Energy balance

- Energy input vs. Energy output
- Balance
  - *(- output > input) Negative: weight loss*
  - *(+ input > output) Positive: weight gain*

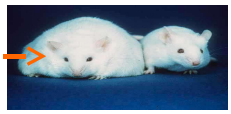
  - *Special implications*
    - *Childhood, Elderly, Illness, Pregnancy & Lactation, Sports…*

Energy input: kcal/g: 4 carb, 4 protein, 9 fat, (7 alcohol)

Factors affecting energy input

- **neuro-endocrine factors** *(neurotransmitters, hormones; complex regulation involving many factors)*
- filling/distention of stomach *(dietaryfibre)*
- social/psychological factors *(e.g., anxiety, depression)*
- food availability and appeal
- illness, drugs, alcohol…

lack of
leptin

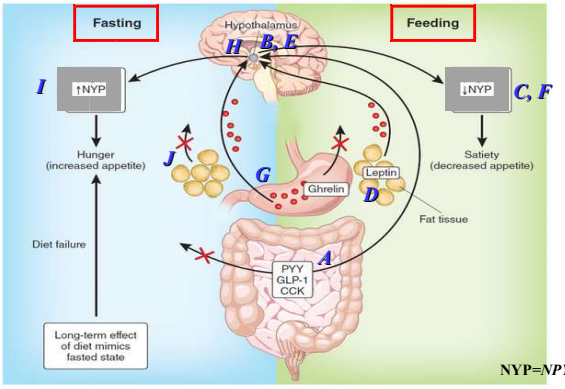


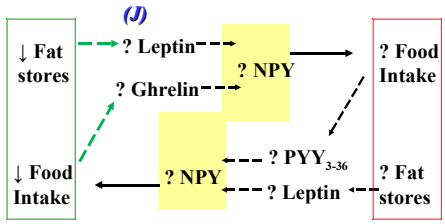
➢NEURO-ENDOCRINE factors influence both feeding behaviour and the production/secretion of other hormones

Consider some of the factors:
Leptin
NPY (NYP)
Ghrelin
Peptide YY (**PYY**)
CCK
apoA IV (chylomicron component)

➢HYPOTHALAMUS: central integrator of circulatory signals (hormones) and neural signals from other brain areas…***to eat or not to eat?***

some neuro-endocrine factors





Some factors & some of their functional associations involved in the control of food intake…replace ? with ↑ or ↓, start at →

Factors affecting energy output

- A. Basic (or Resting) energy expenditure (BEE, REE): ~65%
  - *Minimal amount of calories used by body when awake, resting, fasting, in warm, quiet (low stress) environment*
  - *REE easier to measure (less rigorous conditions, e.g., 4 vs. 12 h fast)*

FACTOR	REE
↑ body size	↑
body comp.	↑ lean body mass
older age	↑
gender	↑ men
hormone status	thyroxine: ↑
fasting	↓
fever	↑
pregnancy/lact.	↑

B. Thermic effect of food (TEF): ~10%

Acute increase in energy expenditure after meal (above REE)

Can be influenced by meal size, spices such as chili peppers/mustard, macronutrient composition (e.g., relative TEF 1 fat < 1.5 carb < 3 protein)

Often lower TEF associated with obesity (lower insulin sensitivity..)

C. Physical activity: ~25% (highly variable; sometimes divided into components such as NEAT and Exercise)

Influences on Energy Balance*...complex*

- Genetic and physiological factors
  - *e.g., leptin production; TEF and insulin sensitivity; adipocyte number*
- Environmental factors
- *- e.g., availability or appeal of food*
- Psycho-social factors
  - *e.g., emotional state, economics, religion*

What contribution does genetics make to obesity risk?

