Biocultural Case Studies

Phenylketonuria, Cretinism and Geophagy

1. Phenylalanine pathways

- Phenylalanine hydroxylase
- Phenylalanine → Tyrosine
- Phenylpyruvic acid

2. Tyrosinase deficiency causes albinism
   - Can have reproductive implications including enhanced or reduced fertility depending on mating preferences.

3. P-hydroxyphenylpyruvic oxidase deficiency causes tyrosinosis
   - Increased levels of circulating tyrosine and tyrosine metabolites

Phenylalanine pathways

PKU

- Phenylalanine hydroxylase insufficiency causes phenylketonuria (PKU)
  - Most common genetic abnormality in the U.S. (1:10,000 overall, about 1:2,500 Europeans)
  - Growth retardation, mental retardation, depigmentation of skin, hair
  - Screened for in infancy and treated by a diet restricted in phenylalanine intake which causes some growth retardation
  - Different screening techniques have different false positive results
    - About 2/3 of positives have classic PKU
    - New test released in 1998 cuts false positives from about 1% to about 0.01%
Phenylalanine pathways

1. Phenylalanine hydroxylase
2. Tyrosinase
3. p-Hydroxyphenylpyruvic oxidase
4. Homogenistic acid oxidase
5. Many steps

Phenylalanine → Tyrosine → Homogenistic acid → Maleylacetoacetic acid

Phenylpyruvic acid → Homogenistic acid → Thyroxin

Goiter and Cretinism

- Iodine is a necessary constituent of Thyroxin made in the thyroid gland at the base of the neck by combining iodine with tyrosine
- Thyroxin functions to increase the cellular rate of carbohydrate metabolism and of protein synthesis and breakdown
- Deficiency in production of thyroxin can result in goiter and cretinism
- Goiter: thyroid hypertrophy
- Cretinism occurs in children born to goiterous mothers
- Musculo-skeletal growth retardation, CNS impairment frequently deaf-mute

Deficiency can by induced by goitrin present in Cruciferae (e.g., cabbage, rutabagas)
- Hypothesized relationship with PTC tasting since PTC tasters are sensitive
- Thiocyanate contained in yams and cassava also suppresses absorption iodine

Endemic pockets:
- Inland and highland settings, Detroit, Peru
- Highland New Guinea

Dani
Woman with large goiter
Dani Women with Goiters

Cretinism among the Maring

- No goiters noticed prior to 1966
  - 1968 survey found 25% goiter rate among adult females and 24 cretins in a population of about 2,000
  - All cretins less than 8 years old
- Focus on change in 1960—non-iodized trade salt introduced
  - Traditional salt source contained iodine but took a lot of work
  - Injected iodized oil and required all salt carried into the area to be iodized after 1970

Dani Men with Cretin
Geophagy

Based on a presentation by Erica Gibson-Staneland

What is Geophagia?

- It is a subcategory of Pica
  - Eating non-food items
  - Pica is derived from the Latin for magpie, a bird with a catholic appetite
- Geophagia is the practice of eating dirt or earthen clays
  - Literally geo “earth” phagia “eating”
  - Clay, laundry starch, and ice are most commonly craved items

Hypotheses

- Pica/Geophagy is practiced for many reasons including:
  - Response to obtain needed nutrients
    - Calcium, magnesium, etc.
  - Response to hunger
    - Where available, clay is free and filling
  - Cultural phenomenon
    - Learned practice transmitted primarily from mothers to daughters

- Response to physiological changes, especially associated with pregnancy
  - Dry up salivary secretions, reduce nausea of morning sickness
- Way of seeking attention
  - Pregnant women use Pica to seek social support
- Protect body from toxins
  - Clay minerals bind with plant toxins like glycoalkaloids rendering them harmless

Dirt Eating Around The World

- Geophagy has been found around the world. It appears to have originated in the tropics of Africa, and is now found on every continent except Antarctica
- Slaves brought the custom of dirt eating to the New World with them, although there is some evidence of geophagy in the New World before European contact
  - Aboriginal peoples of the New World mixed earth with potatoes or acorns to neutralize glycoalkaloids or tannic acids so that the food would be easily digestible
- Slave owners were appalled by the dirt eating practices of the slaves, and they put mouth locks on them to prevent them from eating dirt
- The slaves tried to commit suicide by eating dirt so that their bodies would return to their homeland

Mouth Lock
Iron and Dirt

• Question: Does geophagy cause iron depletion, or is iron extracted from the soil to supplement the women’s low iron levels
  – 52 women from a pre-natal clinic in Kenya
  – 73% of the women practiced geophagy, and the median amount of soil consumed was 41.5 g per day
  – No significant link to iron deficiency
  – But locally, geophagy is thought of as a normal behavior for pregnant women

