Food, Nutrition, Metabolism

the food that we eat must do 2 things:

1. serve as building blocks, ie. nutrients
   used to maintain and build tissues

2. release energy when metabolized in cells
   breaking bonds releases energy
   we break down large organic molecules to release their energy and make ATP

food { **matter** (building blocks); **energy** (metabolism, ATP) }

food contains both:

nutrients that are used as **building blocks**

nutrients that can be used to make **energy**

Food as Building Blocks

nutrients → the most basic atoms or molecules that we need to survive

The chemical composition of your body is roughly equivalent to the proportions of the same elements and molecules in the food that you eat

→ *you are what you eat*

to maintain "yourself" you must continually replenish these **nutrients**

A **nutrient** is any component of the food that we eat that our body needs to function properly

Essential Nutrients

There is a short lists of specific **elements** that the body requires to function

45 –50 different elements are **essential nutrients**
→must be in food we eat

some of these we need relatively large amounts of and are referred to as **macronutrients**

others, we must have, but only in very small amounts = **micronutrients**

eg:	macronutrients		micronutrients
	C	18.5%	Cr, Co
	H	9.5%	Cu, F
	O	65%	Mo, Se
	N	3.2%	Si, Sn (tin)
	P	1.0%	Zn, V
	Ca	1.5%	

we get most of the **macronutrients** and a few of the micronutrients we need from the large complex organic molecules that we eat

eg. proteins, carbs, lipids, etc

In the body these molecules are digested and separated into smaller molecules and individual atoms

the body then uses these **building blocks** to construct most of the molecules that make up our bodies

but a few **essental nutrients** are *molecules* we need but cannot make ourselves

→ they are **essential molecules** that we must get in our diets to survive

Molecules that are Essential Nutrients

O_2 (oxygen gas)
vitamins
8 amino acids
2 fatty acids

Food as Energy

we break down organ foods (sugars, lipids, etc) to extract energy from them

chemical bond energy:

break bonds → release energy

$$\text{glucose} + O_2 \rightarrow CO_2 + H_2O + ATP$$

most cells prefer **glucose** but can also use lipids, proteins, etc

some cells can **only** use glucose as an energy source

Food as Both

most foods are a combination of essential and nonessential nutrients that we use as building blocks and as energy

as a general rule the foods we eat contain the essential nutrients and energy sources in roughly similar amounts as they are found in the body

but if our diets aren't carefully selected

→we can get too little or too much of a particular nutrient

eg. deficiencies may cause diseases
eg. excesses may be toxic

→ we can get too much or too little energy

need average male = 2900 Calories/day
average female = 2100 Calories/day

→ food may contain various **additives** that could be beneficial, neutral or toxic to body

Carbohydrates

Kinds in food:

mainly from plants (fruits, vegetables, and grains)

simple sugars: mono & disaccharides (honey, fruits, lactose is from milk)

complex carbohydrates = polysaccharides: starches and fiber from plants; glycogen from meats

Uses in body

energy

all carbohydrates are polymers of monosaccharides
are main energy source of all cells

ribose and deoxyribose to synthesize DNA and RNA

fiber enhances digestion

complex carbohydrates, the body cannot digest
but required for digestion

excess sugars converted to **glycogen** & **fats**

glycogen
each cell, esp liver and muscle can store some excess glucose as glycogen

~ 1lb/person
1/3rd in liver
2/3rd s in muscle tissue

provides quick energy in muscle cells
in liver helps maintain glucose blood levels

fats
all excess is converted to fats (adipose tissue)

Requirements

no essential carbohydrates

the amount in diet is not critical for essential nutrition

recommend 45 – 65% SN03 of diet is carbohydrates;
120-175 g/day

minimum 100g/d to prevent shift to proteins and fat catabolism

a diet high in complex carbohydrates helps control
body weight
crowds out fat
reduces hunger
reduces "empty calorie" intake

enough fiber to promote digestion

recommended sugar intake ≤ 10% total energy intake

US consumption

carbohydrates comprise 51-33% SN03 of food we eat

about half of our sugar intake is natural and half consists of refined sugar (sucrose)

