What did humans evolve to eat?
Human nutritional health in comparative perspective

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Evolutionary Perspectives on Human Health & Nutrition

• Growing interest in the evolution of human nutritional requirements

• Nutritional implications of changes in hominid evolution

• Evolutionary perspective useful for understanding today’s nutritional problems
Diversity of Modern Human Nutritional Strategies

Chuño (freeze-dried potato) production in the Peruvian Altiplano

Siberian herder (Evenki) preparing reindeer meat

Lowland Bolivian woman (Tsimane’) pounding rice
Evolution of *Homo erectus*: Emergence of the first “human form”

- Increased brain size and body size
- Changes in foraging behavior & diet
- Profound influences on human nutritional needs
Key features of Human nutritional needs established in *Homo erectus*

- *High quality Diet* to support the high costs of brain metabolism

- *High Activity & Energy Demands.* Foraging regimes requiring large activity budgets.
Overview

- *Energetic & Dietary Correlates* of Variation in Body Size & Brain Size in living primates

- Evolutionary changes in *Homo erectus* & their influences on nutritional/metabolic needs:
  - Brain size
  - Body size
  - Foraging/ranging behavior

- Implications for understanding modern nutritional problems
Metabolic Rates of Selected Tissues

a) Mass specific

b) Total Energy Costs

Brain Weight vs. RMR: Primates & Non-Primate Mammals
Brain metabolism as % of Resting Metabolism
Mammals, Primates & Humans

Dietary & Energetic Correlates of Size

Pygmy Marmoset
(110 grams)
Small Body
Small volume; high quality diet

Gorilla
(145 kg)
Large Body
Large volume; low quality diet
Diet Quality vs. Body Weight in Primates

$\text{Diet Quality}$ vs. $\text{Weight (kg)}$

$r = -0.66$

Relative Brain Size vs. Diet Quality

Relative Proportions of Small and Large Intestines in Humans & Apes

Data from: K Milton. 1987. in: *Food and Evolution*, p. 95.
Day Range Variation: Humans & Other Primates
Home Range vs. Body Weight in Primates

H. erectus at 1.8 million year ago: A Major Adaptive Shift

- Increase in *both* brain & body size
- Human-like body proportions
- Evidence for increased hunting & meat eating
- Rapid expansion from Africa
Rapid Brain Evolution with the Emergence of early *Homo*
Hominid Body Weight Estimates: Mid-Sex Averages

Changes in Body Proportions

- Australopithecines retained “ape-like” body proportions

- *H. erectus* – evidence of human-like body proportions
Dietary & Energetic Implications

- Larger body size $\rightarrow$ higher total energy needs
- Large brain size $\rightarrow$ higher dietary quality
- Facial, dental and technology changes – a shift in diet composition
- Environmental Context: Drying Trend
  - *Reductions* in edible plant foods
  - *Increases* in herbivores (secondary productivity)
Adaptive Shifts in *H. erectus* and their Nutritional Consequences

• Large-scale Ecosystem changes →

• Changes in Resource Use and Foraging behavior →
  
  – *fueled* evolution of large brain size → a high quality human diet
  
  – *promoted* increases in body size and ranging patterns → high levels of daily energy expenditure
Amazonia (Tsimane’): 17% Animal foods

Arctic (Evenki): 40-50% Animal foods

High Andes (Quechua): 10% Animal foods
BMI Variation
Subsistence & Industrial Populations

*P < 0.05, relative to each subsistence group

Data from: CL Ogden et al. 2006. JAMA 295:1549.


a) Changes in US Job Types

b) Declines in Energy Expenditure

- Declines in Active Job Categories
- \( \rightarrow \) Reductions in Energy Expenditure

Measuring Energy Expenditure & Work Capacity among Subsistence-level populations
Energy Expenditure & Activity Level in “Modern” vs. “Traditional” Populations

• Industrialized world sample:
  – Compilation of 12 DLW studies
  – 236 men; 257 women
  – From: Institute of Medicine Compilation

• Subsistence population sample:
  – 12 Studies
  – 117 men; 142 women
Daily Energy Expenditure: Subsistence & Industrial Populations

