Feeding Behavior 1

• Feeding Behavior, Obesity & Brain Health

Body Mass Index

- BMI = m/h²
- < 18.5 kg/m², underweight
- 18.5 to 25 kg/m², normal weight
- 25 to 30 kg/m², overweight
- > 30 kg/m², obese
Obesity rates

BMI = \( \frac{m}{h^2} \) (> 30 kg/m\(^2\), obese)

Canada:
- 1 in 4 adults
- 1 in 10 children

Associated with: diabetes, CVD, AD…

Diet, exercise and/or other factors?

• Exercise & low-fat/low-cal diet
• Not very effective…! Why?

• Lack of properly conducted scientific expts for many of these diets, especially **long term**.
  – observational studies (correlational, across countries, self report)
  – human **expts** are very difficult (in hospital vs natural, compliance)
  – weight loss, other end points?
How much? What to eat? When to eat?

• 3 questions to consider

• One size does not fit all.
  – individual genetics differ
  – individual hormones and brain physiology differ
  – individual microbiomes differ
  – individual goals differ
  – individual food preferences/culture differ
Macronutrients

• macronutrients
  – carbohydrates: ~4 kcal / gram, e.g. starch, sucrose, glucose, fructose
  – fats (lipids): ~9 kcal / gram, e.g. saturated fats, unsaturated fats
  – proteins: ~4 kcal / gram

• “standard” advice: 50% carb, 30% fat, 20% protein
  – by calories (not mass)

• low fat vs. low carbohydrate

• Not all calories are equal !
  – 2000 to 2400 kcal / day
  – different effects on pancreas, liver, brain, and other organs
• Not all calories are equal

• e.g. different effects on insulin from pancreas

• eating starch (highly refined carbs) strongly increases blood glucose and thus stimulates insulin secretion

• insulin promotes glycogen synthesis

• …also promotes fat storage!
What Makes You Fat: Too Many Calories or the Wrong Carbohydrates?
Calories vs. Carbohydrates

In the next couple of years, investigators funded by NuSI plan to test two competing hypotheses about the dietary causes of obesity under scientifically rigorous conditions that are designed to force one of the possibilities to emerge as the clear winner.

**Energy Imbalance**
The conventional explanation focuses on how the body regulates the intake and expenditure of energy (measured in calories). Consuming too much of anything—whether fats, carbohydrates or proteins—increases body fat. The only way to lose weight is to eat fewer calories or to expend more calories.

**Hormone Imbalance**
The alternative hypothesis focuses on the complex physiological regulation of fat cells. Consuming carbohydrates raises levels of sugar (glucose) in the blood, which in turn activates the release of the hormone insulin. Fat cells respond to insulin by holding on to their fat stores and even adding to them. Weight gain occurs when insulin levels—triggered by eating carbohydrates—remain elevated for long periods.

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Taubes (2013)
THE GLOBAL SUGAR GLUT

Global sugar supply (in the form of sugar and sugar crops, excluding fruit and wine) expressed as calories per person per day, for the year 2007.

https://www.youtube.com/watch?v=0ndTEu_qDGA&index=2&list=PL39F782316B425249
https://www.youtube.com/watch?v=Of-qvDprr0w&index=5&list=PL39F782316B425249

sucrose
Sugars

- Polysaccharides – starch, glycogen, cellulose
- Disaccharides – sucrose, lactose, maltose
- Monosaccharides – glucose, fructose, galactose
- Glucose stimulates insulin secretion
- Fructose is metabolized primarily in the liver

http://reut.rs/22yBJjr
Prof. Robert Lustig, Fat Chance (2013)
Main goal: keep insulin down.
1. Low refined carbs & sugar
2. High fiber
   - Avoid highly processed food-like products
avoid trans fats (“partially hydrogenated oils“)
exercise

<table>
<thead>
<tr>
<th>GREENS (unprocessed; ad lib)</th>
<th>YELLOWS (minimally processed; 3–5 times per week)</th>
<th>REDS (highly processed; 1 time per week)</th>
<th>LIMBO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTACT WHOLE GRAINS</strong></td>
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<tr>
<td>High-fiber cereal (&gt; 5 g fiber, &lt; 3 g sugar)</td>
<td>Medium-fiber, medium-sugar cereal (&gt; 3 g fiber, &gt; 3 g sugar)</td>
<td>Kashi GOLEAN Crisp Toasted Berry Crumble (9 g fiber, 10 g sugar)</td>
<td>Bagels</td>
</tr>
<tr>
<td>Steel-cut (Irish) oatmeal; Bob's Red Mill (5 g fiber, 0 g sugar)</td>
<td>Rolled oats; Bob Red's Mill (4 g fiber, 1 g sugar)</td>
<td>Kashi GOLEAN Crunch! (8 g fiber, 12 g sugar)</td>
<td>White bread</td>
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<tr>
<td>Steel-cut (Irish) oatmeal; Bob's Red Mill (5 g fiber, 0 g sugar)</td>
<td>Semolina</td>
<td>Raisin Bran (8 g fiber, 19 g sugar, partially from raisins)</td>
<td>Corn bread</td>
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<tr>
<td>Steel-cut (Irish) oatmeal; Bob's Red Mill (5 g fiber, 0 g sugar)</td>
<td>Sugar-free hot cocoa</td>
<td>Grape Nuts (7 g fiber, 5 g sugar)</td>
<td>Potato bread</td>
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<tr>
<td>Fiber One bran cereal (14 g fiber, 0 g sugar)</td>
<td>White rice</td>
<td>Whole-grain pumpernickel</td>
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<tr>
<td>Fiber One bran cereal (14 g fiber, 0 g sugar)</td>
<td>Long-grain rice</td>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
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<tr>
<td>Whole-grain pumpernickel</td>
<td>Arabio rice (risotto)</td>
<td>Whole-grain products (pulverized whole grain)</td>
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<tr>
<td>Whole-grain pumpernickel</td>
<td>Jasmine rice</td>
<td>Whole-oats</td>
<td>Couscous</td>
</tr>
<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Whole-quinoa</td>
<td>Basmati rice</td>
</tr>
<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Whole-rice</td>
<td>Cake, brownies</td>
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<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Whole-sorghum</td>
<td>Hamburger bun</td>
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<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Whole-teff</td>
<td>Hot dog bun</td>
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<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Breads (pulverized whole grain) (&gt; 3 g fiber)</td>
<td>Chips</td>
</tr>
<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Whole-wheat—all whole wheat varieties</td>
<td>Crackers</td>
</tr>
<tr>
<td>Whole-grain bread (&gt; 3 g fiber)</td>
<td>Diet soda</td>
<td>Natural Ovens</td>
<td>Pizza crust</td>
</tr>
</tbody>
</table>
How much? What to eat? When to eat?

