Nutrition

for Sport and Exercise, Third Edition

Marie Dunford
J. Andrew Doyle

6 Fats

Learning Objectives

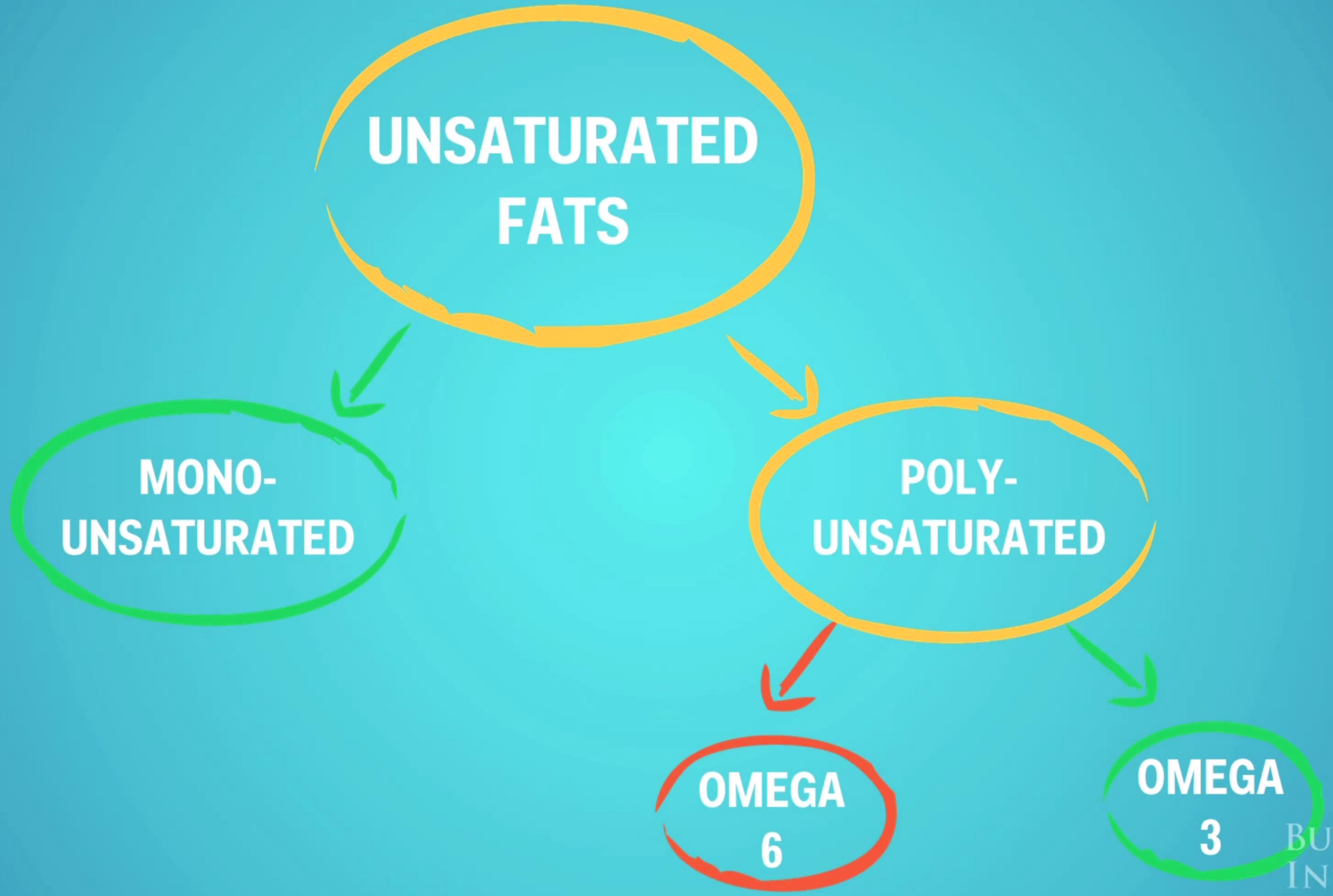
- Classify fats according to their chemical composition and distinguish between saturated and unsaturated, monounsaturated and polyunsaturated, cis and trans, and omega-3, -6, and -9 fatty acids
- Describe the digestion, absorption, transportation, and storage of fat
- Explain the metabolism of fat, including mobilization, transportation, uptake, activation, translocation, and oxidation as well as ketosis and the effect it may have on training

Learning Objectives

- Describe how the body uses fat to fuel exercise
- State fat recommendations for athletes and calculate the amount of fat needed daily
- Identify sources of dietary fat and assess an athlete's dietary fat intake
- Evaluate dietary supplements related to fat metabolism

Fats

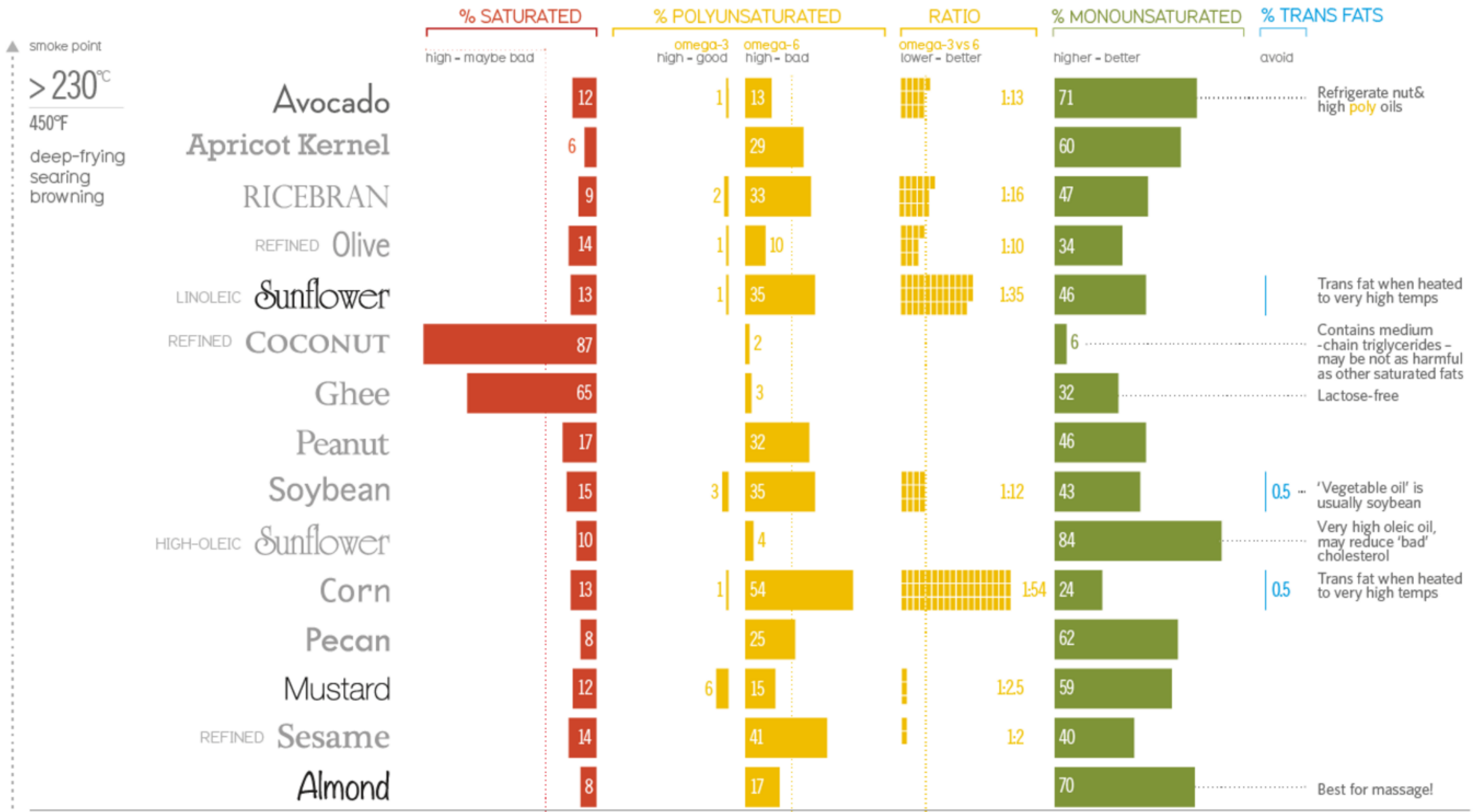
- The word fat has many different meanings
- Primary source of energy at rest and during low-intensity exercise
- Most concentrated source of energy (9 kcal/g)
- Certain fats are associated with chronic diseases, notably cardiovascular disease
- It is important to know the amounts and types of dietary fats found in foods

