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How We Become What We Eat

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Outline

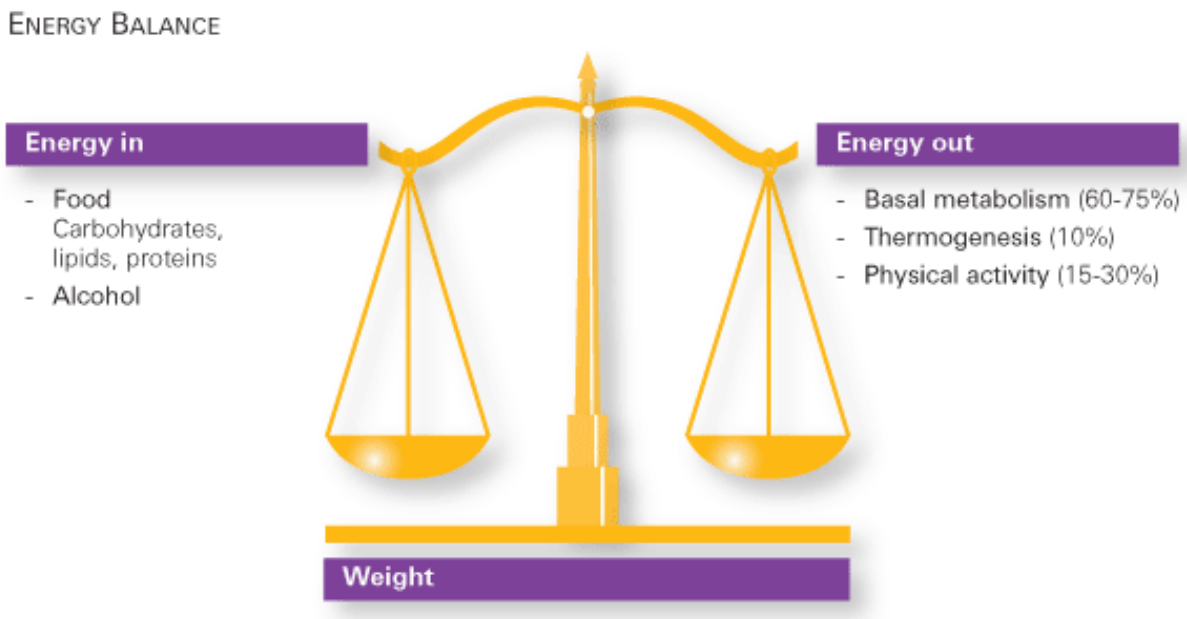
- Crash Course in Basic Terms
- Energy Balance
- Metabolism of carbohydrate, fat, and protein
- Relationship between obesity, insulin, and Type II Diabetes
- Role of exercise

Nutrition 101 in One Slide

- Macronutrients – Nutrients that provide energy – carbohydrates, protein, and fat
  - Fat provides 9kcal of energy/g
  - Carbohydrates provide 4kcal of energy/g
  - Protein provides 4kcal of energy/g
- Metabolism – The range of biochemical processes that occur within us to maintain life.
  - Anabolic – Buildup of substances
  - Catabolic – Breakdown of substances

Energy Balance

- To maintain weight, the energy you take in through food must equal the energy you expend.



- The total number of CALORIES from foods we eat and number of calories burned determines weight balance

For example

- I could choose to eat 1 KFC Doubledown
  - 540 kcal, 11g of carb, 32g of fat, and 53g of protein

