Of Cassavas, Corn, and Chilies

Food preparation and nutrition

Methods of Food Preparation: Adapting foods to people

- How a food is prepared for consumption affects the presence, and availability of some compounds and elements
  - Ex: Vitamin C is heat sensitive
    - With cooking, the amount of vitamin C declines
- Processing can be particularly important when the foods are staple foods

Example of soybeans

- Soybeans are an Asian legume rich in the amino acids that complement amino acids found in cereals
- Soybeans can cause serious indigestion because they contain antitrypsin factor (ATF), which binds the enzyme tripsin that the digestive system uses to break down the protein in soybeans
  - If soybeans are boiled for hours or roasted at high temperatures, the ATF is deactivated, but the amino acids are destroyed

Soybean use

- Chinese and Japanese cooking uses fermentation to make soy sauce, in which the action of the microorganisms deactivate ATF, yet amino acids remain
  - ATF is also removed in process of making tofu by using certain salts to precipitate digestible proteins out of the soybeans.

Tukanoans and Cassava

- Some Amazonian Indians have developed a method to eliminate a toxic compound, cyanide, in cassava
  - Cassava is highly toxic in the raw state.
- Cassava is a dietary staple of many people in the world
- Humans can tolerate small amounts (e.g., that found in cigarette smoke), but large amounts are toxic

Tukanoans

- The amount of cyanide consumed by the Tukanoan Indians of Colombia is large enough to cause death
- Cassava is consumed in the form of a thick soft bread made daily from white-fleshed roots
- It is served with fish, game, and insects

CASSAVA

Cassava

- Cassava is also known as *Yuccu* and manioc.
- It was first produced in Paraguay and Brazil, but is now used as a staple food all over the world
- All parts of the cassava plant contain the cyanide compound and it is most concentrated in the leaves
- There are different varieties of cassava and the more bitter ones have more of the cyanide compound
  - The cyanide is in the plant to protect it from predators

Cassava Preparation

- Roots are rasped to remove outer peel
- Roots are washed and grated to a watery mash
- The mash shows a dramatic increase in free cyanide, which can then be washed away (being water soluble)
- The mash is separated into 3 parts: liquids, starch, and fiber
  - The separation is done by washing with water and juices and squeezing mash through a basket

Cassava Preparation

- Once the starch has settled the supernatant is decanted to make a drink called *manicuera*
- The starch and fiber are stored overnight for 24 to 48 hours
- They are then recombined and baked into bread
  - To recombine the fiber is dewatered in a basket and toasted and then combined with the starch
- The amount of total cyanide appears to decrease with storage and cooking

Does processing decrease the nutritional value of the cassava?

- For the Tukanoans, the answer is no
  - Many nutrients are lost by losing the skin, but other processing techniques that use more heat tend to have greater nutrient losses
  - Also drinking the *manicuera* helps to recover many of those lost nutrients
- Dufour suggests that these processing techniques could be used elsewhere in the world to make this staple food more nutritious

Maize Processing

Maize Processing

- The rise of maize (*Zea mays*) as a major cultivar in the New World from 7,000 b.p. in Mexico was not without a biological price
- Corn is of limited nutritional benefit without appropriate processing or treatment to enhance availability of nutrients

Maize Processing, 2

- 90+% of the protein in the corn kernel comes in four forms
  - Albumins, available, low quality
  - Globulins, available, low quality
  - Zein, relatively available, low lysine, low tryptophan, high leucine to isoleucine ratio
  - Glutelin, soluble in alkaline solution, high lysine, moderate tryptophan, low leucine to isoluecine ratio

Maize Processing, 3

- Nutritional deficiencies of corn when not appropriately processed:
  - Low in essential amino acids lysine and tryptophan
  - High leucine to isoleucine ratio
  - Low availability of niacin
    - Thought to be bound by an insoluble substance
    - Can be synthesized from excess tryptophan
    - Synthesis of niacin is inhibited by leucine
    - Leucine inhibition is removed by isoleucine