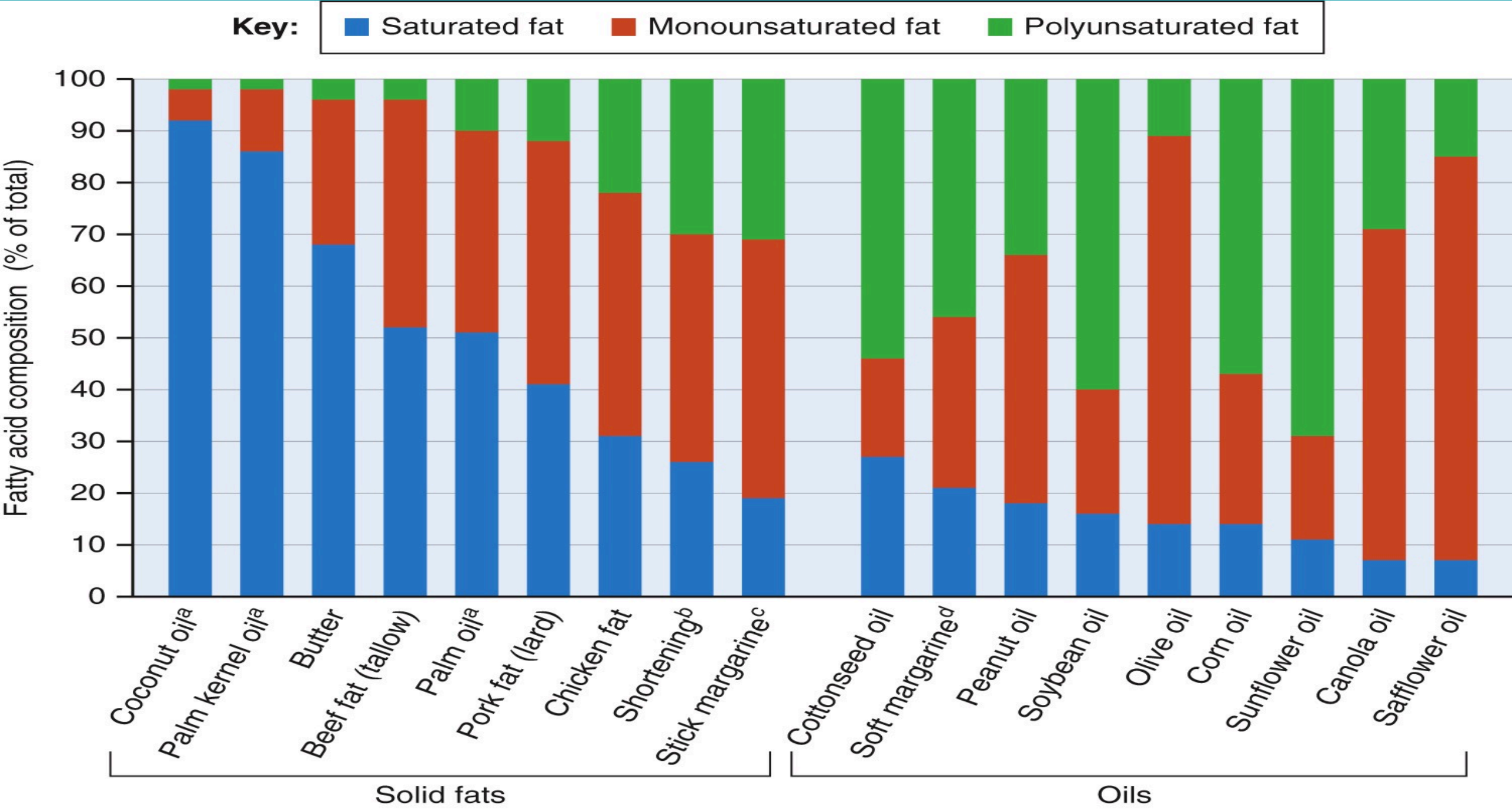

UNSATURATED FATS
MONO-UNSATURATED
POLY-UNSATURATED
OMEGA 6
OMEGA 3
BUSINESS INSIDER

SATURATED	MONOUNSATURATED	POLYUNSATURATED
Coconut oil	Avocado oil	Corn oil
Butter	Olive oil	Grapeseed oil
Palm oil	Sunflower oil	Cottonseed oil
Beef Tallow	Almond oil	Hemp oil
Hydrogenated oils	Hazelnut oil	Walnut oil
	Canola/Rapeseed	Pumpkin seed oil

Oil Well

Omega 6 will 'steal' Omega 3 channels in the body & can block absorption & storage of this vital nutrient



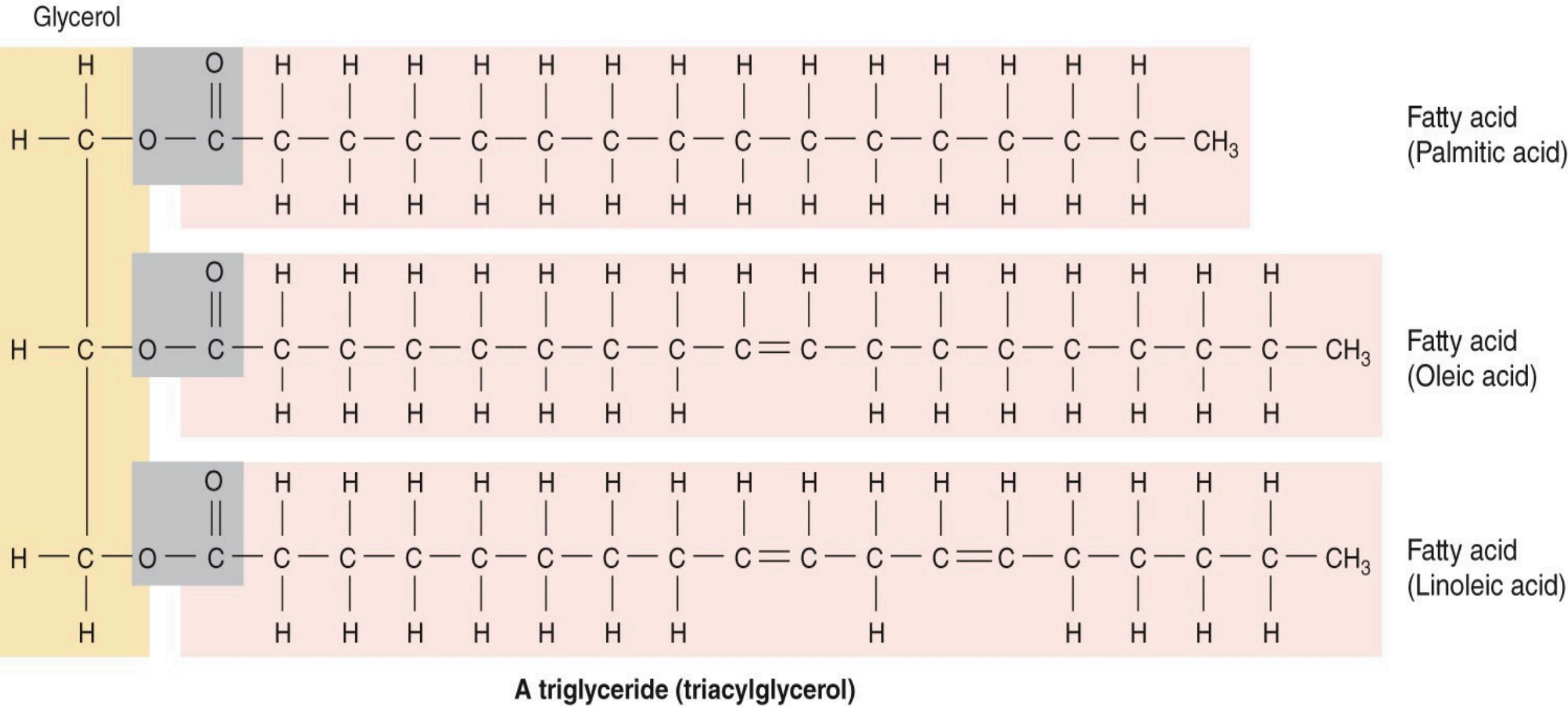


Source: U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 22, 2009.