Clay and Pregnancy in Nigeria

• The Tiv are one of the few groups in the world where men also practice geophagy
• The men eat clay as an anti-diarrheal medication
• Tiv women are universal geophagists during their pregnancies
  – They eat clay throughout their pregnancies
  – To alleviate morning sickness in the first trimester
  – Then as a nutritional supplement as the pregnancy progresses
  – The Tiv are a non-dairying population, and women may eat the clay for extra calcium

Geophagy Across Africa

• Wiley and Katz compared geophagy rates among populations in Africa practicing dairying and those who do not
  – Sixty populations were used
  – Geophagy is more common in non-dairying groups except when geophagy is rarely practiced
  – In the six dairying groups that practiced geophagy, three limited women’s access to milk

<table>
<thead>
<tr>
<th>Geophagy During Pregnancy and Dairying in 60 African Populations</th>
<th>Dairying</th>
<th>Non-dairying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geophagy rating:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AbSENT</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Rare</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
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<td>4</td>
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<tr>
<td>Common</td>
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<tr>
<td>Virtually Universal</td>
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</table>

Dairying and Geophagy in Africa

Clay vs. Dairy

Nutrients from Clay

- The Garifuna women of Belize eat clay during pregnancy to alleviate nausea and to satisfy cravings.
- Their clay comes in the form of religious tablets that are manufactured in Guatemala.
- Eating one tablet per day provides women with 9% of the RDA of calcium and iron, 7% of her magnesium, and 3% of potassium and zinc.
- 6 out of 8 women interviewed ate more than one bar per day.
- This form of supplementation is comparable to Western pharmaceutical supplements “One a Days”.

Anemia and Clay Eating

- 40 of 152 women in Mississippi ate clay during their pregnancy.
  - About 50 g/day
  - No impact on hematocrits
  - Conclusion: Women in Mississippi practiced geophagy as a result of cultural transmission retained from Africa, rather than from nutritional need.
- A second study found that 94% of women геophагists in Mississippi had an inadequate diet.
  - Response to hunger?

Mineral Supplements?

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Table 1—Simulated Human Digestion of Clay Samples (in parts per million [ppm] per gram)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Copper</th>
<th>Zinc</th>
<th>Manganese</th>
<th>Iron</th>
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<td>1</td>
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<td>106</td>
<td>1,200</td>
<td>428</td>
<td>13</td>
<td>1</td>
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<td>2</td>
<td>111</td>
<td>204</td>
<td>2,000</td>
<td>256</td>
<td>24</td>
<td>0</td>
<td>11</td>
<td>0</td>
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<tr>
<td>3</td>
<td>150</td>
<td>173</td>
<td>2,100</td>
<td>350</td>
<td>18</td>
<td>0</td>
<td>73</td>
<td>23</td>
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<tr>
<td>4</td>
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<td>150</td>
<td>1,100</td>
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<td>11</td>
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<td>204</td>
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<td>6</td>
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<td>0</td>
</tr>
</tbody>
</table>

Table 5: Clay v. Dairy: Evidence for Similar Activity

<table>
<thead>
<tr>
<th>Clay</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium for fetal development</td>
<td>Calcium for fetal development</td>
</tr>
<tr>
<td>Mechanism to absorb calcium (via lactose in milk)</td>
<td>Decreased reliance on plants in diet</td>
</tr>
<tr>
<td>Decreased toxicity of plants</td>
<td>Nontoxic to embryo</td>
</tr>
<tr>
<td>Recommended for pregnant women in some cultural contexts</td>
<td>Recommended for pregnant women in some cultural contexts</td>
</tr>
<tr>
<td>Moisture removed, transportable in leaves, readily available</td>
<td>Moisture removed, transportable as chews, readily available</td>
</tr>
<tr>
<td>Available in tropical Africa</td>
<td>Not available in tropical Africa</td>
</tr>
<tr>
<td>Not available in deserts of Africa</td>
<td>Available in deserts of Africa</td>
</tr>
</tbody>
</table>

A woman buying dirt at a convenience store in Alabama.
Summary

- Geophagy may be an adaptive practice, used by women whose physiological need for nutrients drives them to seek out new substances, especially during pregnancy.
- Women eating clays during pregnancy may do so for many reasons:
  - to prevent morning sickness
  - provide nutrients
  - detoxify substances for the mother or fetus
  - satisfy a psychological craving which imparts a sense of comfort

Now, the question of the day:
Would you eat dirt or clay?

You probably already have!
There’s a Fungus Among Us

Mycotoxins

Certain molds produce powerful toxins that poison food. A wide range of diseases result from acute mycotoxicosis and long-term effects include reduced fertility, loss of immune system function, cancer, and growth suppression.