200-300 g/day
much refined sugar
(45 lbs/yr); >46% caloric intake

Imbalances

Deficiencies:

if not enough carbo's the body shifts to fats and proteins for energy

but some cells cannot effectively do this and may become energy starved

tissue wasting

metabolic acidosis (from excessive fat breakdown)

Excesses:

sugar:

US → 45 lbs/yr

"empty calories" → contribute to energy needs but no nutrients

therefore, need to consume even more calories to get proper nutrients

eg. soda: 200 cal → ~0 nutrients

3 slides bread: 200 Cal → includes 9g proteins and some B vitamins

even being careful in food selection it takes at least 1500 calories to get all needed nutrients

the less active a person is the more critical this becomes

→ sugar isn't bad, but nutrients must come 1st

dental caries (refined sugar)

obesity
not only getting more calories
but most foods with added sugar are also high in fats

heart disease
(in carbohydrate sensitive people)

?hyperactivity in children, criminal behavior
no confirming data; just anecdotes

starch & fiber:
(generally, high carbohydrate diets benefit by reducing fat intake and obesity,
reduce risk of heart disease,
reduce risk of cancer,
reduced risk of diabetes,
better GI tract health),

but excessive fiber intake in malnourished, elderly & children can reduce mineral absorption

Lipids

a diverse group of compounds including:
triglycerides
phospholipids
sterols (including cholesterol)

most are polymers of fatty acids

Kinds in foods

95% of dietary fats & oils are triglycerides

responsible for much of the flavor, tenderness, aroma of food

plants high in lipids

→ nuts,
→ vegetable oils } mainly polyunsaturated fats)

animal products high in lipids

→ meats, esp organ foods
→ dairy products } most saturated fats
→ eggs

animal products are only dietary source of cholesterol

fats carry with them fat soluble vitamins (A,D,E & K)

polyunsaturated fats mostly in plant oils

(grains, seeds, nuts, leafy vegetables)

cholesterol: animal foods only, not plants
esp. egg yolks, organ meats such as liver, whole milk, butter, cheese

Uses in Body

triglycerides:
alternate fuel (concentrated stored energy)
shock protection pads
insulation from cold
insulation around neurons and nerves

phospholipids:
cell membranes
emulsifiers to keep fats suspended in blood and fluids

sterols:
hormones (adrenal cortex, gonads)
bile salts
cell membranes (90% of all body cholesterol)

Requirements

2 essential fatty acids: linoleic (linoleic acid = omega 6) and linolenic acids (linolenic acid = omega 3)

(high in fish, grains, seeds, nuts, leafy veggies)

→ needed for
normal brain development
maintain cell membrane
make hormones
immune response

fat soluble vitamins are usually dissolved in fats & oils we eat

80-100g/d; 25 - 35%SN03 of calories should be from fats
unsaturated better than saturated fats

≥3% required Fatty Acids (1-1.5 g/day)

<250 mg/d cholesterol

US Consumption

32 - 34%SN03 of calories in our diets are from fats

only get 10% of required amount of linoleic acid

Imbalances

of all nutrients fats are most often linked to chronic diseases

Deficiencies:

mainly due to inadequate amounts of essential fatty acids

mainly seen in infants and young children fed nonfat milk and low-fat diets

retarded growth
reproductive failure
skin lesions
kidney and liver disorders
neurological and visual problems

Excesses:

1. total fats

of all nutrients, excess fat is most often linked to chronic diseases:

obesity
>50% of those in US are overweightSN03
obesity costs ~$117 Billion/yr in USSN03

cardiovascular disease
(esp. high cholesterol & high LDL)

some cancers (total fat intake)

