Your Body Chemistry

YOUR BODY

ATOMS: 99% Hydrogen

Oxygen

Carbon

Nitrogen

Held together: Chemical Bonds

OXIDATION

- Oxidation: **removing electrons** from molecules
- Happens normally during **metabolism**
- Also- exposure air pollution, cigarette smoke

OXIDATION

- Oxidation: produces "highly reactive" molecules: free radicals
- Damage: DNA, proteins, & fats in cell membranes and blood
- **Oxidative stress**: free radicals accumulate in body
- May cause cell death, cancer, aging, damage to arteries

OXIDATION

- Your body: built in protection- enzyme systems: anti-oxidation- protect against damage due to oxidation
- Diet: Vitamin C, E , beta carotene (carrots), selenium (mineral): **antioxidants:** destroy reactive molecules

Mediterranean Diet

↑ Fruits, vegetables, breads, cereals, beans, nuts, seeds, peas, beans, fresh foods (fiber, vitamins, minerals)

↓ Processed foods

Mediterranean Diet

↓ Saturated (animal) fat & cholesterol

↑ **Monounsaturated fat (Olive Oil)**

Plant proteins: peas, beans, nuts

Mediterranean Diet

↓ Cholesterol levels

↓ Heart Disease

↑ Longer Life

↓ Alzheimer's Disease

↓ **Breast Cancer**

Mediterranean vs. U.S. Women

↓ **Cancer**

Mouth

Esophagus

Stomach

Lungs

Intestine

How Mediterranean Diet May Work

You are what you eat

How Mediterranean may work

- Cancer: fruits & veggies: ↑ **antioxidants**: protect DNA & cell membranes
- Heart Disease: **monounsaturated** fat: ↓ blood cholesterol, blood fats resist **oxidation**
- Aging & Alzheimer's Disease: monounsaturated fat → brain nerve cell membranes → **fluidity, antioxidants: brain protection- oxidation**

Biomolecules: carbon based

Carbohydrates

Fats

Protein

DNA/RNA

Most of your **energy** (food)

- from carbohydrates & fats
- Your body: energy stored as carbohydrates & fats
- protein: not stored for energy

Calories: amount of **energy** in chemical bonds of food

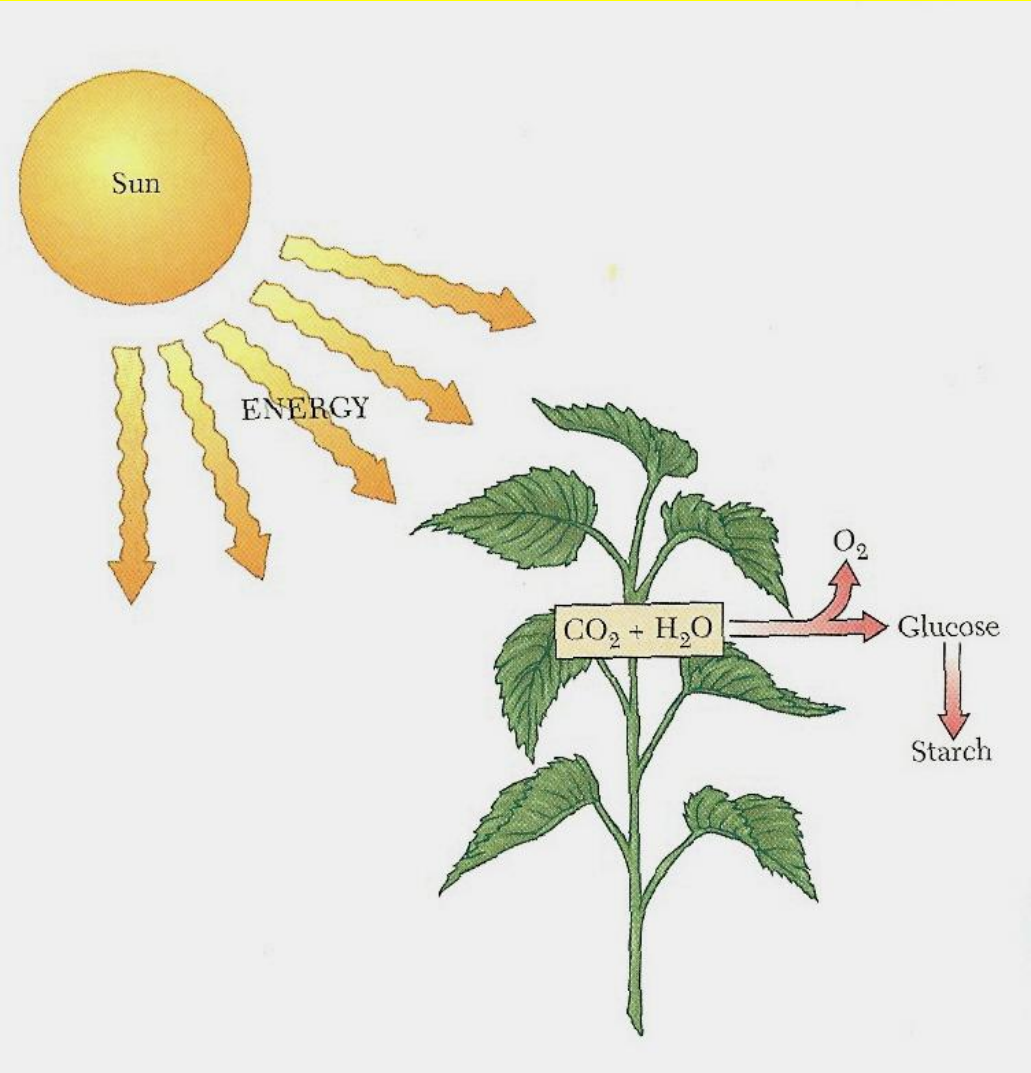
Fats:	**9** calories/gram
Carbohydrates:	**4** calories/gram
Protein:	**4** calories/gram
Alcohol:	**7** calories/gram

What do carbohydrates do?

Main function: give you **energy**

Main carbohydrate for your energy: **glucose**

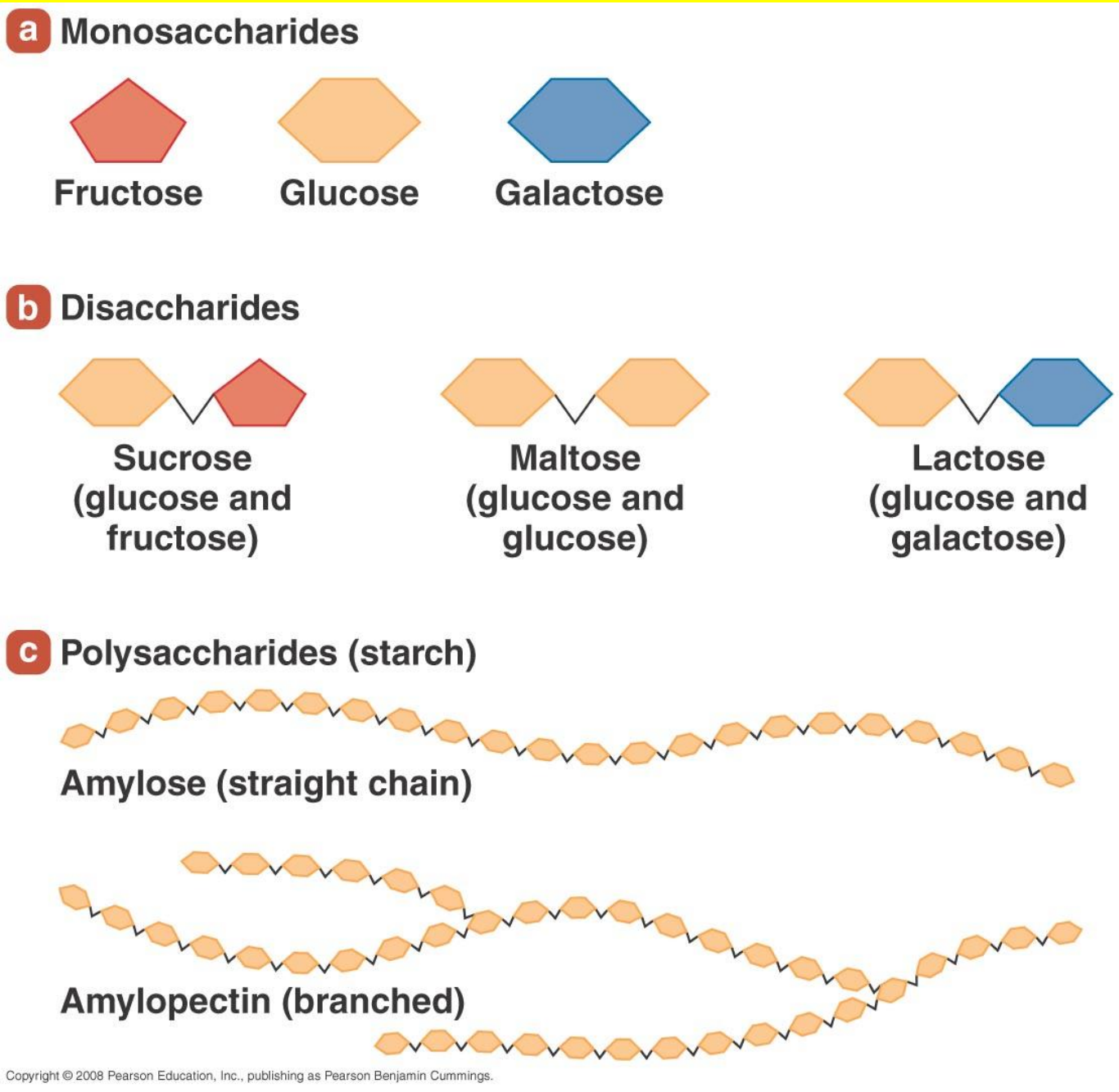
Where do carbohydrates come from?



Carbohydrates

1) **Simple Sugars**

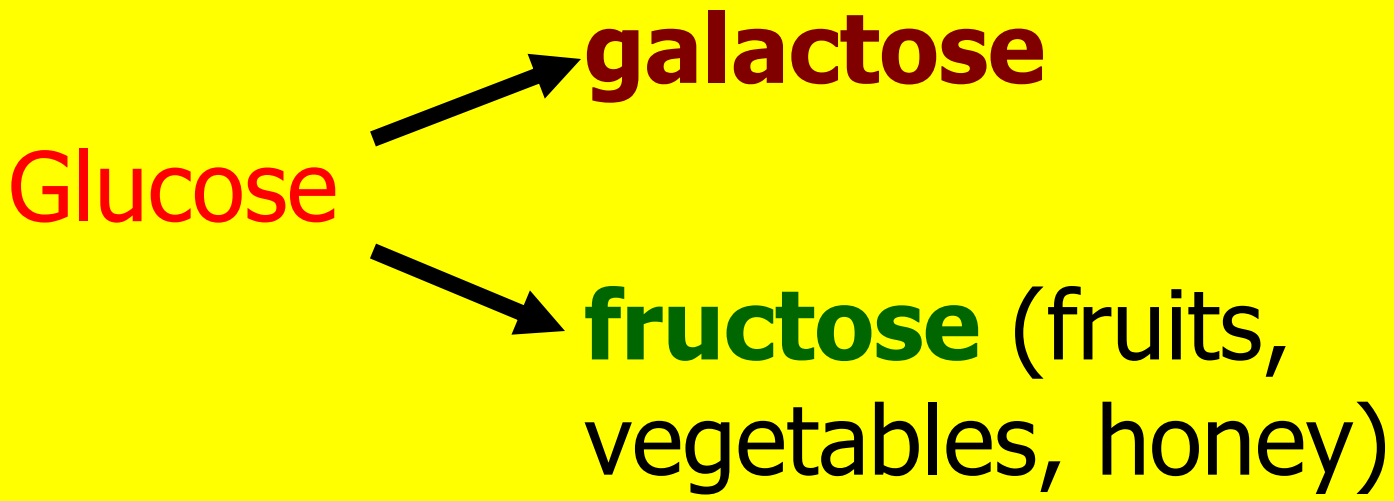
2) **Complex Carbohydrates**
(starch, glycogen, fibers)



Simple Sugars

- **Monosaccharides**:

  Example: **glucose** (blood sugar)



Glucose: very important

Only source energy- red blood cells;

Preferred energy: brain, nervous system, placenta, fetus

Sugars

- **Disaccharides**

Maltose: malt products (brewing, distilling, yeast making)