Sterols and Phospholipids are Types of Fat Found in Foods

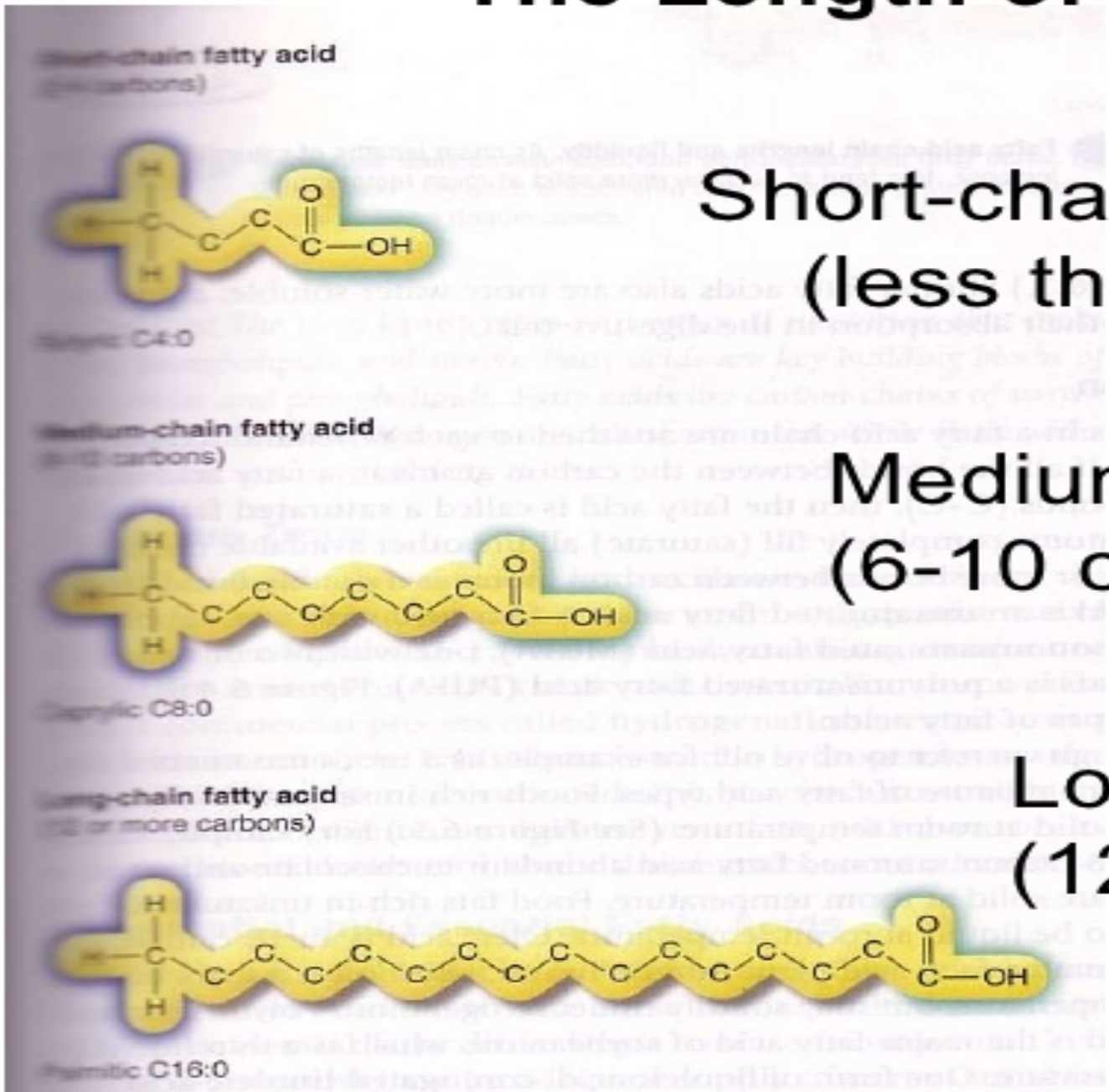
- Sterols have a ring structure
  - Cholesterol; vitamin D; sex hormones
- Cholesterol
  - Only found in animal foods; also manufactured in the body
- Phospholipids
  - Similar in structure to triglycerides; contain phosphate; component of cell membranes

Most Fats in Food Are in the Form of Triglycerides



A triglyceride (triacylglycerol)

The Length of the Carbon Chain



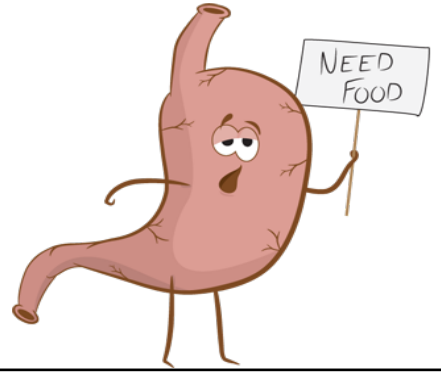
Short-chain Fatty Acid
(less than 6 carbons)

Medium-chain Fatty Acid
(6-10 carbons)

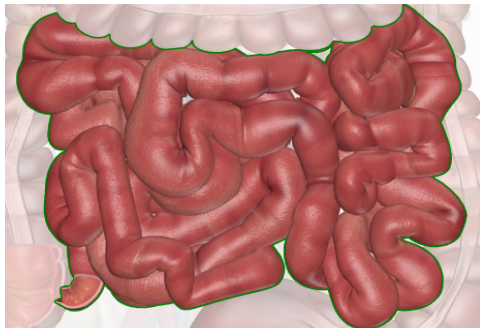
Long-chain Fatty Acid
(12 or more carbons)

Lipid Digestion

- Lingual Lipase – splits short & medium chain triglycerides into fatty acids and glycerol
- 10% - 30% of triglyceride digestion



- Lingual & gastric lipase activity continues
- Slow digestions b/c fat & water-based saliva (which contains the lipase) don't mix well

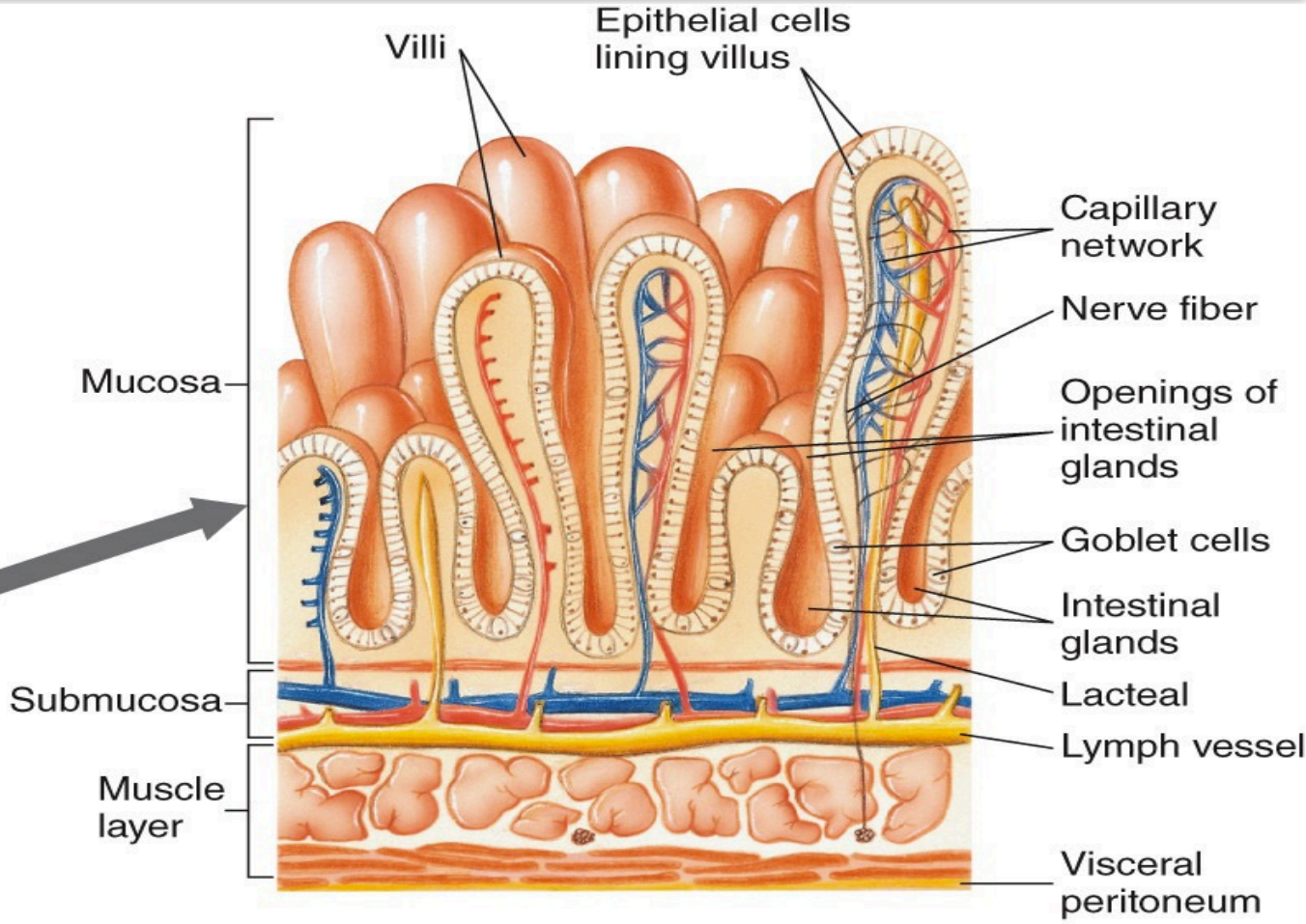


- Fatty acids (FAs) are incorporated into micelles with the help of bile salts from the gallbladder
- Micelles transport FA's to microvilli where FA's are diffused across the epithelial cell
- Within the epithelial cell FA's are packed into Chylomicrons and absorbed into the lymphatic system

The Structure of the Small Intestine

Steve Gschmeissner/Science Source

Light micrograph of a section through the entire width of the small intestine. Magnification: x60



Enlarged view of a small portion of the intestinal wall. Some of the villi have been opened to show the blood and lymph vessels within.