Maize Processing, 4

- Most severe nutritional problem with a high maize diet is the potential for pellagra from niacin deficiency
  - Symptoms:
    - Dermatitis: Skin inflamation where exposed to sunlight
    - Diarrhea: Loss of acidity may allow bacterial growth, causing a decreased ability of the intestinal mucosa to facilitate absorption
    - Depression: Irritability, headaches, sleeplessness, loss of memory hallucinations, delusions of persecution, and severe depression
    - Death through organ failure

Maize Processing, 5

- Historically pellagra has been the only endemic nutritional disease native to the U.S.
  - In 1918, there were an estimated 10,000 pellagra deaths and 100,000 cases, primarily in the cotton growing regions of the Southern U.S.
    - pellagra became a public health issue in the South during the depression
      - Families growing corn and eating mostly non-alkaline processed grits

Maize Processing, 6

- Alkali processing changes the nutritional quality of maize
- Tortilla manufacture in MesoAmerica
  - Heat dried corn to boiling in 5% lime-water solution
  - Cool, discard liquid, wash corn, grind into a dough
  - Form pancake shape and cook on hot clay griddle

Maize Processing, 7

- Sources of alkali (turning the water to a base pH, higher than 7.0) include the mineral lime from bedrock in many areas, commercial lye and soda preparations, and wood ash
  - Lime has the added benefit of increasing dietary calcium

Maize Processing, 8

- Alkali processing increases the bioavailability of niacin and glutelin, while decreasing availability of Zein
- The net effect is to decrease the likelihood of pellagra on a high corn diet
- The populations most likely to experience pellagra historically are those that relied heavily on it
  - Native Americans

Maize Processing, 9

- Many New World Societies were very heavily reliant on maize cultivation and alkali processing
  - Katz and colleagues used the HRAF files to assess processing technique (alkali or not), and cultivation and consumption of corn on 4 point scale (none to high)
  - They found a good association between level of cultivation, consumption, and alkali processing

Maize Processing, 10

Maize Cultivation	Maize Processing	Maize Consumption			
		None	Low	Moderate	High
High	Alkalai	0	0	10[b]	7
	Not Alkalai	0	0	0	0
Moderate	Alkalai	0	1	2	0
	Not Alkalai	0	0	5[c]	0
Low	Alkalai	0	0	0	0
	Not Alkalai	0	12	0	0
None	Alkalai	0	1[a]	0	0
	Not Alkalai	12	1	0	0

Maize Processing, 11

[a]Crow (Plains): use alkali, but have no cultivation of corn, and little consumption of maize

- Their use of maize historically comes from the Hidatsa
  - Crow split from Hidatsa to become nomadic buffalo hunters, but maintained the food habit of alkali processing corn (with wood ashes)

Maize Processing, 12

[b]Paez (Andean): Most Andeans don't process, but the Paez do

- Archaeological evidence suggests that the Colombian area where the Paez live did not develop corn cultivation like others in the Peruvian Andes
- The Maize complex, complete with alkali processing was introduced into Colombian Andes late (like in Southwest U.S.), influencing the Paez and others

Maize Processing, 13

[c]Papago (Southwest U.S.): don't use alkali, but are moderate producers and consumers of corn

- Limits of the arid environment prohibits year-round cultivation and high reliance on corn
- Papago don't store maize nor allow it to fully ripen--they eat it in the roasting ear stage, gorging at a time when other food is abundant (Thrifty Genotype)

