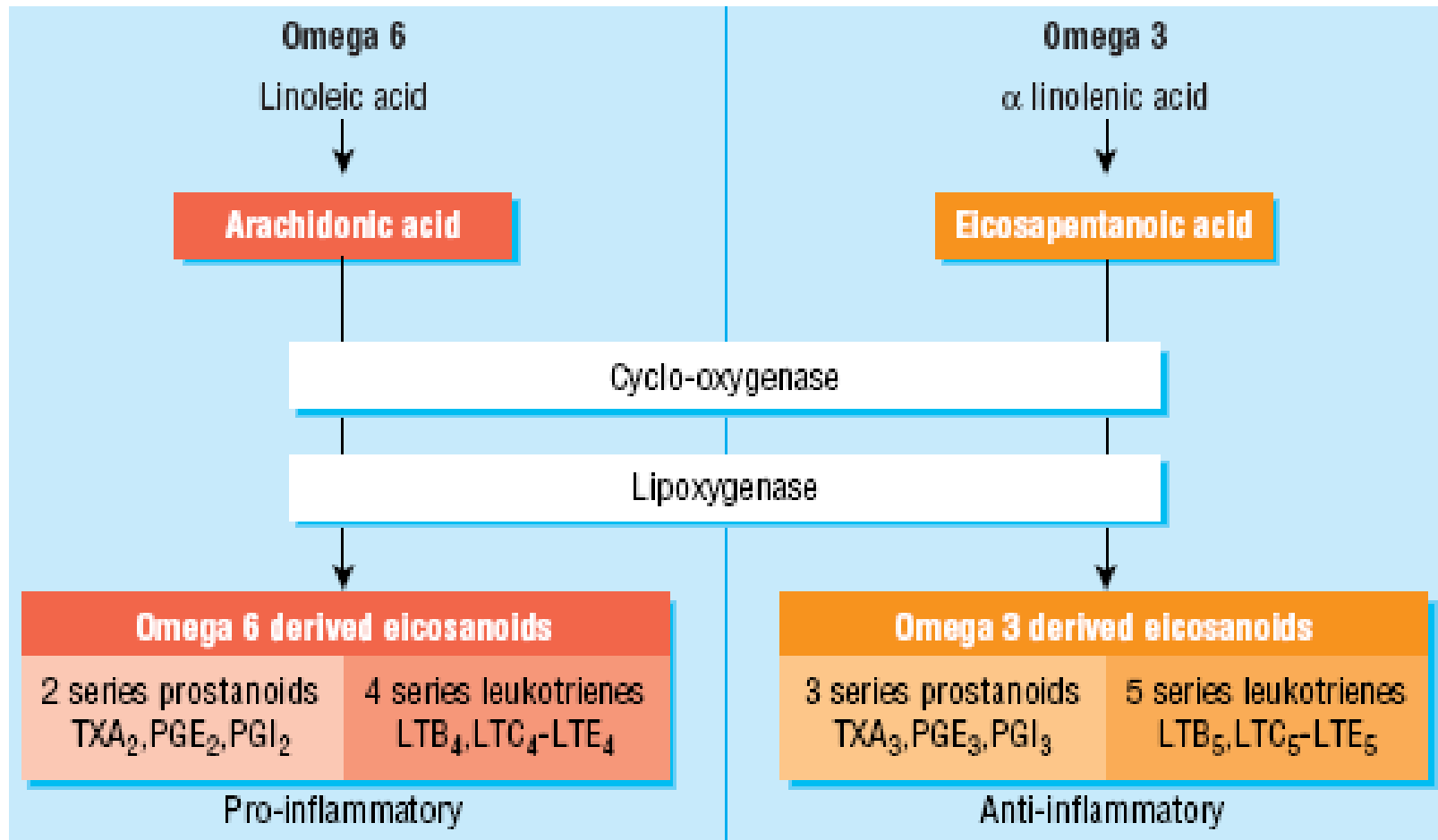
Mozaffarian et al, *N. Engl. J. Med.* 354: 1601-1613, 2006

# Polyunsaturates



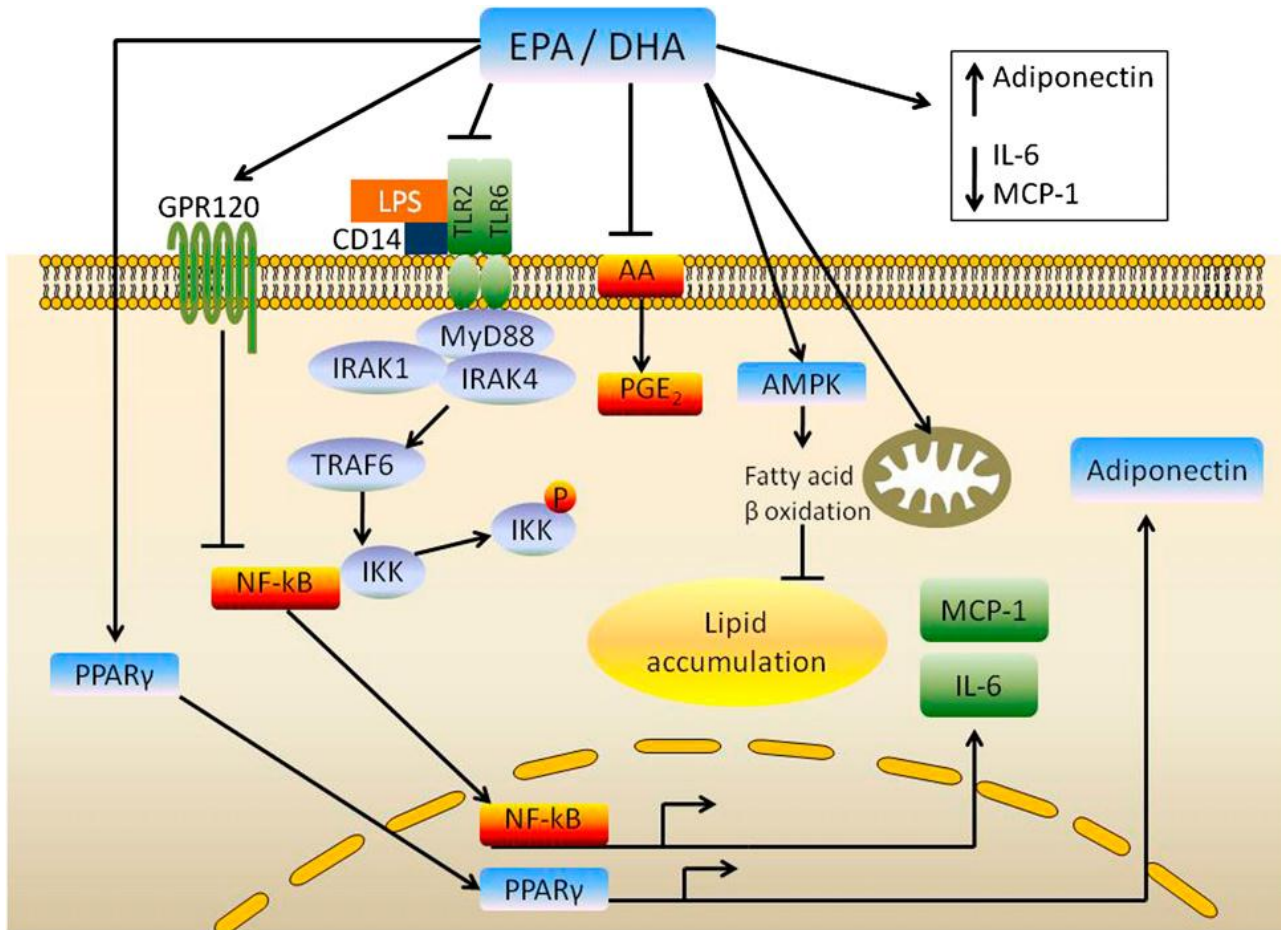
Simopoulos, AP. *Am. J. Clin. Nutr.* 70(suppl):560S-9S,  
Data from Eaton SB & Connor W

