

Regulation of Energy Balance

- Accommodation in TEE
 - Energy restriction & starvation
 - Overeating
- Accommodation in Ein



Regulation of Energy Metabolism

- Average adult TEE – 2500 kcal/d
 - $365 * 2500 = 912,500$ kcal/y
- Average annual weight gain – 0.6 kg/y
 - Adipose tissue $7800 * 0.6 = 4,680$ kcal
 - $4680 / 912500$ is 0.5%
- Note
 - Day-to-day fluctuation in balance 10-20%
 - Between individual variations are large



Semi-starvation

- Minnesota study of 1946

- 32 young males
- Control Ein 3500 kcal/d
- 1600 kcal/d for six months
- 25% weight loss

- Energy deficit

- $180 \text{ d} \times (3500 - 1600 \text{ kcal/d}) = 342,000 \text{ kcal}$
- Exceeds body energy by $>100\%$!

- Why did they not die of starvation?



Accommodations in TEE

- RMR
 - control: 1590 kcal/d
 - S24: 960 kcal/d
- Change in body composition
 - 10 kg reduction in FFM
 - $10 \times 21.6 = 220$ kcal/d
- Other possible changes
 - Reduced protein turnover
 - Reduced thermal regulation
 - Reduced organ mass



Accommodations in TEE

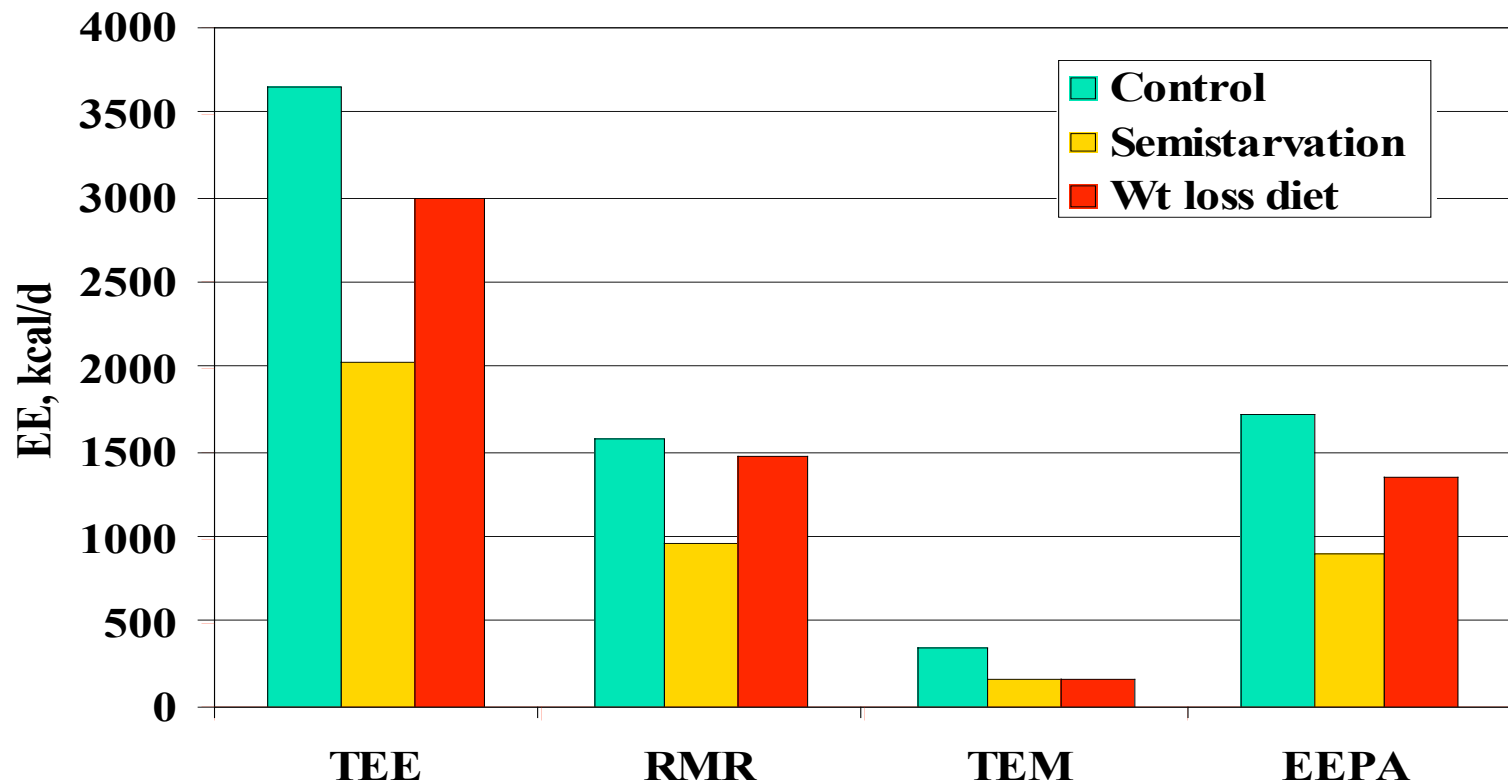
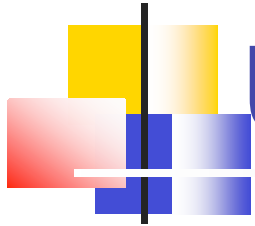
- TEM
 - Not measured
 - Estimate: 10% Ein
 - $0.1 \times (3500 - 1600) = 190 \text{ kcal/d}$