OR

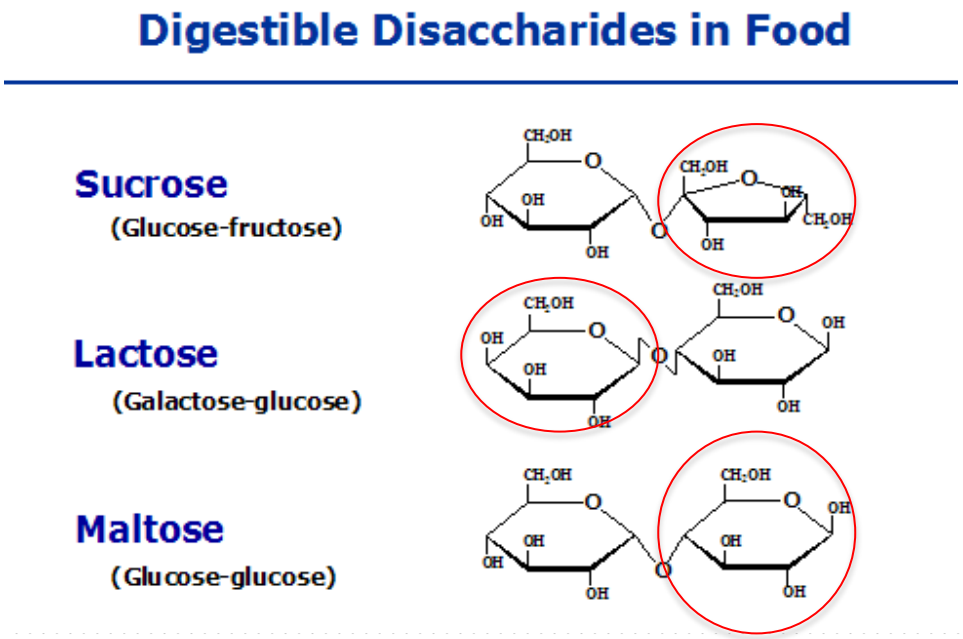
- A grilled chicken breast, a glass of 1% milk, 1.5 cups of steamed broccoli, and 1 cup of brown rice
  - 540 kcal, 8g fat, 68g carb, and 45g protein
- My weight will remain stable

Popular Fad Diets

- The eternal search for the “magic bullet”
- Diets that eliminate entire food or macronutrient categories are limiting your choices
- NOT SUSTAINABLE
- If you expend more calories than you take in you will lose weight – ENERGY BALANCE

Carbohydrate Basics

- Mono, di, and polysaccharides = carbohydrates
- All types of carb are broken down in the digestive tract to monosaccharides for absorption.
- Most fructose and galactose are then converted to glucose derivatives.
- Glucose is our preferred energy substrate



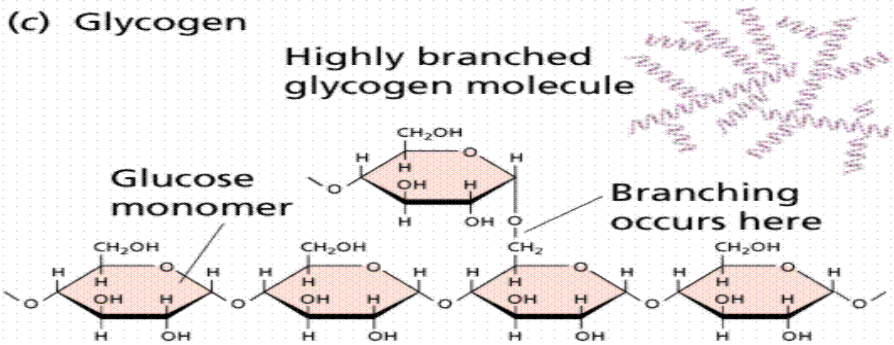


Figure 3.12 (3)

Carbohydrate Basics

- Sucrose = Cane/beet/I-put-that-in-my-coffee sugar. It's composed of glucose and fructose.
- High Fructose Corn Syrup is also composed of glucose and fructose in a similar ratio as in sucrose.
  - Glucose and fructose molecules are not linked together
  - Sucrose and HFCS are digested and absorbed in a very similar process.
- Glycogen = Storage form of glucose in the liver and muscle.