Mycotoxins

• Aflatoxins – acutely toxic and cause liver and esophageal cancer. From Aspergillus flavus.
• Tricothecenes – produced by Fusarium infected cereals
  – Causes alimentary toxic aleukia (ATA), yellow rain, hole in the head disease
• Penitremes – produced by Penicillium species
  – Causes Ijesha shakes in Nigerians and grass staggers in sheep.

How common is this?

• Prior to agriculture cereals were small part of diet
  – Fungal toxicity would have been extremely rare
• Since cereal crop domestication, appears to be regular occurrence
  – ATA epidemic in the USSR estimated to have killed approximately 100,000 people between 1942 and 1948

Recent Outbreaks

• Aflatoxin in Dog Food caused an epidemic just last year
• 2004 saw an Aflatoxin outbreak in Kenya
  – As of July 20, 2004 a total of 317 cases had been reported with 125 deaths
  – 182 (53.2%) of 342 samples of maize purchased in agricultural markets had >20 ppb of aflatoxin
The ergot fungus caused by species of *Claviceps* (typically *Claviceps purpurea*), that appears as an infestation on the flowers of many of our cereal crops (wheat, barley, oats, and especially rye), and whose toxic substances (mycotoxins) can be passed right on through the milling and baking process to the final bread product.

Medicinal Uses
- Migraines (ergotamine tartrate)
- To control bleeding during childbirth (ergometrine)
- For certain psychiatric conditions
- To induce labor (since the 1700s)

Ergotism is poisoning by ergot consumption
- Symptoms include hallucinations (from lysergic acid diethylamide, precursor to LSD)
- Formication (the feeling of being covered by ants)
- Intense pain in extremities due to constriction of blood vessels

Ergotism
- Historically significant as a cause of widespread panic, population suppression, and extreme religious behavior
  - Demographic depression 1430s – 1480s
  - The Salem Witch Trials
  - The Panic of 1789

Reduced Fertility
- 15th Century saw an increase in the consumption of rye due to widespread grain shortages
- Climate was colder than normal with unusual levels of wetness
  - Reports of witchcraft trials closely follow the climate indicators
  - Ergot alkaloids also suppress fertility

Salem Witchcraft
- Rye was a common grain growing in the area before the Puritans arrived
  - There was dissatisfaction with the rye because it made the animals sick
  - Climate in 1691 was conducive to ergot
    - Early rains and warm weather in the spring progressed to a hot and wet summer
    - 1691 was a drought year, dramatically reducing ergot
  - Threshing probably took place shortly before Thanksgiving
    - Children started showing symptoms in December
    - By late fall 1692 the crisis abruptly ended
Salem Witchcraft

- Rye growing in low, wet ground is most susceptible to ergot growth
  - One of the most notorious of the accusing children in Salem was Thomas Putnam's 12-year-old daughter, Ann
  - Her mother also showed symptoms
  - Two other afflicted girls also lived in the Putnam residence
  - Putnam had inherited one of the largest landholdings in the village
    - His father's will indicates that a large measure of the land, which was located in the western sector of Salem Village, consisted of swampy meadows

Putnam: Two afflicted girls, the daughter and niece of Samuel Putnam, lived in the parsonage almost exactly in the center of the village. Their exposure to contaminated grain from western land is also explicable. Two-thirds of Putnam's salary was paid in provisions; the villagers were taxed proportionately to their land-holding. Since Putnam was one of the largest landholders and an avid supporter of Parris in the minister's community disagreements, an ample store of ergotized grain would be anticipated in Parris's larder. Putnam was also Parris's closest neighbor with afflicted children in residence

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Fig. 1. Residence patterns, Salem Village, 1692. The names in parentheses indicate the households to which the afflicted girls were living, excluding Sarah Churchill, whose affliction is unaccounted for. The areas on the map are: A, the western sector of the village, B, the eastern sector, C, the central parsonage area, and E, one of the Putnam residences. The lines on the map denote the limits of the village boundaries. The town book contains the names of the afflicted girls as well as the afflicted person, who was accused of witchcraft by the other afflicted girls, and then became afflicted again. Two depositions filed against her strongly suggest, however, that at least her first affliction may have been a consequence of ergot poisoning.

Panic of 1789

- July 20 – August 6 waves of panic swept the French countryside coinciding with the start of the French Revolution
- Rumors that the rye crop was to be seized coincided with medical reports consistent with ergotism
- At least one eye-witness account of prodigious ergot infection of the rye crop
- Most favorable climate for ergot in France for almost 100 years

Area A: Most of rye was used to pay taxes, not make bread, mixed with oats and barley when consumed

Area B: Rye production peaked after 1789, it was still a rare crop in this area

Area C: Rye carefully cleaned because of earlier episodes of St. Vitus's dance—most effects here were gangrenous ergotism

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