# Eicosanoid Products



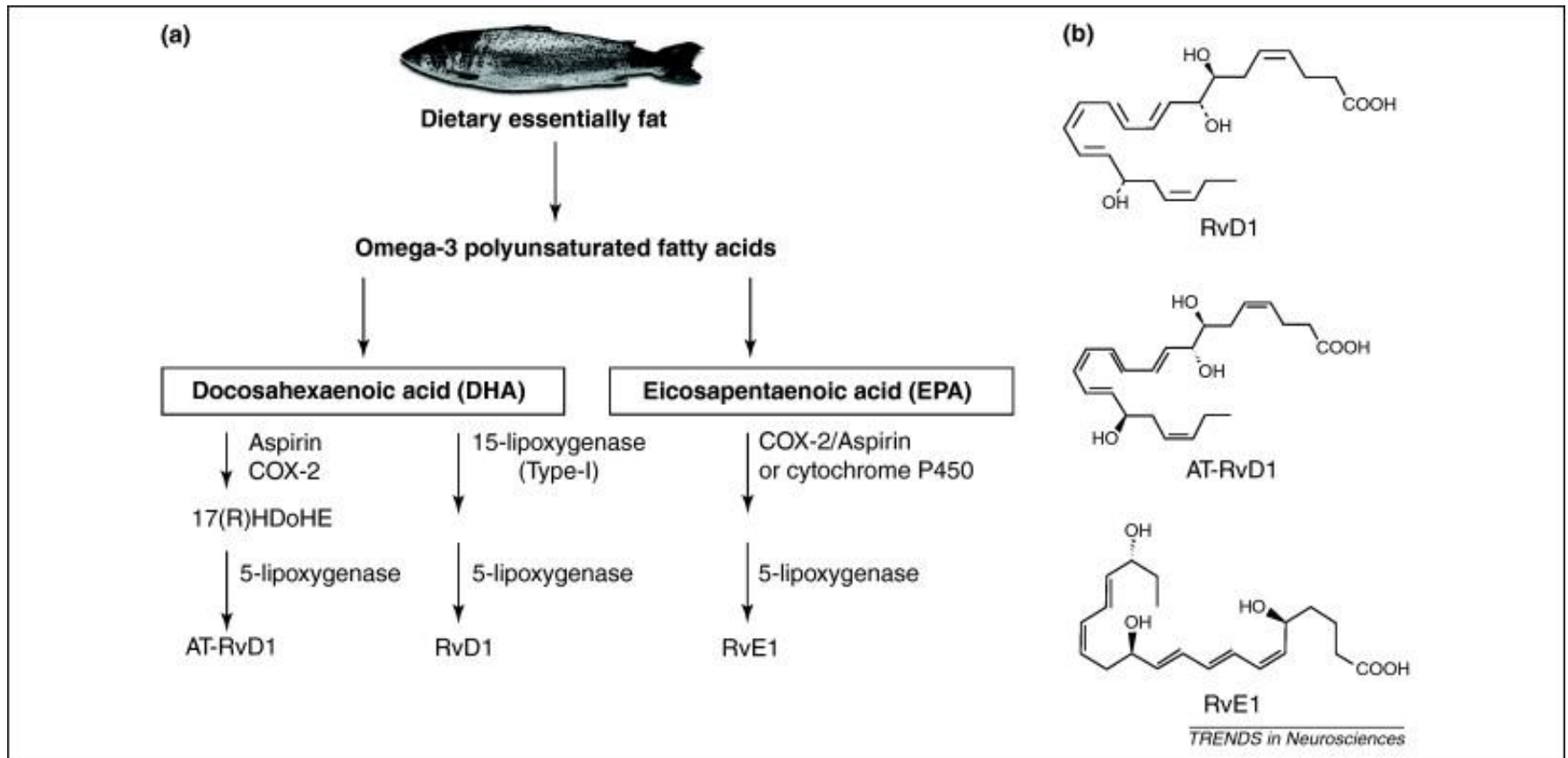
***Din et al. BMJ 2004; 328: 30***

# Omega-3 fatty acids



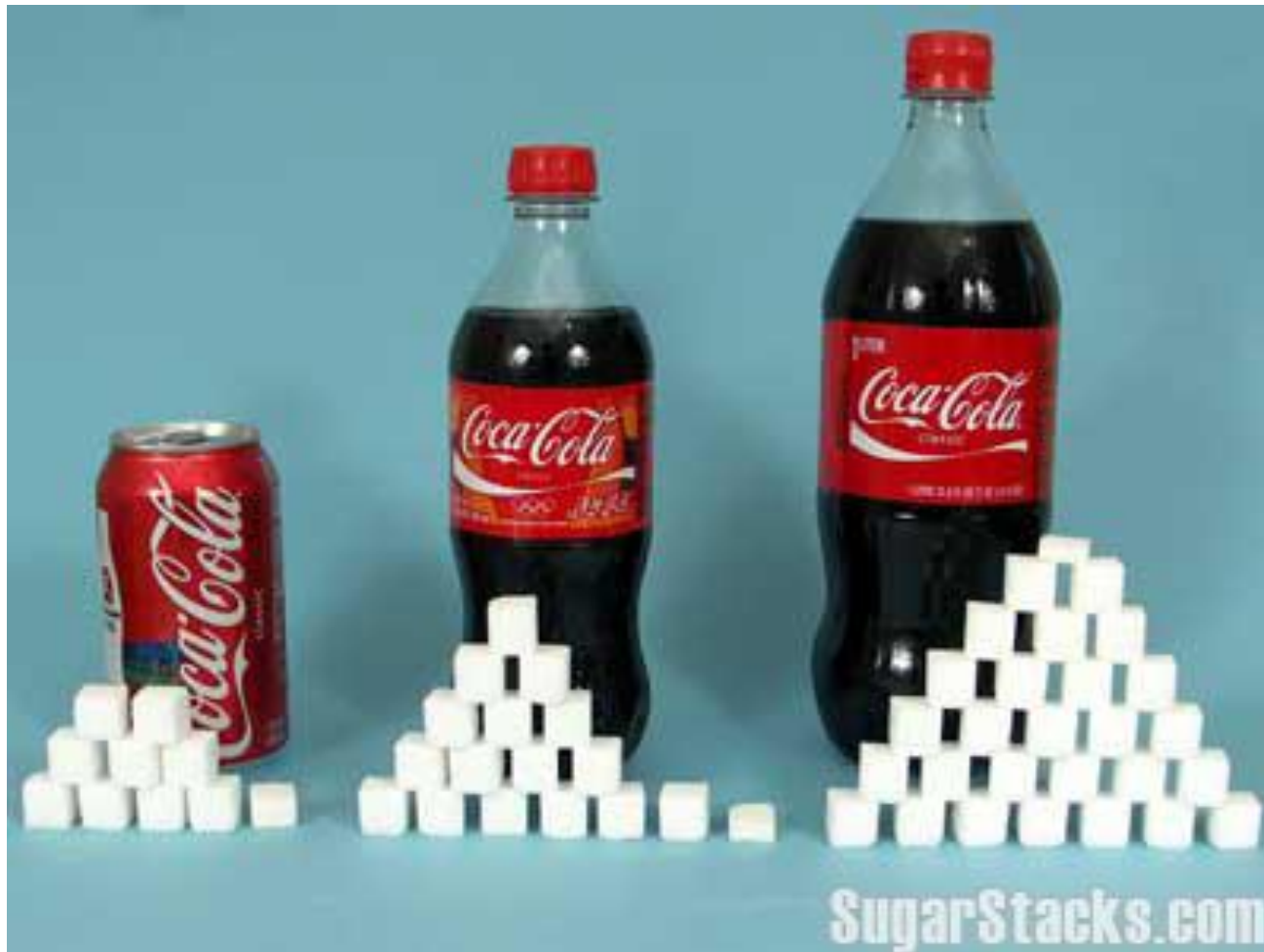
**(n-3) Fatty Acids Alleviate Adipose Tissue Inflammation and Insulin Resistance: Mechanistic Insights<sup>1,2</sup>**

