Evolution not Revolution: what can we learn about human health from nutritional ecology?

David Raubenheimer
Leonard P Ullman Chair of Nutritional Ecology
Faculty of Vet Science | School of Biological Science | Charles Perkins Centre
Nutritional Ecology is ....

- Ecological / evolutionary approach to nutrition
  - focus on how nutrition mediates the relationship between animal & environment

- to determine health and wellbeing
Aims for the talk

- Introduce Nutritional Geometry: approach for studying these interactions
- Show how it has been used to understand:

  - Health
  - Lifespan
  - Reproduction
  - etc.
1) Obesity: a not so obvious question
2) Nutritional geometry
3) Stepping back in time: wild apes
4) Humans
5) Closer look at our environment
6) A closer look at human biology
1. Way back ....

**Staples**
- lean meat
- low GI vegetables

**Luxuries**
- honey
- tubers
- fruit

**Diet**
- high protein (25–30%)

(picture credits: Wikipedia)
2. Agriculture

- Grains
  - high starch

- Domesticated fruit
  - increased sugar

- Livestock
  - higher fat than game

- Diet
  - reduced % protein
3. Industrial revolution

- Bulk extraction
  - carbs
  - lipid

- Processed foods

- Diet
  - further reduction in % P
Overview

- Problem
  - fats + carbs limiting
- Solution
  - culture lifts limitation
  - satisfies appetite

- evolved strong appetite for F+C
- stone age physiology
- modern environment

MALADAPTED
The not-so-obvious question

**Problem**
- fats + carbs limiting
  - strong appetite for F+C
  - stone age physiology

**Solution**
- culture lifts limitation
  - modern environment
- satisfies appetite

**High protein**

**High fats + carbs**

**WHY do we over-eat energy on diets high in fats + carbs?**
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What is nutritional geometry?

- models nutrition in terms of: (i) two or more NUTRIENTS
  (ii) their *interactive* effects on animals/humans
- by constructing a multi-dimensional nutrient space
Can then plot in this space:

1. Nutrient requirements
2. Foods
3. Feeding
4. Consequences

- etc..

- and model the relationships among these
1. Nutrient requirements

(P, C) Intake target
2. Foods

i. amount of nutrients

ii. balance of nutrients
3. Feeding

- the animal gains nutrients in same balance as the food – as it eats, it “moves” along rail

i. balanced

ii. imbalanced

iii. complementary

- what are the options?
- there are main 3 options:

- how to measure the rule of compromise?

"Rule of compromise"

- prioritise carbohydrate
- prioritise protein
- some balance of excesses & deficits
4. Consequences

- response surface

- or contour plot
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How do they prioritise macronutrient intake?

Mountain gorillas

Orangutans
Method

• Direct observations

• Record:
  i. what is eaten
  ii. how much
  iii. nutrient content

• Analyse data using nutritional geometry
Diet

- mainly fruits: 4 months
- mainly leaves: 8 months

- low % protein
- high % protein

Photos: J. Rothman
• Fruit diet: 19% P
• Leaf diet: 31% P
• Rule of compromise
  i. regulated to target Carb + Fat intake
  ii. to do so, over-ate P
  - i.e. prioritise non-P energy

Closer look at what it means

• Similar carb + fat intake on all diets

• AND higher P intake on high-P diets

• i.e. Mountain gorillas eat MORE energy on high P diets

• Unlikely to get fat in modern human environments

*Why do we over-eat energy on diets high in fats + carbs?*
2. Orangutans

Method

- Observations over a 7 year period
- 49 orangs
- 2,233 full day observations
- 49000 hours
- also physiology
Diet

- Preference
  - fruits: high carbs + fat
    - but availability unpredictable

- So also eat
  - leaves + cambium
  - high protein
Result

- Wide variation in carb + fat intake
- Tight regulation of protein
  - i.e. prioritise non-P energy
Implications

- Will over-eat fats + carbs on low-P diets
- Or under-eat fats + carbs on high-P diets
- Could the same pattern explain why humans get fat in modern environments?
And …..

