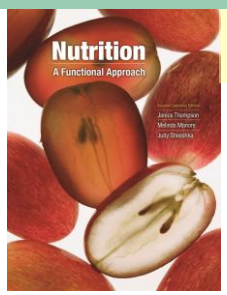
Nutrition: A Functional Approach

Janice Thompson Melinda Manore Judy Sheeshka

5

Lipids: Essential Energy-Supplying Nutrients



The Role of Lipids

Energy

- Fat is very energy dense, containing 9 kcal per gram.
- Fat is used for energy storage.
- 30-70% of the energy used during rest comes from fat.
- Fat is used for energy during exercise, especially after glycogen is depleted.

Storage Sites of CHO and Fat

TABLE 4.2 Principal Storage Sites of Carbohydrate and Fat in the Body of a Healthy, Nonobese (20% Body Fat), 70-kg Male Subject

Note that dietary intake of carbohydrate influences the amount of glycogen stored in both the liver and muscle. Mass units for storage are grams (g) and kilograms (kg). Energy units are kilocalories (kcal) and kilojoules (kJ). Data are from references 29, 30, and 62.

	Carbohydrate (CHO)		
Storage Site	Mixed Diet	High-CHO Diet	Low-CHO Diet
Liver glycogen	60 g (240 kcal or 1,005 kJ)	90 g (360 kcal or 1,507 kJ)	<30 g (120 kcal or 502 kJ)
Glucose in blood and extracellular fluid	10 g (40 kcal or 167 kJ)	10 g (40 kcal or 167 kJ)	10 g (40 kcal or 167 kJ)
Muscle glycogen	350 g (1,400 kcal or 5,860 kJ)	600 g (2,400 kcal or 10,046 kJ)	300 g (1,200 kcal or 5,023 kJ)

	Fat
Storage Site	Mixed Diet
Adipocytes	14 kg (107,800 kcal or 451,251 kJ)
Muscle	0.5 kg (3,850 kcal or 16,116 kJ)

How to Deplete Carbohydrate Stores

How to deplete muscle glycogen?

1. 40 minutes of intense prolonged exercise i.e. distance running
2. 30 s of all out sprinting – depletes ~25% of muscle glycogen
3. 1 min sprints x 10 - depletes ~50% of muscle glycogen
4. Soccer, basketball, football – sprinting for long periods of time

Lipids as Fuel Source

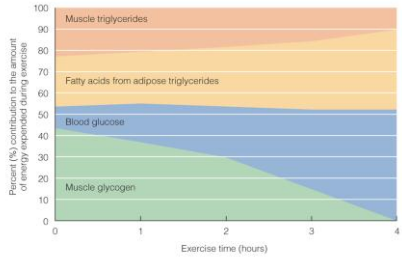


Figure 5.11 Various sources of energy used during exercise. As a person exercises for a prolonged time, fatty acids from adipose cells contribute relatively more energy than do carbohydrates stored in the muscle or circulating in our blood (Coyle 1995).

Lipids as Fuel Source

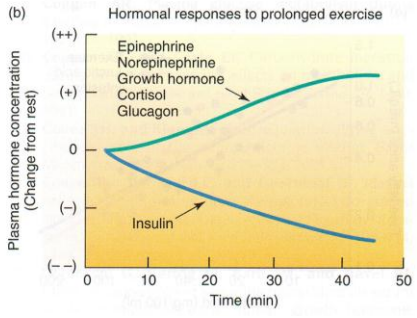
Prolonged low intensity exercise results in greater reliance on fat as fuel.