# Resolution of Inflammation

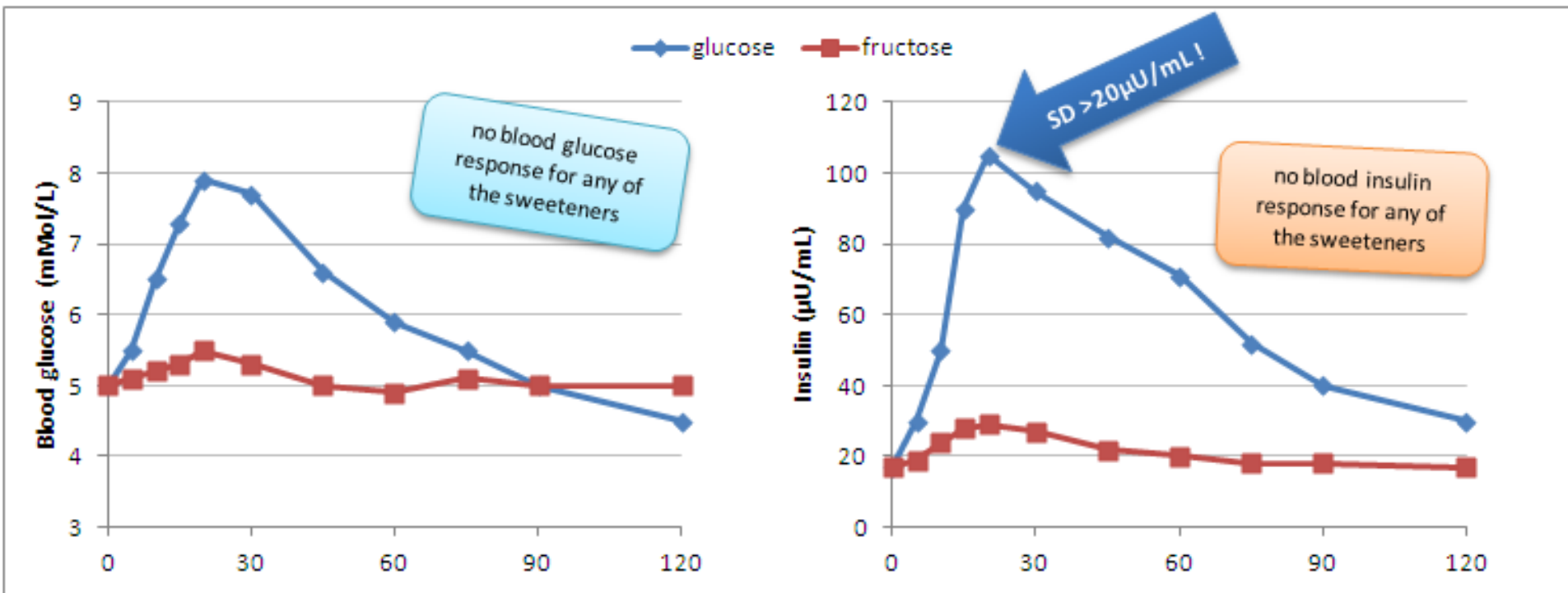


Ru-Rong J et al. Trends in Neurosci. 2011; 34(11; 599-609)

