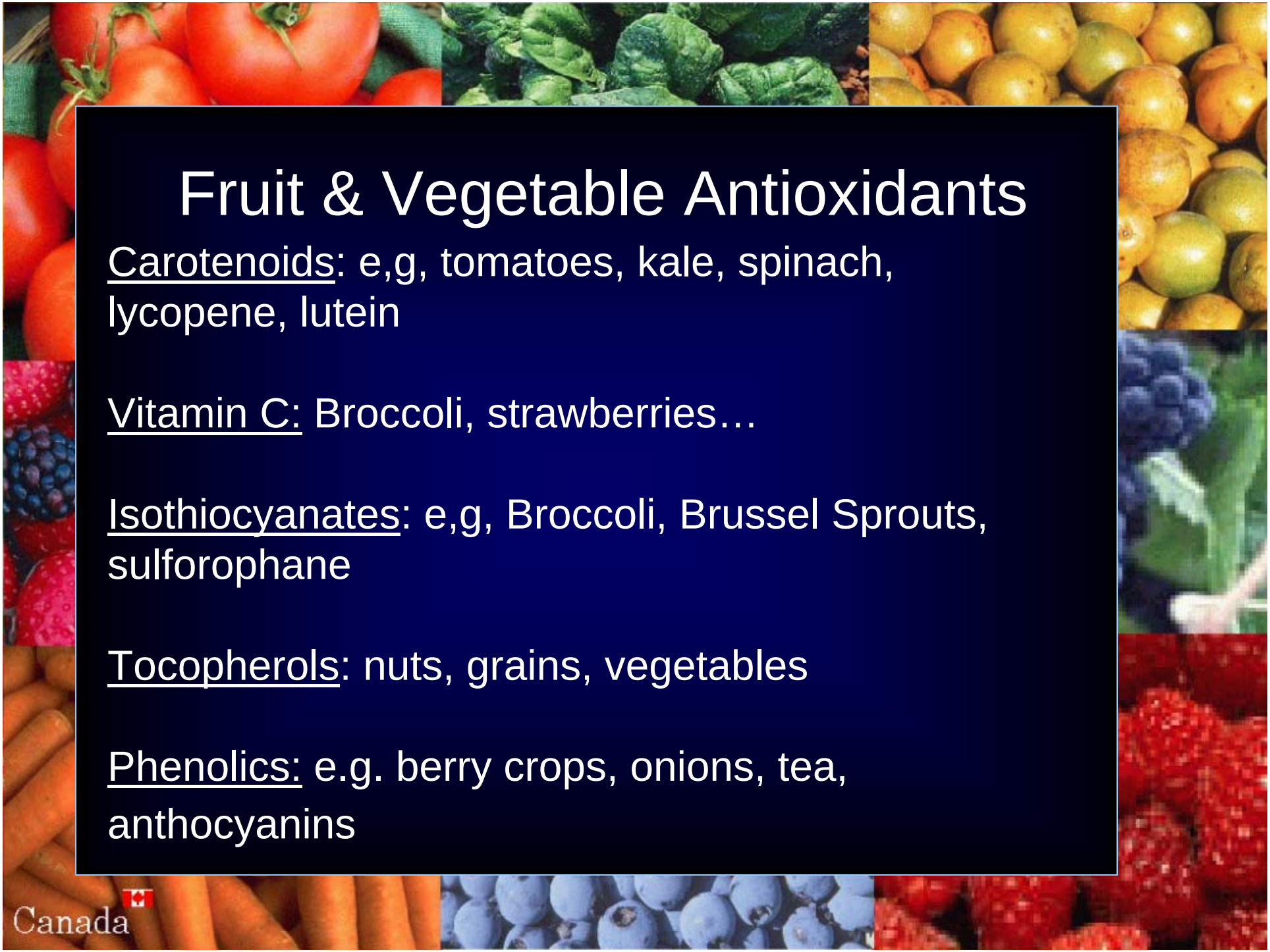

Blueberries Health Research
Survol de la recherche sur
l'aspect santé de bleuet

Fruit & Vegetable Phytochemical Antioxidants

"...the protection provided against diseases by fruits and vegetables has been attributed to the various **antioxidants** contained in these foods." (Ames et al., 1993)

- Certain cancers
  - Block et al.1992; Steinmetz & Potter 1996
- Cardiovascular Disease
  - Hertog et al. 1993; Joshipura et al. 1999
- Neurodegenerative disease



Fruit & Vegetable Antioxidants

Carotenoids: e,g, tomatoes, kale, spinach, lycopene, lutein

Vitamin C: Broccoli, strawberries…

Isothiocyanates: e,g, Broccoli, Brussel Sprouts, sulforophane

Tocopherols: nuts, grains, vegetables

Phenolics: e.g. berry crops, onions, tea, anthocyanins

Canada

Oxidative Stress
Free Radical Theory of Aging

Harman (1968)

- Oxidative Stress: life in an oxygen environment
- Accumulation of deleterious changes to biological molecules
- Change/damage to DNA, lipids, proteins
- Aging & Disease

Oxidative Stress

Contributing Factors

Respiration

- 10,000 ‘hits’ per day to human mitochondrial DNA

Solar irradiation

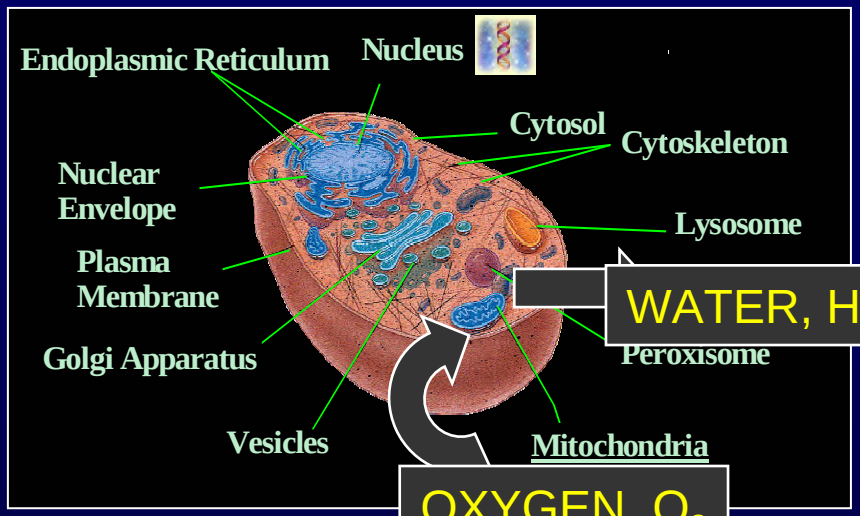
- Enough energy to hydrolyze water & create oxygen radicals in body tissues

Cigarette smoking

- More than ~10^{15} free radicals per puff

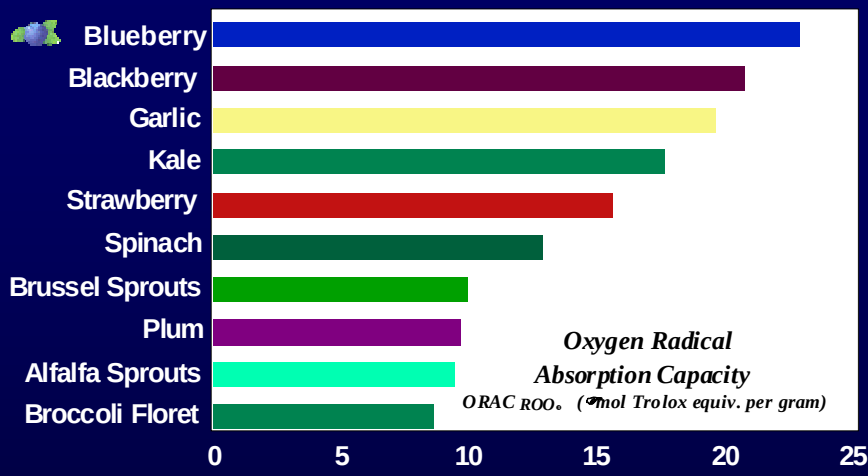
Environmental exposure

- Oxidative damage to DNA, lipids, proteins



Blueberries
Oxygen Radical Absorbance Capacity

(Antioxidant capacities per gram of fresh wt.)