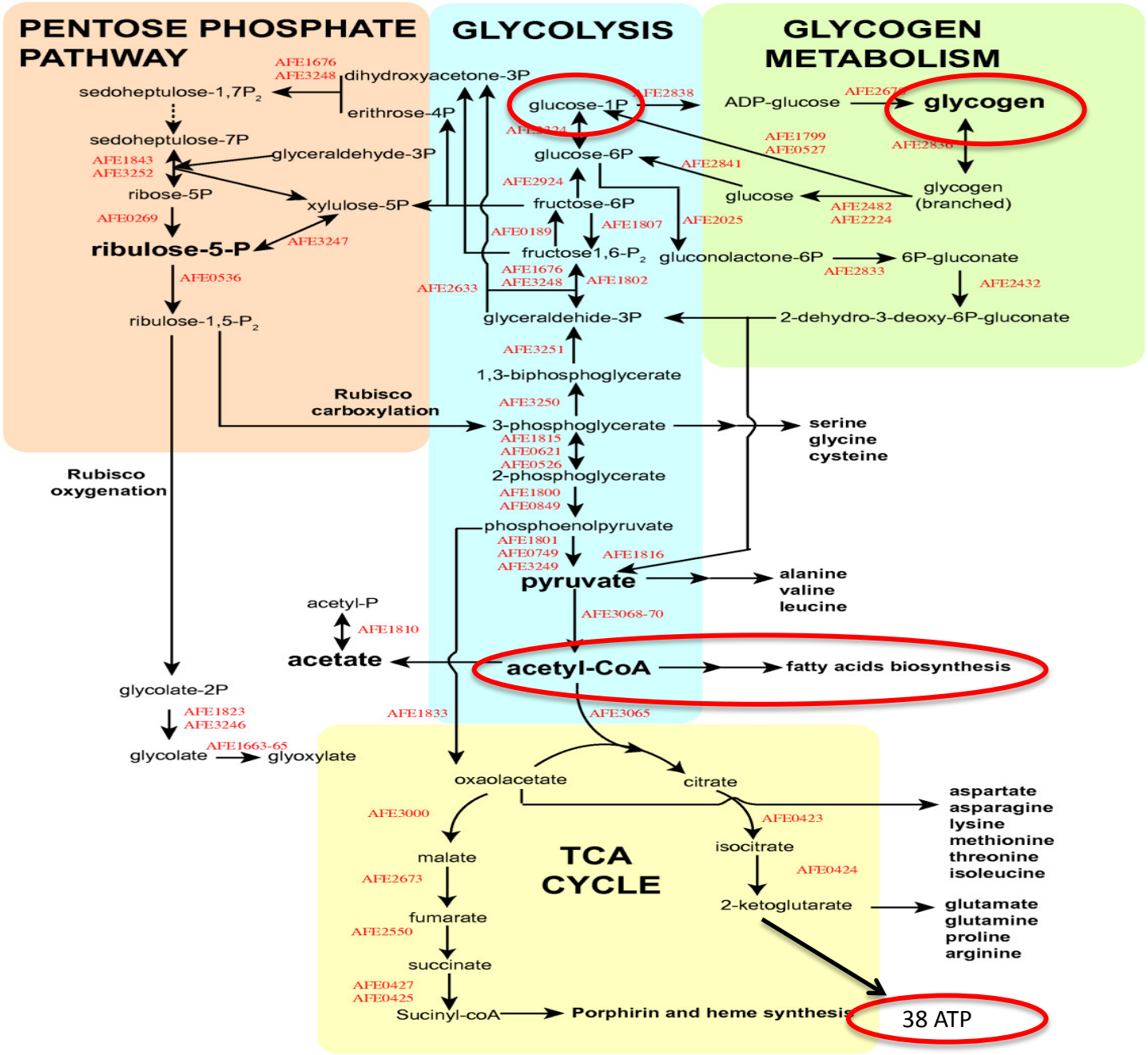
Glucose

Absorbed in the small intestine – begins circulating in the blood

Converted to glycogen and stored for energy in muscles and liver

Converted to Acetyl CoA then ATP and used for immediate energy

Converted to Acetyl CoA ➔ TGs and stored as fat in adipose tissue


PENTOSE PHOSPHATE PATHWAY
GLYCOLYSIS
GLYCOGEN METABOLISM
AFE1676
AFE3248
dihydroxyacetone-3P
sedoheptulose-1,7P2
erithrose-4P
sedoheptulose-7P
AFE1843
AFE3252
glyceraldehyde-3P
ribose-5P
xylulose-5P
AFE0269
ribulose-5-P
AFE3247
AFE0536
ribulose-1,5-P2
Rubisco carboxylation
Rubisco oxygenation
glycolate-2P
AFE1823
AFE3246
glycolate
AFE1663-65
glyoxylate
glucose-1P
AFE2838
ADP-glucose
glycogen
AFE1799
AFE0527
glucose-6P
AFE2841
glucose
glycogen (branched)
AFE2482
AFE2224
AFE2924
fructose-6P
AFE1807
AFE2025
AFE0189
fructose1,6-P2
gluconolactone-6P
6P-gluconate
AFE2833
AFE2432
AFE1676
AFE3248
AFE1802
AFE2633
glyceraldehide-3P
2-dehydro-3-deoxy-6P-gluconate
AFE3251
1,3-biphosphoglycerate
AFE3250
3-phosphoglycerate
serine
glycine
cysteine
AFE1815