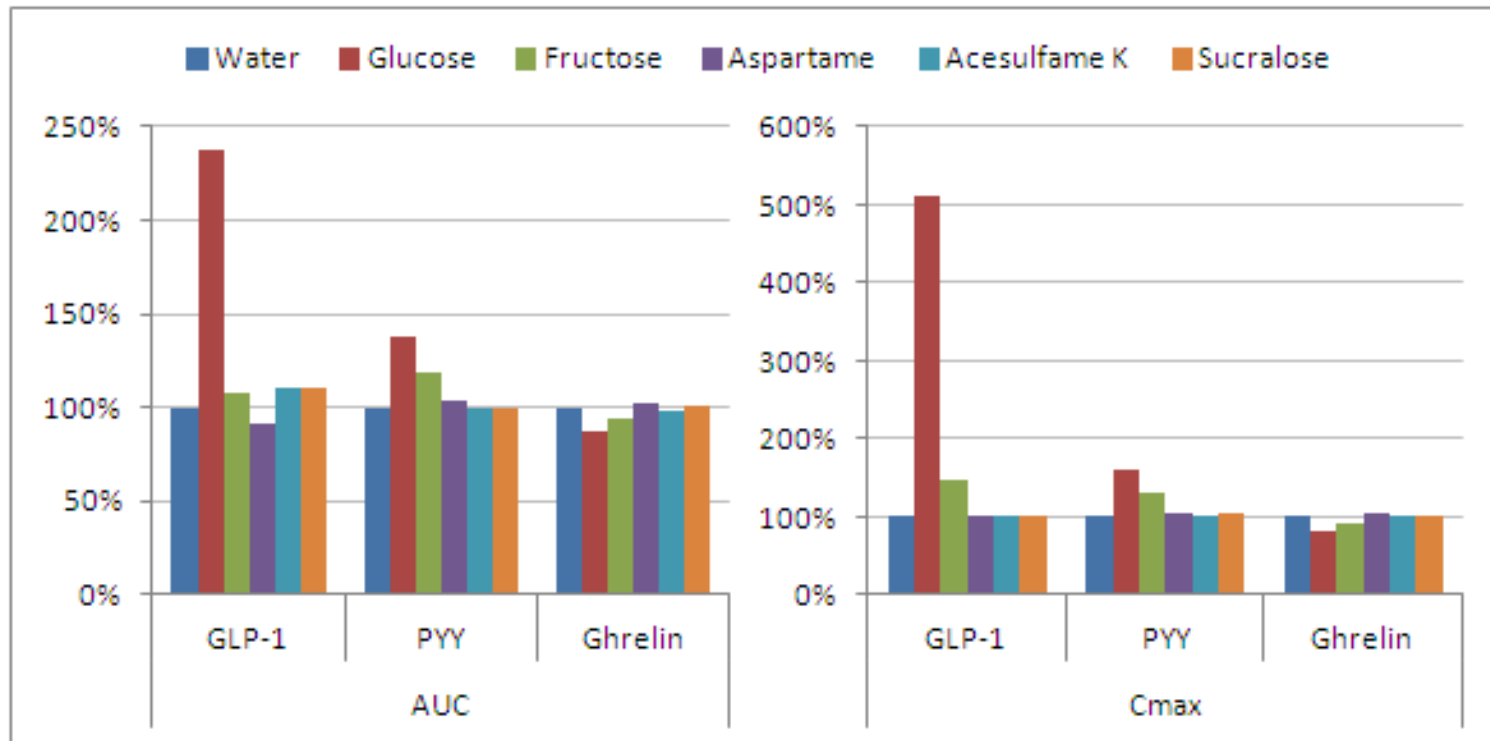
# SUPER foods and drinks

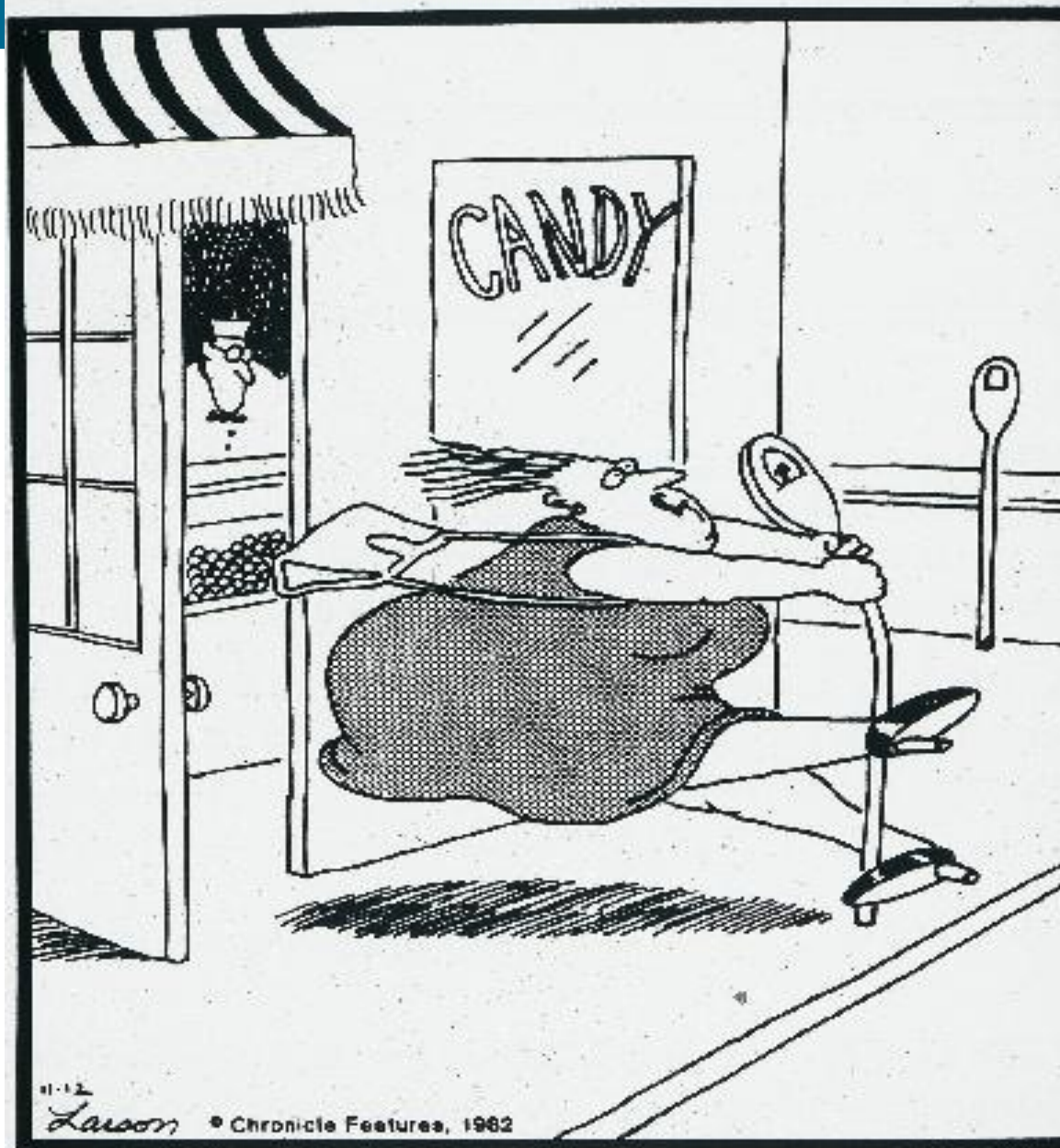


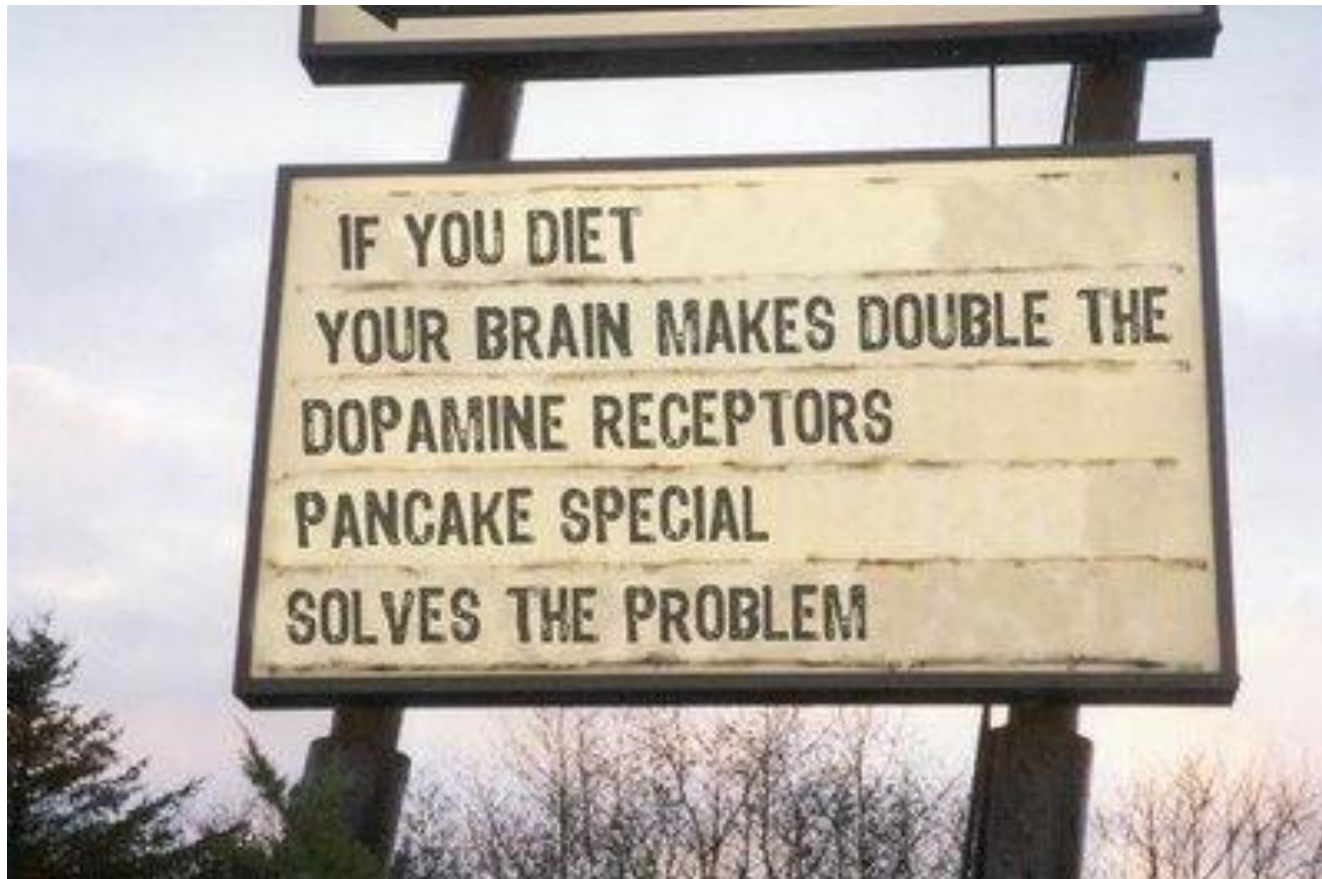
# Sucrose = glucose + fructose



# Satiety







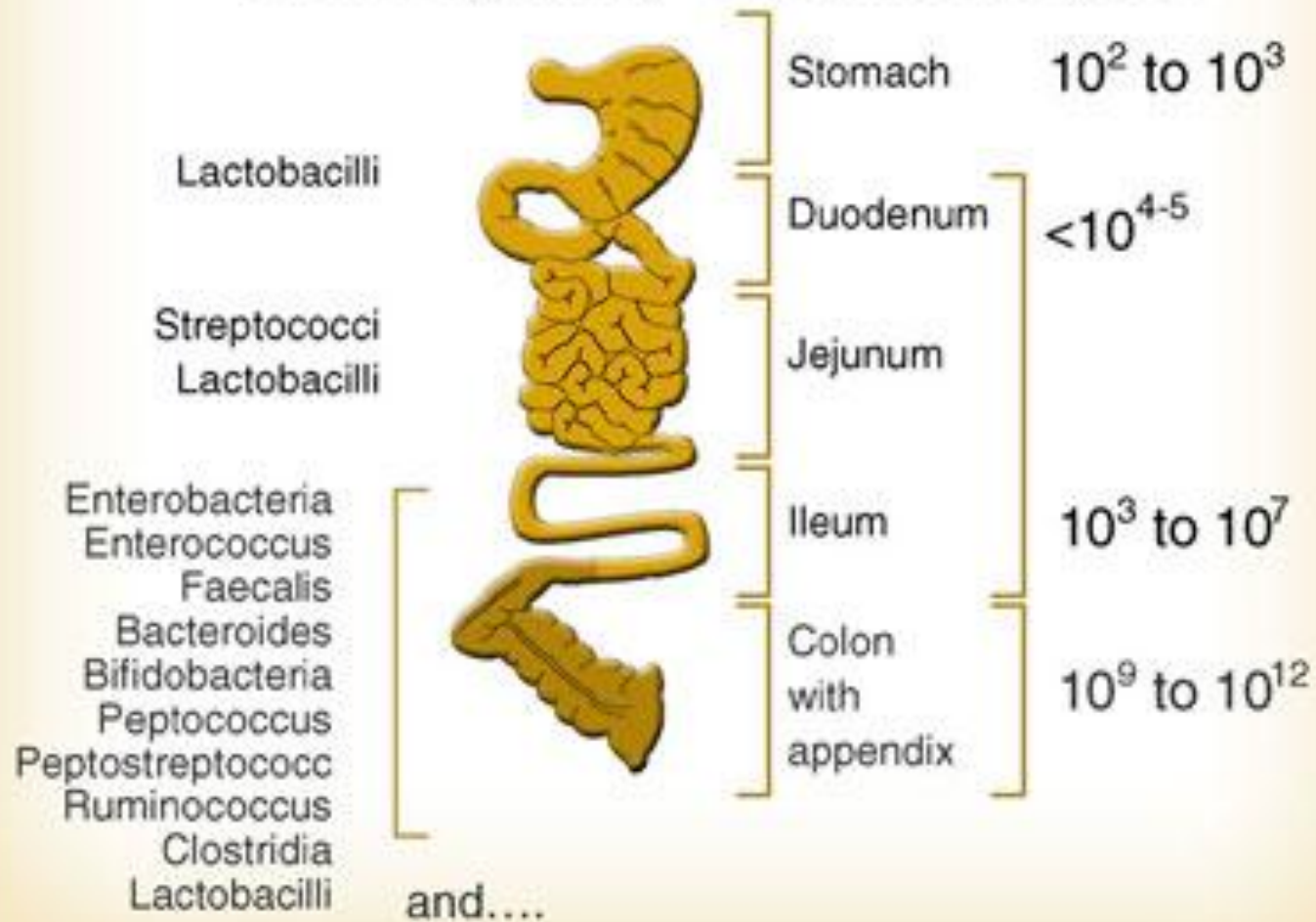