Source: 1997 Research at the Jean Mayer USDA Human Nutrition Research Center on Aging, on the antioxidant characteristics of various fruits and vegetables. Journal of Agricultural and Food Chemistry 44:701-705; 3426-3343

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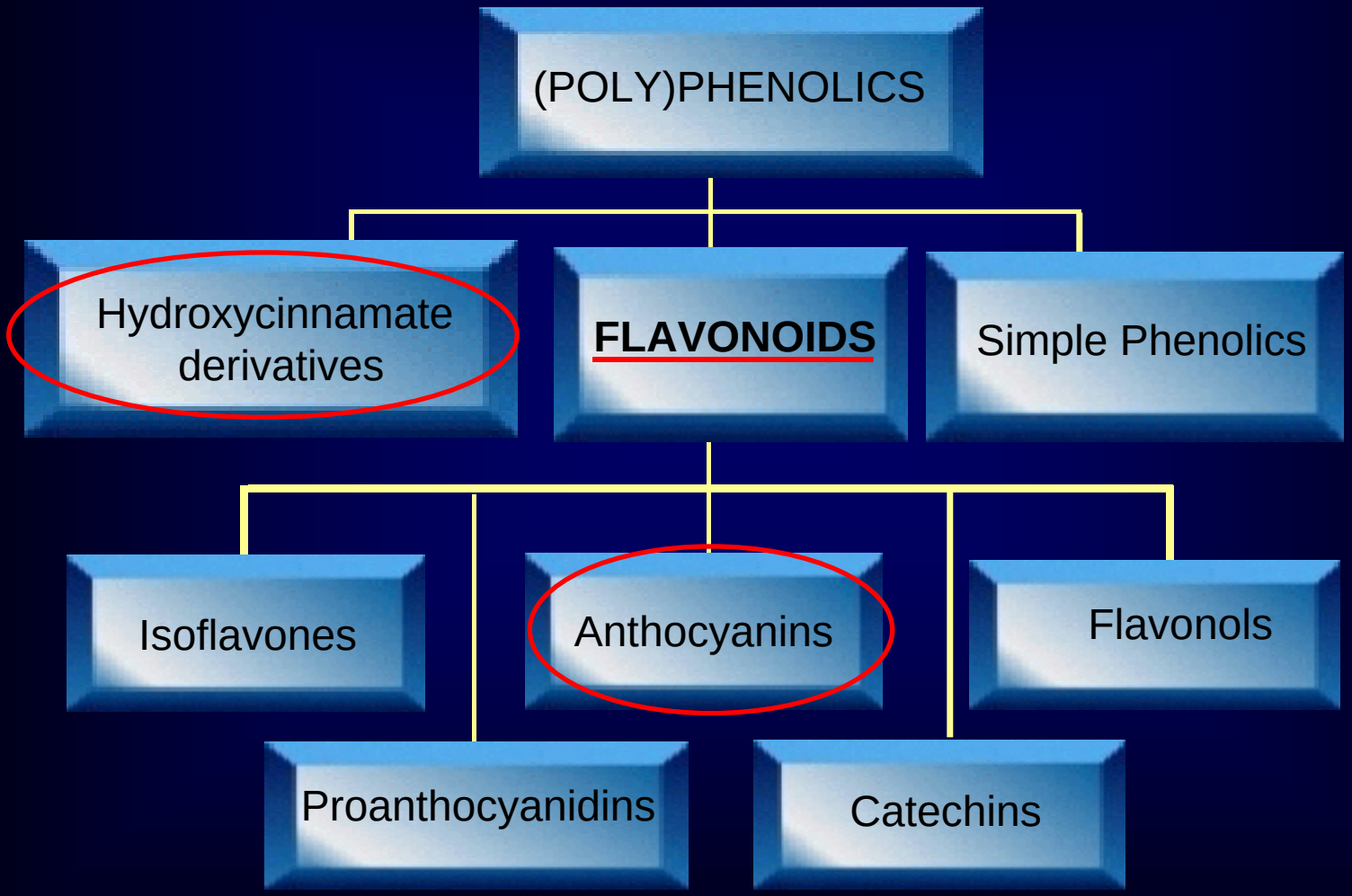
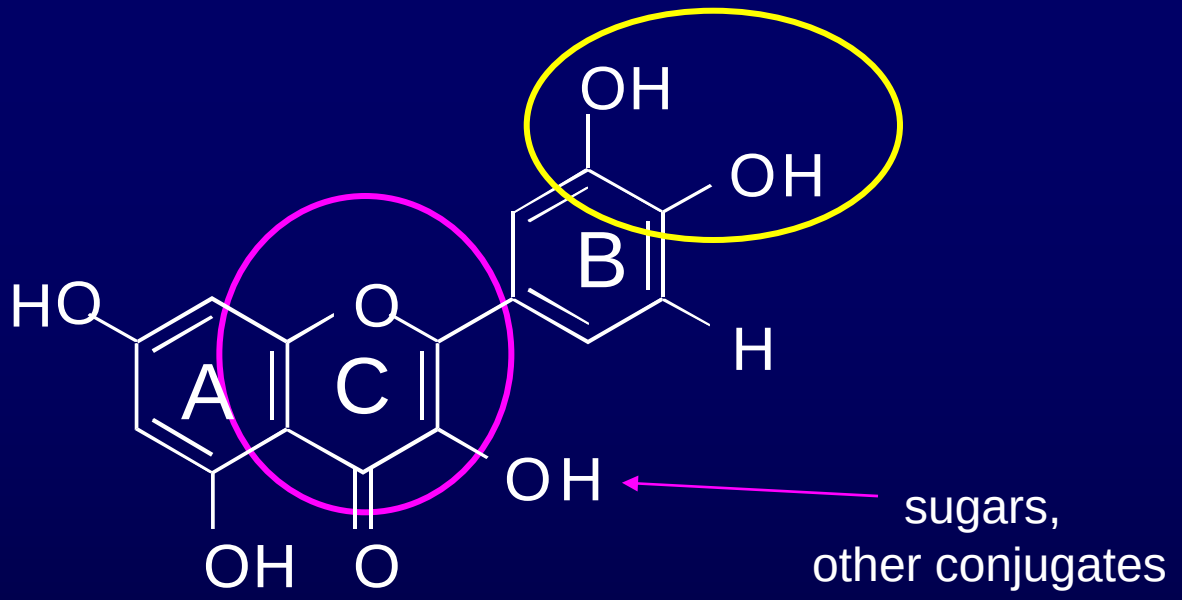
Fruit Phenolic Antioxidants