AFE0621
AFE0526
2-phosphoglycerate
AFE1800
AFE0849
phosphoenolpyruvate
AFE1801
AFE0749
AFE3249
AFE1816
pyruvate
alanine
valine
leucine
AFE3068-70
acetyl-P
AFE1810
acetate
acetyl-CoA
fatty acids biosynthesis
AFE1833
AFE3065
oxaolacetate
citrate
aspartate
asparagine
lysine
methionine
threonine
isoleucine
AFE3000
AFE0423
malate
TCA CYCLE
isocitrate
AFE0424
AFE2673
2-ketoglutarate
glutamate
glutamine
proline
arginine
fumarate
AFE2550
succinate
AFE0427
AFE0425
Sucinyl-coA
Porphirin and heme synthesis
38 ATP

Key Decider - Insulin

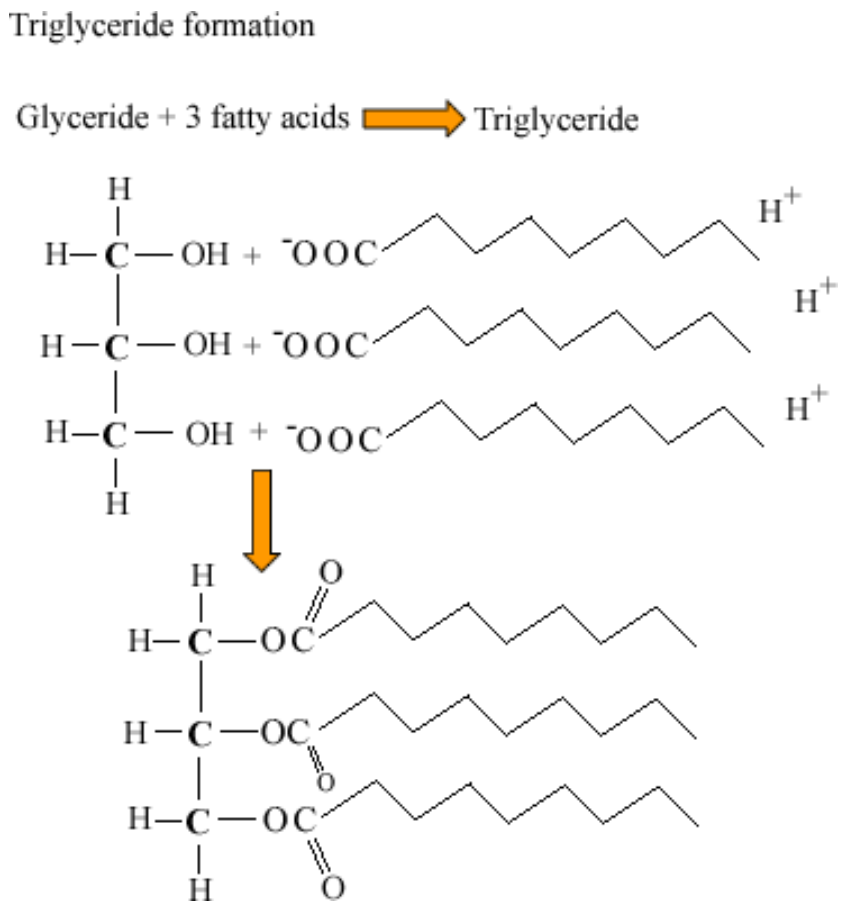
- Insulin is a hormone released from the pancreatic β-cells in response to increased blood glucose levels which occur after a meal.
- Because insulin responds to blood glucose levels, diabetics need to monitor their carb intake.

Insulin and Carbohydrates

- Insulin promotes absorption of glucose in the muscle and fat cells.
- If excess energy/glucose is consumed, insulin promotes glucose uptake by adipose tissue which then converts glucose (through Acetyl CoA) to triglycerides for storage.