# Back to Superfoods





# INTESTINAL MICROFLORA

$10^{14}$  micro-organisms, >500 differentes species



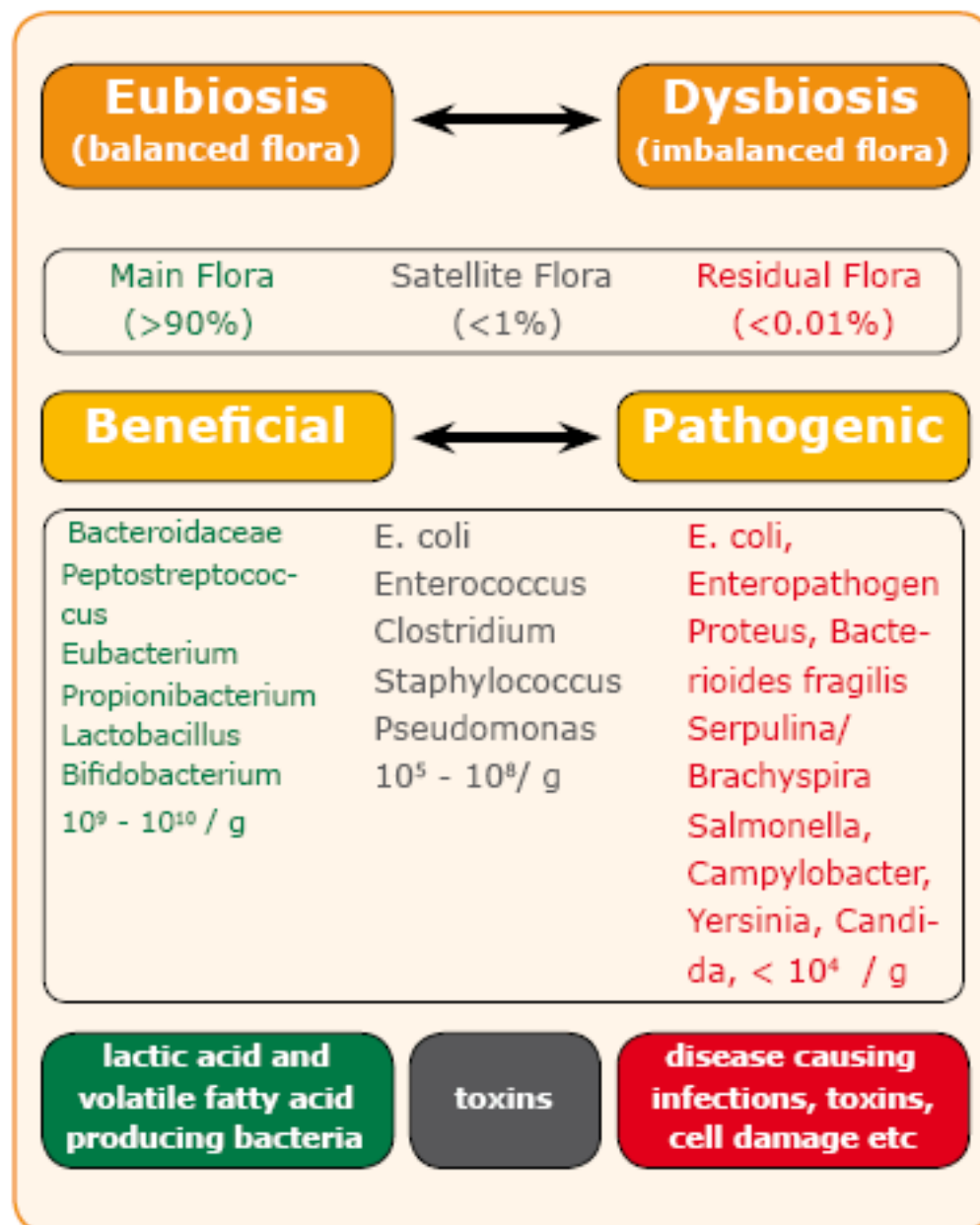
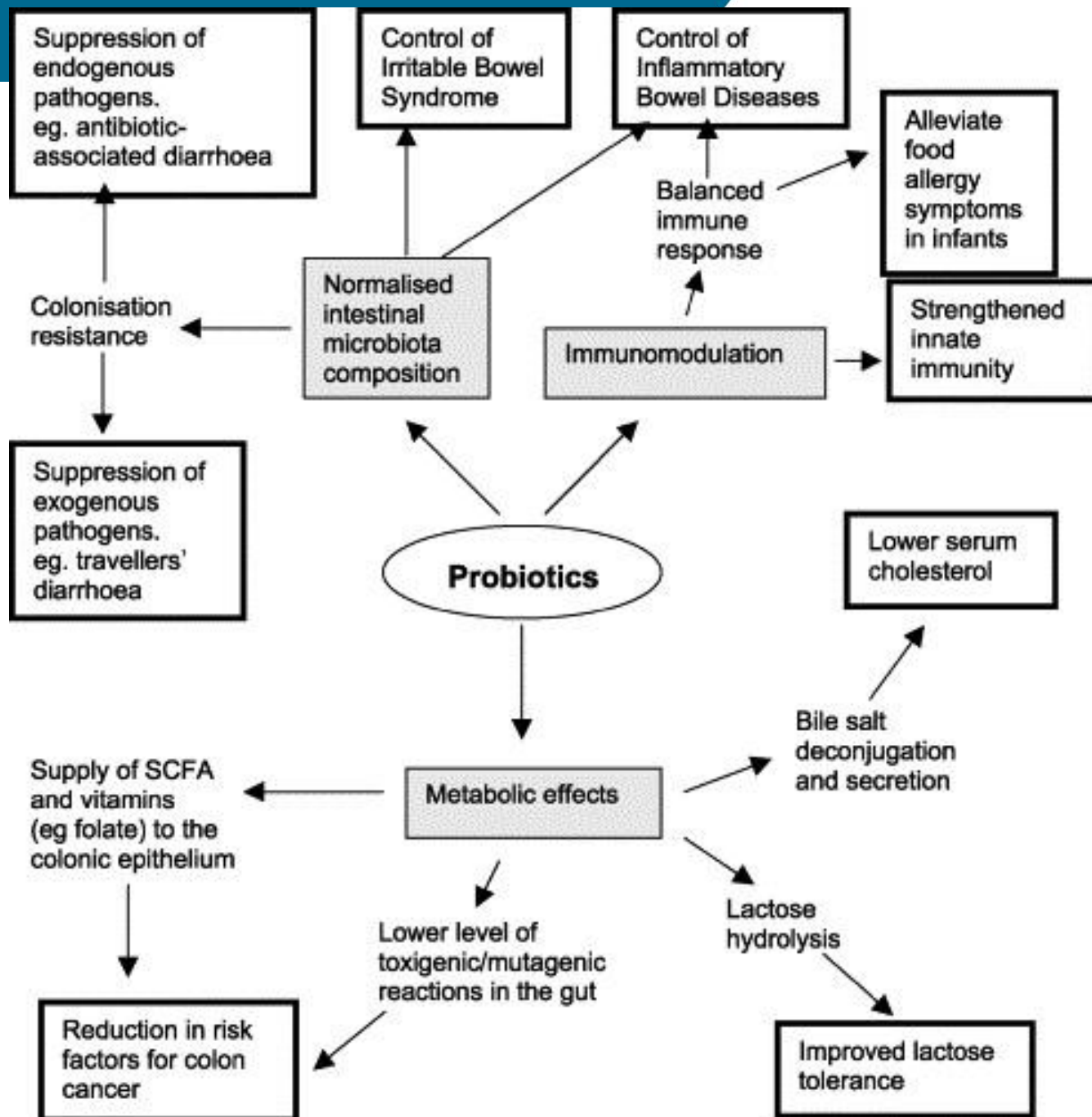
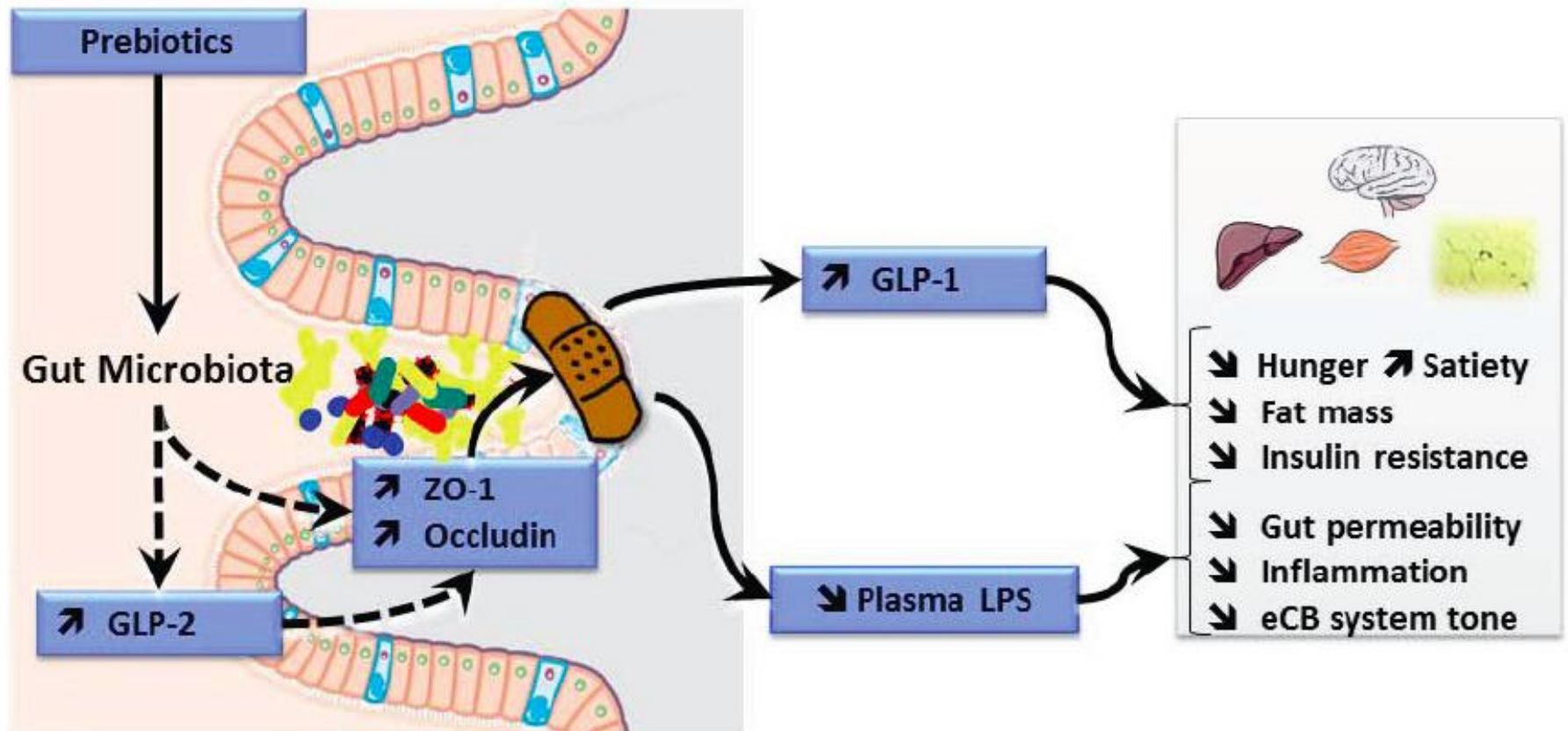