2. Kinds of Fats

trans fats are the 'tobacco' of the nutrition industry

→ <5g/d (1 pc fried chicken & fries)
= 25% increase risk of heart attack

no other kind of fat has this strong of an effect on health

Nutritional BS

1. Lecithin supplements

a phospholipid

not essential

body digests it like other fats

taken at "dosages" recommended; 7g/d
→ can alone add 6.5 lbs/yr excess fats

large doses may cause GI tract distress

2. All cholesterol is bad for you

its made and used by liver

liver makes much more cholesterol than we get in diet
50,000 trillion (50 quadrillion) molecules/second
or 800-1500mg/d

need cholesterol for:
cell membranes
synthesis of steroid hormones
to make bile salts

cholesterol in blood:

LDL's = bad guys
linked to increased risk of heart attack

HDL's = good guys
represent cholesterol being returned to liver for breakdown
high levels → decreased heart attack risk

optimal ranges	
total cholesterol	<200mg/dl
LDL	<130
HDL	>35
Triglycerides	<200

food cholesterol does not raise blood cholesterol as much as saturated fat in diet does

→ sat fats are main cause of >LDL & <HDL

Proteins

Kinds in food:

animal proteins: meats, fish, poultry, cheese, milk, eggs

plant proteins: nuts, cereals & grains, legumes

Uses in Body

amino acids to synthesize the 50,000 or so proteins in our cells

enzymes	hormones	regulators
transport	antibodies	actin/myosin
fiber(collagen)	buffers	complement
active transport	hemoglobin	clotting

salt/water balance
energy alternative (last resort, muscle wasting)

Requirements

~half of 20 amino acids are essential, must be gotten in diet
10 essential in children
8 essential in adults

(body cant make proteins if any one of the Amino Acids are in short supply)

complete protein (generally animal protein)

= all essential amino acids
(meats, fish, cheese, milk, eggs)

incomplete protein (most plant protein)

= missing 1 or more essential amino acids
(nuts, cereals, legumes)

a few plant foods have complete proteins but even then most are "lower quality"

→ essential AA's not present in adequate amounts

eg. soybeans have complete proteins

vegetarians must plan meals well to get complete complement of essential AA's:

eg. blackbeans and rice

eg. peanut butter on wheat bread

eg. tofu & veggies on rice

recommend 10 - 35%$_{SN03}$ of calories from proteins

(0.8g/kgwt/day ≈ 1 - 8oz serving of meat/d)

US Consumption

15%$_{SN03}$ of calories from proteins

1.5 - 2 lbs per day, also mostly also high in fats

Imbalances

Deficiencies:

can have devastating effects, esp on children
eg. Protein-Energy Malnutrition

Marasmus & Kwashiorkor

affect >500 mil children worldwide

includes most of 40,000 children who die PER DAY

impaired brain and learning development

GI tract fails

anemia

edema due to deficits of plasma proteins

during pregnancy – miscarriage or premature birth

Excesses:

may be risk factor in heart disease

some cancers (colon, breast, pancreas, prostate, kidney)

adult bone loss and calcium loss increases with excessive animal (not plant) proteins in diet

obesity (protein rich foods are usually fat rich foods)

Nutritional BS

1. Protein and amino acid supplements:

all reasons touted for their use are unfounded
a. athletes take them to build muscle
b. dieter to spare protein while losing weight
c. women to strengthen fingernails
d. individual AA's to
cure herpes (lysine)
sleep better (tryptophan)
to lose weight
to relieve pain and depression (tryptophan)

normal healthy people NEVER need protein supplements
they are expensive
they are less completely digested
when used as "replacement" they are dangerous

eg. liquid protein diets
→ caused death in many users

single AA's do not occur naturally in foods ad offer no benefit to the body
the body was not designed to handle the large amounts of individual AA's in supplements
→ can create such a demand for a carrier that it prevents the absorption of other AA's
some can be toxic at high levels

Vitamins

vitamins are organic molecules:

1. other than proteins, carbohydrates, lipids and nucleic acids
2. used in very small amounts
3. most cannot be made by body
4. don't form polymers
5. cannot be broken down for energy

categorized as:

water soluble and **fat soluble** vitamins

Water Soluble Vitamins

dissolve easily in water, not fat

sensitive to heat and light

→generally don't store well

→lost in cooking

absorbed directly into blood and travel freely throughout the body

generally not stored well in body

→eliminated daily by kidneys

→fewer toxicities

→ needed in frequent, small doses

The Water Soluble Vitamins = B's, C

B Vitamins

act as coenzymes in many energy reactions

others help in new cell formation

deficiencies cause major shutdown in body systems

toxicities are uncommon but do occur in "pill takers"

toxicities when obtained from food alone are unknown

Vitamin C

coenzyme

collagen formation

antioxidant

Fat Soluble Vitamins

dissolve easily in fat, not water

generally more heat and light stable

→not destroyed by cooking or storage

stored in liver and fat cells and accumulate; not readily excreted

→don't need every day

→easier to have toxicity: can reach toxic levels if consumed in excess

The Fat Soluble Vitamins = A, D, E, K

Vitamin A

promotes
vision
growth
bone remodeling
immune system

A lack of vit A accounts for 600,000 childhood deaths/yr worldwide.
a lack of zinc accounts for another 400,000 deaths

→ >1 M childhood deaths could be prevented for a few dollar a day

Vitamin D

not essential

body can synthesize it with UV

acts like hormone
increases Calcium absorption and raises blood calcium levels

Vitamin E

antioxidant: protects lipids and cell membrane

Vitamin K

blood clotting

synthesized by bacteria in GI tract

Minerals

inorganic elements

cannot be changed or broken down

→ no special care to preserve during storage or prep

→ but may leach into water and be lost during cooking

4% of body weight

some minerals are easily absorbed into blood and transported

others need carriers to be absorbed and transported

body requires relatively large amounts of 7 minerals:

Calcium [2.5lbs/132lbs] } 75% = calcium
Phosphorus [1.3 lbs/132 lbs] } and phoshorus
Sulphur [1/3rd lb/132 lbs]
Sodium
Potassium } [1/2 lb/132 lbs]
Cloride
Magnesium

Calcium :
bones and teeth
membrane transport
nerve transmissions

muscle contractions
heart rhythm
blood clotting
enzyme cofactor

Phosphorus :
bones and teeth
ATP
creatin phosphate
DNA & RNA
phospholipids
active transport

Sulphur
most proteins

K, Cl, Na
osmotic balance
nerve impulses
muscle contractions

Magnesium
coenzymes

trace amounts of 12 others:

F, I, Fe,
F → strengthens bones
I → thyroid hormones
Fe → hemoglobin

Co, Cr, Cu, Mn, Se, Zn
cofactors for enzymes

Use of Vitamin and Mineral Supplements

in general, the body absorbs nutrients best from foods in which they are diluted and dispersed

taken in pure concentrated form they are more likely to interfere with absorption of other nutrients:

eg. >Zn → hinders Cu and Ca absorption
>Fe → hinders Zn absorption
>Ca → hinders Mg and Fe absorption
>Mg → hinders Ca and Fe absorption

eg. even fortified foods can cause problems
> ß carotene → interferes with Vit E metabolism
> Vit E → interferes with Vit K activity

several professional nutritional societies have indicated that people should ordinarily SHOULD NOT use supplements

NIH study (2006):
10's of millions of Americans take vitamin and mineral supplements
→ to feel better
→ live longer

there is little evidence that most supplements are effective or even w

when one does need nutrients
1st try to get them from foods
2nd multivitamin, mineral supplements
betw 50-150% RDA for each nutrients are best

(these are ranges normally found in foods and are therefore within tolerances)
3rd treat any supplement like medicine

2006 NIH study

1 in 2 Americans take multivitamin pills regularly

found little evidence that taking vitamin and mineral supplements does any good and may do more harm

eg. taking extra Vit D with Calcium pills can increase the risk of kidney stones

eg. smokers who take beta carotene to fend off lung cancer actually increase their risk