Triglycerides

- Primarily eat fat in the form of triglycerides (TG)
- TGs are composed of glyceride and 3 fatty acid chains that can be saturated, unsaturated, or polyunsaturated
- All fats have the same number of calories per gram – 9kcal/g



Fat Delivery

- TG are absorbed in the small intestine and packaged into particles called chylomicrons for delivery to peripheral tissues especially muscle and adipose.
- TG can then be stored, or metabolized to ATP for energy

Insulin and Fat Metabolism

- Insulin accelerates lipoprotein lipase activity
  - More TGs delivered from chylomicrons to peripheral tissues including adipose
- Prevents TG breakdown in adipose
- Store baby store!!!

Protein Metabolism

- Protein is composed of amino acids
- Body uses amino acids from protein we eat to synthesize its own proteins
  - Enzymes, hormones, structural proteins, immunoproteins, transporters, buffers, etc.

Protein Metabolism

- If protein intake is greater than protein requirements amino acids can be converted to TGs for storage
- Amino acid → Acetyl CoA → Triglycerides

Insulin Recap

- Insulin promotes energy storage
  - Storage of carb as glycogen and fat
  - Storage of fat as triglycerides in adipose
  - Inhibits fat breakdown
  - Stimulates uptake of amino acids into cells
  - Suppresses production of glucose and VLDL in the liver
- By facilitating glucose uptake in cells, insulin keeps blood glucose levels tightly controlled
- Type II Diabetes develops when one becomes insulin resistant

Insulin Resistance

- Body is less sensitive to effects of insulin
- At first, more insulin is released to overcome the decreased sensitivity – blood glucose is still controlled
- Eventually the body can no longer secrete enough insulin to control blood glucose

Insulin Resistance – Muscle and Adipose Tissue

- Consequences
  - Muscles cannot uptake glucose from blood ➔ hyperglycemia
  - TG breakdown no longer inhibited in adipose, so have elevated TGs in blood

Insulin Resistance – The Liver

- Liver remains insulin sensitive
  - ↑ glucose production because it's getting the message that the tissues don't have enough glucose
  - Takes up excess glucose in the blood and converts it to TGs which ↑ TG levels and LDL levels

Connection Between Obesity, Insulin Resistance, and Type II Diabetes

- Obesity = State of chronic low-grade inflammation
- Body responds to obesity by launching an inflammatory response producing cytokines and adipokines
  - Cytokines – regulatory immune system proteins
  - Adipokines – regulatory proteins produced by ADIPOSE tissue
    - Adipose is not inert tissue

Adipose Cytokines and Adipokines

- Cytokines
  - TNF-α and IL-6
    - Increased in obesity
    - Promote insulin resistance
- Adipokines
  - Leptin
    - Increased in obesity
    - Decreases appetite
  - Adiponectin
    - Decreased in obesity
    - Anti-inflammatory

TNF-α, IL-6, and Insulin Resistance

- TNF-α and IL-6 interfere in the signaling pathway of insulin and the insulin receptor
- Exact mechanism is under investigation

All Obesity is Not Created Equal

- Android Obesity
  - Store fat near your abdomen which is more dangerous because it tends to result in more visceral fat vs. subcutaneous fat.
- Gynoid Obesity
  - Store fat on your hips and thighs

Visceral vs. Subcutaneous Fat

- Visceral fat releases more cytokines and adipokines ↑ inflammation
- Exercise and weight loss may reduce the release of cytokines and adipokines

The Role of Exercise

- Exercise is an important part of weight maintenance, less influential for weight loss
- Even without weight loss exercise may improve disease risk factors
- Just standing up more may have beneficial effects on health

The Full Enchilada

Insulin Released – Signals body to enter storage mode

Body breaks CHO to Acetyl CoA for fatty acid synthesis and storage, sends fat to adipose for storage

Fat cell size and number increase

Release cytokines and adipokines to respond to chronic inflammation

Insulin signaling pathway disrupted

Insulin resistance/hyper glycemia

Type II Diabetes

Associated complications: atherosclerosis, retinopathy, nephropathy, neuropathy, stroke, etc.

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Questions?