Lipolysis = breakdown of fat

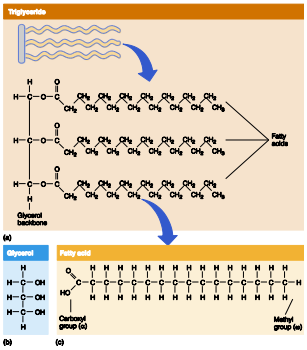
Factors controlling lipolysis:

- epinephrine, norepinephrine, glucagon > stimulate lipase action in adipose cells
- Insulin inhibits lipase action

Lipids as Fuel Source



Lipids



Lipids as Fuel Source

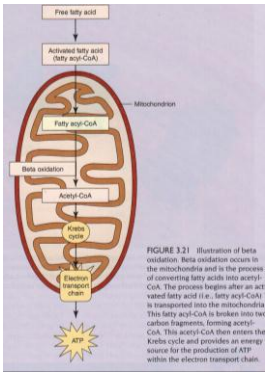
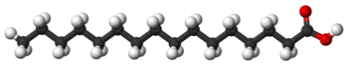


FIGURE 3.21 Illustration of beta oxidation. Beta oxidation occurs in the mitochondria and is the process of converting fatty acids into acetyl-CoA. The process begins after an activated fatty acid (i.e., fatty acyl-CoA) is transported into the mitochondria. This fatty acyl-CoA is broken into two carbon fragments, forming acetyl-CoA. This acetyl-CoA then enters the Krebs cycle and provides an energy source for the production of ATP within the electron transport chain.

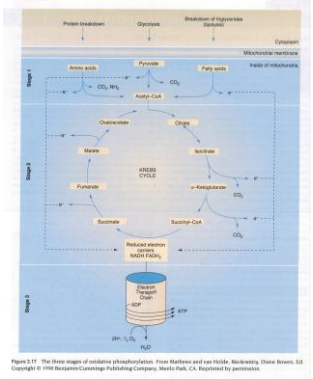
Lipids as a Fuel Source

Palmitate



- 16 carbons
- 8 acetyl-CoA molecules
- 7 cycles of B-oxidation
- Cleavage occurs between the α and β carbons

Lipids as a Fuel Source



Lipids as a Fuel Source

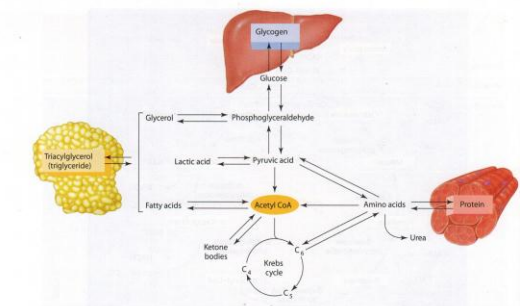


Figure 3.19 The relationships among the metabolism of proteins, carbohydrates, and fats. The overall interaction between the metabolic breakdown of these three foodstuffs is often referred to as the metabolic pool.

Indirect Calorimetry

Respiratory Exchange Ratio

$R = VCO_2 / VO_2$

Ratio of carbon dioxide produced to the oxygen consumed.

R	% Fat	% CHO	Kcal. $L^{-1} O_2$
0.70	100	0	4.69
0.75	83	17	4.74
0.80	67	33	4.80
0.85	50	50	4.86
0.90	33	67	4.92
0.95	17	83	4.99
1.0	0	100	5.05

Respiratory Exchange Ratio

Fat (palmitic acid) = $C_{16}H_{32}O_2$

Oxidation: $C_{16}H_{32}O_2 + 23\ O_2 \rightarrow 16\ CO_2 + 16\ H_2O$

$R = VCO_2/VO_2 = 16\ CO_2 / 23\ O_2 = 0.70$

Respiratory Exchange Ratio

Glucose = $C_6H_{12}O_6$

Oxidation: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

$R = VCO_2/VO_2 = 6\ CO_2 / 6\ O_2 = 1.0$

The Role of Lipids

Essential fatty acids

- Two fatty acids cannot be synthesized in the body and must be obtained in the diet

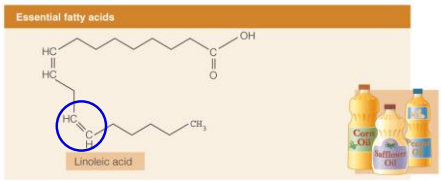
Linoleic acid (omega-6 fatty acid)

- Found in vegetable and nut oils

Alpha-linoleic acid (omega-3 fatty acid)

- Found in vegetables, fish and fish oils

The Role of Lipids



The Role of Lipids

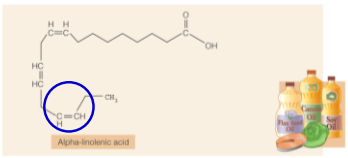


Figure 5.12 The two essential fatty acids: linoleic acid (omega-6 fatty acid) and alpha-linolenic acid (omega-3 fatty acid).