- Physiology tells us
  - lay down fat when energy (fruit) is abundant
  - draw on it when energy is scarce

- i.e. Adapted to “boom and bust” ecology

- As are humans!
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Two Questions:

i. How do we compare with other primates?

ii. What are the implications for obesity?
Human macronutrient regulation

- 3 experimental studies: Oxford, Sydney, Jamaica
- Meta analysis: 26 published trials

- Prioritise P, like orangs

Gosby et al., Obesity Reviews 2014
Implications of protein prioritisation for obesity

- A small change in % P in foods will result in a disproportionately large change in the amount Carbs + Fat eaten

- For example, a 1.5% decrease in % P

- could this explain the obesity epidemic?
And weight loss ...

- a small increase in % protein will result in a large decrease in carbohydrate and fat eaten

- could this explain why high protein weight loss diets work?

-> Called the “Protein Leverage Hypothesis” (PLH)
Two predictions of PLH

1) Energy intake increases with decreasing %P

- Yes!
Prediction 2). Dietary % P has decreased with the rise in obesity

- e.g. USA

- yes!

Data: FAOSTAT 2010
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The general question

• PLH suggests that because humans prioritise P, energy intake will be higher on low-P diets

• What changes in the environment cause the shift to low-P diets?
A Role for Economic$
• A clue that economics is involved:
  - obesity is more common among low SES groups

  ![Graph showing obesity rates by socio-economic status]

  *Source: Australian Institute of Health and Welfare*

• *Is this related to variation in dietary % protein?*
Three predictions

1) Protein is more expensive than fats and carbs

• Test
  - 106 supermarket foods
  - compared the separate contributions of each g of Pro, Fat and Car to the cost food

• Result
  - price increases with P
  - not with fats & carbs

• Conclude
  - suggests an economic incentive to eat low P foods
  - = high energy intake

Brooks et al. (2009) Obesity reviews.
Prediction 2). Low SES groups eat low-protein diets

- Aboriginal study
  - 14 diet surveys of low SES indigenous Australian communities

- Low relative to:
  1. Australian recommendations (AMDR)
    - most have low % P relative to recommended range
  2. Higher SES groups

[With Aboriginal Nutrition Project Node]
Prediction 3. Low protein diets are associated with high energy intake.

- Yes!
- As we found in experimental studies.
A role for global change
Rapid increase in atmospheric CO2

Raubenheimer et al. (2013), in review
CO₂ enrichment results in an average 54% increase in the carbohydrate:protein ratio.

- Robinson et al. 2012*

*New Phytologist 194:321-336

Raubenheimer et al. (2014), in review
Likely to impact not only on plant foods
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A Role for Protein Requirements

- protein leverage is expected to be proportional to protein requirements

- *can variation in P requirements help explain variation in obesity?*
1. Obesity as a cause of increased P requirements

- Physiological effect of obesity: Protein efficiency is reduced

- So more protein needs to be eaten to meet needs
  - and P leverage is enhanced

- Suggests a positive feedback: obesity drives further excess energy intake and obesity
2. Dietary history (evolutionary or developmental?)

- Populations with high protein traditional diets are particularly susceptible to obesity when transferring to westernised diets.

- For example, Alaskan Inuit
  
  - among the highest rates of obesity globally
  
  - traditional diet = 30-35% P
  
  - have developed low P efficiency
  
  - so higher P intake need

- Could this explain their susceptibility to obesity?

Data from Kang-Jey et al. (1972), AJCN 25:737-745.
3. Effects of early nutrition ("developmental programming")

- Formula-fed infants are more susceptible to obesity later in life than if breast-fed
- Milk formula is much higher in protein than human breast milk

Could high-P early in development lead to reduced P efficiency hence increased P target and energy intake?

Data from Koletzko et al. (2009), AJCN 89:1836-49.
CONCLUSIONS

• Nutritional geometry can help to measure interactions among appetites for different nutrients

• Helps to understand the mismatch between humans and modern food environments

• And identify new areas for research and intervention
  - factors that reduce % protein in the human diet
  - factors that decrease human protein efficiency
Thank you for your attention!