The Body's Energy Budget

energy is measured in units called kcals = **Calories**

the more H's a molecule contains the more ATP (energy) can be generated

of the various energy pathways:

fat provides the most energy for its weight

we take in energy continuously

we use energy periodically

optimal body conditions when

energy input = energy output

There is a tremendous variation in daily caloric requirements

1300 - 5000 Cal/day

average male = 2900
average female = 2100

difficult to define a "normal" metabolic rate

any calories above daily need are converted and stored as fat

1 lb of body fat stores ~3500 Calories

2006: overweight people now outnumber the undernourished of the world

65% of Americans are overweight 2003

US spend $40 Billion/yr on diets

95% of all dieters end up weighing more than when they started

most who keep weight off are those who don't follow any fixed diet plan (fad)

weight gains and losses tell little about how the body's composition may have changed

→ but this is how most judge their "fittness"

for most: "overweight" = "overfat"

healthy body weight is defined by 3 criteria:

1. a weight within a suggested range
2. a fat distribution pattern associated with a low risk of illness
3. no medical conditions that would suggest a need for weight loss

Fat Distribution

may be more important than % fat alone

2 major kinds of fat distribution patterns:
a. lower body fat
b. upper body fat

a. lower body fat

fat around hips and thighs

is most common in women in reproductive years

is not associated with any health risks (except children!)

b. upper body fat
(=central obesity, = intra abdominal fat)

stored around abdomen

presents a greater risk than fat elsewhere in body

increases risk of premature death due to:
heart disease
stroke
diabetes
hypertension
some cancers

abdominal fat is common in men and in women after menopause

also, people with central obesity smoke more and drink more than average

→ smoking *may* directly affect fat distribution

more exercise → less central obesity

upper body fat seems to go straight to liver → LDL's

Health Risks of Underweight

1st to die during famine

more at risk when tests require fasting

in greater danger when fighting a wasting disease like cancer
→ many people with cancer die not form cancer but from malnutrition

underweight women more likely to be infertile

pregnancy may result in unhealthy infant

Health Risks of Overweight

obesity has been declared a "disease" because so many health risks are associated with it:

diabetes	cardiovascular disease
hypertension	sleep apnea
osteoarthritis	abdominal hernias
some cancers	varicose veins
gout	gall bladder disease
liver malfunction	arthritis
flat feet	respiratory problems
complications in surgery and pregnancy	
greater rate of accidents	

obesity related illnesses cost $39 Billion/yr (1986)

(2006) over 1 Billion overweight adults; 300 M are obese [vs 800 M undernourished worldwide]

Some Examples:

1. **Cardiovascular Disease**
   strong relationship
   central obesity is as important risk factor as high blood cholesterol, hypertension and smoking
2. **Diabetes**
   Adult Onset (Noninsulin dependent) diebetes is 3x's more likely to develop in obese than nonobese person
   Central body fat cells appear to be larger and more insulin resistant than lower body fat cells
3. **Cancer**
   risk of cancer increases with body fat
   not sure why – may be correlated with greater levels of some hormones
   eg. estrogen in women

Low Carbohydrate Diets

similar to fasting
glycogen reserves are spent
protein is metabolized to make glucose
eventually get onset of ketosis

hype:
brings dramatic wt loss in 1st few days

but:
much of this loss is glycogen and protein and large

amounts of water and minerals

eg. 7 lb loss in 2 days:
1 or 2 lbs of fat
5-6 lbs of protein, water, minerals

after diet, weight quickly rebounds

Protein Sparing Diets

ingesting only protein
but this protein is used to supply glucose
carries serious health risks:
- ketosis
- vitamin and mineral deficiencies
- fluid loss

poor long term record of success
→ people generally regain weight

now sold only to doctors or hospitals and must carry a "Protein Diet Warning"