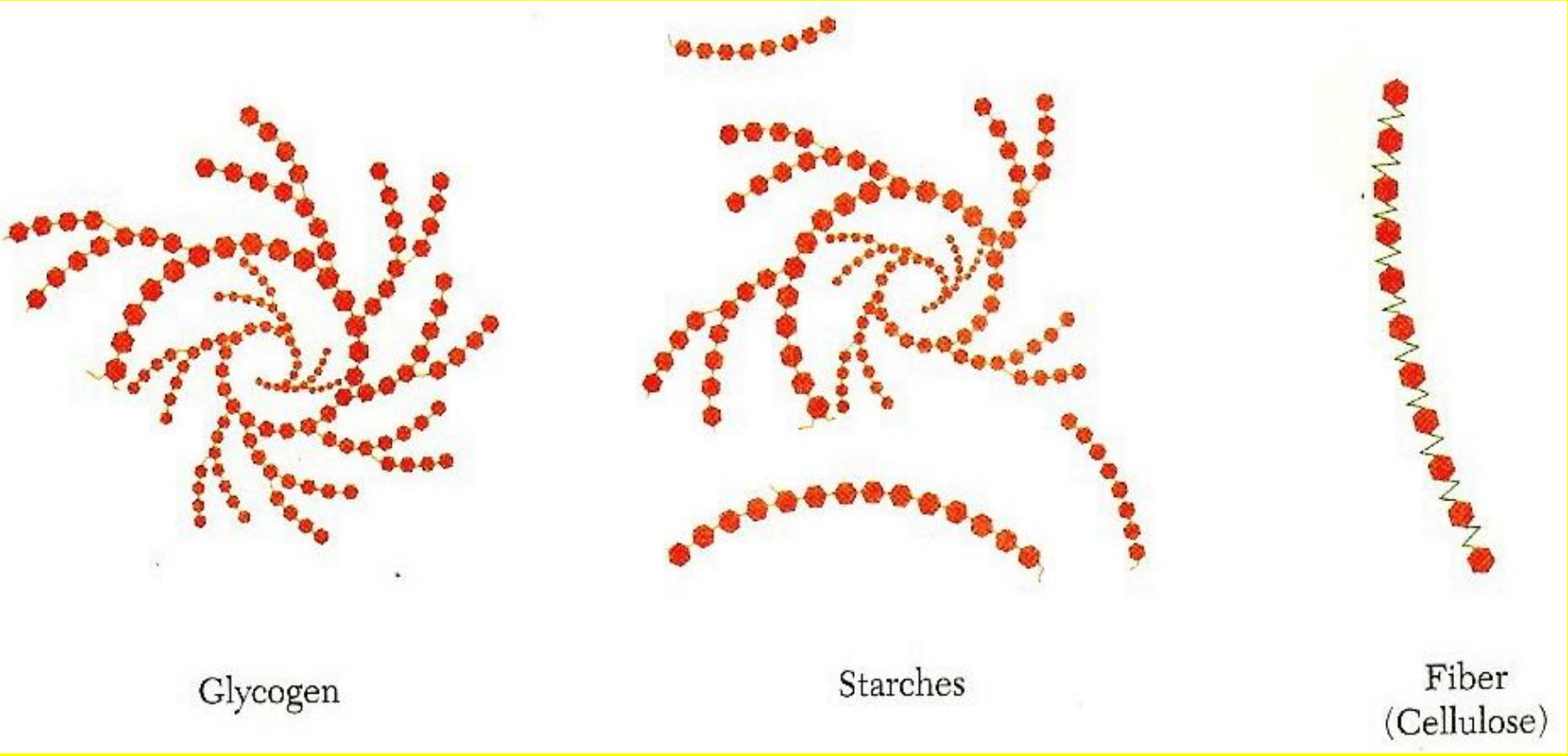
Sucrose: table sugar (sugar cane, maple syrup, honey)

Lactose: milk sugar (human & cow's milk)

Complex Carbohydrates

Many glucose molecules linked: chemical bonds

Differ in structure (straight vs. branched) and type of chemical bonds


Glycogen
Starches
Fiber
(Cellulose)

Animals

Glycogen- stored glucose: liver, muscles

Plants

Starch-stored glucose

&

Fibers (cellulose)

Starch → Glucose → Glycogen

Fiber(s)

- Mostly many **glucose** molecules
- Example: **cellulose-** plant cell walls
- **Nondigestible** carbohydrate
- Fiber breakdown: ~~human enzymes/chemical bonds~~

Why should you eat fiber?

- Slows breakdown starch → glucose
- Slows **increase** in blood glucose
- **Binds** to cholesterol in intestine
- **Lowers** blood cholesterol
- Promotes **fullness, reduces hunger feelings**

Why should you eat fiber?

- Keeps GI tract **clean/healthy**
- **Exercises** your colon muscles
- Regular/easier bowel movements
- Prevents: **constipation**
- Speeds up **movement food through intestines**
- Protects against: **? colon cancer**

FATS

Fats = Lipids

- **Organic** compounds- mostly **carbon**
- Found in animals & plants
- Don't dissolve well in H_2O

Fats in Food

- Solids: butter, lard
- Semi-solids: margarine (tub)
- Liquids: vegetable oils

Types of Fat

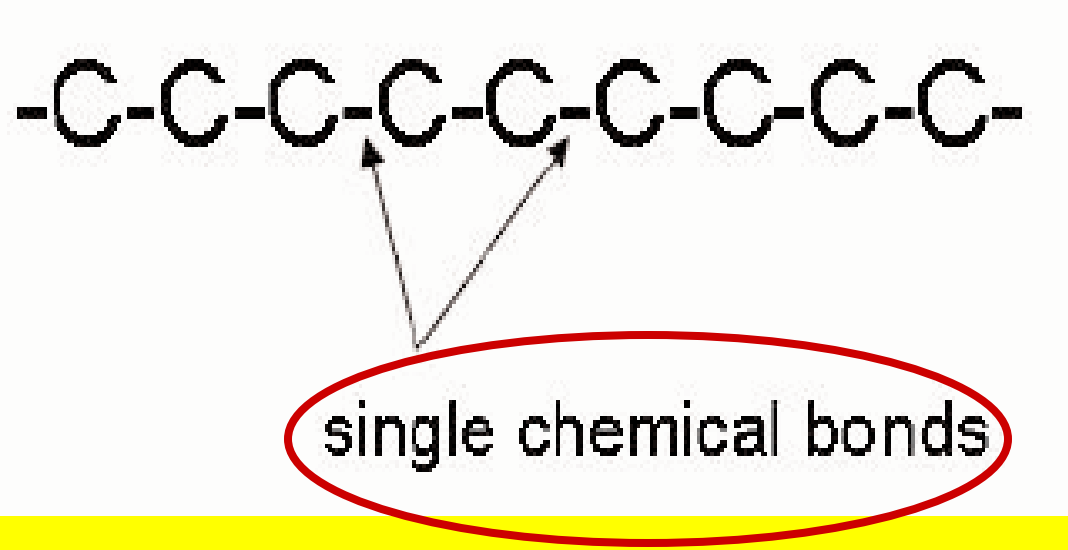
1. **Fatty acids**: long chain of **carbon atoms**

3 types: A) **Saturated**

B) **Monounsaturated**

C) **Polyunsaturated**

Saturated Fatty Acid



Saturated Fat

- Found in: meats, whole milk, cheese, ice cream, prepared foods
- ↓ Plants except ↑ palm/coconut oils
- **Solid** at room temperature

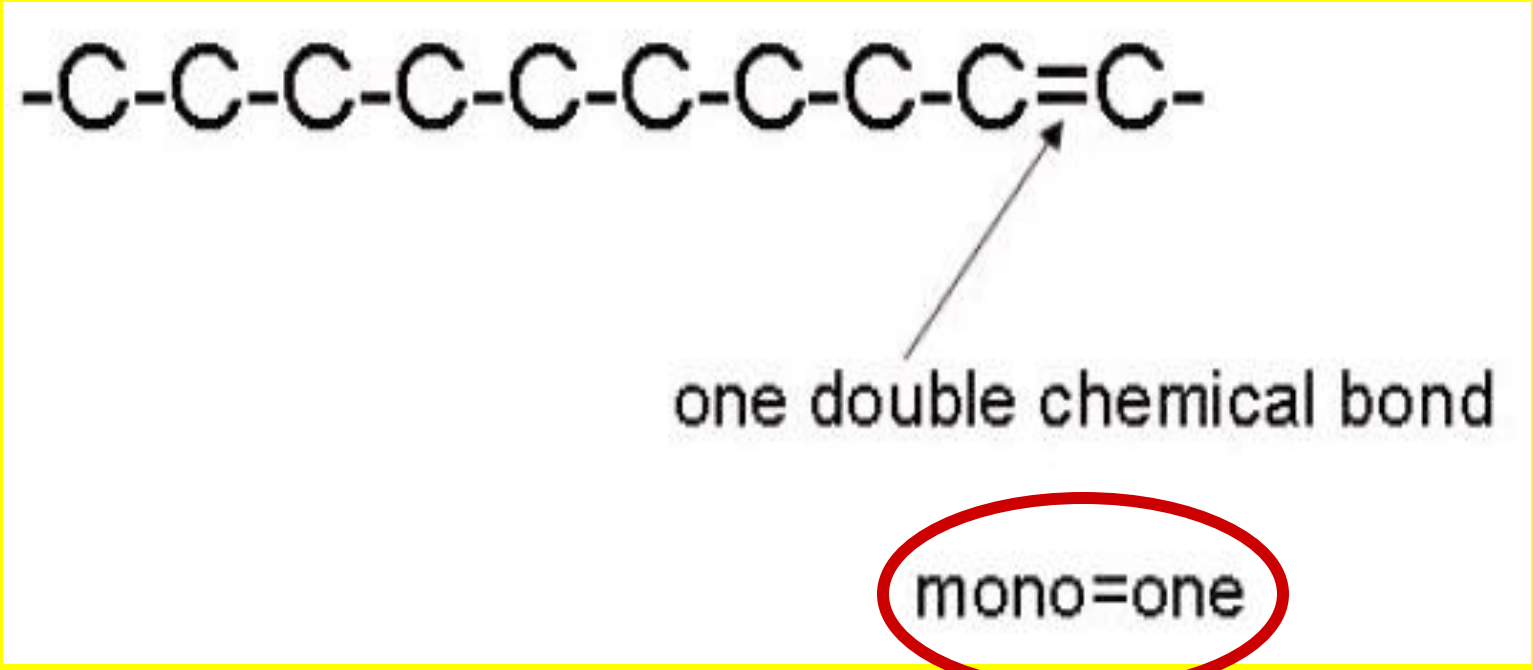
↑ Saturated Fat: **BAD**

↑ Blood Cholesterol

↑ Risk Heart Disease

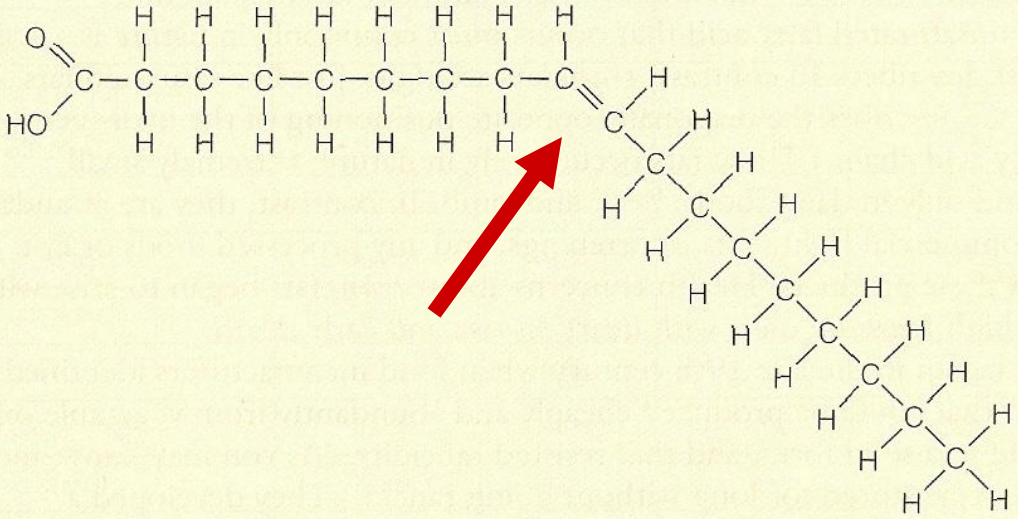
Women ↑ Risk Breast Cancer

Monounsaturated fatty acid

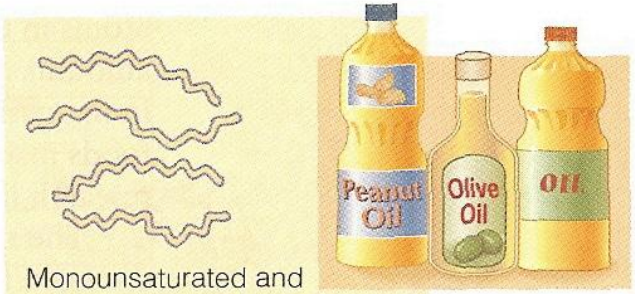


- Double bonds → bends (kinks) in carbon chains
- Liquid at room temperature
- Found in: canola, **olive**, peanuts oils, some safflower and sunflower oils, nuts