Accommodations in TEE

- EEPA
 - Not measured
 - Calculate by difference = $TEE - (RMR + TEM)$
 - Control: 1720 kcal/d
 - S 24: 910 kcal/d
- Change in body weight
 - 20 kg
 - Reduced load = 420 kcal/d
- Other changes
 - Ceased leisure time physical activities
 - No change in muscular efficiency

Accommodation to Underfeeding





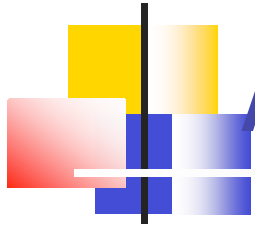
Summary - underfeeding

- Early effects (assumes sufficient PRO)
 - Body uses fat stores to meet deficiency
 - Weight loss: 70-80% fat, remainder FFM
 - Muscle loss minor
 - Energy requirement drops slightly
 - Weight & composition associated decreases
 - Additional 100-200 kcal/d decrease in RMR
- Late effects
 - Fat stores are low
 - Body uses protein
 - Negative health effects
 - Energy requirement drops significantly, but at a cost.

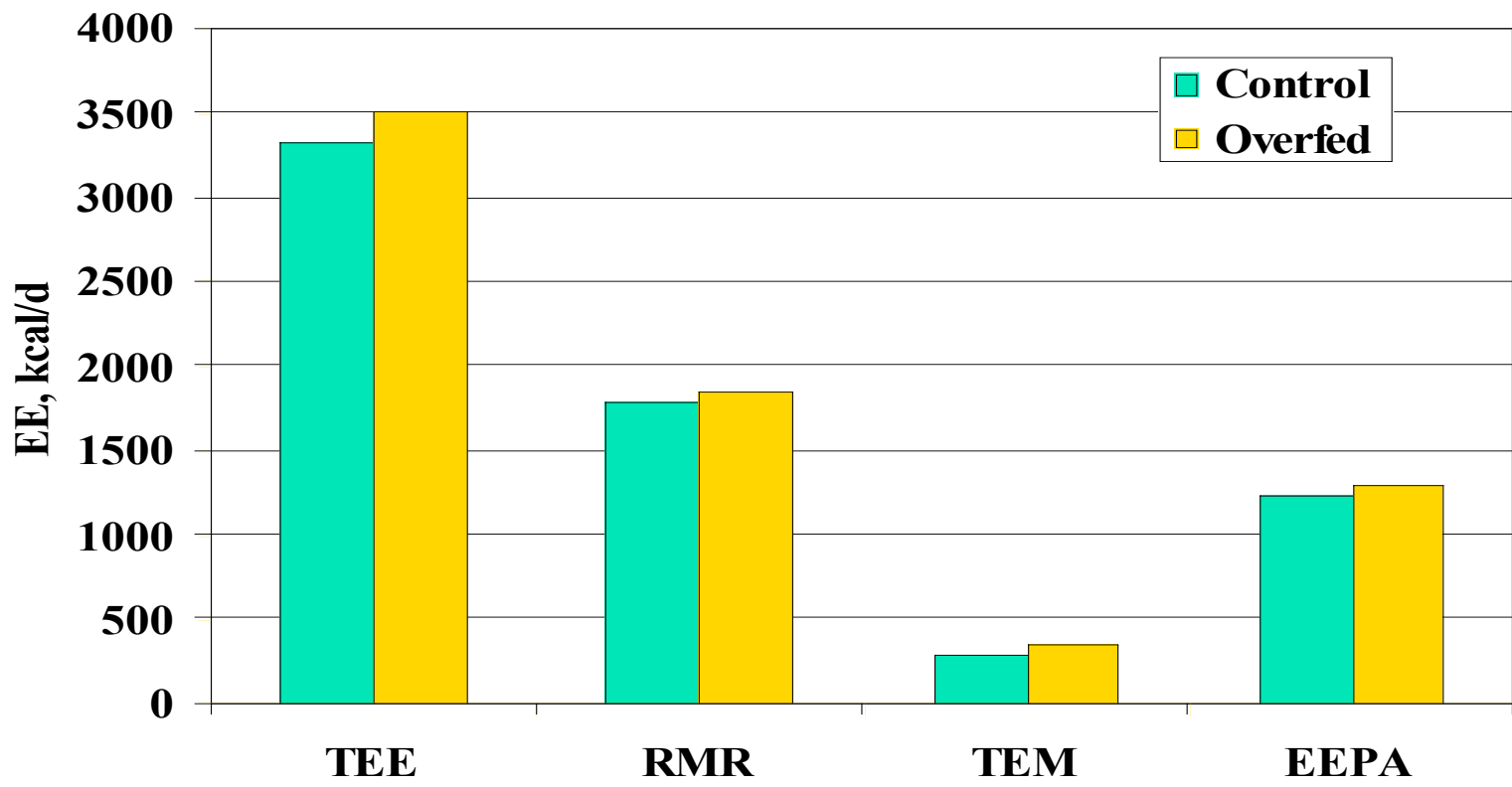


Overfeeding

- Increase Ein 1000 kcal/d
- 21 days of overfeeding
- Young, healthy males



Accommodation to overeating