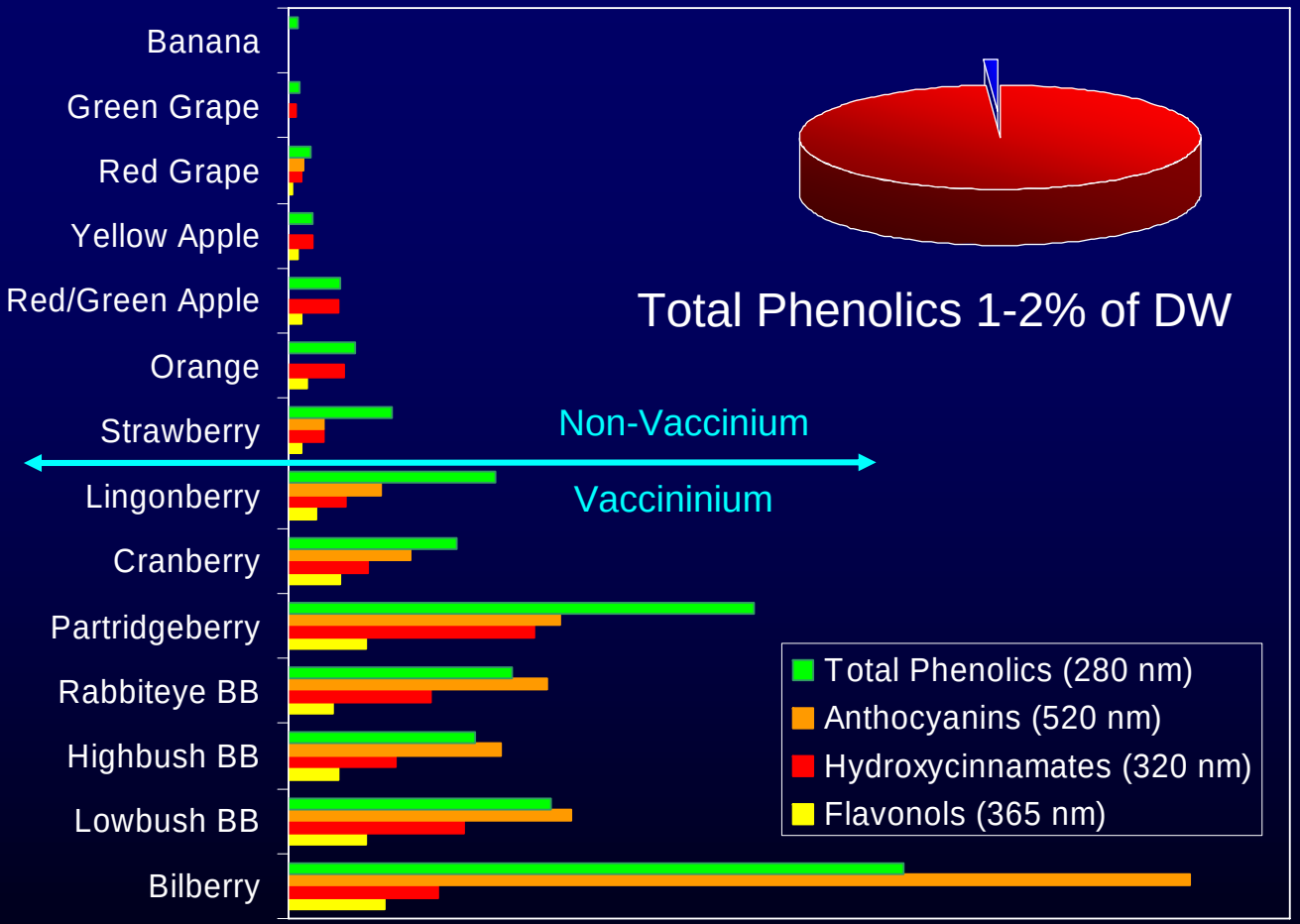


Flavonoid Structure

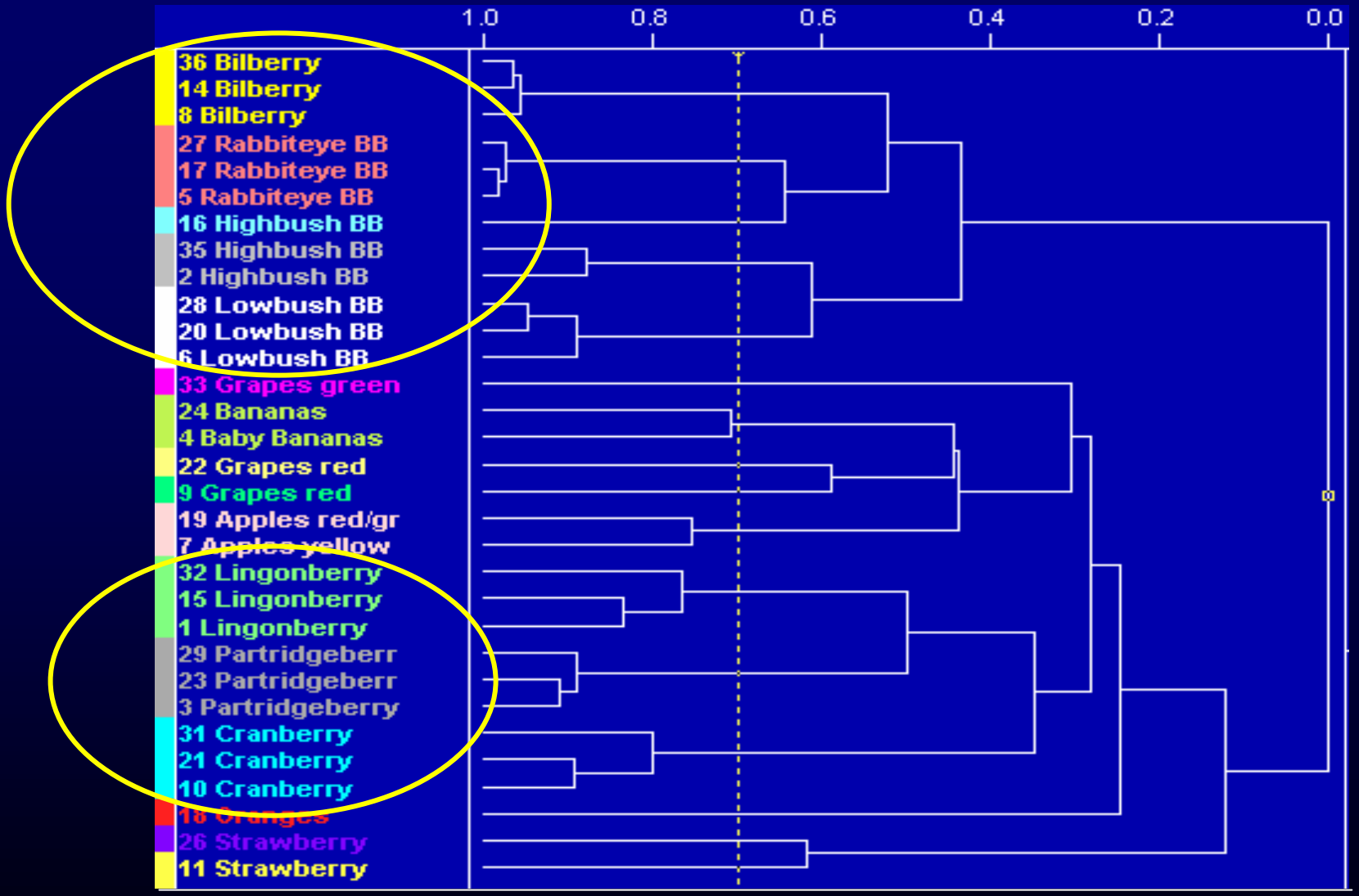


- Approximately 7 major forms
- Each with a large number of variations
- Including oligomeric & polymeric forms
- And conjugated forms
- Blueberries have 25+ anthocyanins and 25+ other phenolics