Monounsaturated fatty acids



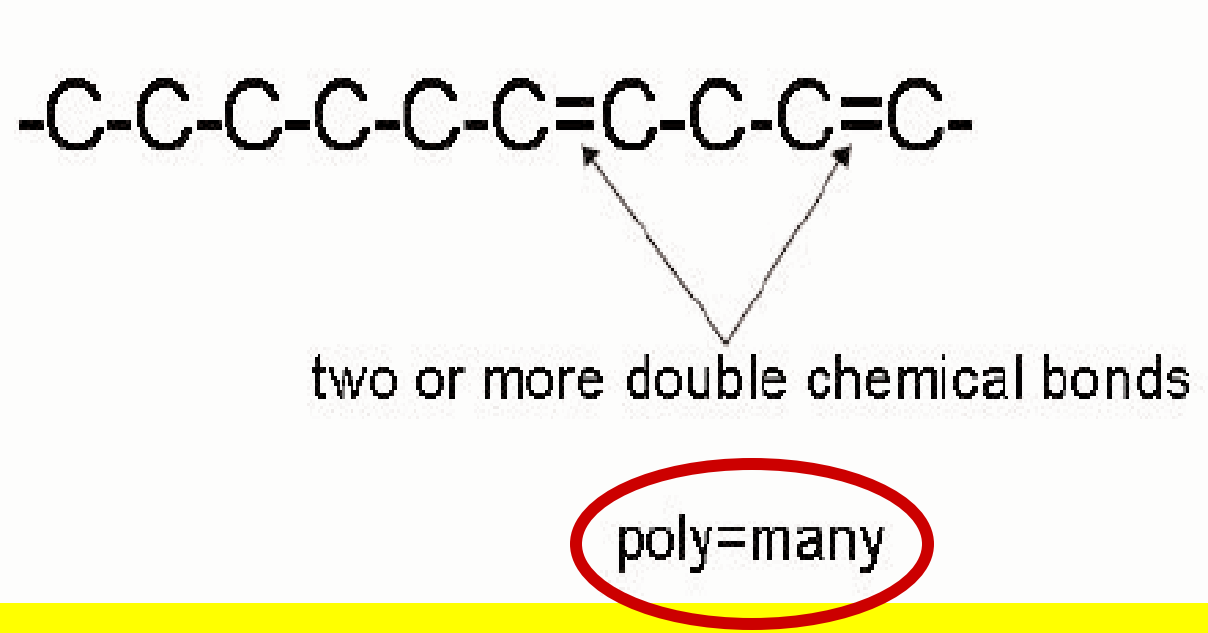
(c)



Monounsaturated and polyunsaturated fatty acids do not stack well together because they are bent. These fatty acids are liquid at room temperature.

(d)

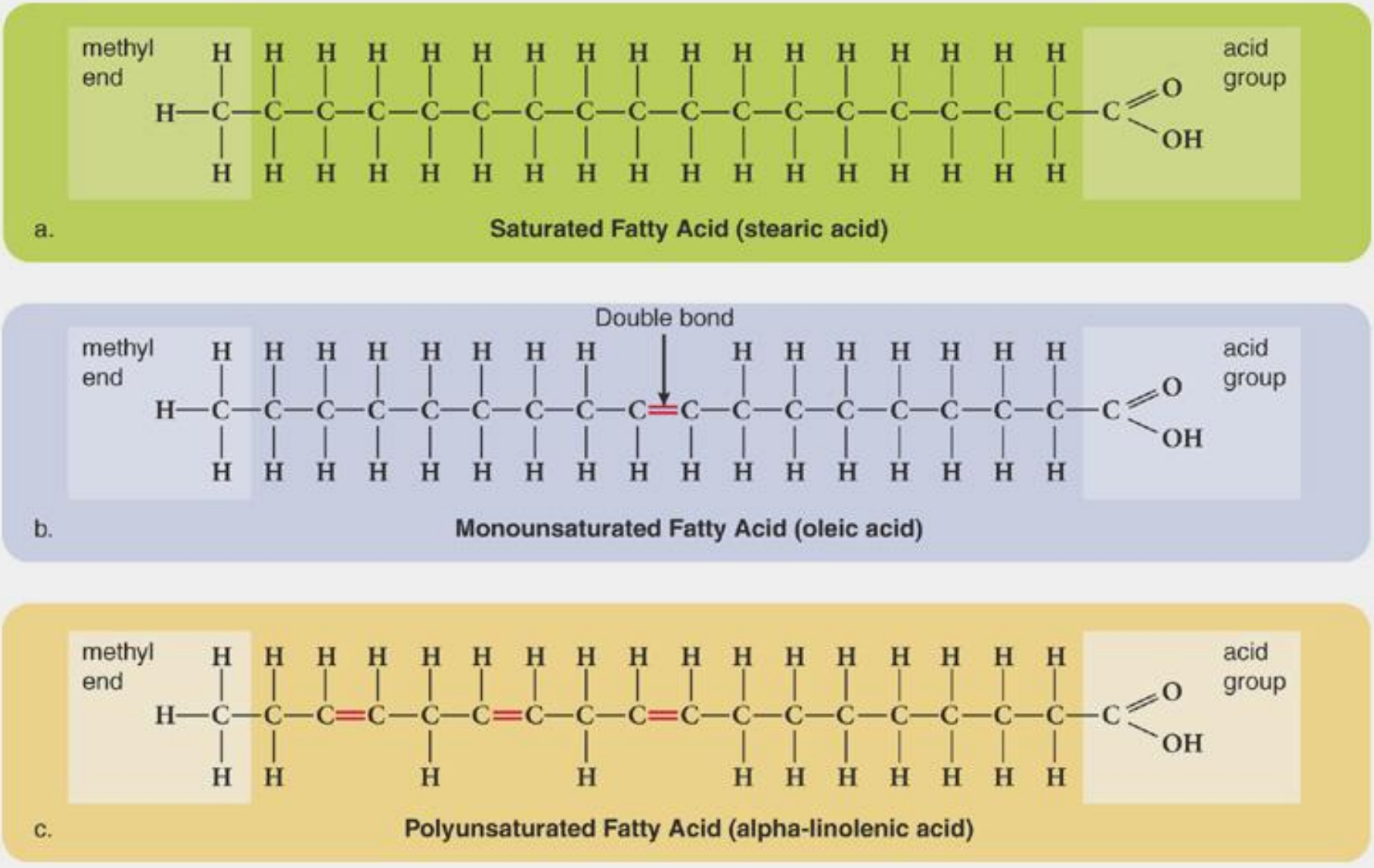
Polyunsaturated fatty acid



Polyunsaturated Fatty Acid

- Also liquid at room temperature

- Found in: vegetable oils (soybean, corn, safflower, sunflower) and margarines (liquid, tub)



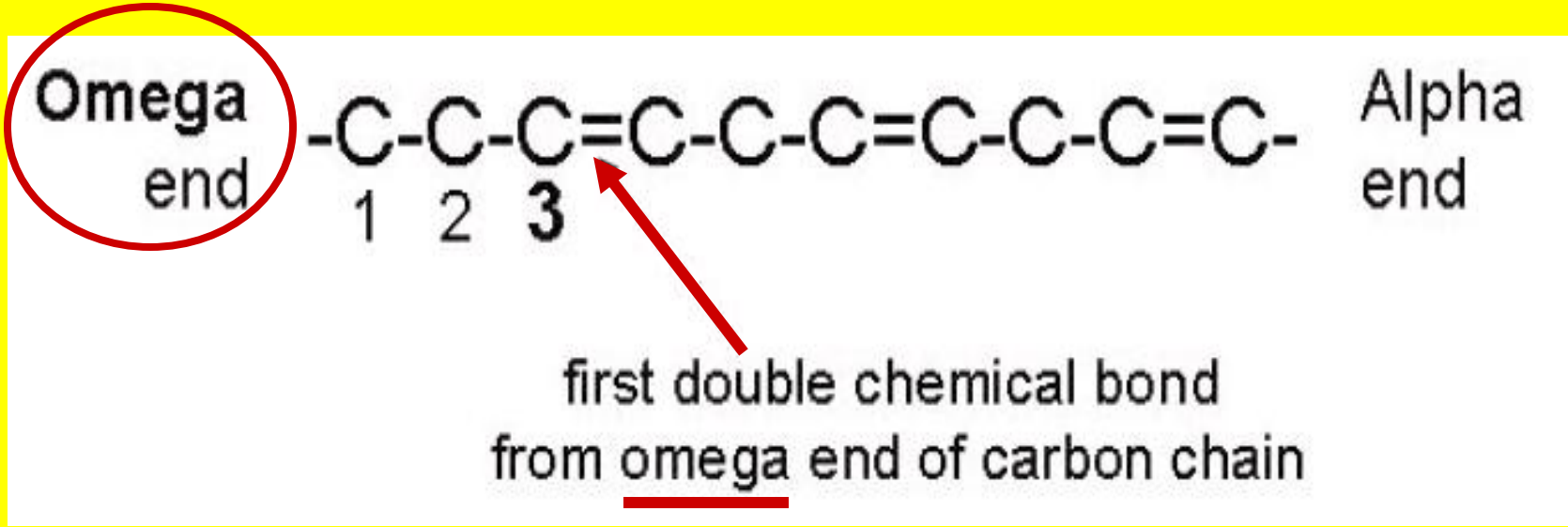
Polyunsaturated & Monounsaturated Fats

Good Fats

↓ Blood Cholesterol

↓ Heart Disease Risk

Omega 3 fatty acids



Omega 3: **Good Fat-** Special Type of **Polyunsaturated** fat

Protect against:

- Heart attack
- Stroke
- Sudden death
- Lower blood triglycerides
- Help maintain normal heart rhythms

Omega 3 fatty acids

- Important: cell membranes of **retina** & **nervous system**;
- Normal **brain** development in **babies** (breast milk, formulas)
- Found: vegetable oils (soybean, canola), **nuts** (walnuts), **seeds** (flaxseed), **fish** (salmon, tuna, trout), **shellfish**