Dietary lipids (mostly triglycerides)

Mouth

Stomach

Physical break-up

Lipid droplets in chyme

Small intestine

Emulsification by bile salts

Partial hydrolysis by pancreatic lipase

Mono- and diglycerides in micelles

Intestinal lining

Absorption

Synthesis of triglycerides packaged into chylomicrons for transport in blood

After Being Absorbed, the Fatty Acids are Resynthesized into Triglycerides

- Enter mucosal cells via passive diffusion
- Majority are re-assembled into triglycerides
  - 12 to 18 carbon fatty acids
  - Incorporated into chylomicrons (lipoprotein)
- Short – and – medium chain (4 to 10 carbon) fatty acids pass through mucosal cells unchanged
- Lipoproteins transport fat throughout the body

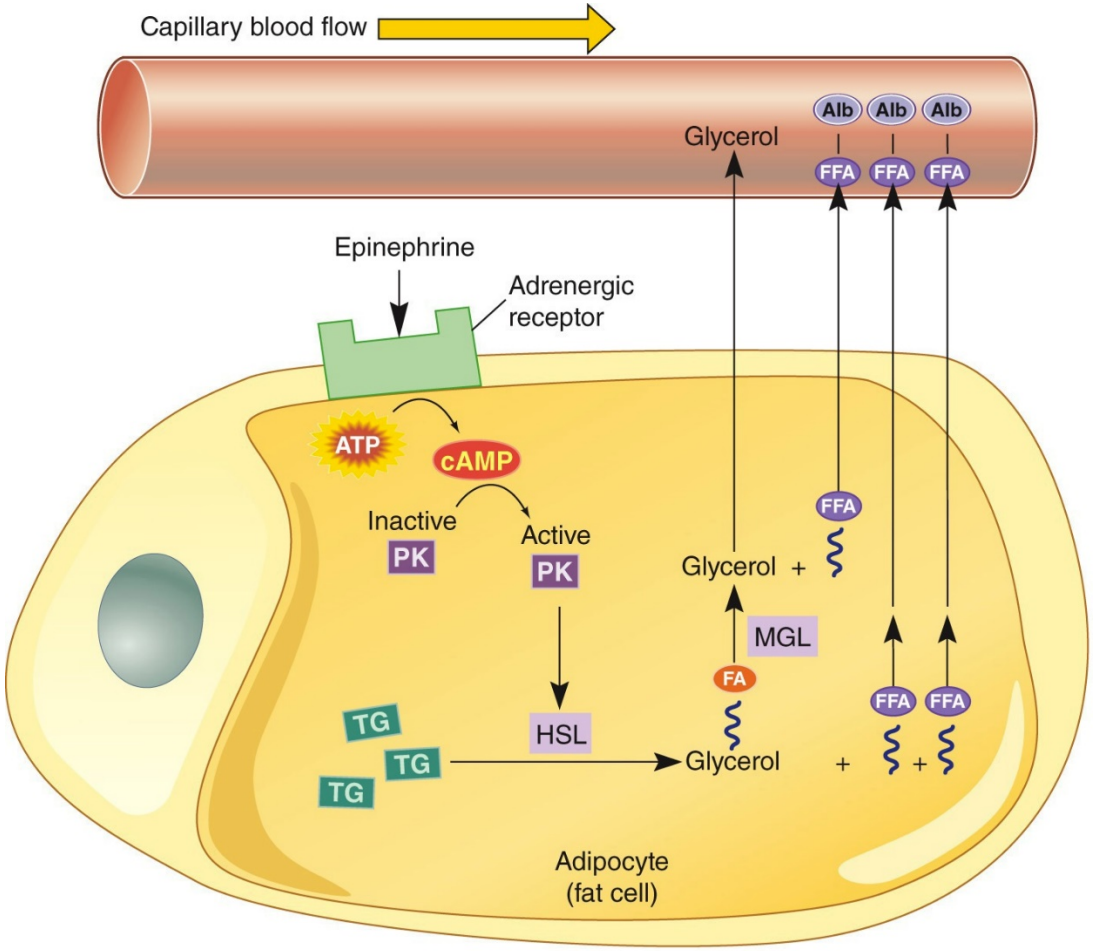
The Transportation of Fats into the Blood is a Slow Process

- Chylomicrons are slowly released into lymph
- Other fatty acids are released into blood via the portal vein
- Blood fatty acid concentration is increased for several hours
- Cellular triglyceride absorption
  - Adipose, muscle and liver cells are important storage sites
  - Lipoprotein lipase (LPL) stimulates the release of fatty acids from the triglycerides

The Transportation of Fats into the Blood is a Slow Process

- Lipoprotein lipase activity is stimulated by insulin
- Fat storage in muscle occurs primarily in muscle that is highly aerobic
- Advantages
  - Very “energy dense” nutrient
  - 9 kcal/g (twice that of CHO or protein)

6.3 Storage and Metabolism of Fats



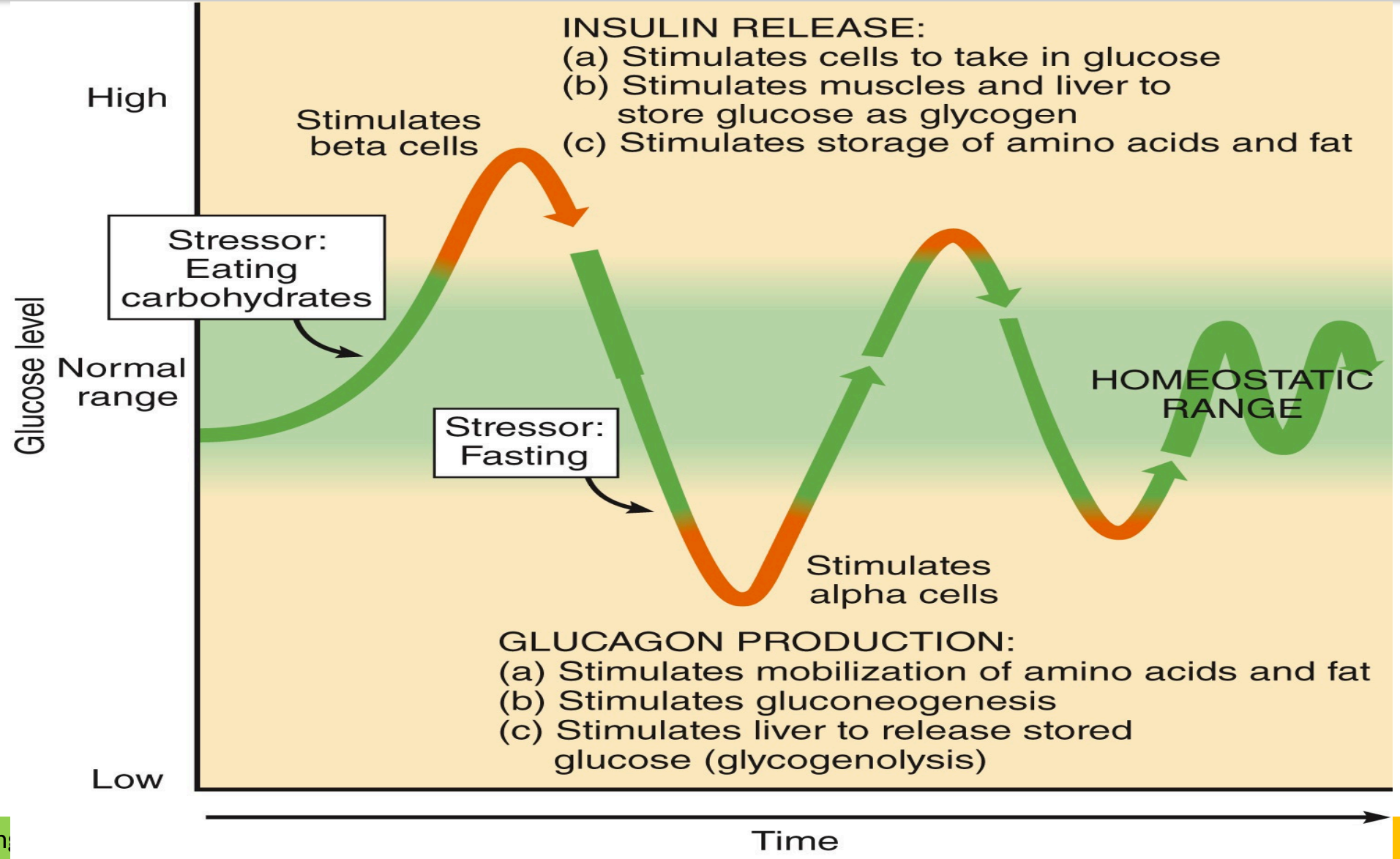
Does Fat Make You Fat?

- Nope!