Compared to many common fruit, *Vacciniums* have a high phenolic content



Similarity of Phenolics Among Fruit Crops



Blueberry Phenolic Antioxidants

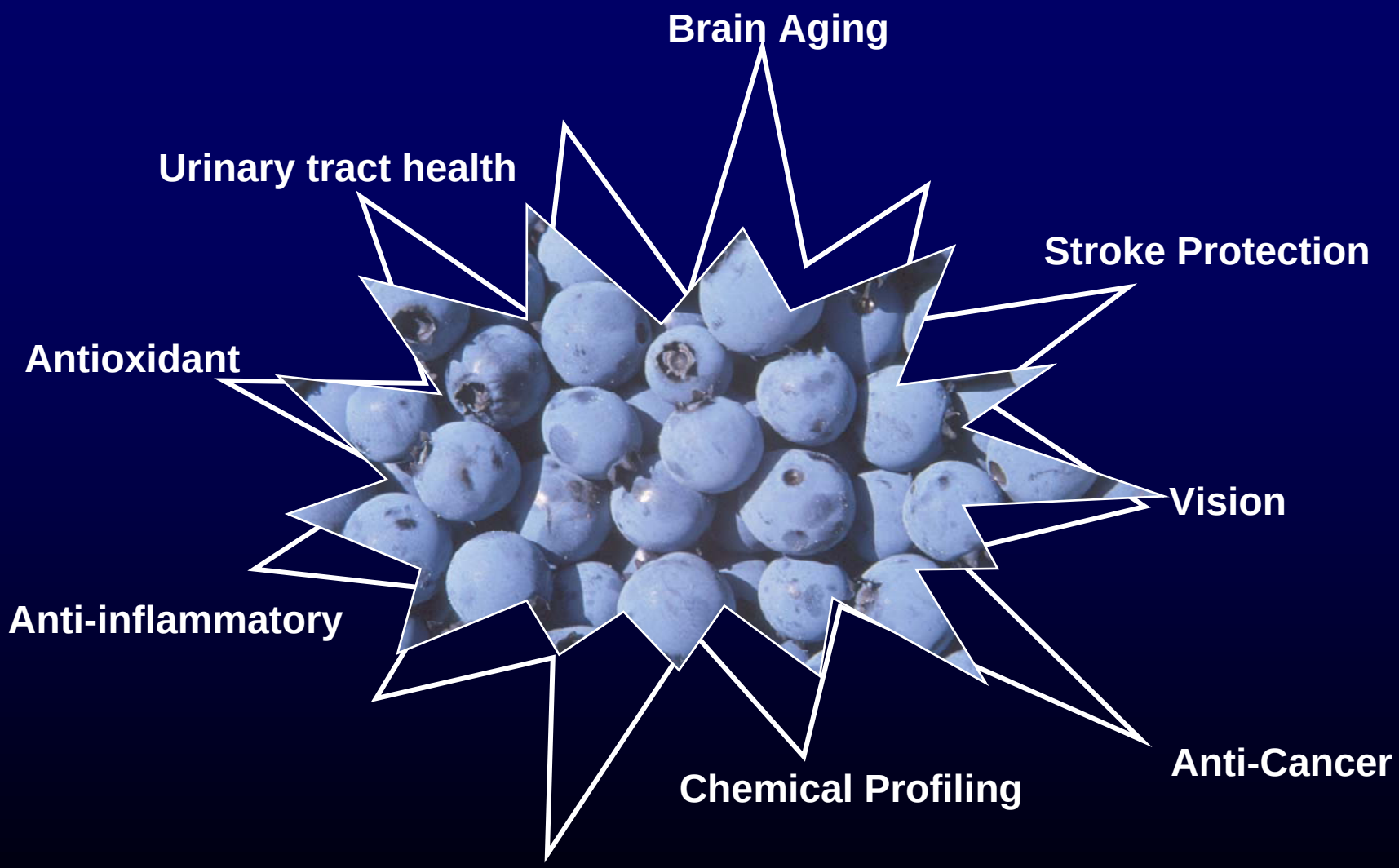
Horticultural & Food Aspects

- Chemical composition
- Genus, Species
- Heritability
- Environment, year, location
- Maturity
- Storage
- Processing ⇐

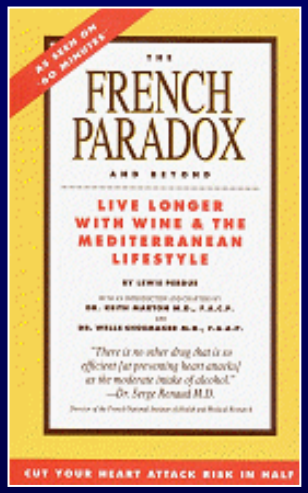
⇒GENETICS

Blueberries & Health

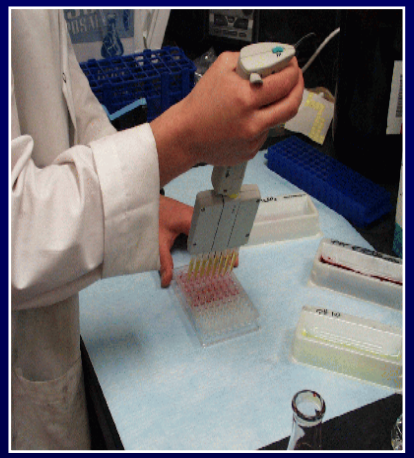
What is the evidence ?



Types of Scientific Evidence



Populations
Epidemiological



Test tubes
in vitro

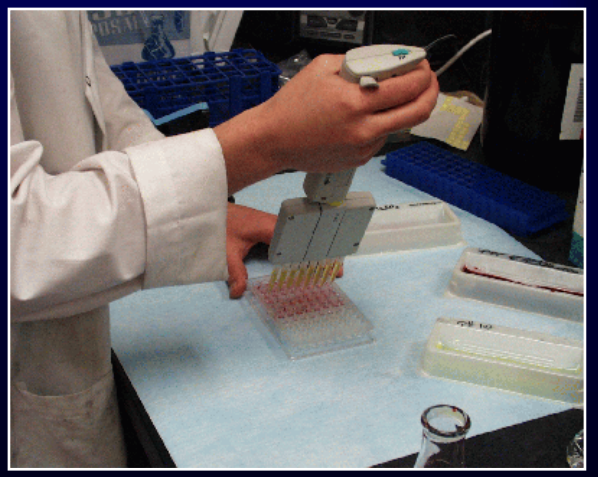
Animals
in vivo

Human trials
Clinical

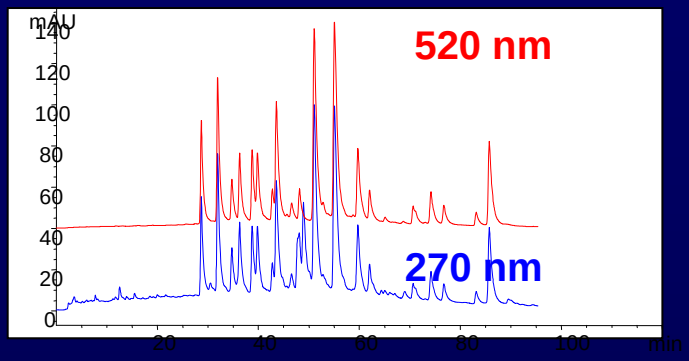
INCREASING STRENGTH OF EVIDENCE

Types of Evidence

- Observational & Mechanistic
- Animal 'Models'
  - Genetic or non genetic
- Stress treatment
  - e.g. Oxidative, inflammatory,dietary stress
- Molecular techniques
  - Genomics, proteomics, metabonomics, nutrigenomics



Fractionation of Blueberry Phenolics



Column chromatography,
solvent partitioning

Sugars +
Organic Acids

Flavonol glycosides +
Hydroxycinnamates

Low M.W.
Proanthocyanidins

Anthocyanins

High M.W.
Proanthocyanidins

Blueberries and Brain Function

in vivo Evidence, J . Joseph et al.

- Cognitive function maintained & restored in aged rats
- Motor abilities maintained & restored in aged rats
- Neurogenesis enhanced in BB-fed
- Other models where BB benefit:
  - Genetic Alzheimer mouse
  - Radiation studies

Blueberries and Neurogenesis

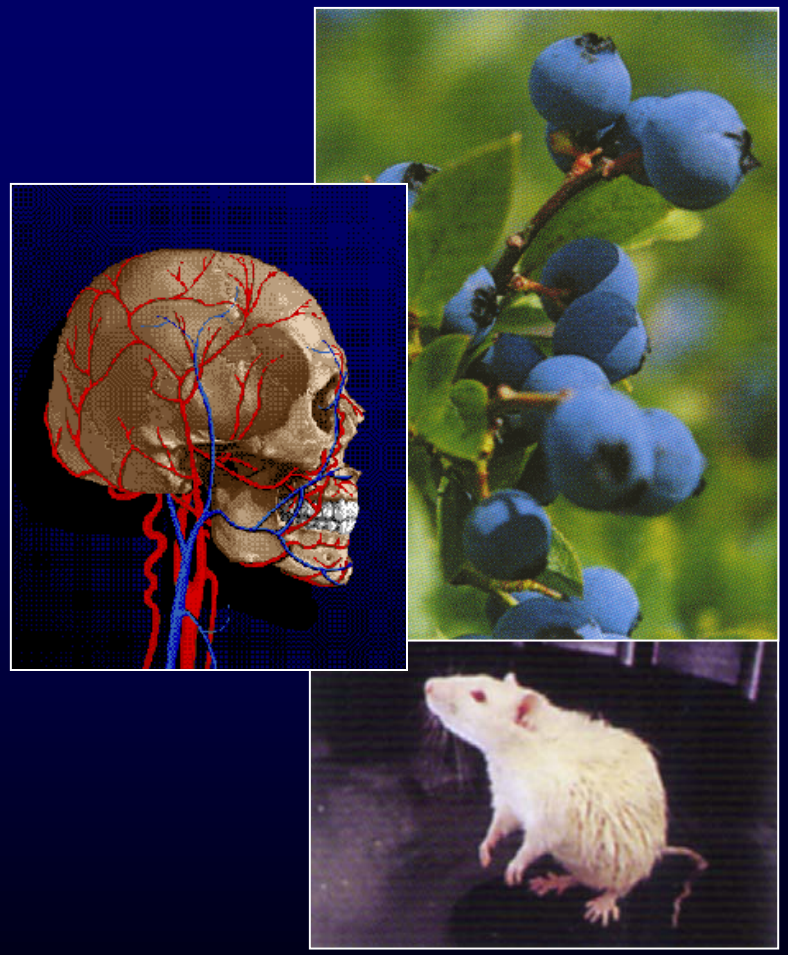
Reversal Effect?