The Role of Lipids

Fat-soluble vitamins

- Vitamins A, D, E, and K are soluble in fat; fat is required for their transport

Fat is essential to many body functions

- Cell membrane structure
- Nerve cell transmissions
- Protection of internal organs
- Insulation to retain body heat

The Role of Lipids

Fat provides flavour and texture to foods.

Fat contributes to making us feel satiated because

- Fats are more energy dense than carbohydrates or protein
- Fats take longer to digest

The Role of Lipids

You can eat more fat in a meal without feeling full because fat is compact in its size.

70 kcal

70 kcal

The Role of Lipids

= 3500 kcal

How Much Fat?

The Acceptable Macronutrient Distribution Range (AMDR) for fat:

20-35% of Calories should be from fat

Athletes and highly active people may need more energy from carbohydrates and can reduce their fat intake to 20-25% of total Calories.

2000 kcal diet: 45-55 g/d

3500 kcal diet: 78-97 g/d

How Much Fat?

Adequate Intake	
Linoleic Acid	
adult men (>19 yrs.)	14 to 17 g/d
adult women (>19 yrs.)	11 to 12 g/d
Alpha-linoleic Acid	
adult men (> 19 yrs.)	1.6 g/d
adult women (>19 yrs.)	1.1 g/d

(Institute of Medicine, 2002)

How Much Fat?

Table 5.2 Comparison of Average Daily Energy Intake and Percentage of Total Energy from Fat, by Age Group and Sex, Canada (excluding territories): 1972 and 2004

	1972	1972	2004	2004
Age and Sex Group	Average Energy Intake (kcal)	% of Total Energy from Fat	Average Energy Intake	% of Total Energy from Fat
20 to 39 Male	3 374	41	2 660	31.0
20 to 39 Female	2 001	40	1 899	31.2
40 to 64 Male	2 671	40	2 345	31.7
40 to 64 Female	1 726	39	1 757	31.8
65 or older Male	2 056	39	1 948	31.0
65 or older Female	1 530	37	1 544	30.5

Source: Adapted from Statistics Canada publication Health Reports, Catalogue 82-003, Vol. 18, No. 2, May 2007, page 19, http://www.statcan.ca/english/freepub/82-003-XIE/82-003-XIE2006006.pdf

How Much Fat?

The type of fat consumed is important.

- Saturated fat intake should be as low as possible.
- Trans fatty acids should be reduced to the absolute minimum.
- Most fat in our diets should be from monounsaturated fats (e.g., olive oil).

How Much Fat?

Health Canada Research, 2005

Canadians eat on average, 8.4 g/d of trans fat, 10% of their total fat intake.