Ketosis

- Ketone bodies
  - Acetoacetate, beta-hydroxybutyrate, acetone
- Normal metabolic pathway
- ~2 to 6% of body's energy needs after overnight fast
- Pathway is sometimes emphasized
  - Starvation state
  - Low CHO intake
  - Impaired CHO metabolism (diabetes)
    - Dangerous, can result in ketoacidosis in type 1 diabetics

Ketoacidosis in Type 1 Diabetics



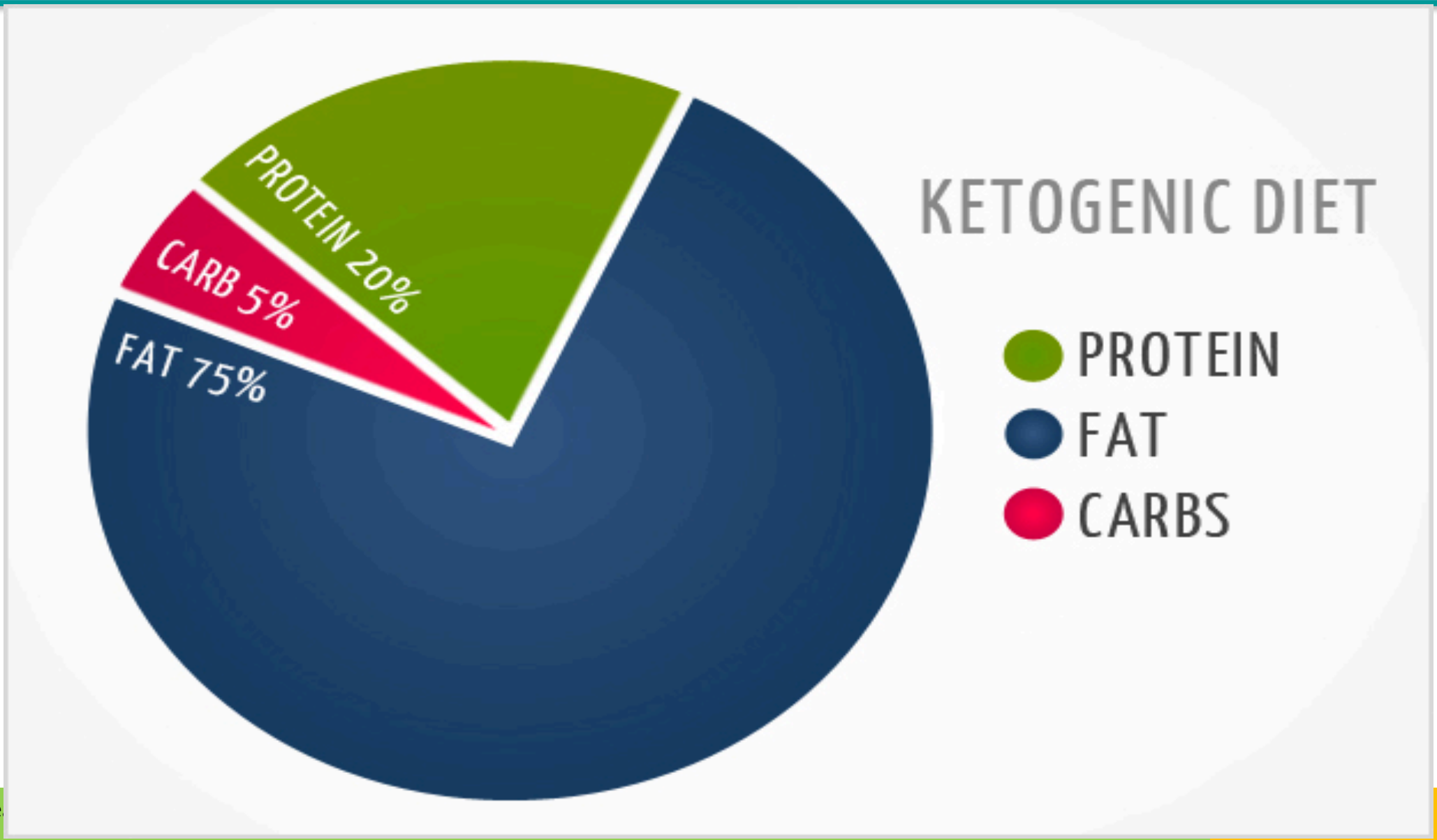
Ketosis

- Low CHO intake/ starvation
  - Ketones are source of energy for brain
  - Muscle glycogen depleted
  - Loss of some skeletal muscle
  - Weight (fat) loss
- Not likely to be beneficial for athletic performance
- Can be used to reduce seizures in patients with certain types of epilepsy

2. While removing, draw the edge of the strip against the rim of the urine container to remove excess urine.
3. **Exactly 15 seconds** after removing from specimen, compare reagent side of test area with corresponding color chart.

LOT:
10M05AA

Weight Loss Advantage to Ketogenic Diet?



Weight Loss Advantage to Ketogenic Diet?

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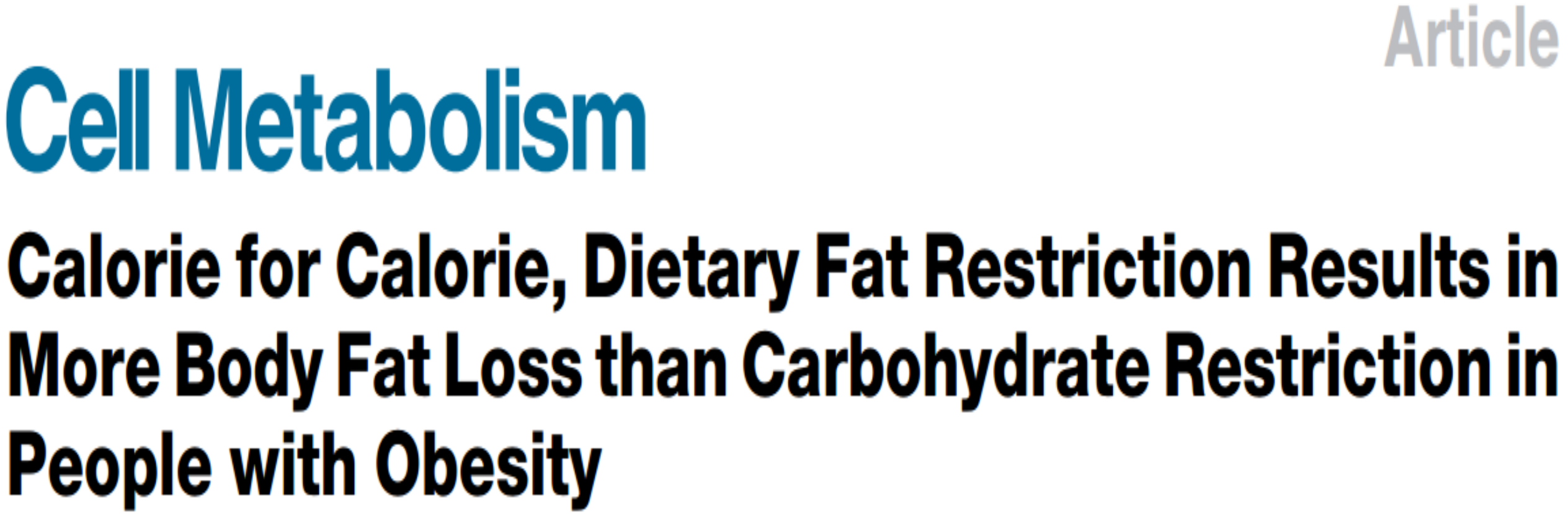
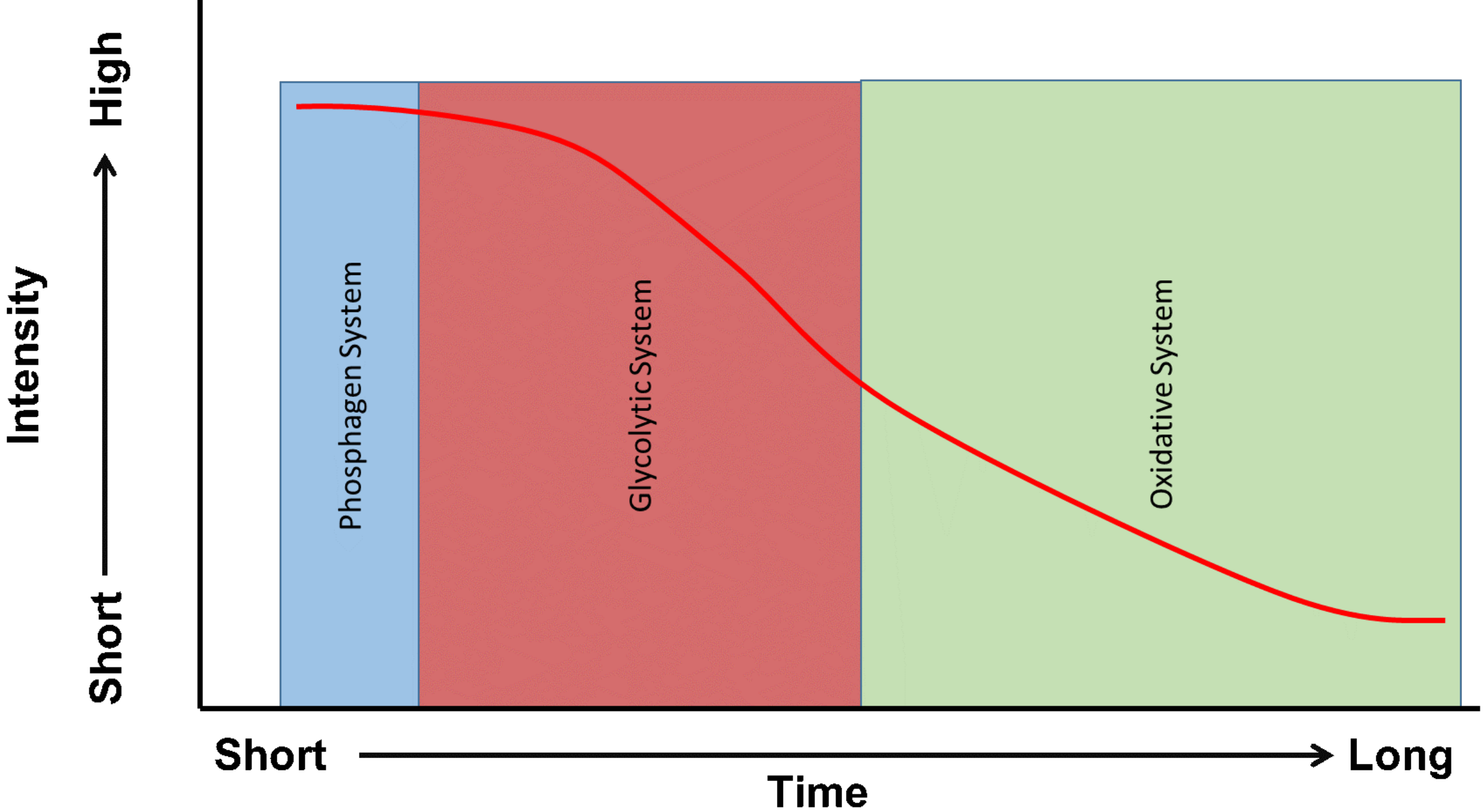