Chili Peppers

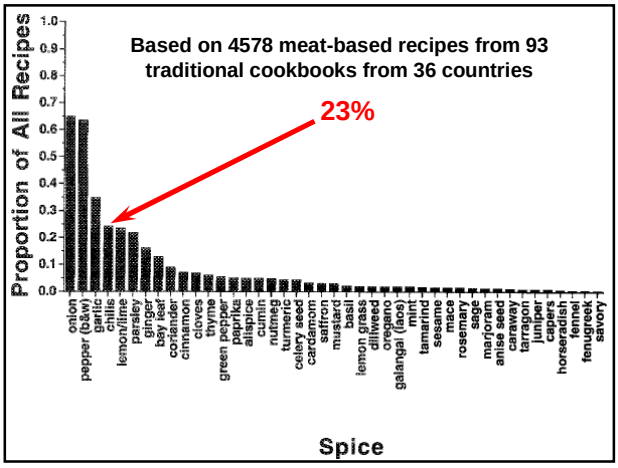
- Most widely used food seasoning in the world
- Fiery taste comes from capsaicin
  - Capsaicin is not detected by most vertebrates
    - Especially birds who are excellent seed dispersers
    - Mammals are sensitive to the burning
      - Most mammals damage the seeds in the process of consumption
    - Humans are sensitive, so why consume?

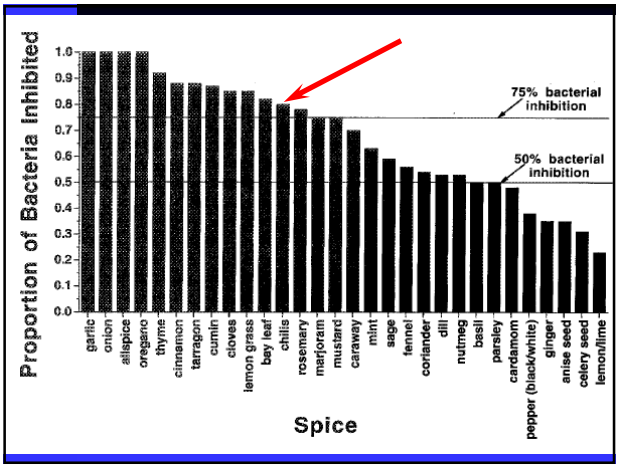
Peppers

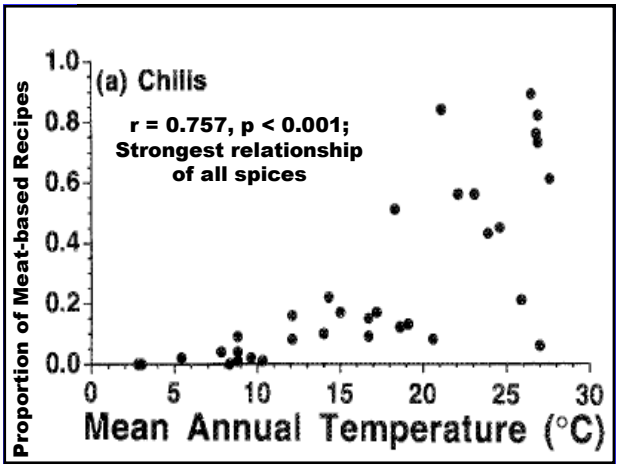
- Peppers are early domesticates (~ 9000 ya in MesoAmerica)
- Moved from New World to Old World
  - Rapidly adopted in European cuisines
- Nutritional Benefits of Chili Peppers
  - One of the top plant sources of vitamin A
  - Rich source of vitamin C and the B vitamins

Other reasons for use

- Lower body temperature
  - Capsaicin causes sweating which facilitates evaporative cooling
- Facilitates digestion of starches, increases gastric secretion, stimulates appetite
  - Helps to liven up bland staples
- Inhibit bacterial growth







Chili peppers

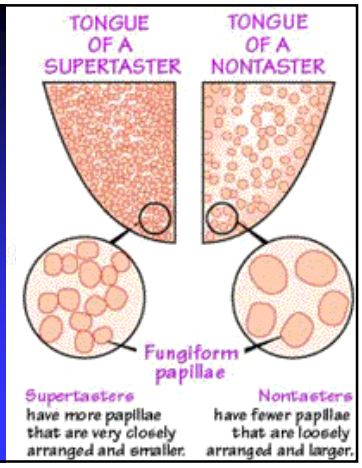
- Acquisition of chili pepper preference depends on social influences
  - Convert an aversion to a preference
  - Chili peppers cause oral pain, salivation, runny nose, eyes water
  - In rural Mexican villages, 2-6 year olds are exposed to peppers, permitted to refuse
    - Children observe elders enjoying pepper
    - By 5-8 years, most had acquired taste for "hot" foods