Omega 3 fats- abundant in gray matter

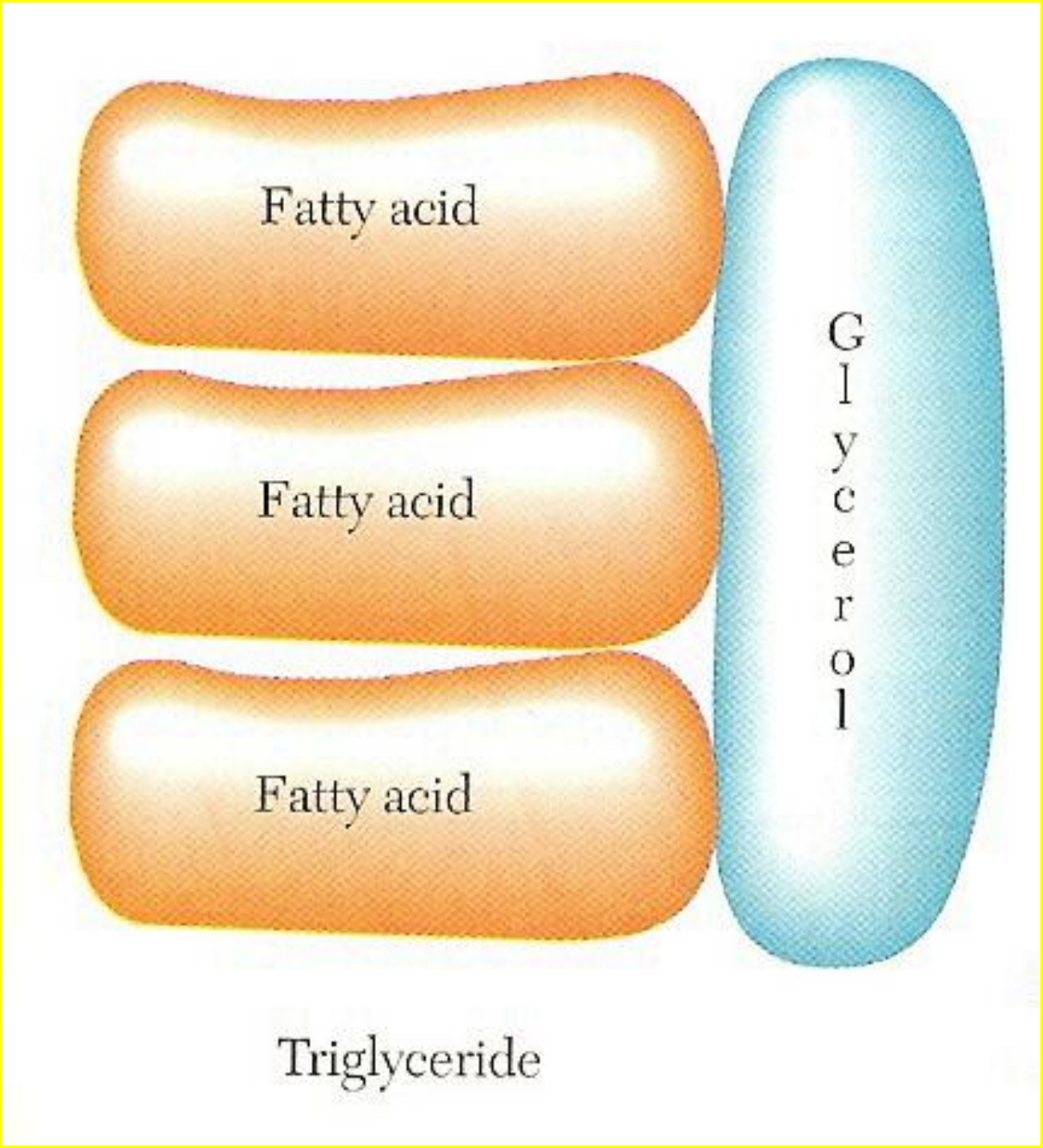
↓ Mental decline-**age**

↓ Alzheimer's Disease

2) Triglyceride

Most of **fat** in your foods

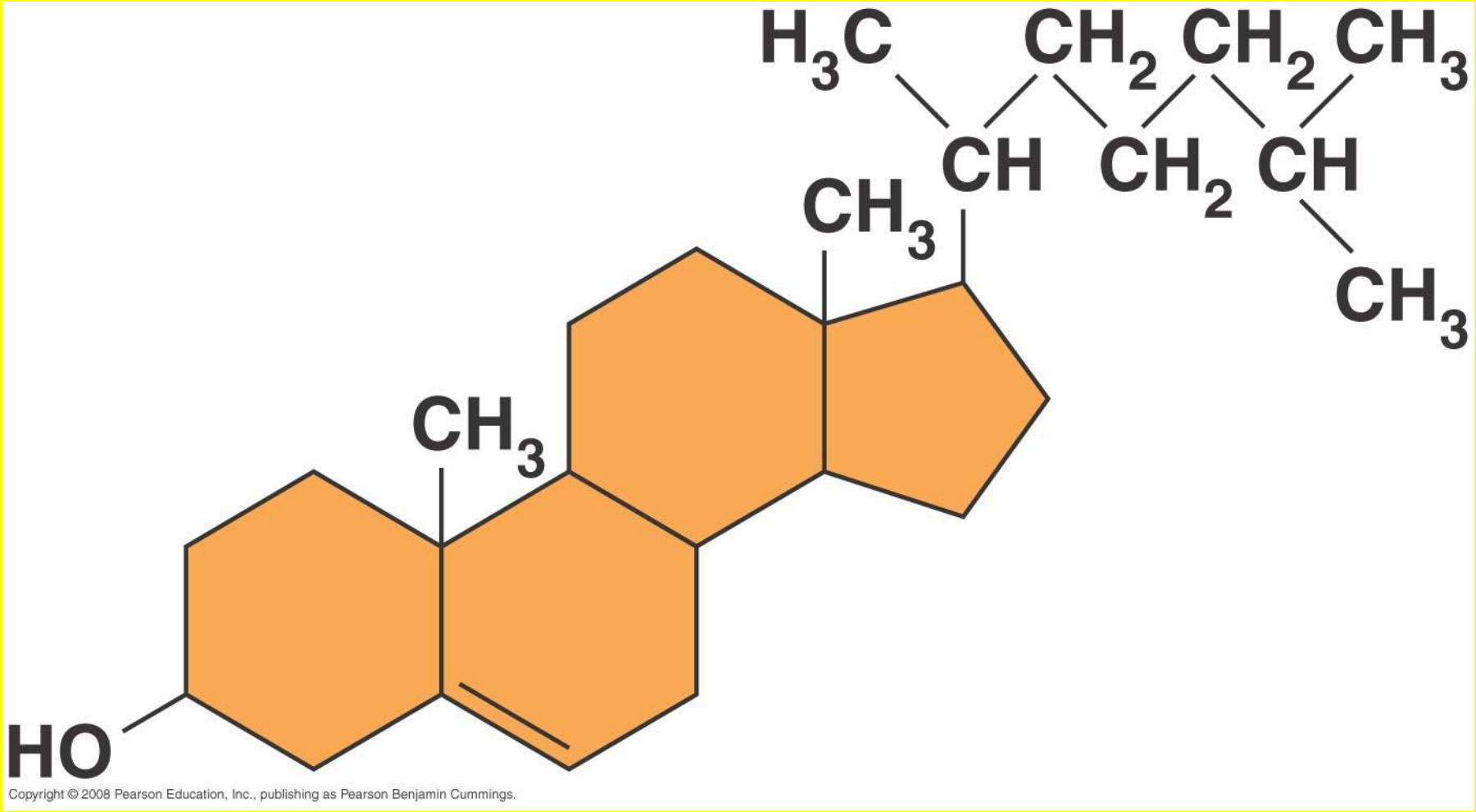
Major fat **stored** in fat (adipose) & muscle tissue

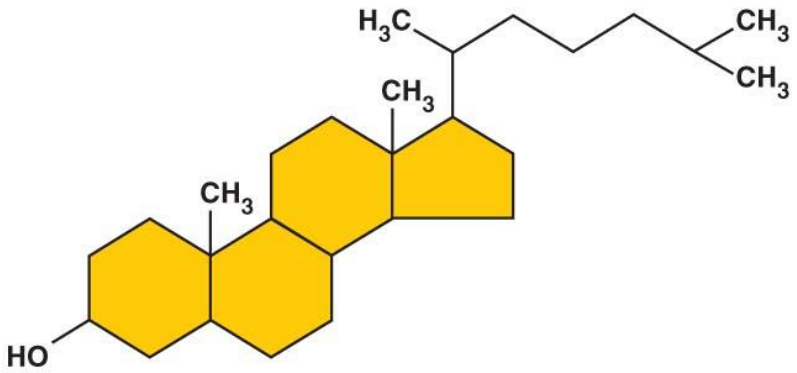

Fatty acid
Fatty acid
Fatty acid
Glycerol
Triglyceride

3) Sterols

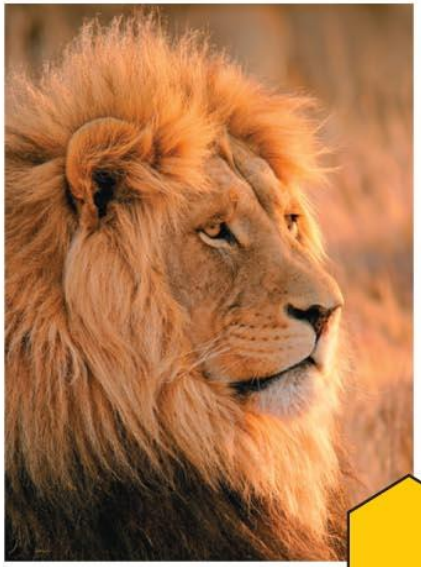
4 Interconnected rings

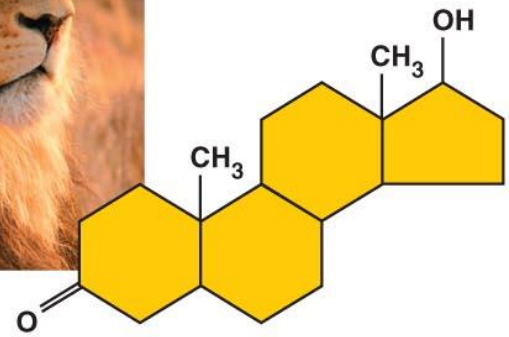
"chicken wire"



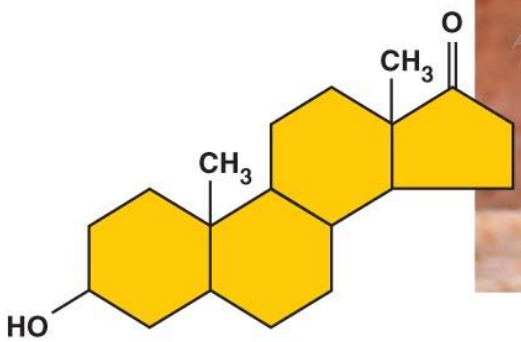


Cholesterol





Testosterone



A type of estrogen

Sterols: Examples

- **Plants**: **Phytosterols**- help lower your blood cholesterol

- **Animals**: **Cholesterol**

  Made in **liver**

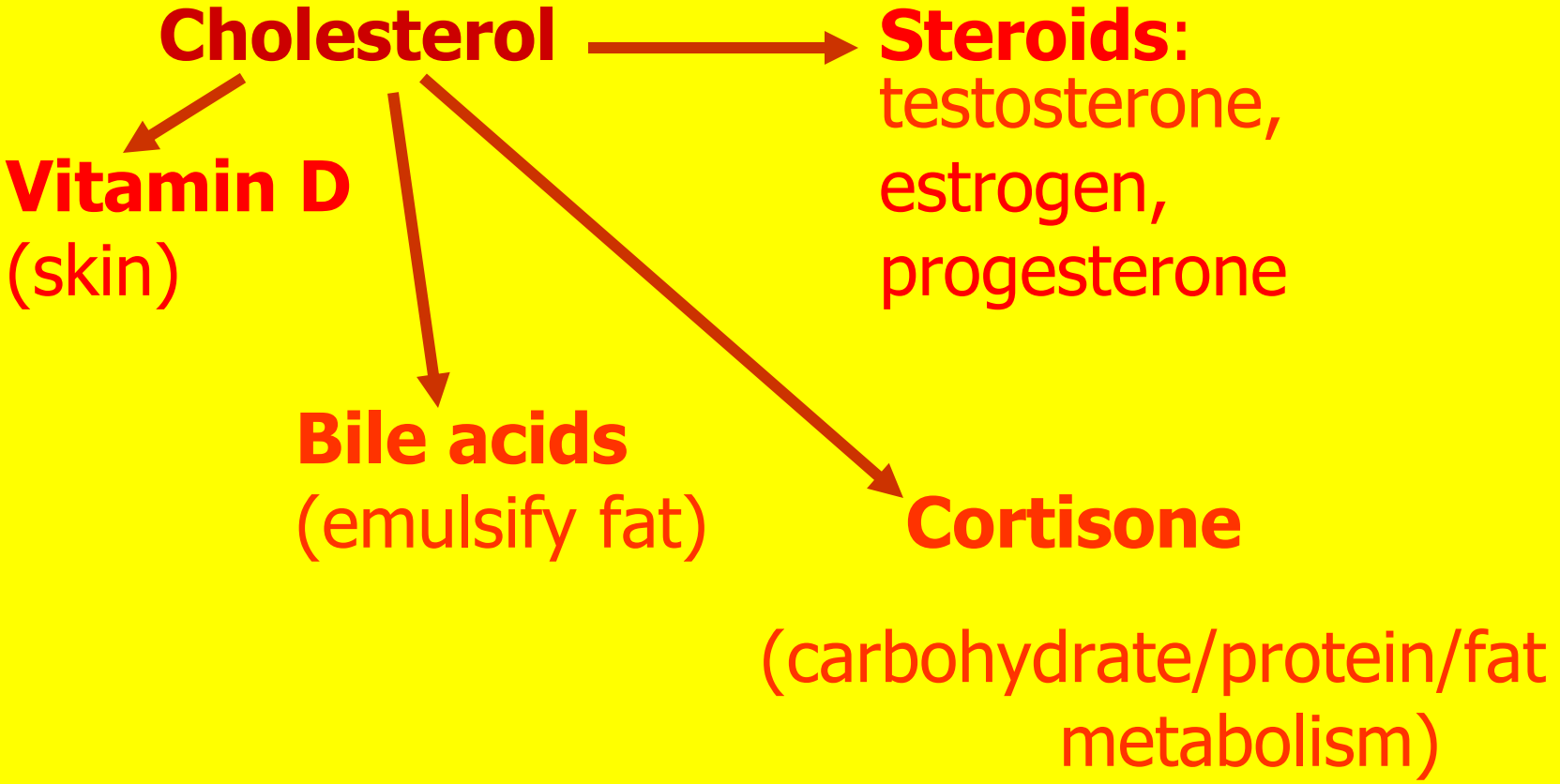
  Don't need to eat in foods

  ↑ egg yolk, liver, kidney, some prepared foods

No cholesterol in plants

Cholesterol

- Most cholesterol: your cell membranes, coating nerve cells (nerve impulses)