Figure 1: Bacterial genera and their influence on the host





# Prebiotics and Health





# Plant Secondary Metabolites

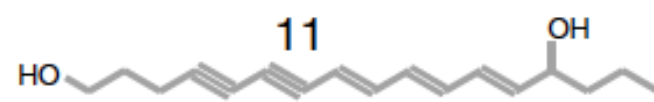
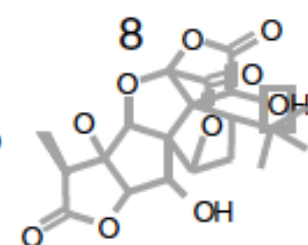
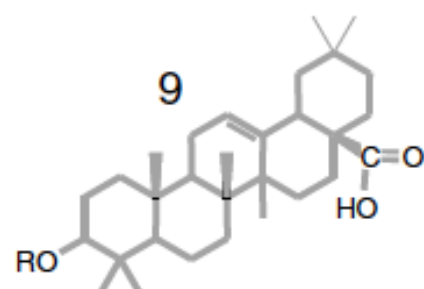
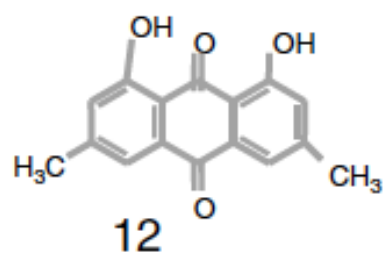
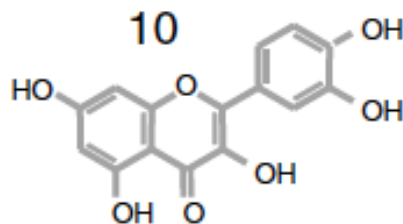
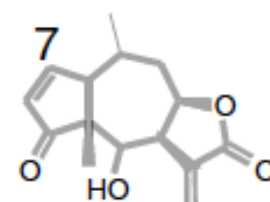
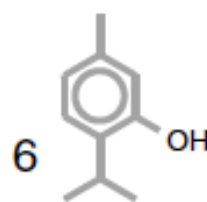
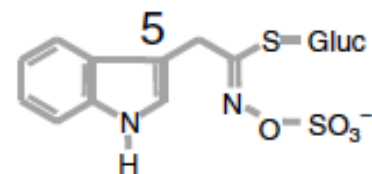
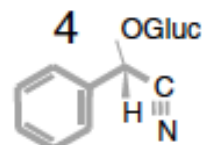
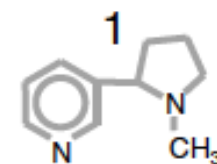
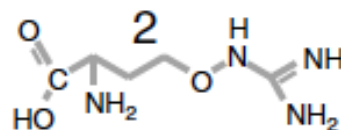
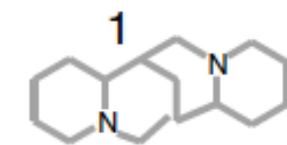
## With N

|                            |        |
|----------------------------|--------|
| 1. Alkaloids               | 12 000 |
| 2. Non-protein amino acids | 600    |
| 3. Amines                  | 100    |
| 4. Cyanogenic glycosides   | 100    |
| 5. Glucosinolates          | 100    |

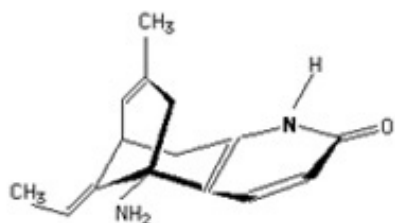
## Without N

|                                    |       |
|------------------------------------|-------|
| 6. Monoterpenes                    | 1 000 |
| 7. Sesquiterpenes                  | 3 000 |
| 8. Diterpenes                      | 2 000 |
| 9. Triterpenes, Saponins, Steroids | 4 000 |
| Tetraterpenes                      | 350   |
| 10. Flavonoids                     | 2 000 |
| 11. Polyacetylenes                 | 1 000 |
| 12. Polyketides                    | 750   |
| Phenylpropanes                     | 1 000 |

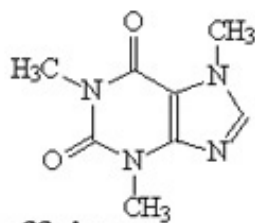
No. of natural products



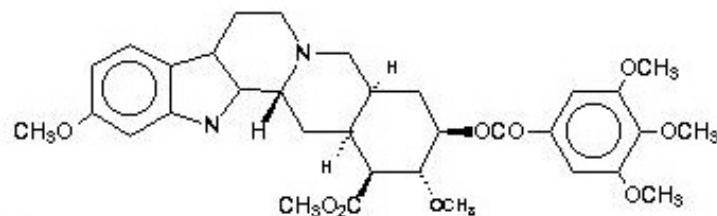
# An Assortment of Alkaloids



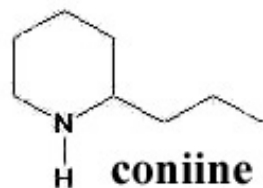
**huperzine A**  
*Chinese herbal medicine*  
*nootropic*



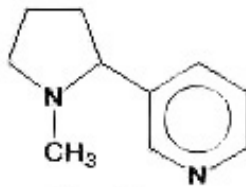
**caffeine**  
*Coffea arabica*  
*study*