Assessment of body mass and fat:

- Body mass index (BMI) = weight (kg) ÷ height^2 (m^2)

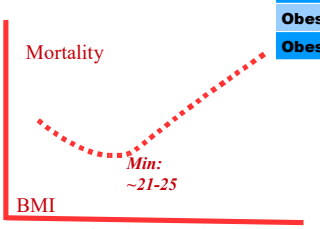
e.g., 70 kg person of height 175 cm: $70/(1.75)^2 = 23$

- Many methods to estimate body fat (BF)
  - *skin-fold thickness*
  - *underwater weight*

Lean body mass LBM = body weight - BF

The ideal body weight is often defined as the weight range that maximizes health (minimizes risk of diseases that affect lifespan and quality)

Underweight	**< 18.5**
Normal	**18.5-24.9**
Overweight	**25.0-29.9**
Obesity I	**30.0-34.9**
Obesity II	**35-39.9**
Obesity III	**>= 40**

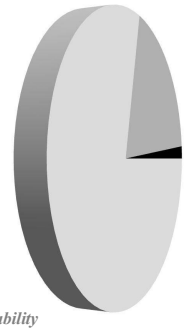


(statistics form large populations of adults)

[in relation to disease risk, also consider type/location of fat storage]

Energy stores of body (usable energy)

- Fat: usually > 78%
  - *adipose TG*
- Mobilizable protein: often about 20%
  - *Muscle*
- Carbohydrate: usually < 2%
  - *glycogen*

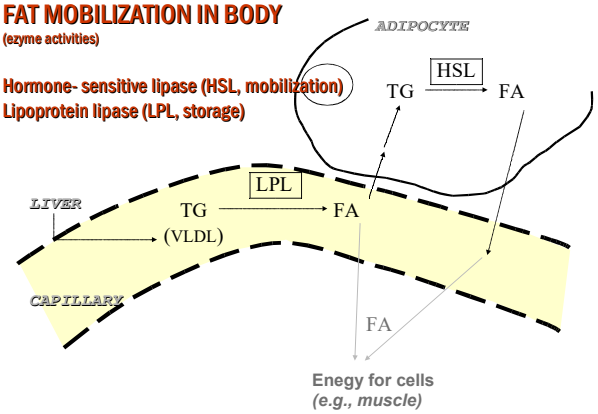


body is efficient at storing fat
...survival in (past) times of low energy availability
...but metabolic problems in (modern) times of high energy availability

FAT MOBILIZATION IN BODY

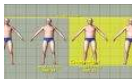
(ezyme activities)

Hormone- sensitive lipase (HSL, mobilization)
Lipoprotein lipase (LPL, storage)



Some general points about obesity (overfat) and fat storage

- Why large increase in obesity over last few decades?
  - ↑ ***availability of high energy foods; ↓ physical activity; both in context of genetic predisposition***
- ~1:3 Canadians is overweight
- ~8:10 Canadians don't get enough exercise
- when weight is lost, only ~1:20 can maintain the loss over 5y



- BMI > 25: weight-associated health risks, *esp. males*
- BMI: ≥30 obesity
  - *Obese: body fat > 25% (men), > 35% (women)*

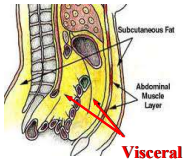
Circumference measurements

- Waist to Hip ratio
  - *good indicator of obesity & co-morbidities*
- Waist circumference
  - *if > 100 cm for ♂, 90 cm for ♀,*
    - *50% have health problems*
      - » *cholesterol, blood pressure, or glucose (metabolic syndrome)*

2 Types of fat

- Essential
  - *around vital organs, nerves, bone marrow (~3%)*
  - *women: breasts, pelvic (~9%)*
- storage (non-essential)
  - *subcutaneous, visceral*
  - *can build up body fat even with low-fat diet....carbohydrates/amino acids can be used to make fatty acids*

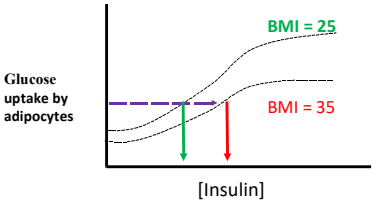
Types of fat distribution



- Visceral **vs.** Subcutaneous
- Upper ('apple'; android) **vs.** Lower ('pear'; gynoid) body
  - ***android****, high waist:hip ratio: ↑ risk of type 2 diabetes, CVD, etc*
- Visceral (intra-abdominal) fat: *more strongly associated with components of* ***metabolic syndrome…*** *(atherogenic dyslipidemia, poor glucose control, hypertension)*
- Obesity co-morbidities:
  - *Structural/shape: visceral vs. subcut.; android vs. gynoid*
  - *Chronological: earlier age of obesity, ↑ risks*
  - *Gender: men typically have more visceral fat*