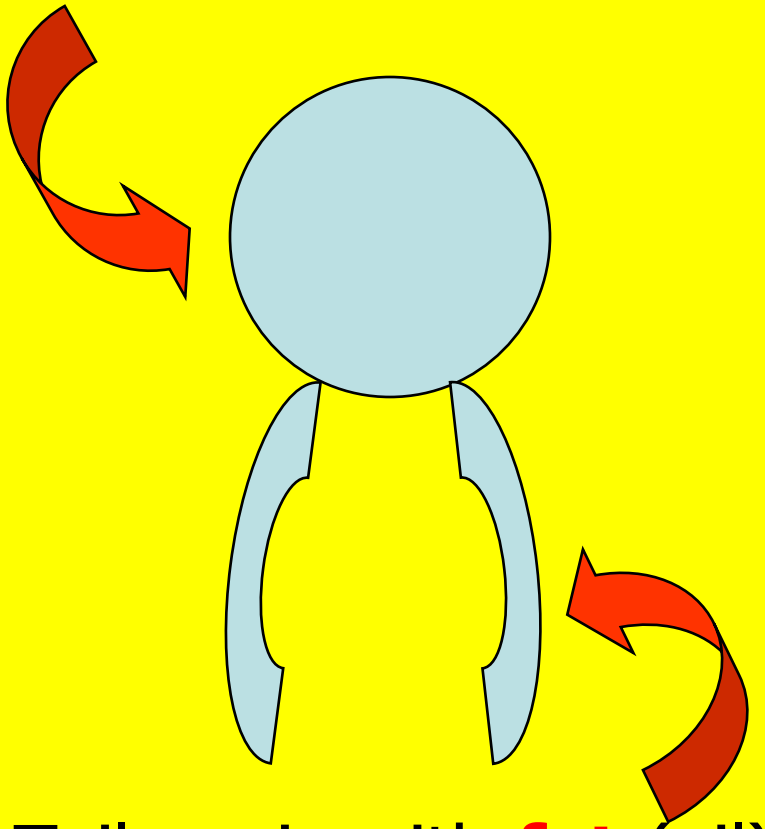


4) Phospholipids

- Contain phosphorus
- Emulsifiers (emulsification): break other fats → small droplets, helps fat mix with water
- Found in bile (gallbladder)- **emulsifies** fat in intestine
- Found: all your **cell membranes**

PHOSPHOLIPID

Head part: mixes with **H_2O**



Tails: mix with **fat** (oil)

Example: **Lecithin**

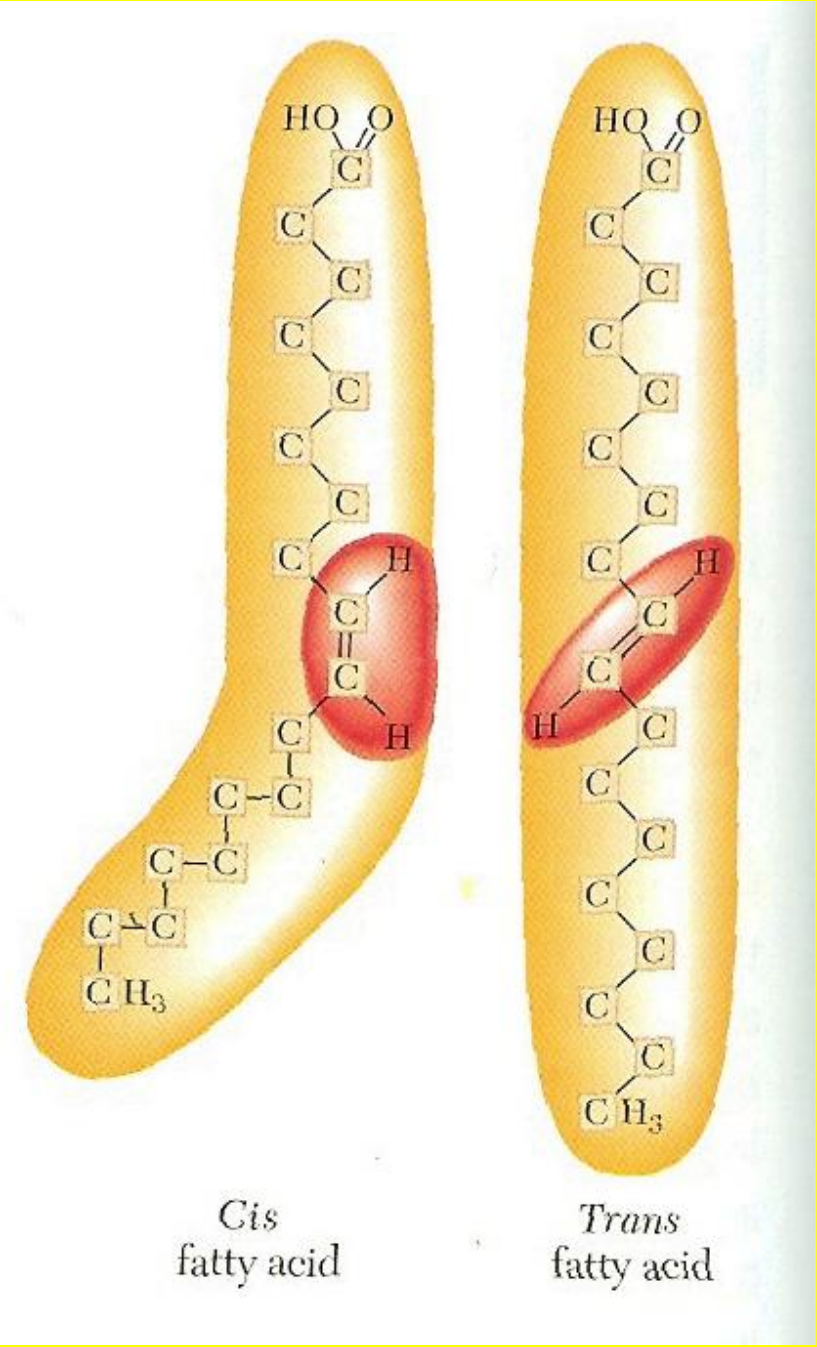
- In eggs and **soybeans**
- Used in: mayonnaise, margarine, salad dressings, chocolate, frozen desserts, baked foods
- Keeps oil mixed with other ingredients

Trans Fat: Bad Fat

↑ Heart Disease Risk

Artificially modified fat: Trans Fat

- Bubble hydrogen gas: **vegetable oil**
- **"Partially hydrogenated"** changes some double bonds → single bonds
- Makes fat **semi-solid**
- Looks more like **saturated fat**
- Changes **shape**- some double bonds
- **"Trans"** = **"Across"** in Latin
- Cheaper to use, longer shelf-life


HO
O
H
H
CH_3
Cis
fatty acid
Trans
fatty acid

Fats and You: Bottom Line

Bad Fats:

Saturated

Trans Fat

Cholesterol

Good Fats:

Monounsaturated

Polyunsaturated

Omega-3 Fats

How do you carry fat in your blood?

Fat: energy rich **(9 calories/gram)**

Transport fat to tissues → Energy/Storage

Problem: **Fat** + H20 ≠ **Mix**

How do you dissolve fat in blood?

Solution: **Lipoproteins**

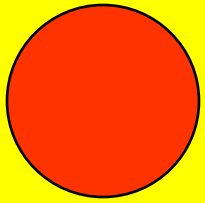
Lipoproteins

- **Proteins** dissolve in water

- So combine fat **(lipid)** with **protein**= **lipoprotein**

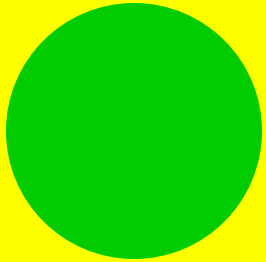
3 types

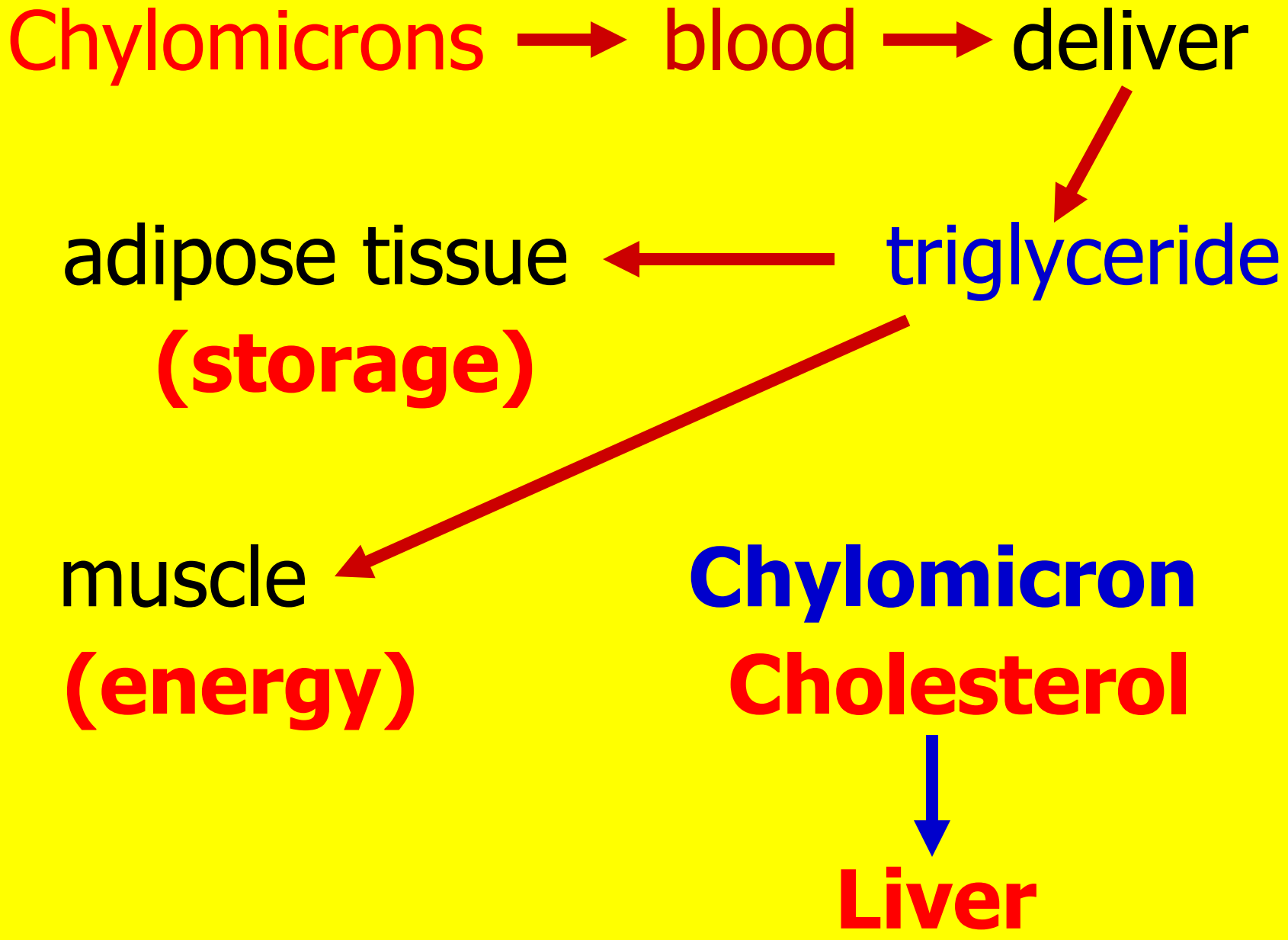
- All spherical (ball shaped)



#1 Chylomicrons

- Fat in food → broken down by enzymes → fatty acids
- Intestinal cells remake triglyceride
- Triglyceride + protein → **chylomicron**




Chylomicrons
blood
deliver
triglyceride
adipose tissue
(storage)
muscle
(energy)
Chylomicron
Cholesterol
Liver

- 1-2 hours after fatty meal: see chylomicrons in **blood**
- Plasma = cloudy
- Chylomicrons in blood 8-10 hours
- **Fasting** before lipid blood test