Low Fat Does not Mean Low Kcal

Table 5.3 Comparison of Full-Fat, Reduced-Fat, and Low-Fat Foods

Product	Serving Size	Energy (kcal)	Protein (g)	Carbohydrate (g)	Fat (g)
Milk, whole (3.3% fat)	250 mL (8 fl. oz.)	150	8.0	11.4	8.2
Milk, 2% fat	250 mL (8 fl. oz.)	121	8.1	11.7	4.7
Milk, 1% fat	250 mL (8 fl. oz.)	102	8.0	11.7	2.6
Milk, skim (non-fat)	250 mL (8 fl. oz.)	86	8.4	11.9	0.5
Cheese, cheddar regular	30 g (1 oz.)	111	7.1	0.5	9.1
Cheese, cheddar low-fat	30 g (1 oz.)	81	9.1	0.0	5.1
Mayonnaise, regular	15 mL (1 Tbsp)	100	0.0	0.0	11.0
Mayonnaise, light	15 mL (1 Tbsp)	50	0.0	1.0	5.0
Mayonnaise, fat-free	15 mL (1 Tbsp)	10	0.0	2.0	0.0
Margarine, regular corn oil	15 mL (1 Tbsp)	100	0.0	0.0	11.0
Margarine, reduced-fat	15 mL (1 Tbsp)	60	0.0	0.0	7.0
Peanut butter, regular	15 mL (1 Tbsp)	95	4.1	3.1	8.2
Peanut butter, reduced-fat	15 mL (1 Tbsp)	81	4.4	5.2	5.4
Cream cheese, soft regular	15 mL (1 Tbsp)	50	1.0	0.5	5.0
Cream cheese, soft light	15 mL (1 Tbsp)	35	1.5	1.0	2.5
Crackers, Wheat Thins Original	16 crackers	158	2.3	21.4	6.8
Crackers, Wheat Thins 33% less fat	16 crackers	120	2.0	21.0	4.0
Cookies, Oreos regular	3 cookies	160	2.0	23.0	7.0
Cookies, Oreos 25% less fat	3 cookies	130	2.0	25.0	5.0
Cookies, Fig Newtons regular	3 cookies	210	3.0	30.0	4.5
Breakfast bars, regular	1 bar	140	2.0	27.0	2.8

Source: Data from Food Processor, Version 7.01 (ESHA Research, Salem, OR).

How Much Fat?

Omega-3 Fatty Acids

- Eicosapentaenoic acid (EPA):
  - May reduce risk of death from a heart attack.
- Docosahexaenoic acid (DHA):
  - Critical for development of central nervous system and retina of eyes
- EPA and DHA are long chain polyunsaturated fatty acids found in fish and fish oils
- Canada's Food Guide recommends eating at least two servings of fish per week

How Much Fat?

Table 5.4 Estimated EPA + DHA Content of 150 Grams Selected Fish Species

Fish (150 grams per week)	EPA + DHA (grams per week)	EPA + DHA (averaged as mg per day)
Herring, Pacific	3.15 g	450 mg
Salmon, Atlantic	3.00 g	429 mg
Mackerel, Pacific and Jack	2.70 g	386 mg
Salmon, Sockeye, canned	2.10 g	300 mg
Mackerel, Atlantic	1.80 g	257 mg
Trout, Rainbow	1.65 g	236 mg
Sole	0.75 g	107 mg
Light tuna, canned	0.45 g	64 mg
Shrimp	0.45 g	64 mg
Cod	0.45 g	64 mg
Haddock	0.30 g	43 mg

Source: U.S. Department of Agriculture, Agricultural Research Service, 2005. USDA National Nutrient Database for Standard Reference, Release 18, Nutrient Data Laboratory Home Page, www.ars.usda.gov/ba/bhnrc/ndl.

Fat Content Claims

Table 2.2 Examples of Common Nutrient Content Claims

The following are examples of what the nutrient content claims made by manufacturers really mean:

- Claims of "free" mean that the number of kilocalories (kJ) or the amount of a nutrient is nutritionally insignificant in a specified amount of food. For example, to be "sodium free," a product has to contain less than 5 mg of sodium per serving. "Free of sugar" means that a product has less than 50 mg of sugar and fewer than 5 kcal (17 kJ) per serving. Other wording can be used instead of "free of sugar": "no sugar," "0 sugar," "contains no sugar," and "sugar free" all mean the same thing on a label.
- "Low" means there is a small amount of a nutrient present in 1 serving. For example, "low fat" indicates the product contains 3 g of fat or less per serving.
- "Reduced" indicates that there is at least 25% less of a nutrient in 1 serving, compared with the original product or a similar product. For example, Christie's Ritz 25% Less Fat crackers have 25% less fat than the original Ritz crackers. Kellogg's Frosted Flakes 1/3 Less Sugar cereal has 33% less sugar than the original Frosted Flakes product.
- "Source" means that there is a significant amount of a nutrient in 1 serving. For example, a product must contain 2 or more grams of dietary fibre to be called a "source of fibre."

Source: Health Canada. 2003. Frequently Asked Questions About Nutrition Labelling. http://hc-sc.gc.ca/fn-an/label-etiquet/nutrition/educat/te_quest-eng.php#18. Accessed September 2008.