Blueberries & Ischemic Stroke

in vivo study

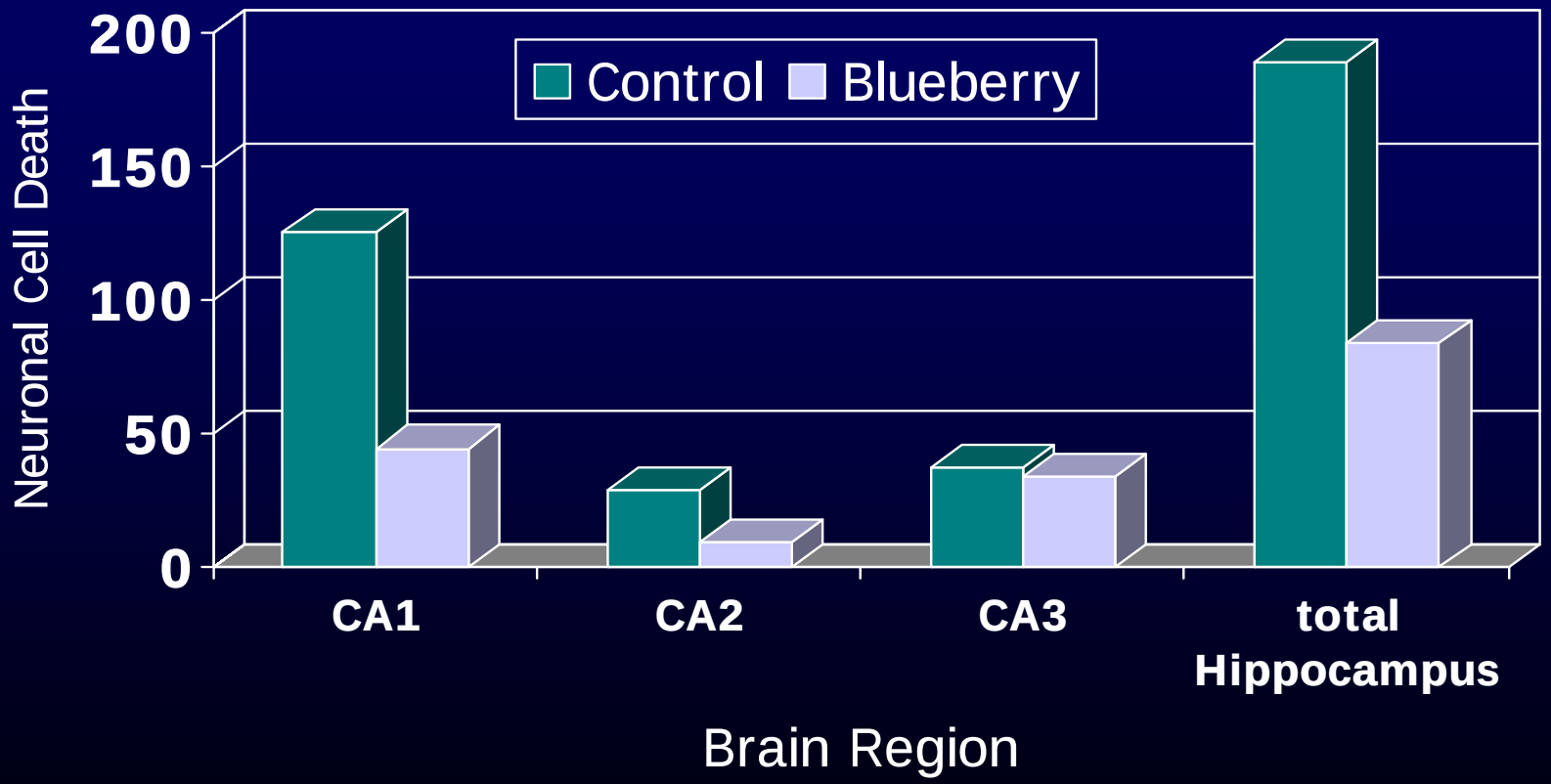
Feeding Diets Enriched in Lowbush Blueberry (*Vaccinium angustifolium* Aiton) Extract Decreases Stroke Severity in Rats.

Sweeney et al. 2002. Nutritional Neuroscience, 5: 427-431.



Blueberries and Ischemic Stroke

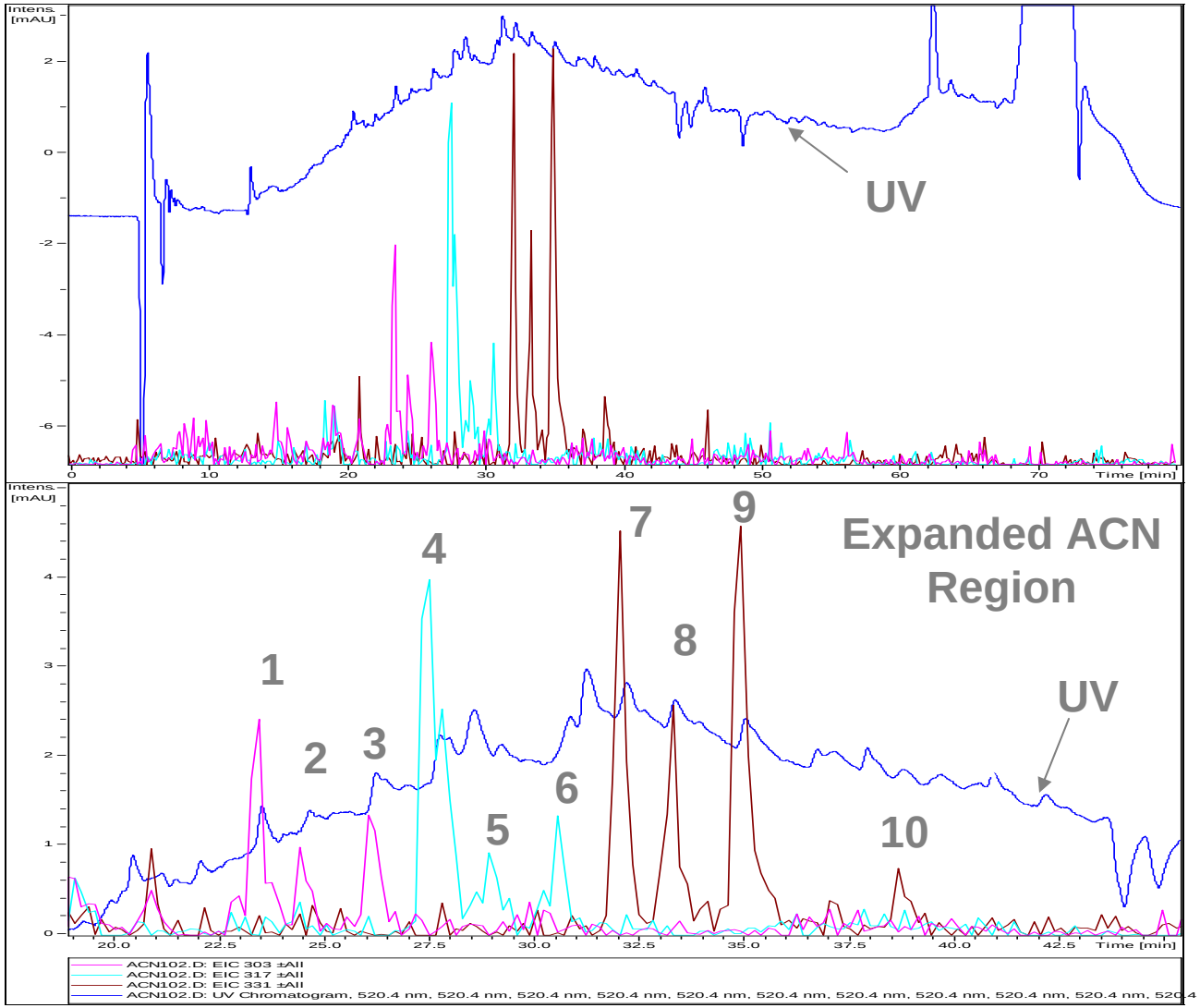
Rat study



Pig Feeding Trials

- What happens when ‘I’ eat blueberries?
- ‘Normal’ BB doses
  - 1 to 4 cups human eq./day
  - Diet rich in plant-based food (soy, barley oats)
- Bioavailability
  - Anthocyanins
- Bioactivity