Chylomicrons : important for **fat deposition**

Fat Mobilization

Triglyceride (adipose tissue) → fatty acids → blood → cells/tissues → Energy

- **Smoking**
- **Coffee**
- **Fasting**
- **Starvation**
- **Exercise**

#2 **Low Density Lipoprotein**

- Major cholesterol carrier in **blood**
- Good role vs. bad role

Good role

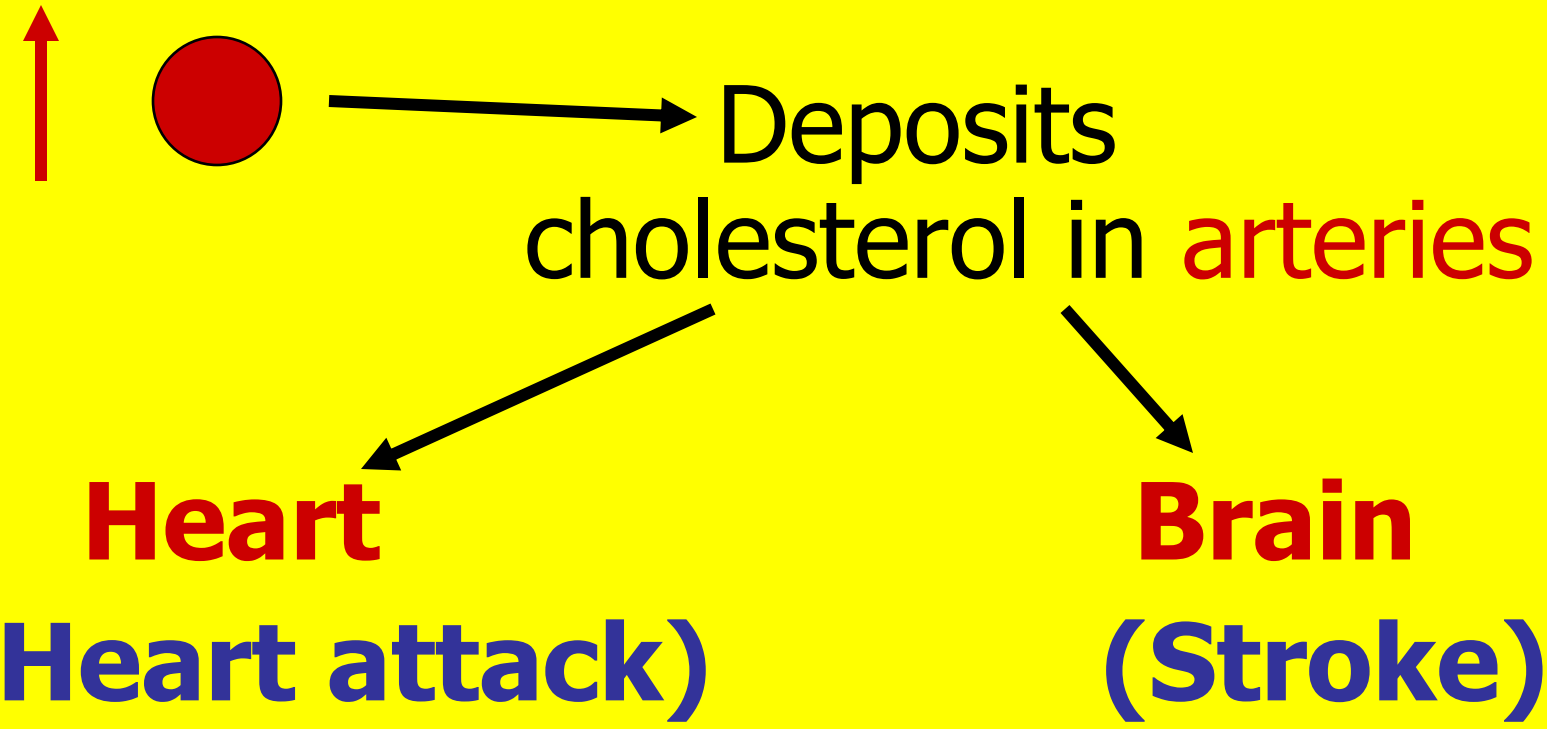
- Readily available **pool** of **cholesterol** for cell needs;
- Cells take cholesterol from LDL

LDL

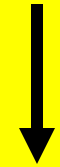
delivers cholesterol

cells: make new membranes (replacement worn out parts)

LDL
Bad Role


Deposits
cholesterol in arteries
Heart
(Heart attack)
Brain
(Stroke)

#3 High Density Lipoproteins (HDL)

 **HDL**  Heart Disease

HDL removes cholesterol from cells

(arteries)

liver

Removed in **bile**

(feces)

Cholesterol

The Good and The Bad

HDL **LDL**

LDL vs. HDL: Balance is important

Keep LDL **Low**, HDL **High**

Fat Functions

- Stored **energy** for future use
- 9 calories/gram (calorically dense)

~**120** calories= **1** tablespoon of butter or oil= **2.5** cups steamed broccoli= **1** slice whole wheat bread

Fat Functions

- Insulates body from temperature changes (adipose tissue under skin, around internal organs)
- Cushions/protects against shocks

Fat Functions

- Provides **structure** to cell membranes (regulates what goes in/out)
- Keeps cell membranes **fluid (flexible)**

Fat Functions

- Lubricates body surfaces: oil in skin

- Adds taste, texture, flavor, aroma to foods

Fat Functions

- Help us feel **satiated** after meal

- Dissolves fat-soluble vitamins (A, D, E, K) in intestine for proper **absorption**

PROTEINS

Proteins: C, H, O, and N

Protein Synthesis (in cells)

Amino acids → Polypeptides → Protein

Protein Breakdown (in cells & during digestion → absorption)

Amino acids ← Polypeptides ← Protein

Nitrogen

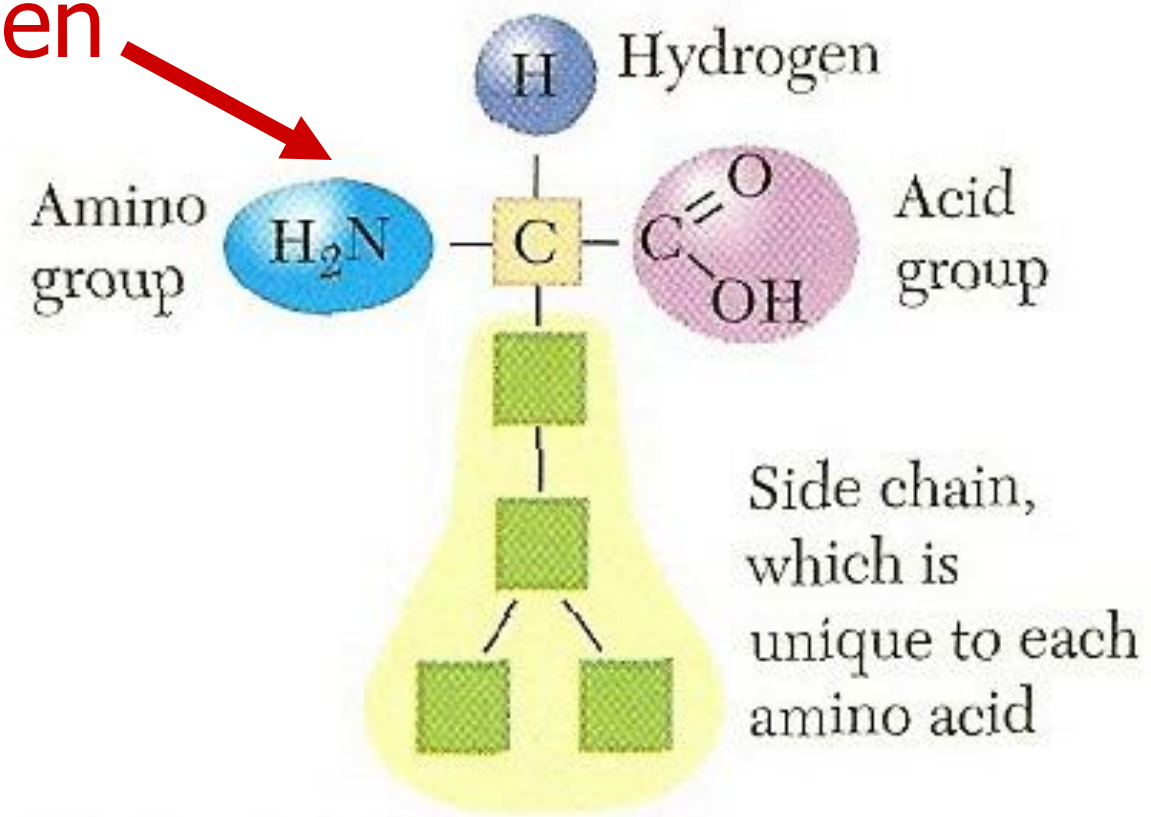
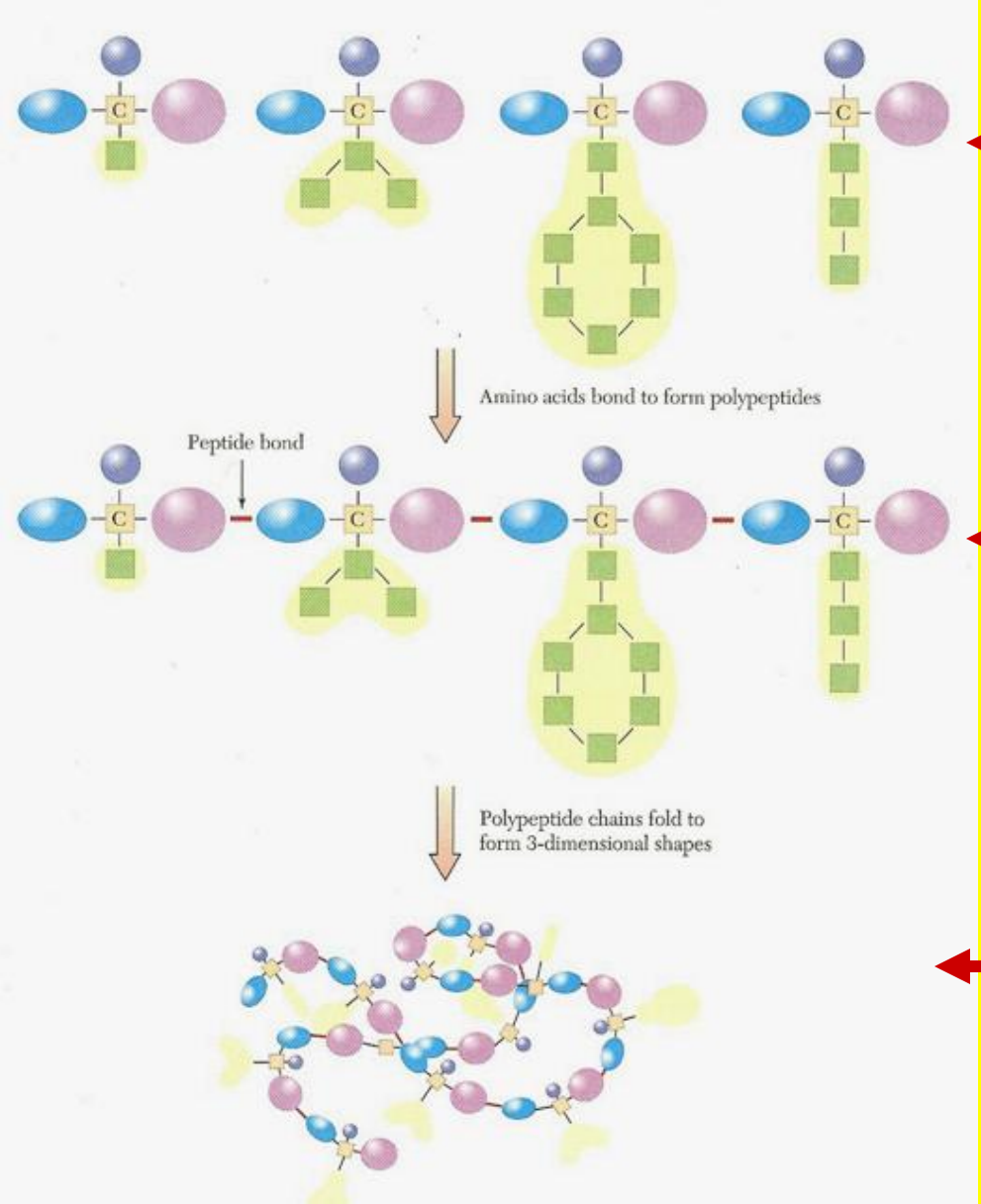


FIGURE 6.2

All amino acids have a similar structure, but each has a unique side chain.