Chili peppers

- The pepper flavor and salivating enhance an otherwise dry and bland meal
  - Deeper reasons include "thrill-seeking" behavior--pain without any real danger
  - Mouth burn stimulates endorphin excretion (morphine-like neurotransmitters)
    - Some evidence that pepper eaters are less reactive to other endorphin-generating pain relievers

Tasting

- Much individual variation in tasting
- Supertasters, medium tasters, nontasters
- Supertasters very sensitive to bitter, sweet, spicy
  - Avoid peppers, cruciferous vegetables, fatty foods
- Nontasters less sensitive to spicy



The Fava Bean Taboo

Based on a presentation by Christine Newkirk

Interpretations of Fava Bean Taboo

- 1900 – 1960: Taboos linked to magico-religious belief systems
- 1960's – 1990's: Taboos linked to favism, an illness resulting from genetically based enzyme deficiency
- 1990's forward: Previous models contested, new synthesis explored

The Fava Bean: Background

- The fava bean has been called "the bean" of antiquity
- The genus name, *Faba*, refers to its round shape
- The bean was widely considered to possess spiritual and magical properties
  - Often the target of specified taboo
- Pythagoras is credited with issuing a ban on fava consumption due to the bean's flesh-like character
  - His community near Croton eschewed the beans

Early Interpretation of Fava Bean Taboo

- Andrews (1949) viewed taboo from a cultural evolutionary and symbolic perspective
  - Explained that the flesh-like character attributed to the bean was reason for an institutionalized taboo in some parts of the ancient world
    - Like a ban on meat eating

Revision of the Meaning-Centered Approach

New data from genetic and biological research suggested a biological basis for the fava bean taboos: G6PD deficiency was linked to favism through laboratory tests.

Biocultural Evolutionary Model

- Katz and Schall (1979) sought to understand responses to fava beans and favism in light of selection pressures and human adaptability
- Katz correlated fava bean consumption restrictions with prevalence of G6PD deficiencies throughout the world
- The new biocultural evolutionary approach:

Food Practices ↔ Genetic Characteristics

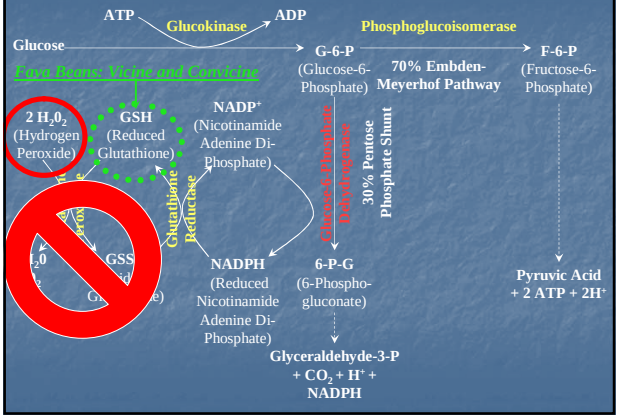
G6PD Hemolysis

- Red blood cells will hemolyze or burst when the oxidant stress level becomes too high
  - Hemolysis occurs in G6PD deficient individuals due to the consumption of certain foods or drugs
    - Substances that increase the oxidation of glutathione, thereby diminishing the available GSH for oxidation of peroxide, creating a potential for hemolysis
      - Fava Beans contains vicine and convicine whose metabolites can cause a hemolytic crisis in GD^{Med} individuals
      - Many anti-malarial drugs, sulfonamides, sulfones and other drugs produce the same reaction in severely deficient individuals
  - Can also cause the oxidation of hemoglobin, making it lose the ability to be a reversible oxygen carrier