6.4 Fats as a Source of Energy During Exercise

- Use of fat during exercise
  - Advantages
    - Abundant in food supply
    - Energy dense
    - Substantial storage in adipose tissue
    - Produces large amount of ATP
  - Disadvantages
    - Takes time to transport and metabolize
    - Requires oxygen


Intensity
High
Short
Phosphagen System
Glycolytic System
Oxidative System
Short
Long
Time

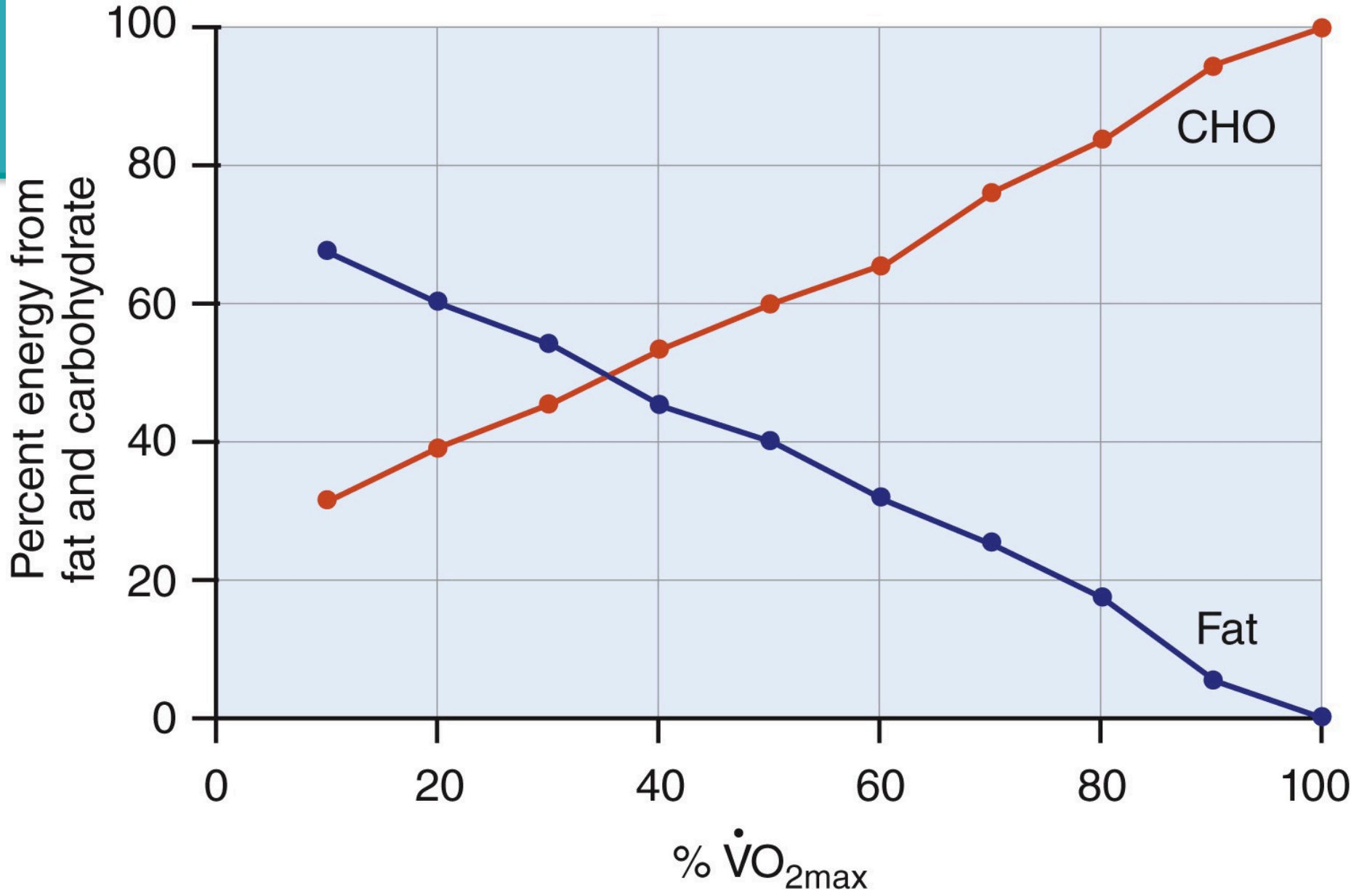
Fats as a Source of Energy During Exercise

- Energy expenditure and fuel utilization during running can be measured.

The Relative and Absolute Amount of Fat Utilized as a Fuel

- Respiratory exchange ratio (RER) ~0.70
- Relative
  - Percentage of energy derived from CHO or fat
- Absolute
  - Total amount of energy expended
- Rate
  - Number of calories expended each minute