$$E_{in} = TEE + Stores, +1000 = +200 + 800$$

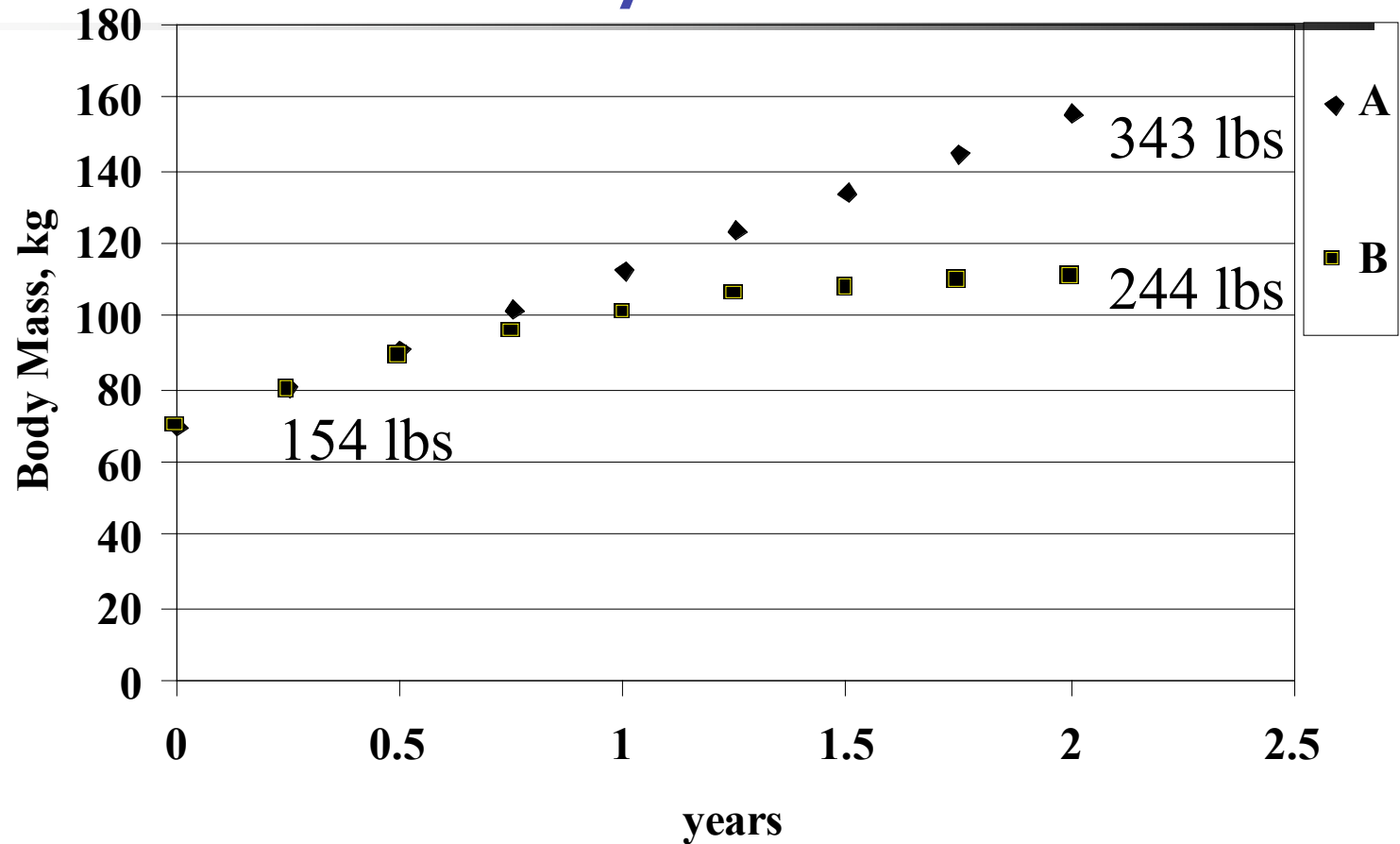
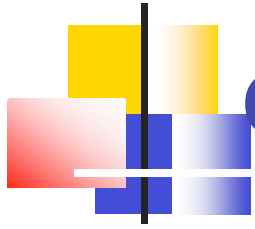


Overfeeding

- Increase Ein 1000 kcal/d
- 21 days of overfeeding
- Young, healthy males

- Weight gain:
 - 2.4 kg (5.5 lbs)
 - 78% of excess Ein

What would happen if overeating continued for 2 yrs?





Hunger and satiety

- Which study do participants dislike the most?
 - Under- or over-eating
- Does this change with time?
 - 2 weeks vs. 6 months