BB have complex ACN profile, in vivo conjugates, ‘normal doses’, ad libidum



Comparison of Anthocyanin Bioavailability

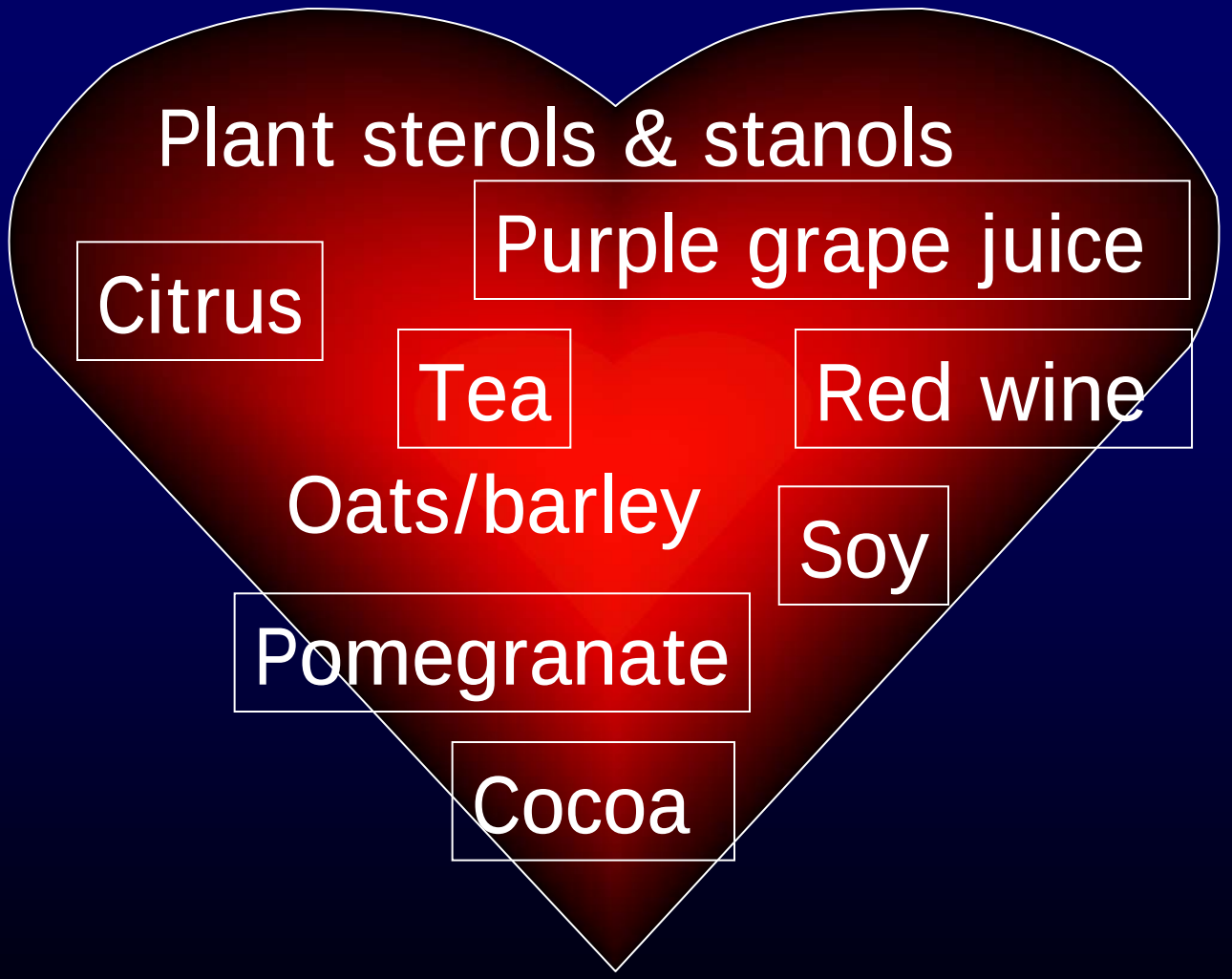
Talavθra et al.	Blueberry
• Study • Rats • Fed 659 mg C-glu per day/kg BW • 15 days feeding • Whole brain content of total C-glu eq = 0.25 +/- 0.05 x 10^{-9} mol per g FW tissue	• Pigs • Fed up to 5 mg C glu eq per day/kg BW • 60 days feeding • Brain cortex content of total C-glu eq = +/- 0.133 a 10^{-12} mol per g FW tissue

Talavθra S, Felgines, Texier O, Besson C, Gil-Izquierdo, Lamaison J-L, Rθmθsy C. Anthocyanin metabolism in rats and their distribution to digestive areas, kidney and brain J Agric Food Chem 2005

Flavonoids in the Body

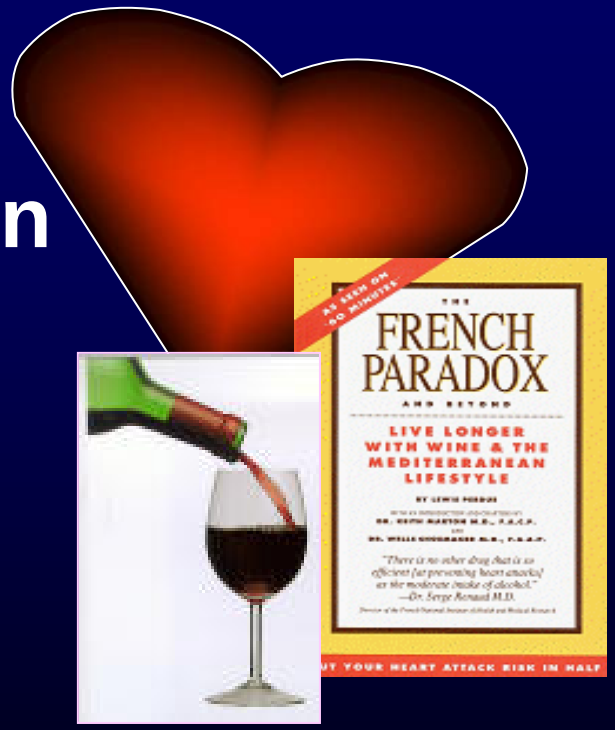
- Flavonoid structure is very important
  - Bioavailability
  - Bioactivity
- Isoflavones > catechins > flavonols > anthocyanins > proanthocyanidins
- > 1000X differences

“Heart Smart” Foods



Cardioprotection by Flavonoids

- **Anti-oxidative activity**
- **Anti-plaque activity**
- **Modulate vascular function**
- **Anti-platelet aggregation activity**
- **Reduce plasma lipids**



No significant effect of BB diet on platelet aggregation or blood clotting in pigs.