Favism

- The Fava Bean (Vicia faba) is a favored cultigen in areas where the GdMed allele is common including Greece
  - Vicine and convicine make up about 0.5% of the wet weight of the Fava bean
    - These compounds metabolize to divicine and isouramil in the intestine
      - These metabolites decrease RBC reduced glutathione (GSH)
        - Increase the production of hydrogen peroxide and free radicals
      - Creates a severe oxidant stress in G6PD deficient cells

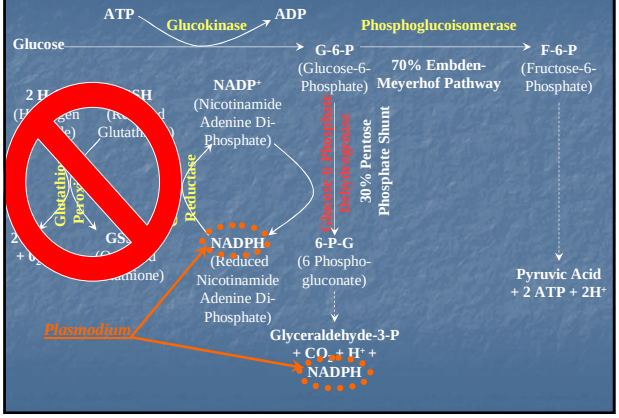
G6PD and Fava Beans



Malaria in the RBC

- Plasmodium protozoans preferentially attack immature RBC but P. falciparum can invade RBC of all ages
  - Plasmodium oxidizes RBC NADPH from the Pentose Phosphate pathway for its metabolism
    - This results in a deficiency of RBC GSH, most severe in G6PD deficient individuals, leading to peroxide-induced hemolysis which curtails the development of Plasmodium
      - After several cell cycles the Plasmodium can adapt to produce its own G6PD, reducing the adaptive benefit of G6PD deficiency

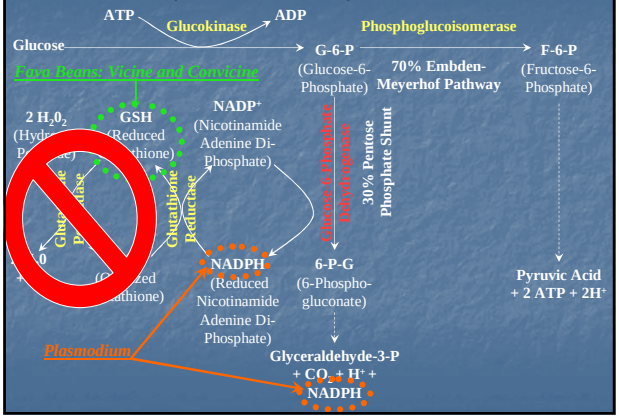
G6PD and Malaria



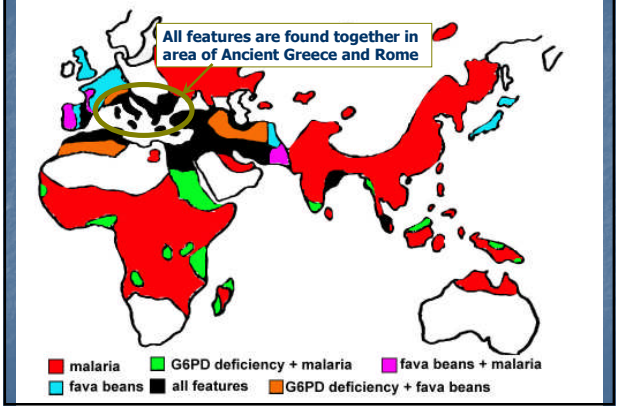
Fava Beans and Malaria

- Recall that fava beans contain compounds that metabolize to powerful oxidants
  - In a cell that is oxidant-stressed by Plasmodium infection, the addition of another strong oxidant can lead to a rapid build-up of peroxide
  - In vitro and in vivo (mouse) studies indicate a mild suppressant effect of divicine and isouramil on Plasmodium in G6PD normals
    - This effect is even greater in G6PD deficient individuals