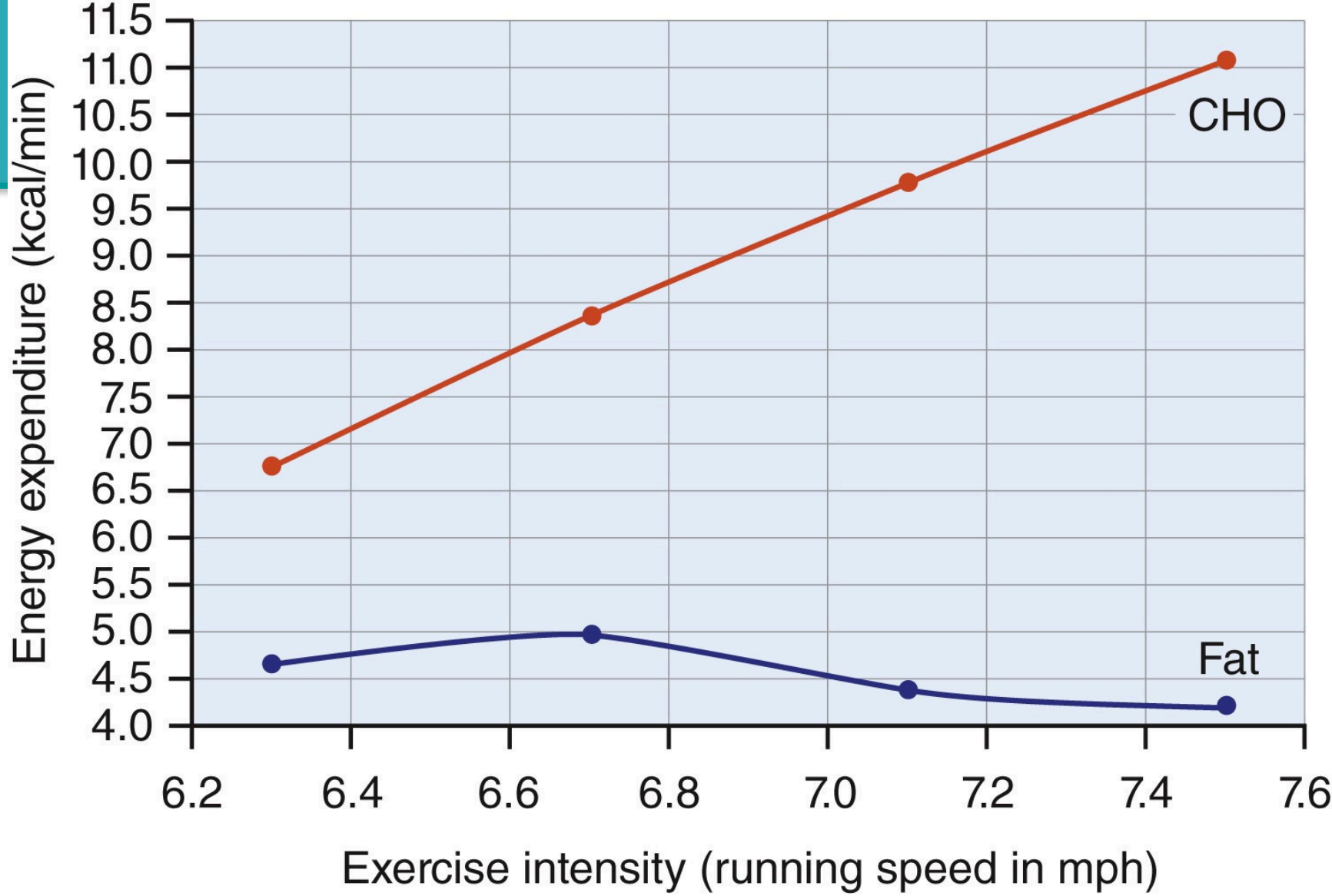
Fat Oxidation During Exercise



CHO = carbohydrate

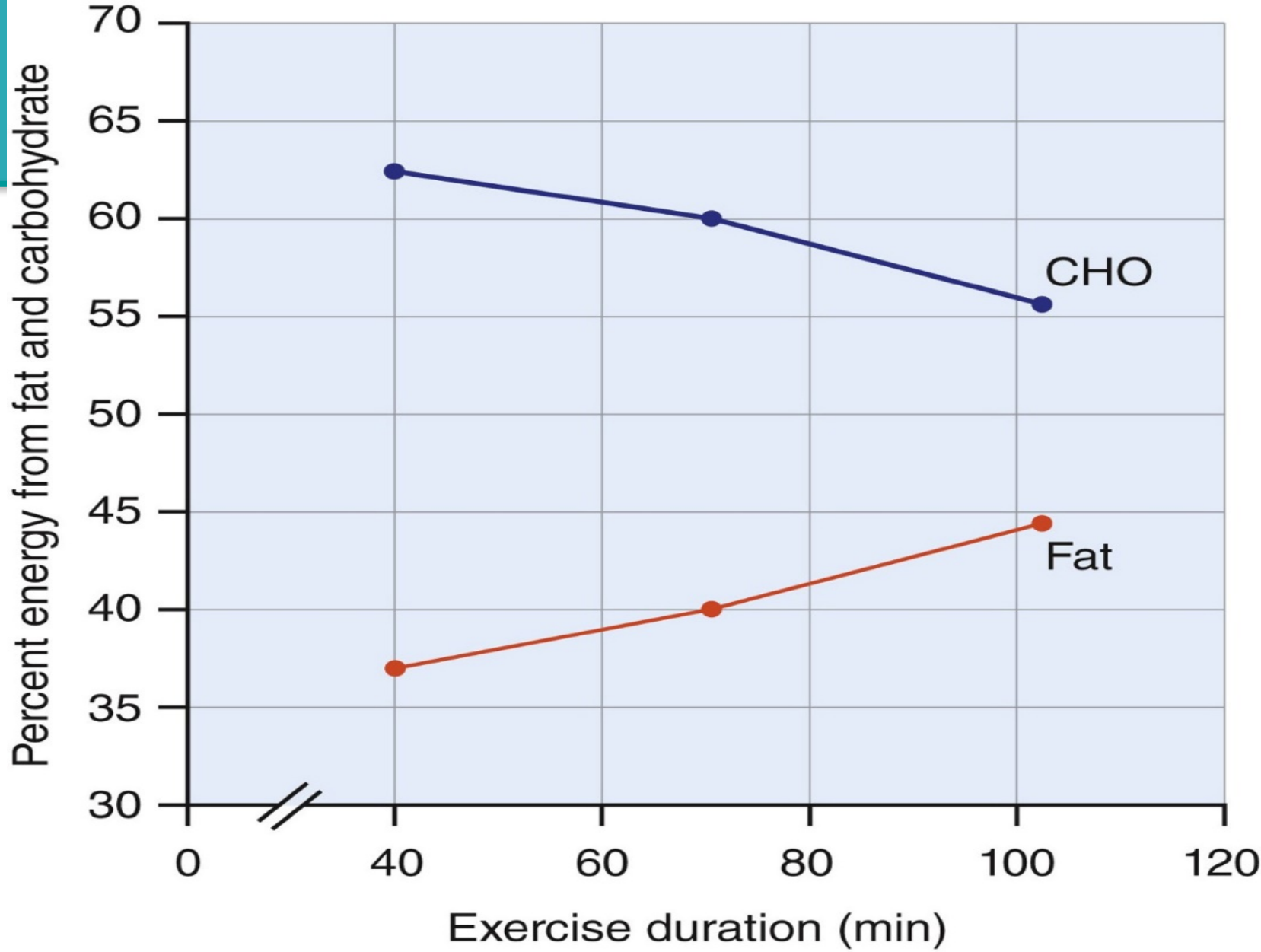
$\dot{V}O_{2max}$ = maximum oxygen consumption

Fat Oxidation During Exercise



CHO = carbohydrate
kcal/min = kilocalories per minute
mph = miles per hour

Steady-State Exercise



CHO = carbohydrate
min = minutes

Do You Have to Burn Fat to Lose Fat?

- Low-intensity exercise ("fat-burning zone")
  - RER is lower than during high-intensity exercise
  - Percentage of energy derived from fat is high
  - Total amount of energy expended is lower
- Total energy expended is more important than percentage expended from fat

The Relative and Absolute Amount of Fat Utilized as a Fuel

Table 6.2 Energy Expenditure and Fuel Utilization

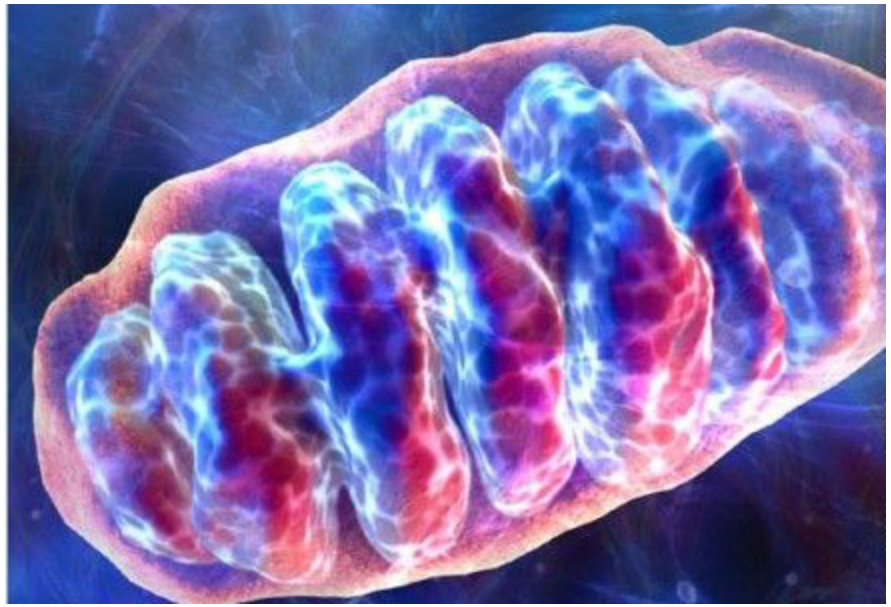
Run pace (min/mile)	Heart rate (bpm)	RER	Percent energy from fat	Percent energy from CHO	Total energy expenditure (kcal/min)	Fat (kcal/min)	CHO (kcal/min)
Rest	72	0.77	78.2	21.8	1.4	1.1	0.3
9:30	127	0.88	40.8	59.2	11.5	4.7	6.8
9:00	138	0.89	37.4	62.6	13.4	5.0	8.4
8:30	144	0.91	30.6	69.4	14.2	4.4	9.8
8:00	153	0.92	27.2	72.8	15.3	4.2	11.1

Heart rate, RER, and relative and absolute energy expenditure from fat and carbohydrate at rest and at four different running paces for a 49-year-old male marathon runner.

min = minutes; bpm = beats per minute; RER = respiratory exchange ratio; CHO = carbohydrate; kcal = kilocalories

General Adaptations to Endurance Exercise

- Fatty acids are more easily mobilized from adipocytes
- Uptake of fatty acids into muscle cells is enhanced
- Number and size of mitochondria are increased (mitochondrial biogenesis)