Human Platelet Aggregation *ex vivo*

	Closure Time (sec)	s.d.	% c.v.
Before BBJ	124	17	4.6
After BB Juice	123	33	5.2
+ Aspirin	>300	0	0

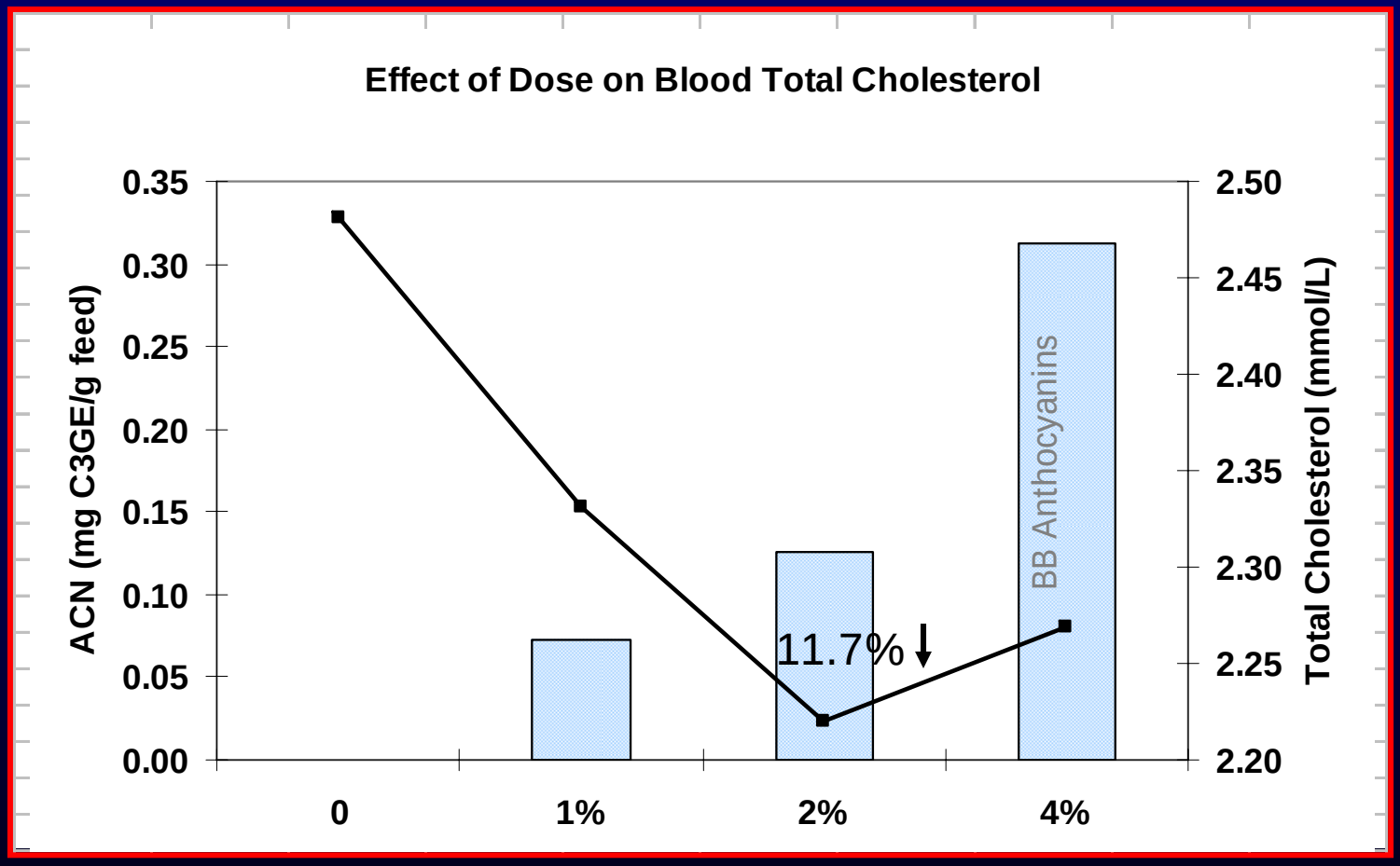
Flavonoid bioactivity and/or bioavailability too low for platelet effects?

Blueberries vs. no Blueberries

	F Prob	
	+/- BB	Time (4 & 8 wk)
Total Cholesterol	0.004*	0.277
LDL Cholesterol	<.001**	0.610
HDL Cholesterol	0.022*	0.101
Triglycerides	0.119	0.310
Platelet Activity	0.649	0.095

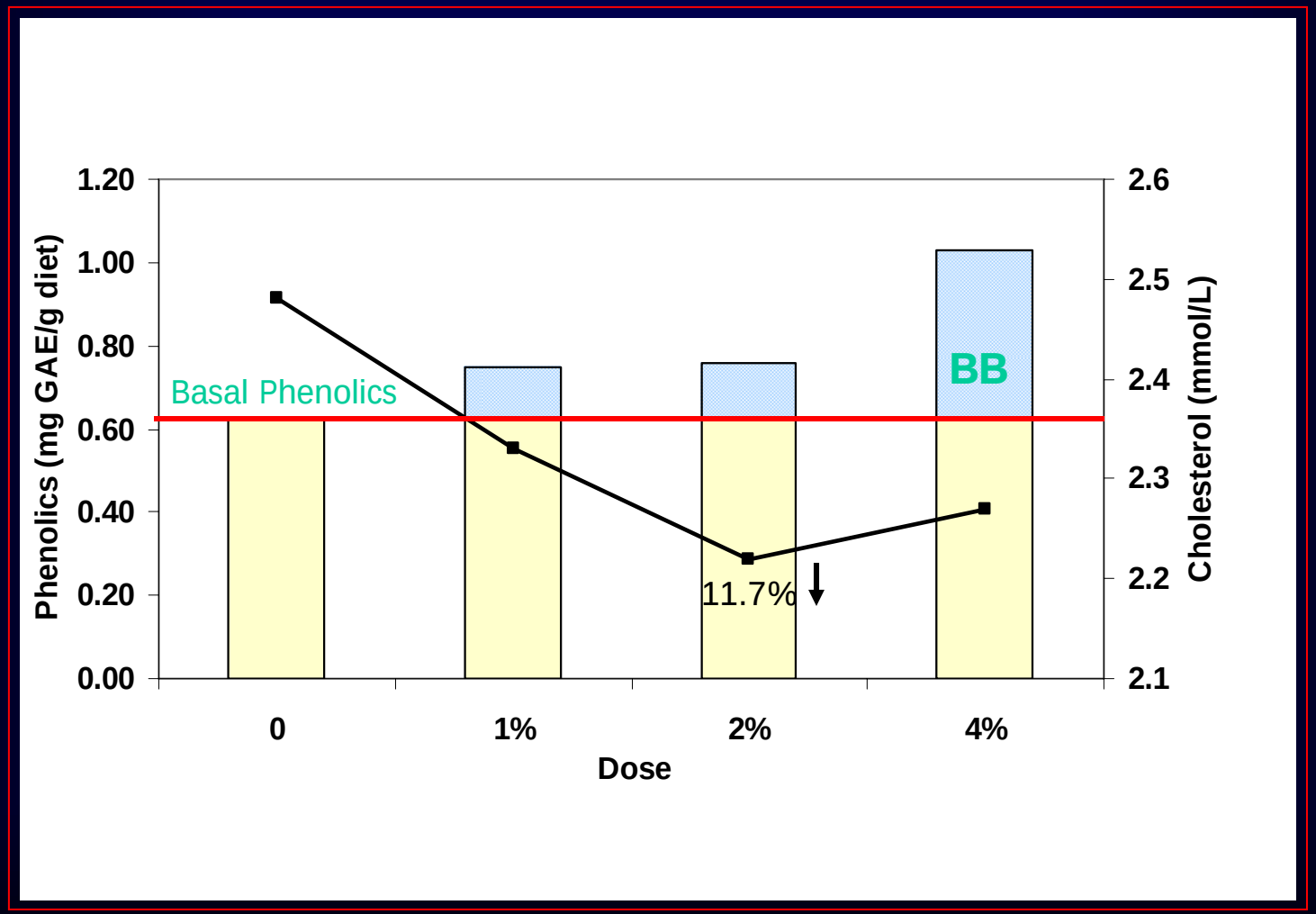
**P=<.001; *P< 0.05

Trial 1. Plasma Cholesterol (PC) and Dietary BB Anthocyanin vs. BB Dose



8.6% ↓ in PC w/BB (P = .004)