G6PD, Fava Beans, and Malaria



Distribution of G6PD, Fava Beans, and Malaria



The Pythagorean Bean Ban

- Simoons conducted a comprehensive review in 1998
  - Concluded that the fava bean ban had no relationship to G6PD deficiency in the population of Croton
  - Argued for a strictly magico-religious explanation for the fava taboo

Simoons

- A study of Greeks from Samos (the origin of Pythagoras' parents) found no G6PD deficiency at all
- Studies of populations in Italy and Greece find rates of G6PD deficiency ranging from zero to 35 percent, including mild to severe forms of the deficiency
- Based on descent lines and geography, Simoons posits that the rate of G6PD deficiency among Greek males in the Ancient Greek colonies in Southern Italy at the time of Pythagoras averaged 2-4 percent
  - He asserts that only around 13 percent of these individuals would have developed favism

Simoons' Conclusions

- G6PD deficiency was not frequent in any populations during Pythagoras' time
  - There is no account of favism in the medical records, despite common knowledge of malaria and its symptoms
  - Restrictions against fava bean consumption were most likely linked solely to cultural meaning:

    The richness of ancient views surrounding the bean—in terms of death and the underworld, decay, spirits of the dead, flatulence, meat eating and cannibalism, sex and regeneration, and purity and impurity—makes Pythagorean revulsion at the thought of eating beans all the more understandable. . . . [T]he powerful magico-religious motives reported in both Greece and Rome were quite sufficient to have brought on the bans of fava beans all by themselves, without implicating favism at all.

So where does that leave us?

- The continued cultivation of fava beans in areas where there are substantial numbers of individuals with G6PD deficiency may be related to malaria
- The ancient taboo on fava bean consumption probably has nothing to do with G6PD deficiency

References

- Katz, SH. and Schall, J. 1979. Fava bean consumption and biocultural evolution. Medical Anthropology. 3: 459-476.
- Simoons, F. 1998. Plants of Life, Plants of Death. Madison, WI:University of Wisconsin Press.

Next

Adaptation to Dairy Products

History of Dairy Production

- Origins in the Old World
- Early pictorial evidence from the Sahara Desert during the Neolithic (c. 5500-2000 B.C.)
- Domesticated faunal assemblages from Neolithic sites

Recent 'Direct' Detecting of Dairying

- Extraction of lipids (fats) from Neolithic vessels
- Can distinguish isotopic $\delta^{13}C$ of dairy fat vs. adipose fats (milk vs. meat)
- Demonstrated processing of dairy products ~4500 B.C. in Britain
- As early as ~6th Millenium B.C. in SE Europe

Milking Populations

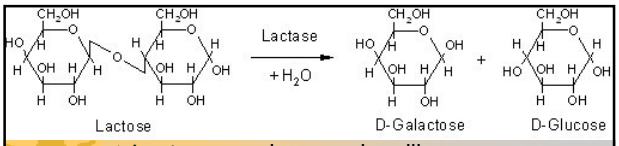
- Northern and Central Europe
- South Asia (India), Tibet and Mongolia
- Pastoralist populations in Africa (Masai and the Fulani)
- Some circumpolar peoples in Siberia (reindeer milk)

Non-milking Peoples

- New World populations
- Old World: Eastern Asia (China, Japan) and most other groups of East and SE Asia
- Despite presence of pastoralists (e.g., Masai) in Africa, 1/3 of continent is non-milking

Why Not Adopt Dairying?