Hunger and Satiety

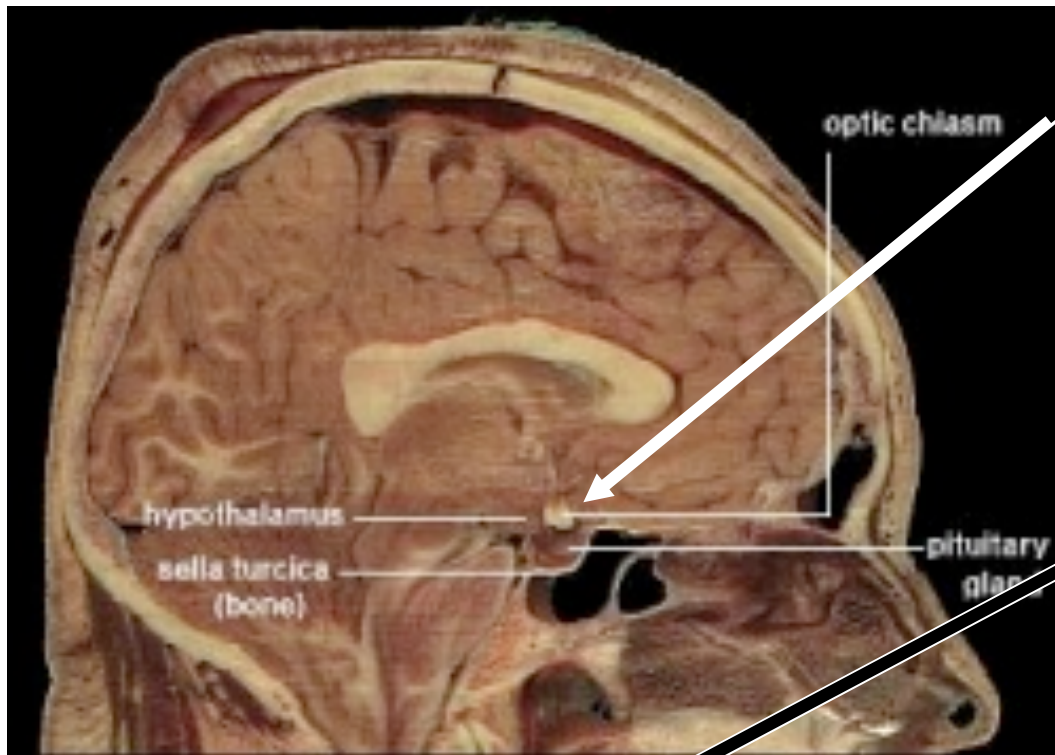
- Hunger – the desire to locate and consume food.
- Satiety – the absence of hunger or the cessation of eating.
- Appetite – the totality of food seeking and consumption



Signaling

- Control points of hunger and satiety
 - Hypothalamus (ARC)
 - dorsal vagal complex (brainstem)
- Signals integrated to control meal size, frequency, and overall E_{in}
- Short-term and long-term peripheral signals
 - Act on CNS to influence feeding behavior