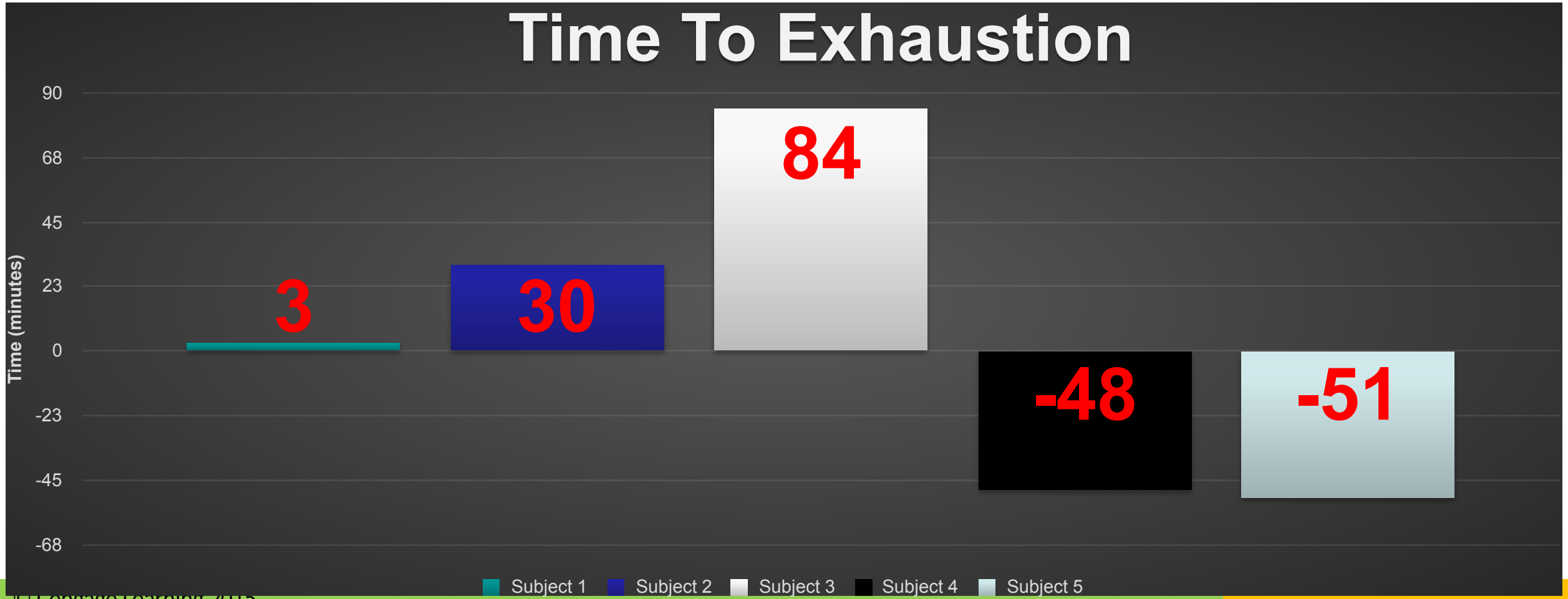


Dietary Manipulations to Enhance Fat Metabolism

- Endurance performance not likely to improve
  - There are those that will improve but at the cost of ability to perform intense exercise
- Intensity of exercise would be too low to be competitive

The Human Metabolic Response to Chronic Ketosis Without Caloric Restriction: Preservation of Submaximal Exercise Capability with Reduced Carbohydrate Oxidation

S. D. Phinney, B. R. Bistrian, W. J. Evans, E. Gervino, and G. L. Blackburn



Effect of Caffeine on Fat Usage

- May enhance fat mobilization
- Fat oxidation is not significantly increased
- Central nervous system stimulant
  - Increases sense of awareness
  - Decreases perceived effort

↓Don't be this guy↓

6.6 Fat Recommendations for Athletes

- Total energy (kcal) need
  - Macronutrient balance
    - Higher CHO/protein intake typically means lower fat intake
    - Severe restriction of fat intake not recommended
  - Often expressed as a % of total energy intake
    - 20 to 35% total caloric intake
  - May be expressed on g/kg body weight basis
    - ~1.0 g/kg daily
    - May need to be as high as 3.0 g/kg (ultra-endurance athletes)

Fat Recommendations for Athletes

- Adjusting fat intake to achieve energy deficits
  - Reducing body fat may result in improved performance
  - Fat intake is typically reduced since reductions to CHO or protein intakes may be detrimental to performance
  - Athletes may consume a short-term, low fat diet to achieve body composition goals
  - The fat intake of a bodybuilder will vary depending on the training cycle

Inadequate Fat Intake Can Negatively Affect Training, Performance, and Health

- Effects of an inadequate fat intake on training, performance, and health
  - Inadequate replenishment of intramuscular fat stores
  - Inability to manufacture sex-related hormones
  - Decline in high-density lipoprotein cholesterol (HDL-C)
  - Inadequate fat-soluble vitamin intakes

Translating Fat Recommendations to Food Choices

- Many athletes fail to consume an appropriate amount of fat
- Certain unsaturated fatty acids may help to reduce heart disease risk
- Excess saturated fat intake should be avoided
  - No established benefit to consuming a large portion of your diet from saturated fat.

Table 6.4 High-Fat Foods That Also Contain Carbohydrate and Protein

Food	Amount	Energy (kcal)	Fat (g)	Predominant type of fat*	CHO (g)	Protein (g)
Avocado	One (173 g)	306	30	Monounsaturated	12	3.5
Peanuts	¼ c, oil roasted	213	18	Monounsaturated	6	10
Almonds	¼ c, dry roasted	206	18	Monounsaturated	7	8
Hazelnuts (filberts)	¼ c, dry roasted	183	18	Monounsaturated	5	4
Pecans	¼ c, dry roasted	187	19	Monounsaturated	4	2.5
Pistachios	¼ c, dry roasted	183	15	Monounsaturated	9	7
Walnuts	¼ c	196	19.5	Polyunsaturated	4	4.5
Sesame seeds	1 T	51	4	Polyunsaturated/monounsaturated	2	1.5
Tahini (sesame seed paste)	1 T	89	8	Polyunsaturated/monounsaturated	3	2.5
Sunflower seeds	¼ c, oil roasted	208	19	Polyunsaturated	5	7
Pumpkin seeds	¼ c, oil roasted	296	24	Polyunsaturated	8	19
Flax seeds	1 T	59	4	Polyunsaturated	4	2
Bacon	2 slices	70	6	Monounsaturated/saturated	0	4
Canadian-style bacon (pork sirloin)	2 slices	50	1.5	Saturated	0	8
Coconut, sweetened, shredded	2 T	58	4	Saturated	5.5	0
Coconut milk	¼ c	138	14	Saturated	3	1

kcal = kilocalorie; g = gram; CHO = carbohydrate; c = cup; T = tablespoon

*When two fats are listed, both are found in approximately equal amounts.

Table 6.5 High-, Medium-, and Low-Fat Meat, Fish, Poultry, and Dairy Products

Food	Preparation method	Amount	Fat (g)
Ground beef, regular	Broiled	3 oz	17.5
Ground beef, lean	Broiled	3 oz	16
Ground beef, extra lean	Broiled	3 oz	14
Tuna salad	Mayonnaise added to tuna	¾ c	20
Light tuna, canned in oil	Drained	2 oz	7
Light tuna, canned in water	Drained	2 oz	0.5
Chicken wing (meat and skin), flour coated	Fried	3 oz	19
Chicken wing (meat and skin)	Roasted	3 oz	16.5
Chicken leg (dark meat)	Roasted	3 oz	7
Chicken breast (white meat)	Roasted	3 oz	3
Whole milk (3.3% butterfat)		8 oz	8
Reduced fat milk (2% butterfat)		8 oz	5
Low-fat milk (1% butterfat)		8 oz	2
Nonfat (skim) milk		8 oz	0.2
Creamed cottage cheese (4% butterfat)		½ c	5
Low-fat cottage cheese (2% butterfat)		½ c	2
Low-fat cottage cheese (1% butterfat)		½ c	1
Dry curd cottage cheese (0.4% or less butterfat)		½ c	~0.5

g = gram; oz = ounce, c = cup

The Typical American Diet is Usually Too High in Fat for an Athlete in Training

- High intake of:
  - Red meat
  - Processed meat
  - High-fat dairy products
  - French fries
  - Refined grains
  - Sweets
  - Desserts

The Americanization of Traditional Ethnic Meals Often Results in the Addition of Fat

Felicia Martinez/PhotoEdit

Ways to Modify the Typical American Diet So That It is Lower in Fat

- Reduce portion size
- Prepare foods with less fat
- Add less fat to foods
- Order carefully at restaurants
- Be aware of “hidden fats”

- Consume lower-fat cuts of meat or poultry, low-fat or nonfat dairy products, and lower-fat versions of high-fat processed foods
- Substitute fruits and vegetables for fat-containing snack foods

Summary

- Fat is the most energy-dense nutrient found in food
- The predominant fat in food and in the body is the triglyceride
- Fat absorption, digestion, transportation, and metabolism are slow and complicated
- The main sites of fat storage are adipocytes, liver, and muscle cells
- Fat is the primary energy source at rest and during low-intensity activity

Summary

- Athletes find that their diets tend to be relatively lower in fat than the typical American diet
- Caution should be used when restricting fat because athletes can reduce the fat in their diets too much