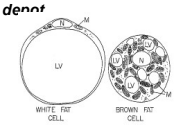
Associated health risks (BMI >30)

- type 2 diabetes *(esp. visceral)*
- hypertension
- heart disease & stroke *(dyslipidemia, hypertension)*
- some cancers
- joint disease *(e.g., knee)*
- *INFLAMMATION chronic low-level....cvd/some cancers*



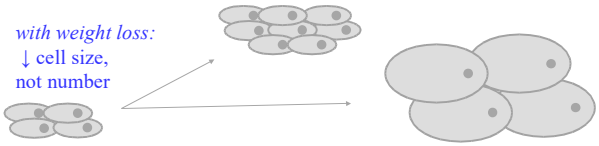
Adipose tissue & Adipocytes

- **WAT**...*fat (energy) storage, but not just an inert depot*
...regulators of energy balance
- **BAT**...*regulatory functions, energy balance (heat production)*



- **Adipocyte growth:**
  - *in terms of size (hypertrophy, e.g., obese vs. normal BMI: 3x TG)*
  - *in terms of cell number (hyperplasia, e.g., o vs. n BMI: 3x cells)*

with weight loss:
↓ cell size,
not number



- **Satiety: neural state that leads one to ↓ or stop eating *(loss of drive or desire to eat)***
- **Hunger: physiological drive to get food and eat**
- **Appetite: psychological desire to eat *(more conditional than hunger)***

Other concepts…
- **balancing response to over/underfeeding**
- **set point theory of body weight**

...complex regulation not yet well understood

Management of obesity

...three components for most strategies

- changes in **diet (D)** that can be maintained over time
  - *e.g., weight loss of ~10% over about 6 months*
  - *nutritional education; changes in food choices (large, radical changes are typically less likely to be maintained over time; large sudden changes can ↓ REE, ↓ leptin, ↓ TH)*
- increased **physical activity (P)**
  - *e.g., 30 min/d; 4-7d/w (high intensity, or 1h/d moderate; also ↑ NEAT)*
- changes in **behaviour (B)**
  - *e.g., slowing eating activity; don't eat while distracted by other activities such as TV*

Energy-restricted diets— *general principles*

- **intake**
  - fewer calories than required to meet output
    - *e.g., 500-1000 kcal deficit/day*
- **ensure**
  - adequate nutrient intake (incl. dietary fibre)
    - *micronutrient supplements? especially if <1800 kcal/d males, or <1200 for females*
  - adequate physical activity
  - adequate fibre...(PYY)

- **combine with**
  - "life-style" changes (behavioural)
    - e.g., avoid keeping stores of unhealthy foods; inlcude extra vegetables/high fibre foods in meal; read labels of prepared foods; increase walking activity on weekends

Macronutrient guide (% total daily calories)

Example of macronutrient-balanced, energy-restricted diet

AMDR accept.macronutr.distrib.ranges:

- 54% carbohydrate (range 45-65)
- 18% protein (range 10-35)
- 28% fat (range 20-35)

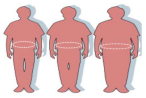
e.g., 28% fat on 2000 kcal diet represents about 62 g fat:
1-2 big burgers, 2-3 large slices of pizza....both high SFA

➢ ***Consider not only % calories for each macronutrient, but also very important are the types of each consumed*** *(e.g, saturated vs. monounsat fats; complex vs. simple carbohydrates; dietary fibres)*

Some Diet Categories

and examples of daily caloric intake

- moderate calorie-deficient
  - *~1200 kcal ♀, ~1500 ♂*
- low calorie diet, LCD
  - *~ 1000 kcal ♀, ~1100 ♂*



- very low calorie, VLCD
  - *~800 kcal/d (health benefits of <800 not well established)*
  - *when BMI > 32 or lower BMI with co-morbidities*

➢Typically calorie-restricted diets start with very moderate caloric deficits….calories decreased as necessary over time, e.g., after 10% weight loss over 6 mo., emphasis over next 6 months is weight maintenance
➢Typically the greater the caloric restriction, the greater is the risk of micronutrient deficiencies and macronutrient imbalances