Hunger-satiety center

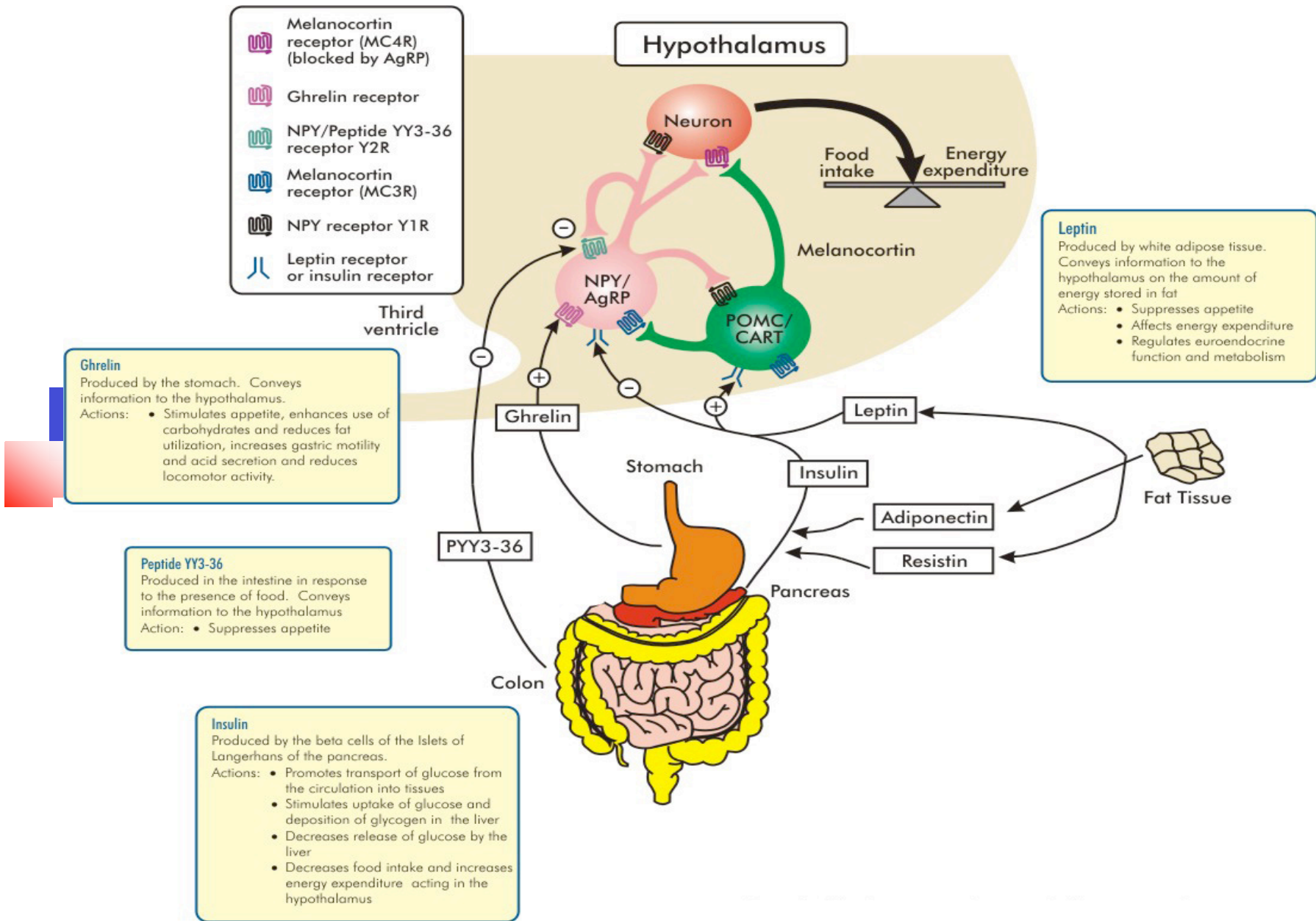


- Hypothalamus
 - ARC Integrates signals
 - Nervous system
 - Circulatory system
- Dorsal vagal complex (brainstem)



Two subsets of neurons:

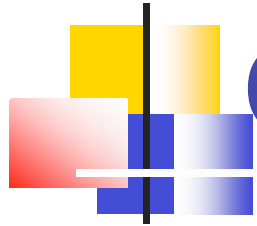
- Neuropeptide Y (NPY) and Agouti-related peptide (AgRP) neurons
- Proopiomelanocortin (POMC) and Cocaine-and amphetamine-regulated transcript (CART) neurons
- NPY/AgRP: increase appetite/hunger (Orexigenic) and may decrease EE
- POMC/CART: decrease appetite/hunger (Anorexigenic) and may increase EE





Hunger/satiety Summary

- Volume – short-term
 - Gastric/intestinal distension decreases hunger
- GI hormones – short-term
 - Increased ghrelin increases hunger
 - Increased cholecystokinin decreases hunger
 - Increased polypeptide YY decreases hunger
 - Increased insulin decreases hunger
- Fat stores – long-term
 - Increased leptin decreases hunger
- But there are probably 1 to 2 dozen more to be characterized or discovered



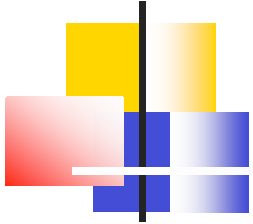
Complicating factors

- Palatability
- Learned food/taste preferences
- Social influences
- Emotions
- Disease
- Medications



Expenditure vs. intake

- Primary regulation of balance is controversial, but compensatory changes of E_{in} appears more important in humans.



Energy budgets

If the amount of energy an adult can consume to maintain constant weight is relatively fixed,
is relatively fixed,
then why might it be said:

“Everything we eat has two effects”