**Subsistence**

- **Males**
  - Weight (kg): 58.0
  - Basal Metabolic Rate (BMR) (kcal/day): 1526
  - Additional Energy Expenditure (AEE) (kcal/day): 1489
  - Total Energy Expenditure (kcal/day): 3015

- **Females**
  - Weight (kg): 50.2
  - BMR (kcal/day): 1242
  - AEE (kcal/day): 1082
  - Total Energy Expenditure (kcal/day): 2324

**Industrial**

- **Males**
  - Weight (kg): 70.0
  - BMR (kcal/day): 1659
  - AEE (kcal/day): 1215
  - Total Energy Expenditure (kcal/day): 2874

- **Females**
  - Weight (kg): 58.6
  - BMR (kcal/day): 1300
  - AEE (kcal/day): 934
  - Total Energy Expenditure (kcal/day): 2234
Daily Activity Levels in Subsistence & Industrialized Populations

![Graph showing PAL (Total Energy Expenditure/Basal Metabolic Rate) for males and females in subsistence and industrialized populations.](image)

- **P < 0.05**
- **P < 0.01**
# Energetic Consequences of Shift from Industrial to Subsistence PALs

<table>
<thead>
<tr>
<th>Sex</th>
<th>Weight (kg)</th>
<th>TEE-Ind (kcal/d)</th>
<th>TEE-Sub (kcal/d)</th>
<th>Difference (kcal/d)</th>
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</thead>
<tbody>
<tr>
<td>Males</td>
<td>70</td>
<td>2874</td>
<td>3285</td>
<td>+411</td>
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<tr>
<td>Females</td>
<td>58.6</td>
<td>2234</td>
<td>2444</td>
<td>+210</td>
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</table>
## Energetic Consequences of Additional Physical Activity (extra kcal/day)

<table>
<thead>
<tr>
<th>Sex</th>
<th>IOM 2005 (kcal/day)</th>
<th>1 hr/day Intense (kcal/day)</th>
<th>Subsist v. Indust Difference (kcal/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>+190</td>
<td>+330</td>
<td>+411</td>
</tr>
<tr>
<td>F</td>
<td>+152</td>
<td>+260</td>
<td>+210</td>
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</tbody>
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**IOM 2005 Recommendations:** 1 hr/day Moderate Exercise
Physical Activity in Subsistence Populations: 
*Sustained, modest increases in metabolism*
Modern Life: A “Shifting” Energy Balance

"Modernization" of Dietary Patterns

Increased Food Availability & Energy Density of the Diet

Reduced Energy & Activity for Subsistence

"Modernization" of Lifestyle & Activities

INTAKE

+ -

EXPENDITURE
Implications for Understanding the Obesity Problem

- Nutritional recommendations must give greater attention to physical activity

- Debate over *how much* PA is necessary for a healthy lifestyle
  - Comparative, evolutionary approach relevant for answering this question
Conclusions:
Evolutionary insights

• Insights into the origins and constraints of distinct nutritional needs
• Distinctive human nutritional needs
  – High quality diet
  – Large activity budgets and Energy Expenditure
• Ever-more efficient ways of extracting energy from our environments
  – Obesity epidemic – an extension of earlier trends in human evolution
  – Increased Energy returns + Reduced Energy Demands
Acknowledgments

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Percent (%) of Dietary Energy from Fat, Protein & CHO: Human & Apes

<table>
<thead>
<tr>
<th>Species/Group</th>
<th>Fat</th>
<th>Protein</th>
<th>CHO</th>
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<tbody>
<tr>
<td>Humans (<em>Homo sapiens</em>):</td>
<td></td>
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<tr>
<td>United States (2000)</td>
<td>33</td>
<td>14</td>
<td>53</td>
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<tr>
<td>Modern foragers</td>
<td>28-58</td>
<td>19-35</td>
<td>22-40</td>
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<tr>
<td>Chimpanzees (<em>Pan troglodytes</em>)</td>
<td>6</td>
<td>21</td>
<td>73</td>
</tr>
<tr>
<td>Gorilla (<em>Gorilla gorilla</em>)</td>
<td>3</td>
<td>24</td>
<td>73</td>
</tr>
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