- Timing of food intake is very important.
- Time restricted feeding (TRF)
  - 16:8, 20:4 etc
- Intermittent fasting (IF)

https://www.youtube.com/watch?v=gEmTsmsXuUM
Figure 2. Green arrows indicate findings published in the literature. Red arrows signify potential pathways. Mice on a diet-induced obesity (DIO) protocol have ad libitum access to a high-fat diet (HFD). These mice have changes in the gut microbiome, stool metabolomics, and hepatic gene expression. There are presumed changes in gut signaling, particularly in the bile acid signaling pathway. As a result, these mice are particularly predisposed to obesity and dysmetabolism. With TRF, cyclical fluctuation is restored in the gut microbiota, luminal metabolites, and hepatic gene expression. Presumably TRF also restores oscillations in gut signaling. As a result, TRF protects against obesity and dysmetabolism. Abbreviations: CYP7A1, cytochrome P450 7A1; FGF15, fibroblast growth factor 15; FXR, farnesoid X receptor; LIPC, hepatic lipase.
Intermittent fasting

• No or greatly reduced calories during a fasting period
• **Not** chronic (moderate) caloric restriction
• In human studies:
  – alternate day fasting; or 1-2 fast days per week
  – no calories; or reduced calories (500-600 kcal) per fast day
• In rodent studies:
  – typically alternate day fasting
  – fast day: no food, ad libitum water
  – feed day: ad libitum food and water
• Increasing evidence for neural and behavioral benefits
  – Michael Mosley, Mark P. Mattson (Alzheimer’s disease)

http://www.dailymotion.com/video/x18a1b6_michael-mosley-eat-fast-live-longer_lifestyle
Risk Factors for AD

- Age
- Genetics
- Female gender
- Obesity
- Diabetes
- Cardiovascular disease

- Can dietary manipulations (timing of food intake) help?
Intermittent fasting and caloric restriction ameliorate age-related behavioral deficits in the triple-transgenic mouse model of Alzheimer’s disease

Veerendra Kumar Madala Halagappa, Zhihong Guo, Michelle Pearson, Yasuji Matsuoka, Roy G. Cutler, Frank M. LaFerla, and Mark P. Mattson

- Mouse model of AD (3xTgAD mouse)
- Amyloid (Aβ) plaques & neurofibrillary (phosphoTau) tangles
Male and female mice (n = 80 males, 80 females)
Non-transgenic (NonTg) or 3xTgAD
At 3 months of age: randomly assigned to 1 of 4 groups
- NonTg,AL
- 3xTgAD,AL
- 3xTgAD,CR (given 60% of food eaten by AL group)
- 3xTgAD,IF (no food on every other day)
Tested when 10 or 17 months old (Morris water maze)
One week after testing, hippocampus was collected
Body weight measured weekly
- significant effect of CR
- no significant effect of IF in this study
Fig. 3. Old male 3xTgAD mice exhibit a deficit in performance in the hidden platform test in the water maze that is ameliorated by caloric restriction and intermittent fasting. Male mice of the indicated genotypes (non-transgenic and 3xTgAD) were maintained on the indicated diets (ad libitum, caloric restriction or intermittent fasting) for 14 months. The goal latency (a) and path length (b) were measured in the hidden platform test. Values are the mean and SEM (n=7–10 mice per group). 1DayP and 2DayP, first and second days of the visible platform test.
Fig. 5. Caloric restriction, but not intermittent fasting, reduces levels of Aβ1–40 and Aβ1–42 in the hippocampus of older 3xTgAD mice. Levels of Aβ1–40 and Aβ1–42 in hippocampal tissues from the indicated groups of mice were quantified by ELISA methods. Values are the mean and SEM (n=13–19). *p<0.05 compared to the AL and IF values.
Fig. 6. Caloric restriction, but not intermittent fasting, suppresses tau pathology in the hippocampus of older 3xTgAD mice. Levels of total tau and phospho-tau were measured by immunoblot analysis using HT7 and AT8 antibodies, respectively, in hippocampal tissues from the indicated groups of mice. (a) Immunoblot probed with the indicated antibodies. (b) Results of densitometric analysis (values are the mean and SEM; n = 3–5). *p < 0.05 compared to the AL and IF values.

https://www.youtube.com/watch?v=4UkZAwKoCP8
• Breakfast: water and black coffee (0 kcal)

• Lunch: 2 boiled eggs, large salad (lettuce, tomatoes, celery, cucumber, lemon juice), water, black coffee (~300 kcal)

• Dinner: miso soup, salmon sashimi (3 oz), steamed vegetables, water, herbal tea (~300 kcal)