**reserpine**  
*Indian herbal medicine*  
*antipsychotic*



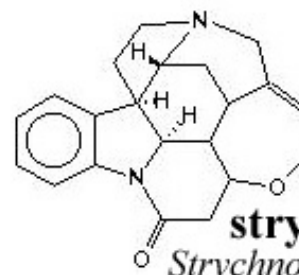
**coniine**  
*hemlock*  
*ants, Socrates*



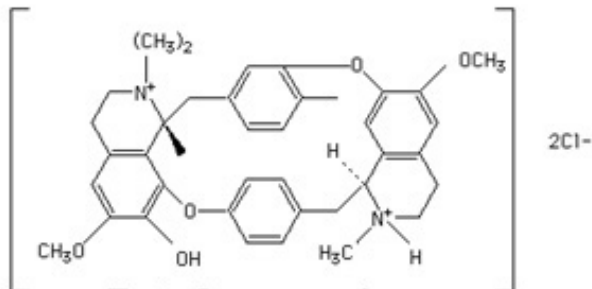
**nicotine**  
*tobacco*  
*Black Leaf 40*  
*insecticide*



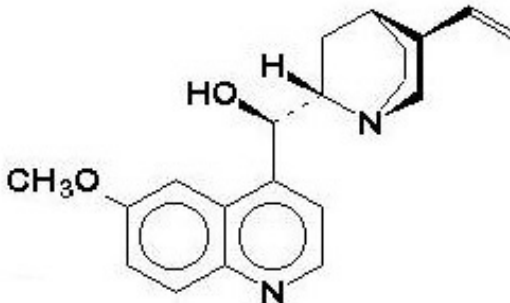
**vinblastine**  
*Madagascar periwinkle*  
*antileukemic*



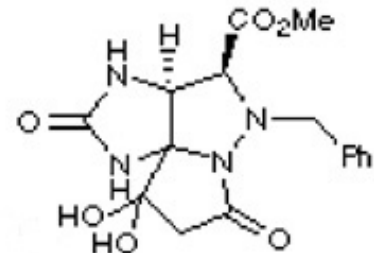
**strychnine**  
*Strychnos nux-vomica*  
*rodenticide*



**D-tubocurarine**  
*arrow poison, muscle relaxant for surgery*



**quinine**  
*Cinchona tree, antimalarial*



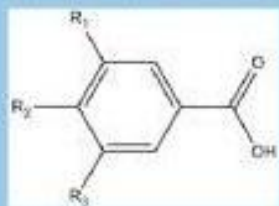
**saxitoxin**  
*deadly algal toxin*  
*chemical warfare agent*  
*CIA suicide pill*

## Phenolic acids

## Representative compounds

## Major food sources

### Hydroxybenzoic acids



Protocatechuic acid:

$R_1=R_2=OH$ ,  $R_3=H$

Gallic acid:

$R_1=R_2=R_3=OH$

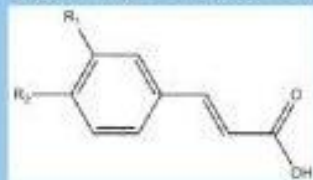
Vanillic acid:

$R_1=OCH_3$ ,  $R_2=OH$ ,  $R_3=H$

Red fruits: strawberries, raspberries, blackberries, blackcurrants

Beverages: tea

### Hydroxycinnamic acids



Coumaric acid:

$R_1=OH$

Caffeic acid:

$R_1=R_2=OH$

Ferulic acid:

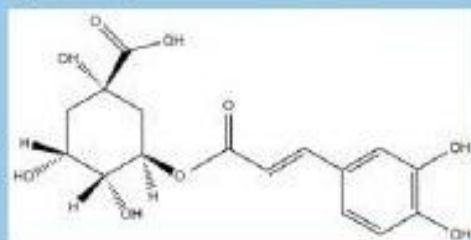
$R_1=OCH_3$ ,  $R_2=OH$

Large variety of fruits: kiwis, blueberries, plums, cherries, apples, etc.

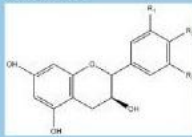
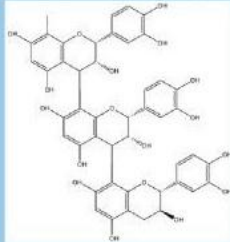
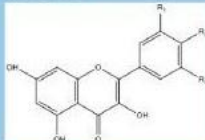
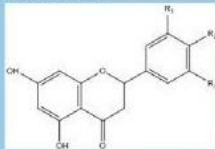
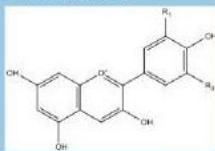
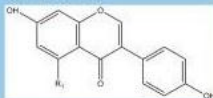
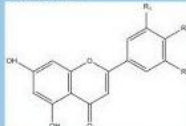
Vegetables: artichokes, potatoes, eggplants