Invisible Fats

Table 5.5 Common Fat Replacers

Types of Fat Replacers	Names of Common Fat Replacers	Description	Foods That May Contain Fat Replacers
Carbohydrate-based fat replacers that provide energy	Dextrins Maltodextrins Modified food starch	Bland, nonsweet carbohydrates made from hydrolyzed starches that can mimic the texture and mouth feel of fat due to their gel-like structure. Provides 1 to 4 Calories (4 to 17 kJ) per gram. Can completely replace or partially replace the fat in food.	Salad dressings Puddings Spreads Dairy products Frozen desserts
	Oatrim (Beta-Trim™, NutrimX)	A beta-glucan (type of soluble fibre) derived from oat fibre. Provides 4 Calories (17 kJ) per gram. Can replace fat and add the additional cholesterol-lowering benefit of oat bran.	Baked goods Fillings and frostings Frozen desserts Dairy beverages Cheese Salad dressings Processed meats Confections

Need to ensure fat-soluble vitamins remain in foods

Invisible Fats

Carbohydrate-based fat replacers that provide negligible energy (dietary fibres)	Z-Trim	A noncaloric, bland mix of insoluble fibre made from the crushed hulls of corn, oats, and rice.	Baked goods Burgers Hot dogs Cheese Ice cream Yogurt
	Polydextrose	A nonsweet starch polymer made from food-grade dextrose and small amounts of sorbitol and citric acid. Polydextrose passes through the body largely undigested, with only 5% to 10% digested, and provides only 1 Calorie (4 kJ) per gram. Can replace up to one-half the fat in a product.	Baked goods Chewing gums Confections Salad dressings Frozen dairy desserts Gelatins Puddings
	Gum	Gums are a type of dietary fibre that mimics the functional properties of fat when water is used to replace fat in foods. Gums are not digested in the small intestine so add few Calories to the products made with them.	Salad dressings Desserts Processed meats

Invisible Fats

Protein-based fat replacers	Microparticulated protein (Simplesse)	Made from milk or egg white proteins, water, sugar, pectin, and citric acid. Supplies 1 to 2 Calories (4 to 8 kJ) per gram.	Baked goods Butter Cheese Mayonnaise spreads Salad dressings Sour cream
	Dairy-Lo™	Manufactured by Parmalat Canada for use in ice cream. Made of 100% whey protein.	Ice cream
Fat-based fat replacers	Olestra (Olean)	Only available in the United States. Made by binding sucrose with 6 to 8 long-chain fatty acids. Olestra is not sweet, has the appearance, taste, texture and mouth feel of fat, and can be used in fried, cooked, and baked products. Because it is not digested, it is calorie-free, but it may reduce the absorption of fat-soluble vitamins. Foods made with olestra have vitamins A, D, E, and K added, but not carotenoids.	Chips Crackers

Source: Calorie Control Council, 5775 Peachtree-Dunwoody Road, Building G, Suite 500, Atlanta, GA 30342, www.caloriecontrol.org.

Food Sources of Fat

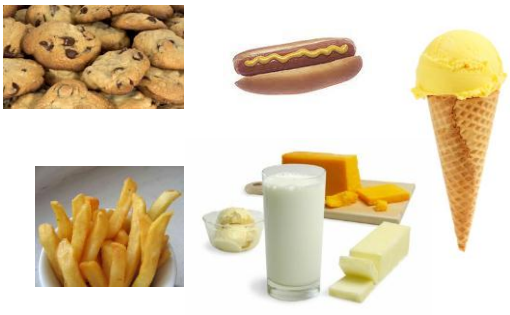
Visible fats

- Fats we knowingly add to foods
- Butter, cream, mayonnaise, dressings

Invisible fats

- Fats hidden in foods
- Naturally occurring or added during processing

Invisible Fats



Fat Tax

Denmark introduces world's first food fat tax

COMMENTS (201)

Denmark has introduced what is believed to be the world's first fat tax - a surcharge on foods that are high in saturated fat.

Butter, milk, cheese, pizza, meat, oil and processed food are now subject to the tax if they contain more than 2.3% saturated fat.