VLCDs

- Examples
  - *Protein-sparing modified fast*
  - *Liquid diet (based on milk or egg protein)*
- In general, modern VLCDs
  - ensure sufficiency of essential nutrients
  - replace normal food
  - are used for about 4 months under medical supervision
  - used for those with BMI over 30
  - benefits over LCDs?
- Some potential problems
  - unbalanced macronutrients
  - fatigue, nervousness, GI problems…
  - possible CVD complications? In extreme cases…long time period, unbalanced, esp. if no micronutrient supplementattion

Fad diets & weight loss aids

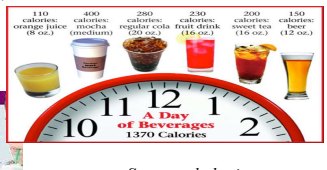
- **Beware…**
  - **unbalanced macronutrients** (in terms of % calories)
    - e.g., very low carb: ketosis, low intake of fruit/veg or whole-grain foods
    - e.g., very high protein intake: high saturated fat foods, red meats

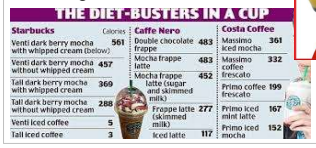
    both of the above often associated with high intake of SFA/animal products
  - **exclusion** (or near exclusion) **of a major food group...*if fruit/veg, miss the benefits of a most healthy food group***
  - **promises of fast results with minimal effort**
  - **micronutrient deficiencies**
  - **replacement of normal foods with supplements/pills**

    ...medical supervision
  - **lack of emphasis on increased physical activity**

Variety - different foods from each group
Balance – foods from different groups
Moderation – small enough serving sizes to facilitate variety & balance

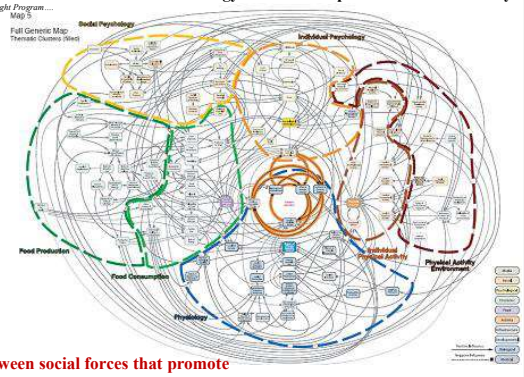
High calorie foods whose consumption has increased in last few decades (number of servings and/or serving size)
-High-sugar drinks
-Flavored coffees
-Fried potatoes (fries)
-Hamburgers





Sugar and obesity: more than just calories?

Complex interactions that can offset energy balance and promote overfat/obesity



Conflict between social forces that promote overeating, high-energy foods, inactivity vs. social forces that associate thinness with a person's self-worth and the ideal body image

Complex interactions that can offset energy balance and promote overfat/obesity
UK Government Foresight Program: ***Factors classified into the following groups***

1.Psychology
1. **Social**, *e.g., influence of media and social networks*
2. **Individual**, *e.g., confidence in terms of achieving outcomes*

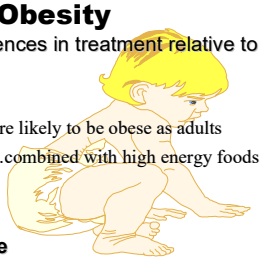
2.Food
1. **Production**, *e.g., foods that are cheap to produce & sought by consumers*
2. **Consumption**, *e.g., demand for convenience foods vs. cooking at home*

3.Physical Activity
1. **Environment**, *e.g., environment that promotes walking vs. driving*
2. **Individual**, *e.g., exercise program & activity required for daily living*

4.Physiology, *e.g., neuroendocrine eating signals & metabolic reactions, genetic & epigenetic factors*

Childhood Obesity

- A special problem…some differences in treatment relative to adult obesity
  - about half of those obese at age 6 are likely to be obese as adults
  - **low physical activity problem**…combined with high energy foods
  - management
    - **healthy eating & exercise**
    - **usually involves controlled weith gain, not loss…**



Estimated weight gain/yr =
[(est. adult weight +/- 10%) – (current child weight)] / (yrs to adulthood)
e.g., 8 yr old boy, 40 kg, with estimated ideal adult weight of about 60 kg: (54-40)/10=1.4 kg/yr, (66-40)/10=2.6 kg/yr...thus, 2.0 +/- 0.6 kg/yr
...but rates of growth vary over childhood/youth