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

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>C</td>
<td>18.5%</td>
</tr>
<tr>
<td>H</td>
<td>9.5%</td>
</tr>
<tr>
<td>O</td>
<td>65%</td>
</tr>
<tr>
<td>N</td>
<td>3.2%</td>
</tr>
<tr>
<td>P</td>
<td>1.0%</td>
</tr>
<tr>
<td>Ca</td>
<td>1.5%</td>
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eg: micronutrients

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Cr, Co</td>
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</tr>
<tr>
<td>Cu, F</td>
<td></td>
</tr>
<tr>
<td>Mo, Se</td>
<td></td>
</tr>
<tr>
<td>Si, Sn (tin)</td>
<td></td>
</tr>
<tr>
<td>Zn, V</td>
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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 essential nutrients are molecules we need but cannot make ourselves

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

Food as Energy

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

chemical bond energy:

we break bonds → release energy

\[ \text{glucose} + O_2 \rightarrow CO_2 + H_2O + \text{ATP} \]

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

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### 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

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### US consumption

carbohydrates comprise 51-33% 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 slices 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
(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)

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
g      → 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

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

fat soluble vitamins are usually dissolved in fats & oils we eat
80-100g/d; 25 - 35% 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% 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 overweight
   obesity costs ~$17 Billion/yr in US
   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
   it’s 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

<table>
<thead>
<tr>
<th>cholesterol</th>
<th>total cholesterol &lt;200mg/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDL</td>
<td>&lt;130</td>
</tr>
<tr>
<td>HDL</td>
<td>&gt;35</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>&lt;200</td>
</tr>
</tbody>
</table>

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 can’t 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% of calories from proteins
(0.8g/kgwt/day ≈ 1 - 8oz serving of meat/d)

**US Consumption**
15% of calories from proteins

**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

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
day 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)

**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 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:

\[
\begin{align*}
\text{Calcium} & \quad \{2.5 \text{lbs/132 lbs}\} \\
\text{Phosphorus} & \quad \{1.3 \text{ lbs/132 lbs}\} \\
\text{Sulphur} & \quad \{1/3^\text{rd lb/132 lbs}\} \\
\text{Sodium} & \quad \{1/2 \text{ lb/132 lbs}\} \\
\text{Potassium} & \quad \{1/2 \text{ lb/132 lbs}\} \\
\text{Cloride} & \quad \{1/2 \text{ lb/132 lbs}\} \\
\text{Magnesium} & \quad \{1/2 \text{ lb/132 lbs}\}
\end{align*}
\]

Calcium:
bones and teeth
membrane transport
nerve transmissions
Anatomy & Physiology: Nutrition & Metabolism, Ziser, 2003

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:

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

eq. even fortified foods can cause problems
>β 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 work

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

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

<table>
<thead>
<tr>
<th>Cal/day</th>
<th>1300</th>
<th>5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>average male</td>
<td>2900</td>
<td></td>
</tr>
<tr>
<td>average female</td>
<td>2100</td>
<td></td>
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</tbody>
</table>

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

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 “fitness”

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

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

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:
-hearth disease
-stroke
diabetes
hypertension
some cancers

abdominal fat is common in men and in women after menopause

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)

need for weight loss

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) diabetes 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

e.g. 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"