Some consumers began hoarding to beat the price rise, while some producers call the tax a bureaucratic nightmare.

Some scientists think saturated fat may be the wrong target

http://www.bbc.co.uk/news/world-europe-15137948

Health Problems From Fat

Cardiovascular disease

- Dysfunction of the heart or blood vessels
- Can result in heart attack or stroke
- Underlying cause of death for 1/3 of Canadians!

The type of fat in our diet can contribute to or protect against cardiovascular disease.

Cardiovascular Disease

Risk factors for cardiovascular disease include:

- Being overweight
- Physical inactivity
- Smoking
- High blood pressure
- Diabetes

My Heart & Stroke Risk ASSESSMENT

HEART & STROKE FOUNDATION

Cardiovascular Disease

Blood lipids include:

- Chylomicrons
- VLDLs – very low-density lipoproteins
- LDLs – low-density lipoproteins
  - "bad cholesterol"
- HDLs – high-density lipoproteins
  - "good cholesterol"

Blood Lipids

Fats are transported in the blood via lipoproteins made up of a lipid centre and protein outer coat.

Lipoproteins are water soluble = Blood Lipids

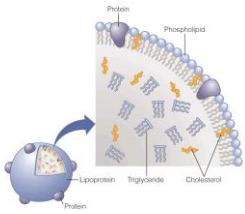


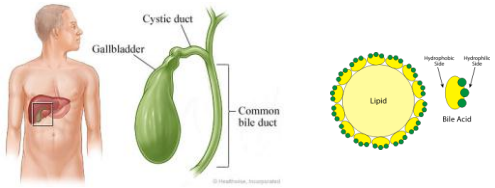
Figure 5.8 Structure of a lipoprotein. Notice that the fat clusters in the centre of the molecule and the phospholipids, which are water soluble, form the outside of the sphere. This enables lipoproteins to emulsify fat (i.e., keep it dispersed and soluble in water) and to transport fats in the lymph and bloodstream.

Types of Blood Lipids

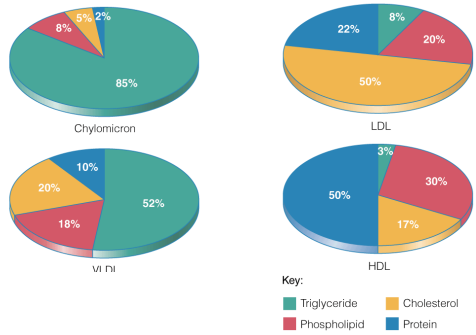
Lipoprotein	Description	Primary Function
Chylomicrons	Formed in the gut after a meal, these lipoproteins are released into the lymph system and then into the blood Largest of the lipoproteins, with the lowest density After triglycerides are removed from this lipoprotein, a chylomicron remnant remains and is taken up by the liver	Transports dietary fat into the blood and transports it to the tissues of the body
Very low-density lipoproteins (VLDLs)	Formed in the liver (80% of production) and the intestine (20% of production)	Transports endogenous lipids, especially triglycerides, to the various tissues of the body
Low-density lipoproteins (LDLs)	Formed in the blood from VLDL Transformation from VLDL to LDL occurs as the triglycerides are removed from the VLDL	Transports cholesterol to the cells of the body
High-density lipoproteins (HDLs)	Synthesized in the liver and released into the blood Move in the blood through the body, picking up free cholesterol	Transports cholesterol from tissues back to the liver

Blood Lipids

Liver uses cholesterol from HDL to make bile.



Blood Lipids



Blood Lipids in Adults

Table 5.7 Blood Lipid Values for Those at Moderate Risk of Developing Heart Disease or Stroke

Blood Lipid	Suggested Target Levels
Total cholesterol	Less than 5.2 mmol/L (200 mg/dL)
LDL cholesterol	Less than 3.5 mmol/L (about 130 mg/dL)
HDL cholesterol	Greater than 1.0 mmol/L for men and 1.2 mmol/L for women (about 40 mg/dL)
Total cholesterol: HDL cholesterol ratio	Less than 5.0
Triglycerides	Less than 1.7 mmol/L