- Ecological Reasons:
  - Africa: tropical zone with tsetse-borne sleeping sickness that decimates cattle herds
  - Shortage of grazing land; need to devote to crops and to plough animals
- Cultural:
  - Distaste for drinking milk (seems like urine)
- Biological:
  - Lactose intolerance



- Lactose - main sugar in milk
  - Also called milk sugar
  - Only significant CHO from animal origin
- Lactase (intestinal enzyme) – required to digest lactose
  - Breaks bond between galactose and glucose
- Most humans, like other mammals, lose lactase after infancy
- Persistence of intestinal lactase in some populations

What is Lactose Intolerance?

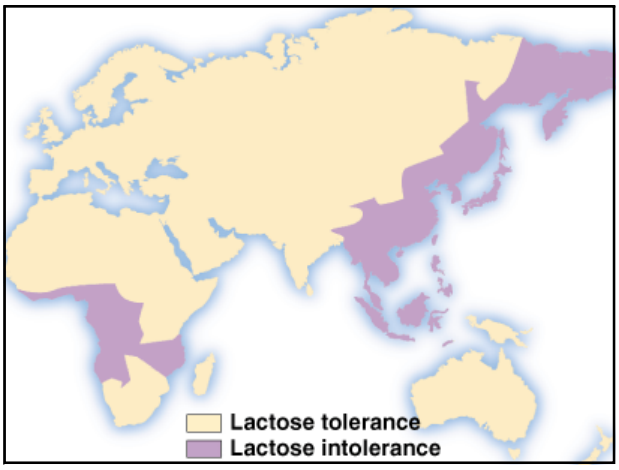
- Primary adult lactose malabsorption
- Symptoms: bloating, flatulence, diarrhea, cramps, sometimes nausea and vomiting
- Determined by the administration in a fasting state of a 50 g dose of lactose in water:
  - measure subsequent rise in blood glucose level (no rise = lactose intolerant)
  - appearance of additional hydrogen in breath
  - (increase = lactose intolerant)
  - direct intestinal biopsy

Lactose Digestion

- Genetic trait inherited as an autosomal-dominant characteristic
  - Malabsorption caused by DD or Dd genotype
- Most common among peoples of Northern and Central Europe & other populations that eat dairy products
- Genetic mutation that must have arisen with the rise of dairy production

Population Distribution of Lactose Intolerance

- Approximately:
  - 79% of Native American people;
  - 75% of African-Americans;
  - 51% of Hispanics;
  - 21% of Europeans
- In Africa, Asia and Latin America prevalence rates range from 15 -100% depending on population studied
  - Populations formed by recent admixture between lactose-absorbing and non-absorbing ethnic group exhibit mixed numbers (as expected).
    - Ex: African Americans – about 80%



Explanations

- Cultural-Historical hypothesis
  - Lactase persistence is an adaptation to milk consumption and pastoralism
- High latitude, low UV areas at risk for calcium deficiency
  - Lactose promotes calcium absorption
    - Could explain high persistence in Northern Europe
- In arid settings lactose digestion will aid hydration
  - High frequency of persistence among desert dwelling pastoralists

Cultural-Historical Hypothesis

- Simoons (1974) postulated that certain groups produced dairy products in high amounts
  - Processed foods like yogurt and cheese contain less lactose; began with these and moved on to unprocessed milk
- Certain individuals had ability to digest lactose without distress
- Through process of natural selection this genetic mutation increased in the population

Simoons (1974) continued…

- Have to consider all factors when trying to explain why some populations adopted milking and others didn't
- i.e. Ecology of land and animals; cultural interest in cattle, goats, and dairying; and physiological adaptation to milk digestion

High Latitude Hypothesis

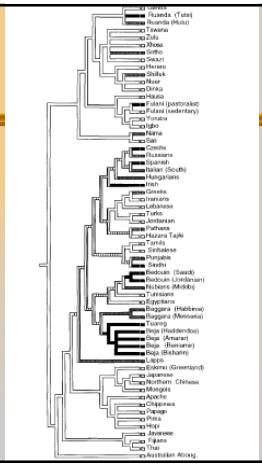
- Consumption of fresh milk
  - High latitude, low UV, low vitamin D synthesis puts people at risk of rickets
  - Digested milk products like cheese and yogurt have reduced lactose content
  - Only fresh milk has full lactose value
  - Lactose aids in the absorption of calcium
- Northern Europe has higher rates of lactase persistence than Southern Europe
  - Southern Europeans consume more milk as cheese and yogurt
  - Northern Europeans at higher risk of Vitamin D and calcium deficiency