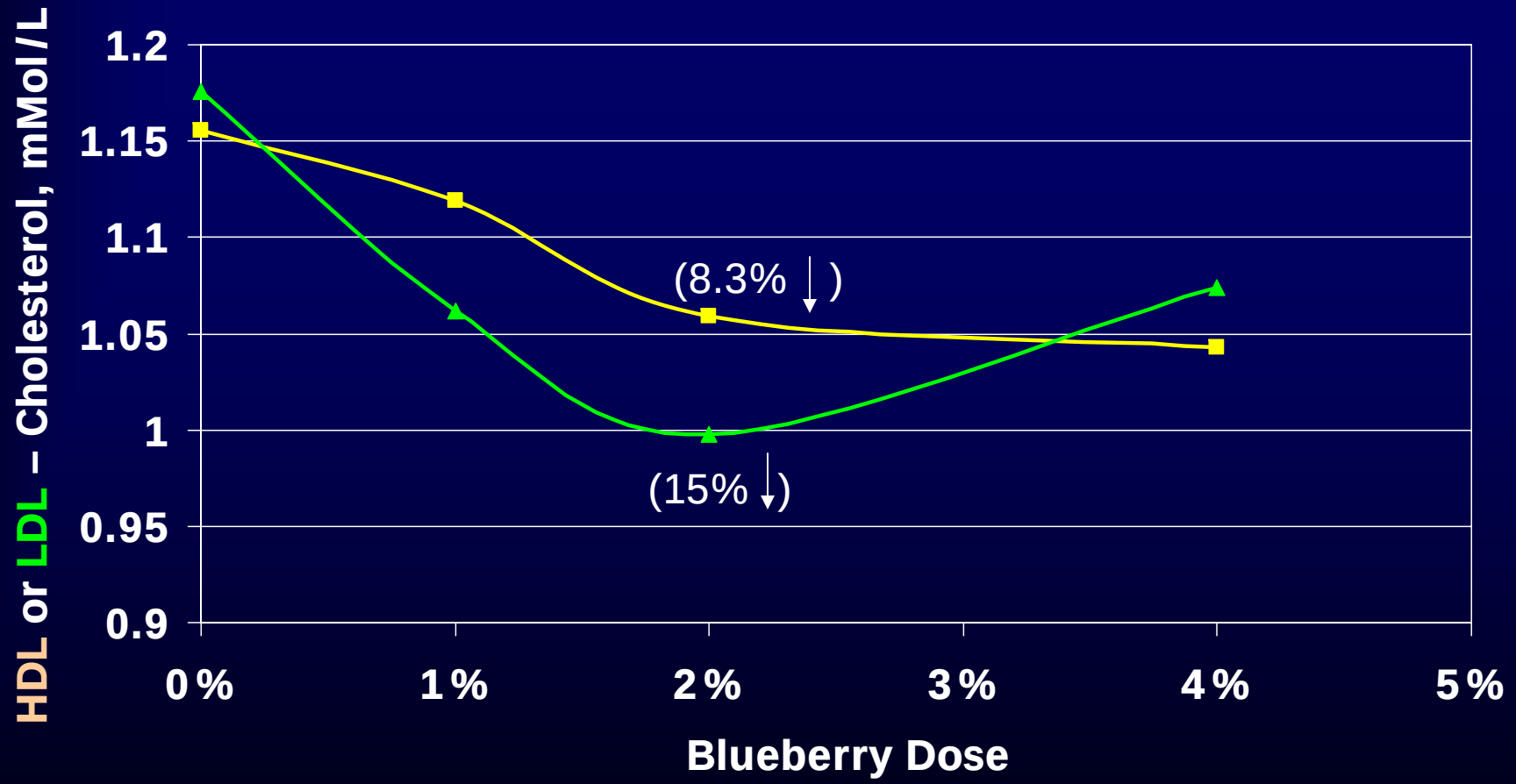
Trial 1: Plasma Cholesterol and Dietary Phenolics vs. BB Dose



Trial 1.

HDL cholesterol P = 0.022 for +/- BB

LDL cholesterol P = 0.005 for +/- BB



Plant Food Effects on Cholesterol

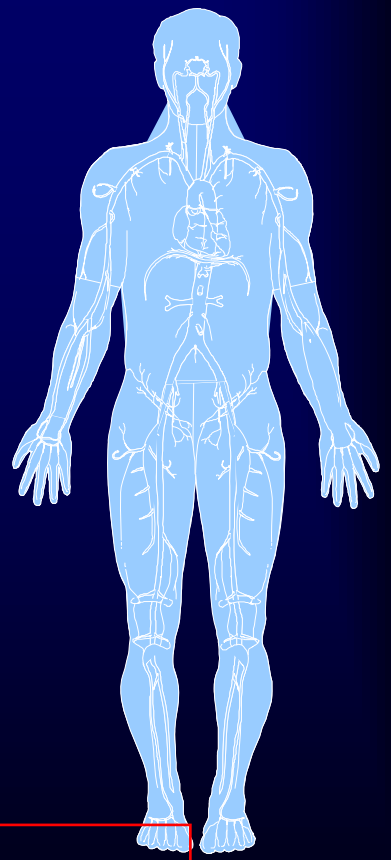
Results of PubMed Search

Diet component	Active Components	Pubs.
Soy	protein, inc. isoflavones	669
Oats	β–glucan	98
Barley	β–glucan	69
Blueberries	?	0


So how do Blueberries benefit health?
Oxidative Stress & Inflammation

Oxidative Stress and Inflammation

- **They are inextricably linked**
- **Inflammatory response**
  - **Acute vs. chronic**
- **Chronic Inflammation and disease**
  - **Atherosclerosis**
  - **Diabetes**
  - **Alzheimer & Parkinson disease**
  - **Arthritis**
  - **Irritable bowel disorder**
  - **AGING**



Inflammation is a highly regulated process

Oxidative Stress and Inflammation

Oxidative stress  disease, aging

Flavonoid (BB)
antioxidants

But,

- In vivo flavonoid concentrations are very low
- Flavonoid metabolites are less active
- Endogenous antioxidants are very high

Oxidative stress —X→ disease, aging

Flavonoid (BB) antioxidants

What we now think…

Pro-inflammatory Cell signaling

Low concentration, short exposure time

X Flavonoid (BB) antioxidants

Inflammation

Oxidative stress ⟶ disease, aging

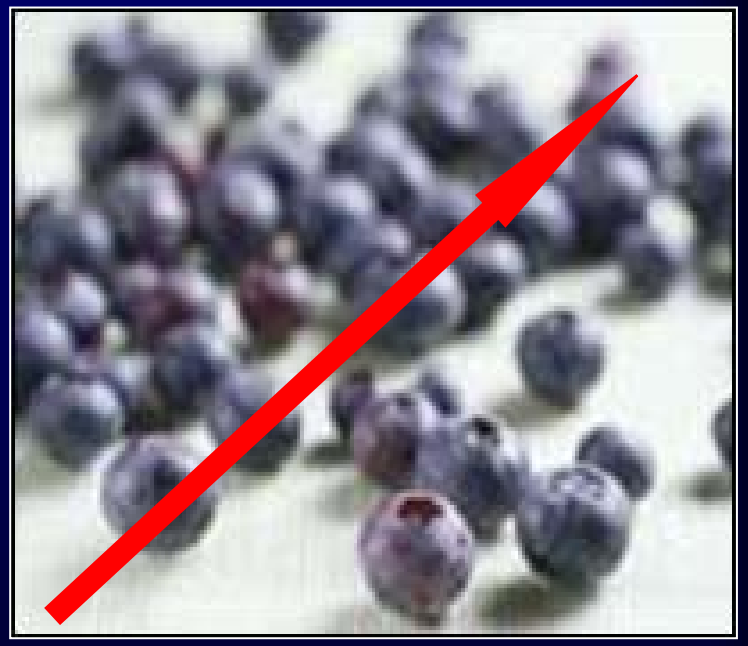
<u>Cell signalling modulators</u>

MAPK
TNF-a
NFk-B
CRP
PK-C
ERK
JNK…

The Future

- Blueberries are a rich source of flavonoids that have health promoting properties
- Research points to more than antioxidant effects.
- Food & health ‘arena’ is sophisticated.
- Well-substantiated heath messages are essential.
- United States Highbush Blueberry Council Research: meta-analysis, ‘functional’-benefits, public funding, and possibly health claims
- WBANA Research Summit

MARKET OPPORTUNITIES



SCIENTIFIC EVIDENCE


Questions?
kaltw@agr.gc.ca
Agriculture and Agri-Food Canada