Source: Heart and Stroke Foundation of Canada, *Living with Cholesterol: Cholesterol and Healthy Living*. © Reproduced with the permission of the Heart and Stroke Foundation of Canada, 2008. www.heartandstroke.ca

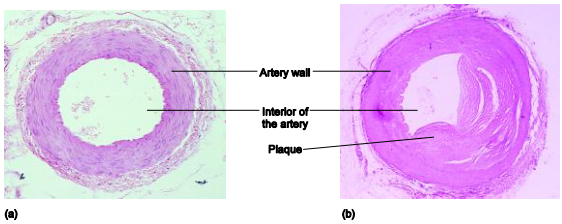
Cardiovascular Disease

Diets high in saturated fats:

- Decrease the removal of LDLs from the blood
- Contribute to the formation of plaques that can block arteries
- Increase triglyceride levels (chylomicrons and VLDLs)

Cardiovascular Disease

Cross-section of **(a)** a normal artery and **(b)** a partially blocked artery.



The more cholesterol circulating in the blood, the greater the risk that it will adhere to the walls of the blood vessels.

Cardiovascular Disease

Trans fatty acids:

- Increase blood LDL cholesterol levels and reduce blood HDL cholesterol levels
- Are abundant in hydrogenated vegetable oils (margarine, vegetable oil spreads)
- Should be reduced to the absolute minimum

Cardiovascular Disease

How can fat intake protect against heart disease?

Diets high in omega-3 fatty acids (along with moderate exercise) can increase HDL "good" cholesterol levels.

Cardiovascular Disease

How to reduce our risk?

- Fat intake should be 20-35% of total caloric intake
  - Polyunsaturated can comprise up to 10% Monounsaturated can comprise up to 20%
  - Decrease saturated fat to less than 7%
  - Keep trans fat low
- Decrease cholesterol intake to less than 300 mg/d
- Replace saturated fat with healthful cooking oil

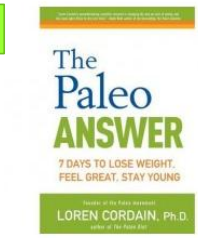
Cardiovascular Disease

How to reduce our risk?

- Eat foods high in fibre, this decreases blood LDL cholesterol
- Meet fibre recommendations: 20-30 g/d
- Limit high sugar foods
- Maintain blood glucose and insulin concentrations within normal ranges
- Eat throughout the day
- Maintain an active lifestyle
- Maintain a healthy body weight

Nutrition Debate

Paleo Diet
Caveman Diet
Meat and Nut Diet
Stone age Age Diet
Hunter-Gather Diet



Claims:

Cure for Acne

You'll lead a healthier, fitter, disease-free life.

http://thepaleodiet.com/

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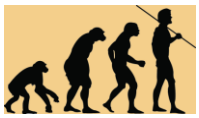
Paleo Diet

The Premise:

- If the cavemen didn't eat it, you shouldn't either.
- Limit refined sugar, dairy, legumes, and grains
- Choose meat, fish, poultry, fruits, and veggies.



http://thepaleodiet.com/

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Paleo Diet Recommendations

- Eat fresh fruits.
- If overweight or insulin resistant, limit high sugar fruits (grapes, bananas, mangos, sweet cherries, apples, pineapples, pears, kiwi).
- Include more vegetables in lieu of the high-sugar fruit.
- Eat at least 0.5-1.8 grams/d of EPA + DHA, either by eating fish or fish oil supplements.
- Regular consumption of fish or supplemental omega-3 fatty acids may be helpful in preventing, treating, or improving a wide variety of diseases and disorders.

http://thepaleodiet.com/

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Paleo Diet – How Does it Measure up?

Nutrient	AMDR	Paleo Diet
CHO	40-65%	23%
Fat	20-35%	39%
Protein	10-35%	38%

*ADMR: ranges of intakes for energy sources associated with reduced risk of chronic diseases while providing adequate intakes of essential nutrients

http://health.usnews.com/best-diet/paleo-diet

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Paleo Diet

Some Considerations?

- Cost
- Weight loss
- Easy to follow
- Health benefits
- Health risks
- Does it allow for food restrictions/intolerances?