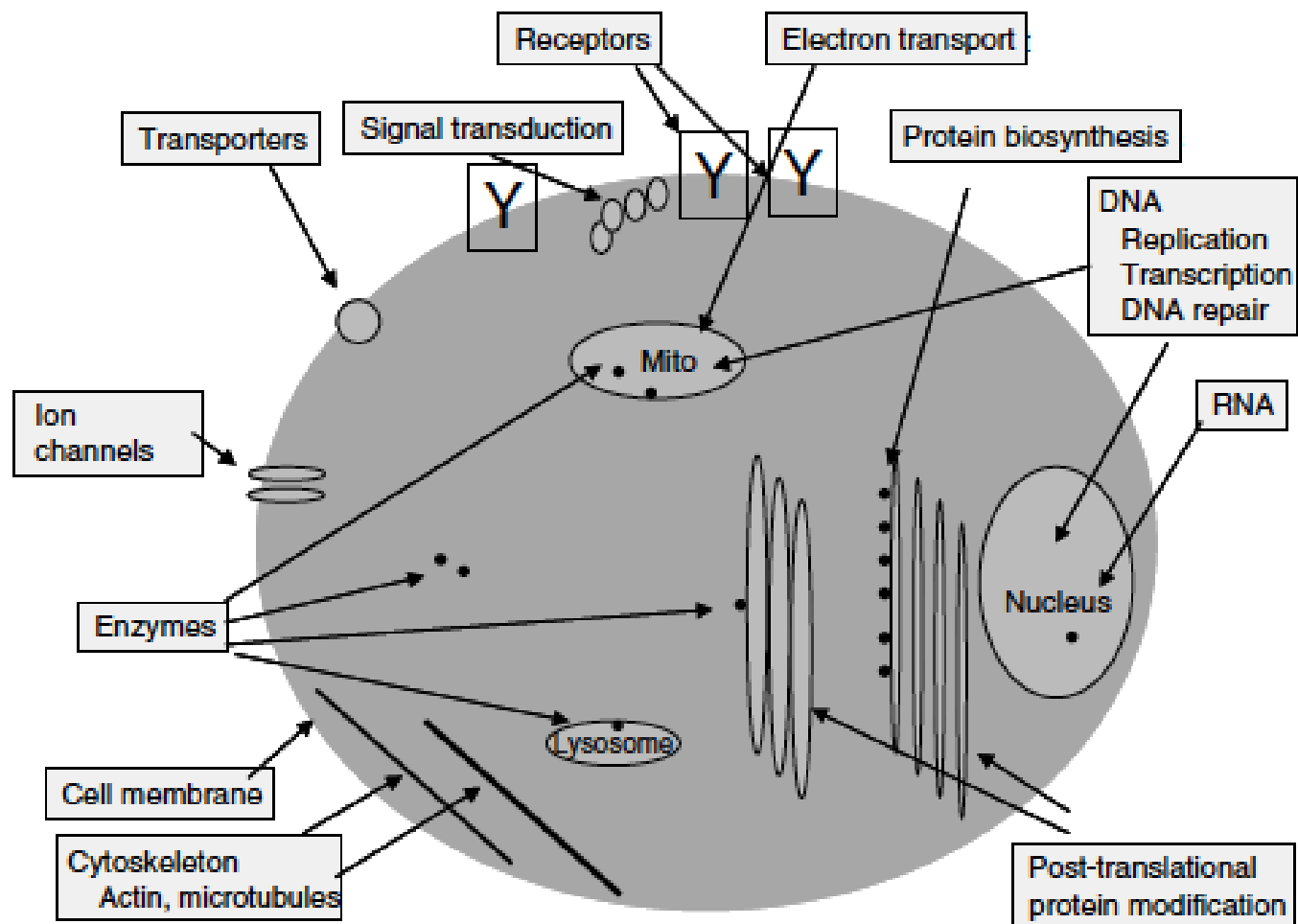
Beverages: coffee, cider

### Example of an ester of hydroxycinnamic acid:



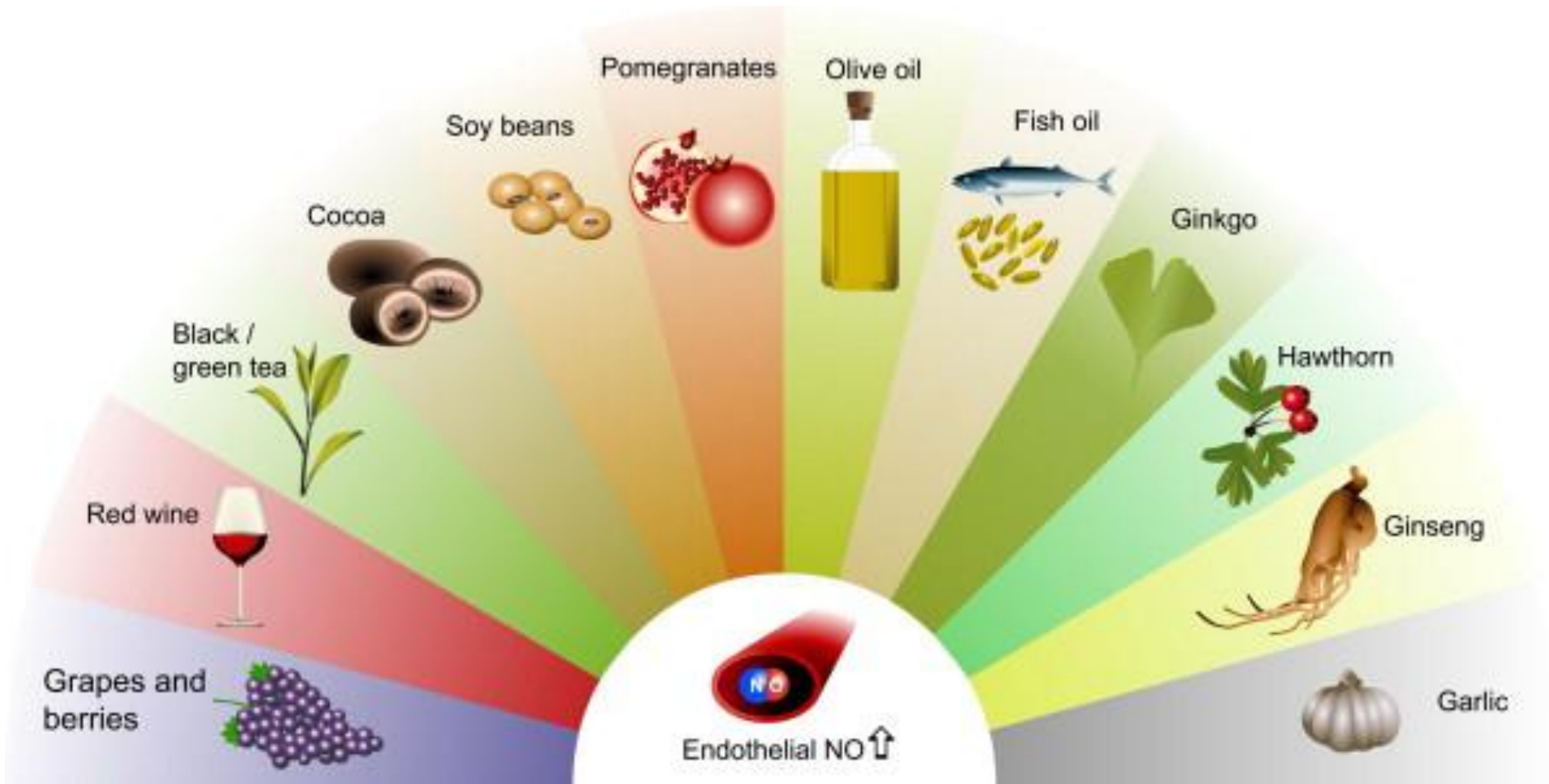
Chlorogenic acid  
(5-cafeoyl quinic acid)

| Flavonoids                                                                                                                                                                                | Representative compounds                                                                                                                                                | Major food sources                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Flavanols</b><br><br> | <b>Monomers</b><br>Catechin:<br>$R_1=R_2=OH$ ; $R_3=H$<br>Epigallocatechin:<br>$R_1=R_2=R_3=OH$<br><br><b>Polymers</b><br>Proanthocyanidins<br>(or condensed tannins)   | Cocoa-derived products<br><br>Fruits: apples, apricots, cherries, grapes, peaches, blackberries<br><br>Beverages: green tea, black tea, red wine, grape juice, cider                 |
| <b>Flavonols</b><br>                                                                                     | Quercetin:<br>$R_1=R_2=OH$ ; $R_3=H$<br>Kaempferol:<br>$R_2=OH$ ; $R_1=R_3=H$<br>Myricetin:<br>$R_1=R_2=R_3=OH$                                                         | Fruits: apples, apricots, plums, cranberries, strawberries, grapes<br><br>Vegetables: kale, onions, broccoli, tomatoes<br><br>Beverages: red wine, green tea, black tea, grape juice |
| <b>Flavanones</b><br>                                                                                    | Hesperetin:<br>$R_1=OH$ ; $R_2=OCH_3$<br>Naringenin:<br>$R_1=H$ ; $R_2=OH$<br>Eriodictyol:<br>$R_1=R_2=OH$                                                              | Fruit: citrus fruits (orange, grapefruit, lemon)<br><br>Beverages: citrus juices                                                                                                     |
| <b>Anthocyanidins</b><br>                                                                               | Pelargonidin:<br>$R_1=R_2=H$<br>Cyanidin:<br>$R_1=OH$ ; $R_2=H$<br>Delphinidin:<br>$R_1=R_2=OH$<br>Petunidin:<br>$R_1=OCH_3$ ; $R_2=OH$<br>Malvidin:<br>$R_1=R_2=OCH_3$ | Fruits: black grapes<br><br>Beverages: red wine, grape juice                                                                                                                         |
| <b>Isoflavones</b><br>                                                                                 | Genistein:<br>$R_1=OH$<br>Daidzein:<br>$R_1=H$                                                                                                                          | Legumes: soybeans<br><br>Processed products: miso, tofu, tempeh, soy milk                                                                                                            |
| <b>Flavones</b><br>                                                                                    | Apigenin:<br>$R_1=H$ ; $R_2=OH$<br>Luteolin:<br>$R_1=R_2=OH$                                                                                                            | Vegetables: parsley, celery, sweet peppers                                                                                                                                           |



**Fig. 2.** Summary of potential cellular targets for plant secondary metabolites. Mito, mitochondrion. (Adapted from Wink, 2004.)

# Enhance Nitric Oxide Synthesis



THE FUTURE OF BUSINESS

18 LEADERS AND LUMINARIES TELL YOU WHAT'S NEXT (PAGE 44)

# FORTUNE

## DRINK WINE AND LIVE LONGER\*

The exclusive story of the  
**biotech startup** searching for  
anti-aging miracle drugs. (PAGE 68)



The chemical  
resveratrol,  
found in red  
wine, has  
shown signs  
of helping  
ward off the  
ill effects  
of old age.

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# ANTIOXIDANT DEFENSE SYSTEM

UNSTABLE FORMS OF OXYGEN -- OXYGEN FREE RADICALS

**Singlet  
Oxygen**

**Hydroxyl  
Radical**

MOST HARMFUL  
TO DNA

**Superoxide  
Radical**

GENERATES HYDROGEN  
PEROXIDE, RELEASES  
IRON & COPPER

## ENZYMATIC ANTIOXIDANTS

(Produced Naturally In The Body From Precursors Zinc, Manganese, Copper)

**Catalase**

**Glutathione**

**Superoxide  
Dismutase**

Riboflavin  
Vitamin B2

Glutathione  
reductase

Glutathione  
peroxidase

## DIETARY ANTIOXIDANTS

**Vitamin A**

**Vitamin C**

**Vitamin E**

**Carotenoids**

Beta carotene, lutein, lycopene, astaxanthin

**Bioflavonoids**

**Coenzyme Q10**

PRO-OXIDANT-ANTIOXIDANT BALANCE



ORGANIC

ORGANIC

ORGANIC



life is  
short  
eat