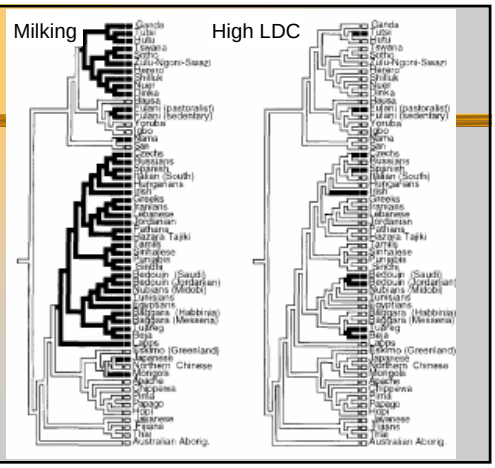
Arid Area Hypothesis

- Fresh milk consumption increases water intake, especially important in hot-dry environments
- Desert Pastoralists tend to have high lactase persistence rates
  - Those without lactase would be subject to diarrhea which would accelerate dehydration
  - Bedouin, Tuareg, Fulani cases would support this model

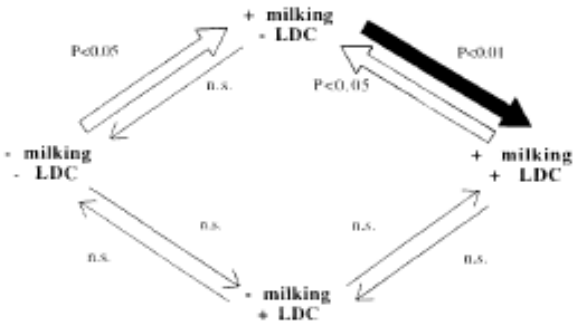
Phylogenetic Analysis

- A phylogenetic analysis comparing milking rates to lactose digestion capacity (LDC) supports the cultural-historical explanation
- High latitude and Arid Setting models are not supported





Milking came first



Hidden Sources of Lactose

- Bread and other baked goods
- Processed breakfast cereals
- Instant potatoes, soups, and breakfast drinks
- Margarine
- Lunch meats
- Salad dressings
- Candies and other snacks

Institute of Medicine Calcium Guidelines (1997)

Age Group	Amount of Daily Calcium
0-6 months	210 mg
6-12 months	270 mg
1-3 years	500 mg
4-8 years	800 mg
9-18 years	1,300 mg
19-50 years	1,000 mg
51-70 years	1,200 mg

Nutritional Implications of Lactose Intolerance

- May be forcing dairy products on people who cannot digest them
- Are there alternatives?
  - Butter, aged cheese
  - Low-lactose dairy products
  - Foods rich in calcium

Alternative Foods with Calcium

Broccoli (1 cup)	94-177 mg
Chinese cabbage (bok choy) 1 cup	156 mg
Sardines (3 oz.)	226 mg
Molasses (2 tbsp)	274 mg
Tofu (3 oz.)	225 mg

Inappropriate Substitutes

- Swiss chard, rhubarb and spinach are all rich in calcium, but contain oxalates that stop calcium absorption in the body
- Calcium is absorbed and used only when there is enough vitamin D in the body (eggs, liver, and sunlight)
  - Or in the presence of lactose

Summary

- Biological adaptation to dairy products probably genetic, enabling certain people to digest lactose better than others
- Adaptation probably occurred in milking populations
- Milking occurred as a result of a combination of ecological, cultural, and biological factors
- Dietary recommendations should include dairy alternatives for lactose intolerant people