← amino acids

← polypeptides

← proteins

Amino Acids

20 different kinds: in human protein

11 can be made in cells =

Nonessential

Made in body or from diet

9 you can't make=

Essential

Must eat in diet

- Absence of essential amino acids in diet  Protein

Children ↓ Growth

Not enough protein: world health problem

Protein/calorie malnutrition

Kwashiorkor (↓ protein)

Marasmus

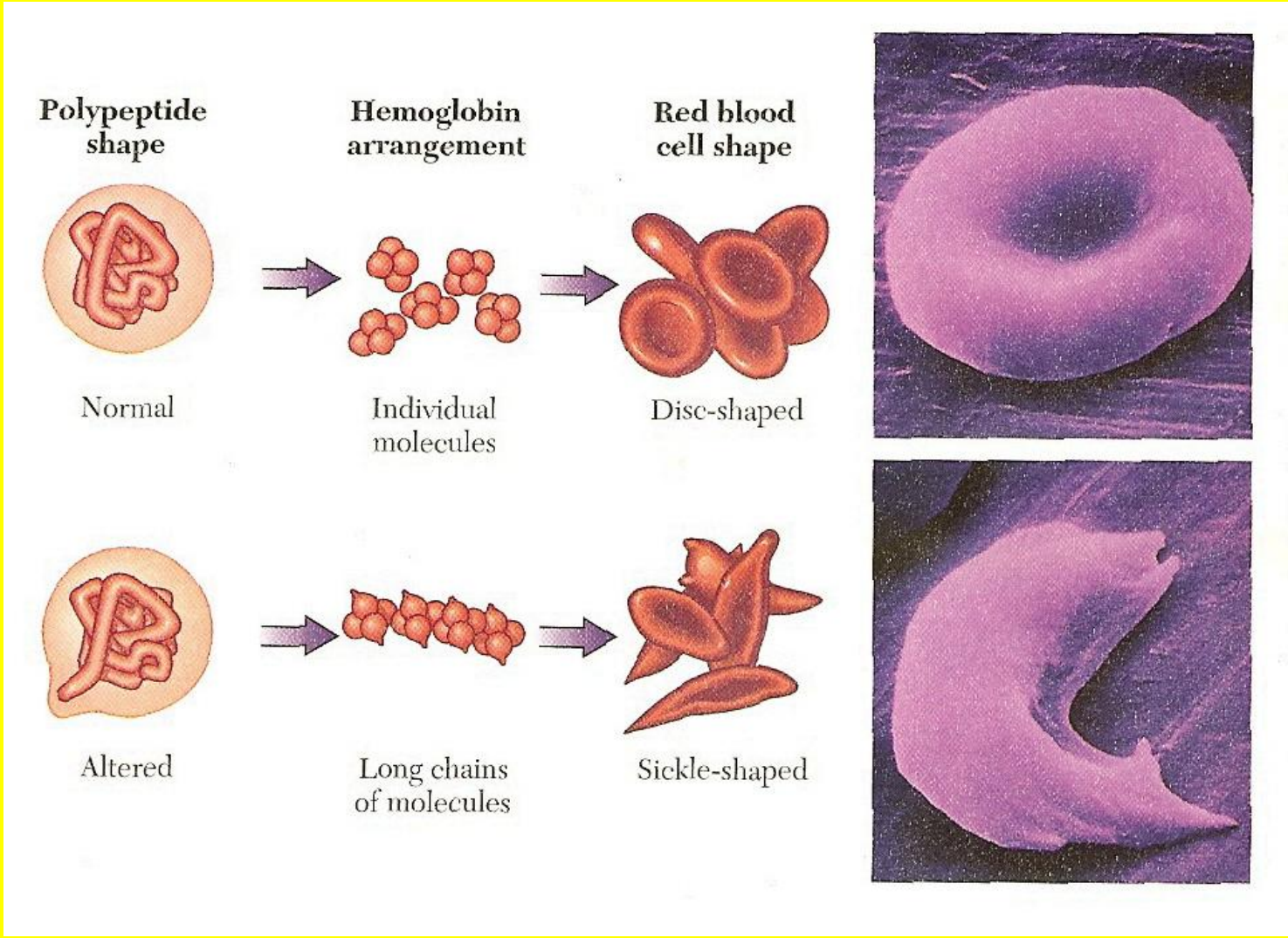
(↓ calories/nutrients)

Starvation

Different amino acid **combinations**= different types of protein

- Amino acids: which ones, how they are arranged: important
- Determines: what protein does (functions)
- Example: amino acids- hair protein: straight vs. curly

Mistake in amino acid order: change in shape of protein **(hemoglobin)**



Sickle cell anemia:

1 in 12 African-Americans

1 in 100 Hispanic Americans

carry mutated gene for this disease

What proteins do in your body

1) **Enzymes**: catalysts

   Speed up chemical reactions

2) Tissue Growth & Maintenance

- Protein found in every cell **(structure)**
- During growth → add tissue → need protein
- Examples: muscles/biceps: weight lifter; thighs (skaters); skin, hair, collagen (bones, teeth)

3) Movement

- Muscle proteins: muscle contractions- all your movements
- Heart muscle- beating
- Digestive tract- moving food along
- Blood vessels: **constrict** & **dilate**

4) Hormones

- Many are proteins
- Chemical messengers: produced in one place → blood → another place in body → response
- Pancreas → insulin → blood → all cells ← stimulates

glucose uptake

5) Antibodies

- Proteins produced when foreign material **(antigen)** enters body;
- Destroys **antigen**
- **Antigens**: **bacteria, virus, transplanted organ**

6) **Transport** (carrier) molecules: help carry (shuttle) things

Examples:

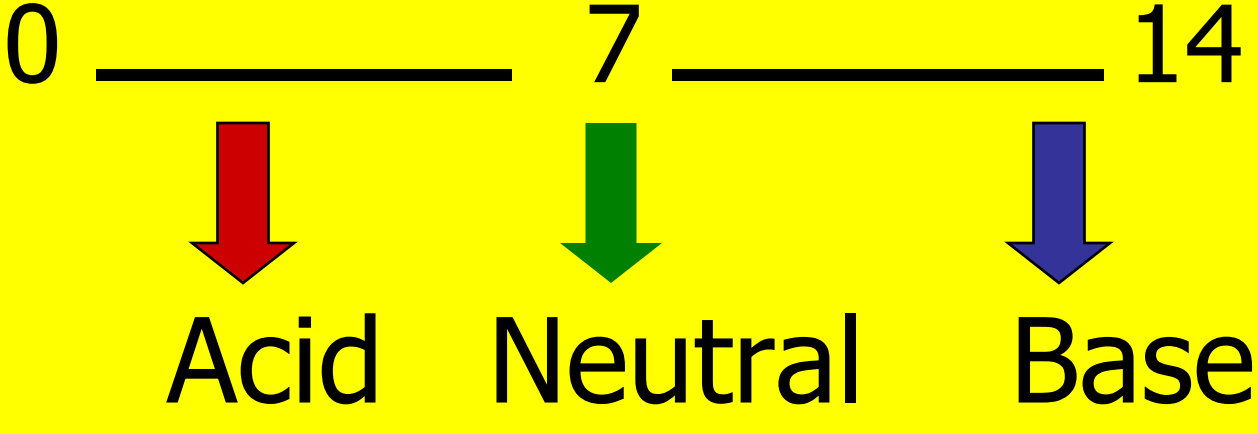
- **Hemoglobin**- carries oxygen
- **Lipoproteins**- carry fats (lipids)
- **Cell membranes**: shuttle molecules in & out of cells

7) Fluid Balance

Proteins: maintain proper amounts of **H_2O** inside/outside of cells by absorbing & holding water

8) Blood acid/base balance

pH scale



Blood: 7.35-7.45

Gastric juice: 1.0-5.0

Pancreas juice: 8.4-8.9

Proteins: **buffers**- help maintain normal pH: blood and cells

9) **Calories-** Protein:**4** calories/gram

How dietary protein is used:

1st amino acids → new body proteins

(structure, enzymes, hormones)

2d amino acids → energy

or

3rd amino acids → glucose

10) **Receptors** on cell surface:
glycoproteins: carbohydrates + protein

- Ex.

  receptors:

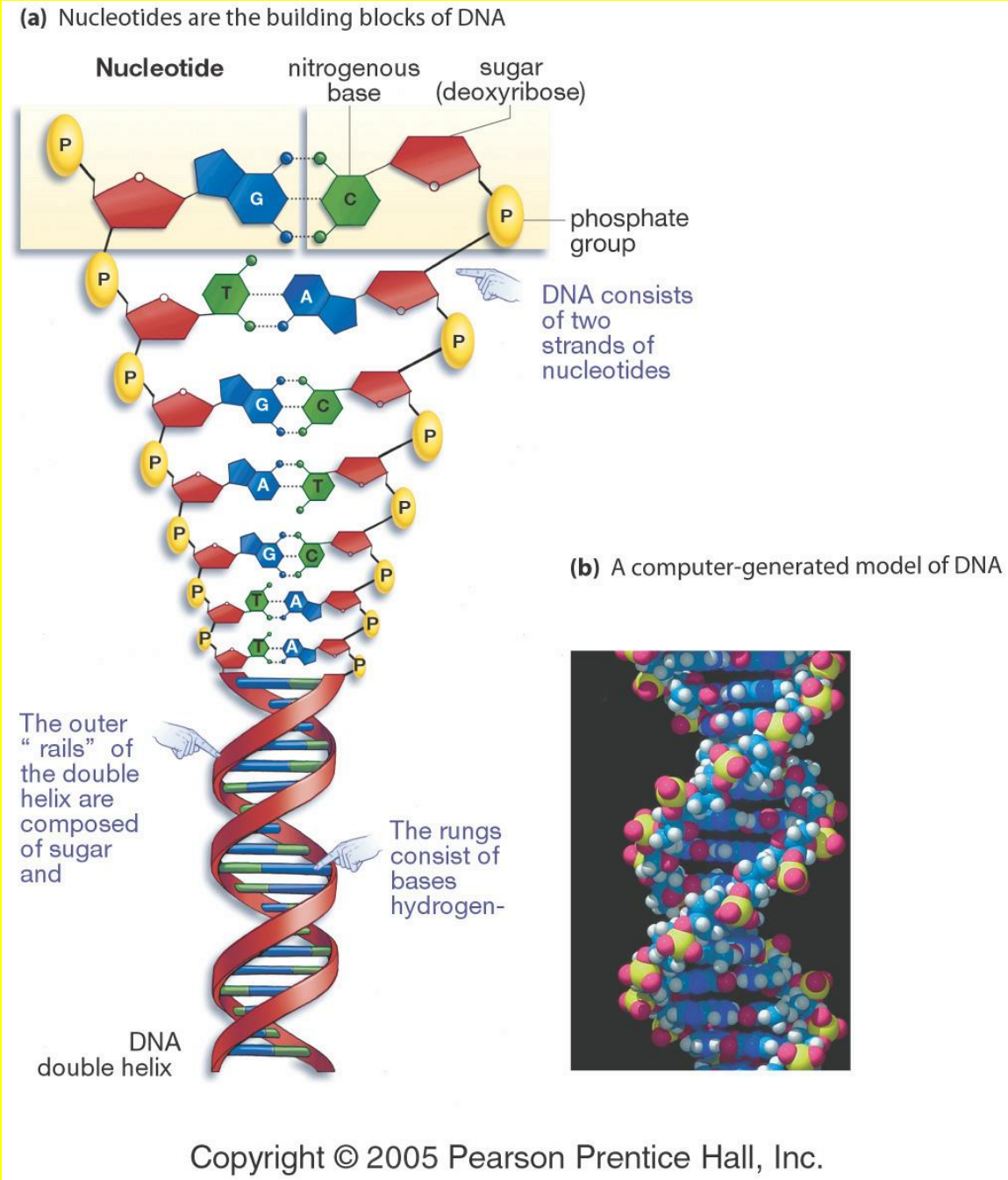
  Insulin,

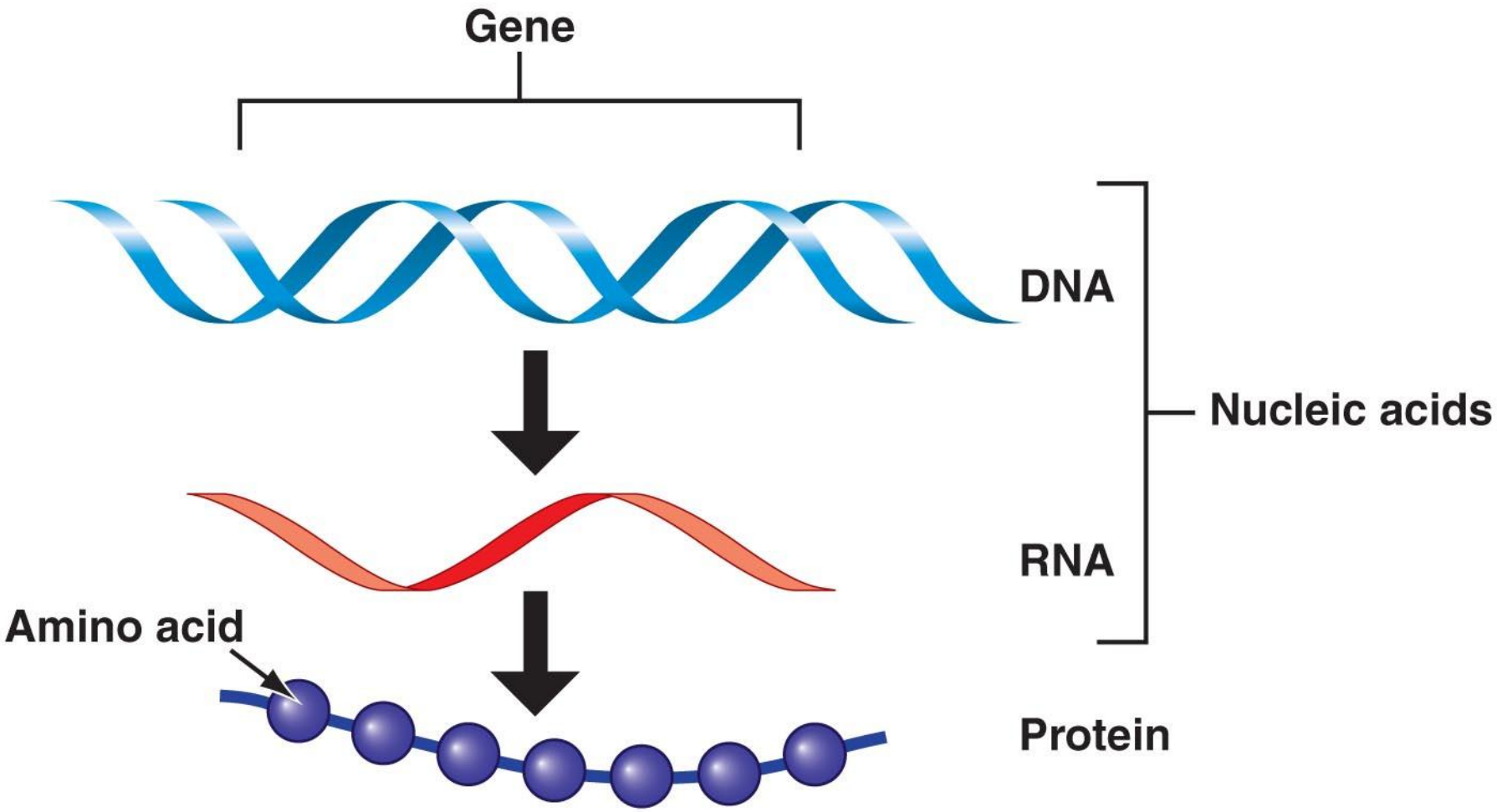
  LDL

Nucleic Acids : DNA & RNA

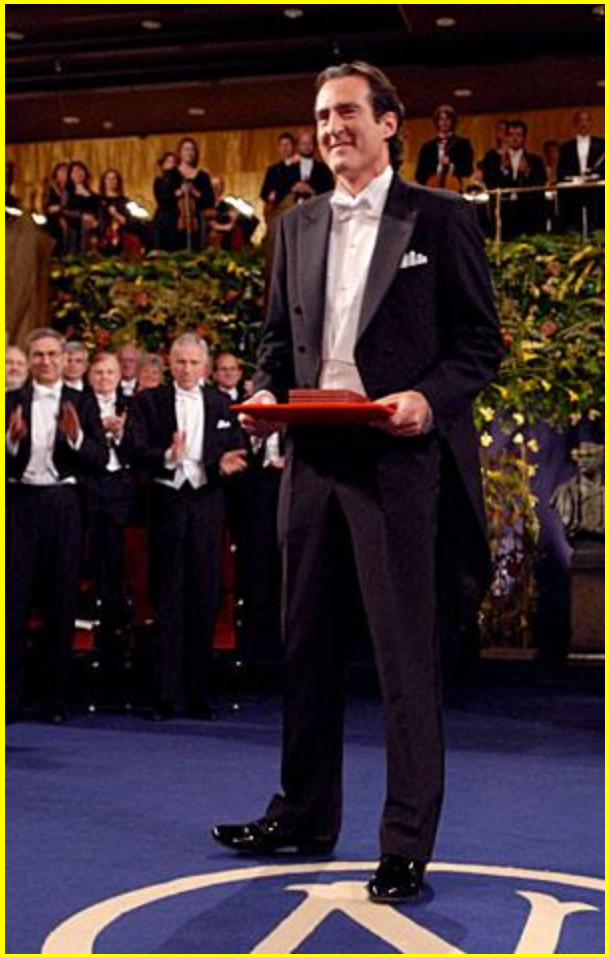
- **DNA**: genes on chromosomes
- **RNA**: important role in protein synthesis

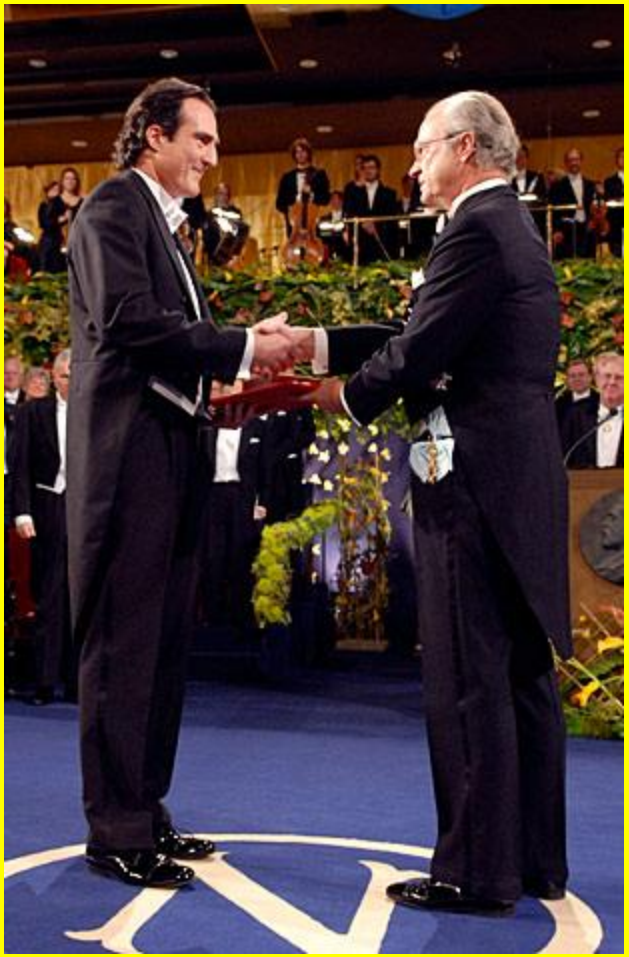
Double Helix: Twisted Ladder





2006 Nobel Prize in Physiology or Medicine: Dr. Craig Mello UMass Medical School





RNA interference

- Double stranded RNA in cells
- Important in:

  Gene Silencing

  Defense against viruses

  Controlling "jumping genes"

  2008 Harvard scientists use RNAi to **silence genes** needed by HIV to make copies of itself

Metabolism
&
Cell Respiration

Metabolism: all chemical reactions in your body

Anabolism: building up processes

Example:

Making **new cell protein**

Anabolic steroids- mimic testosterone

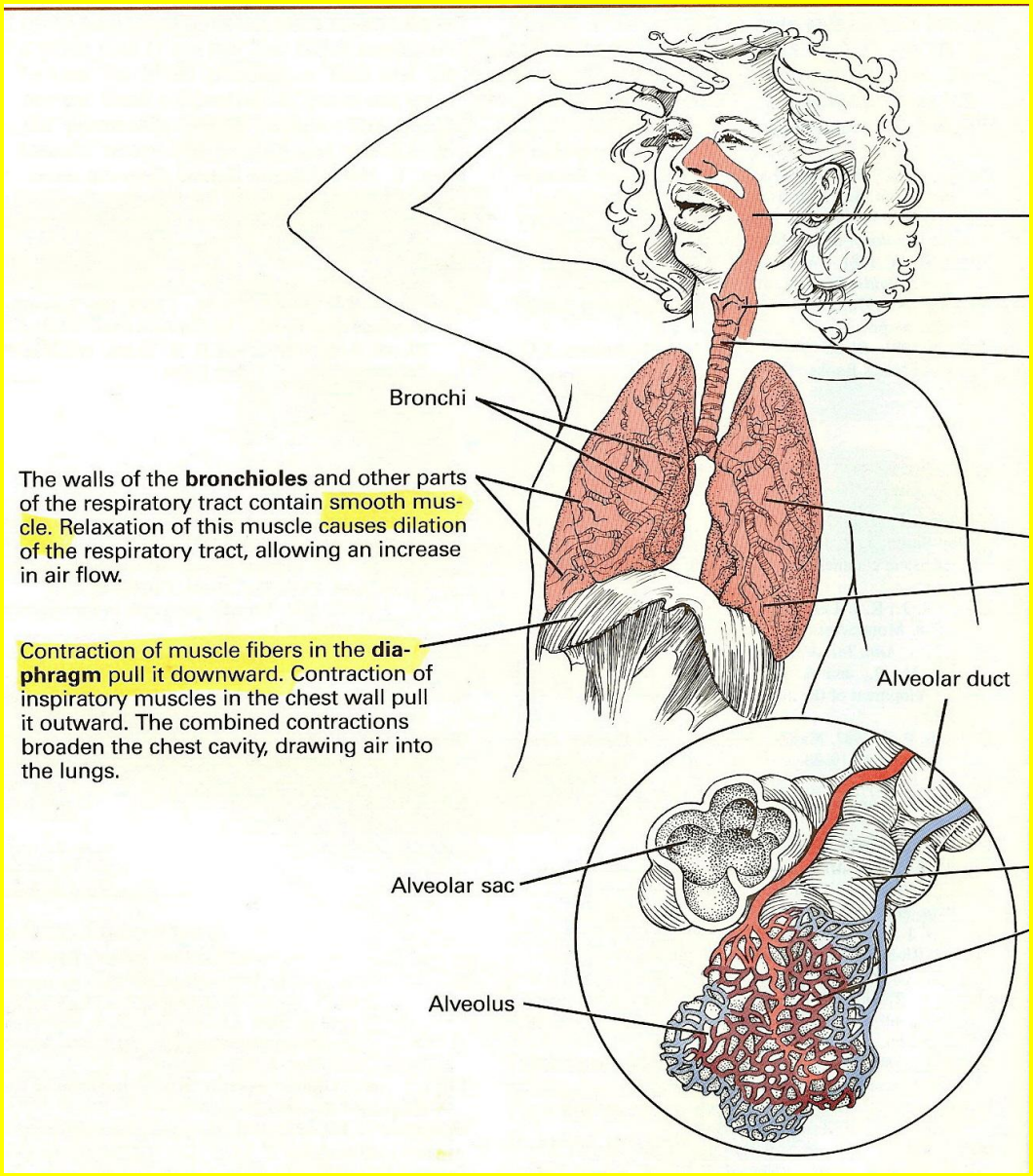
↑ muscle strength, mass

Metabolism:

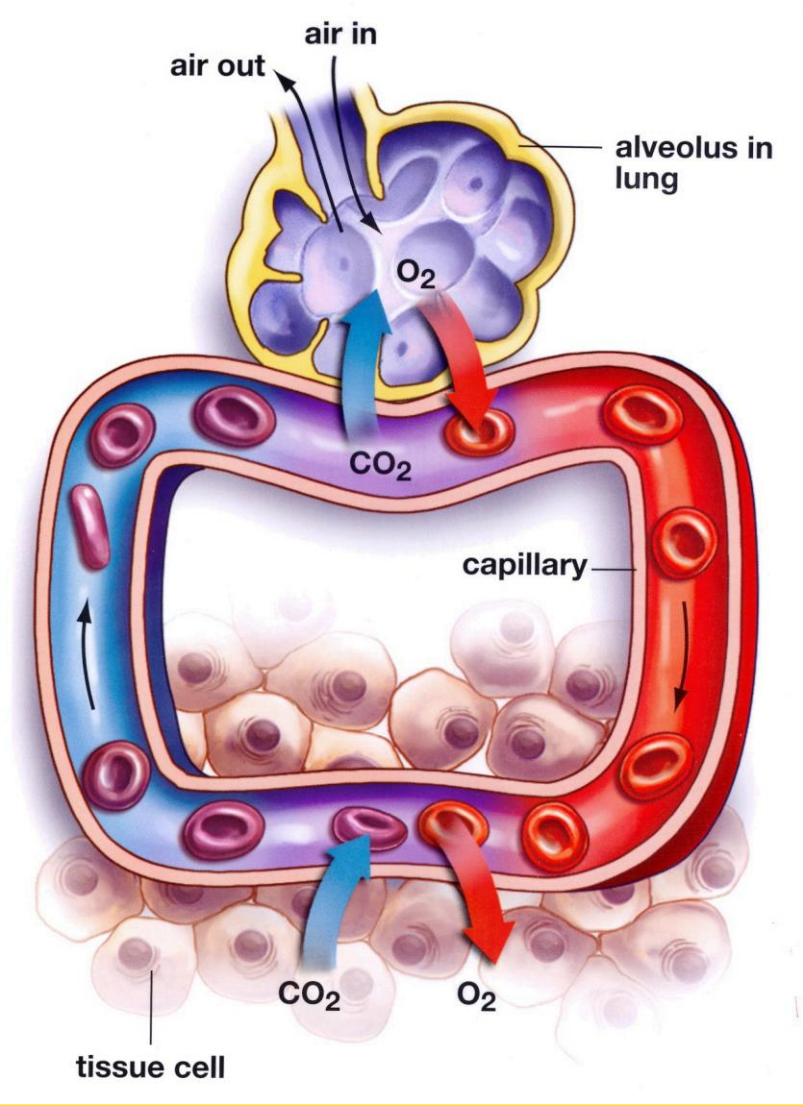
Catabolism- breaking down processes

Example: energy release from glucose

What happens when you breathe?



Do your cells "breathe"?



Cell Respiration: inside your cells

- Energy trapped in **chemical bonds**: carbohydrates, fats, protein

- Break chemical bonds ⟶ energy

ENERGY + P + ADP → **ATP**

(from chemical bonds of food)

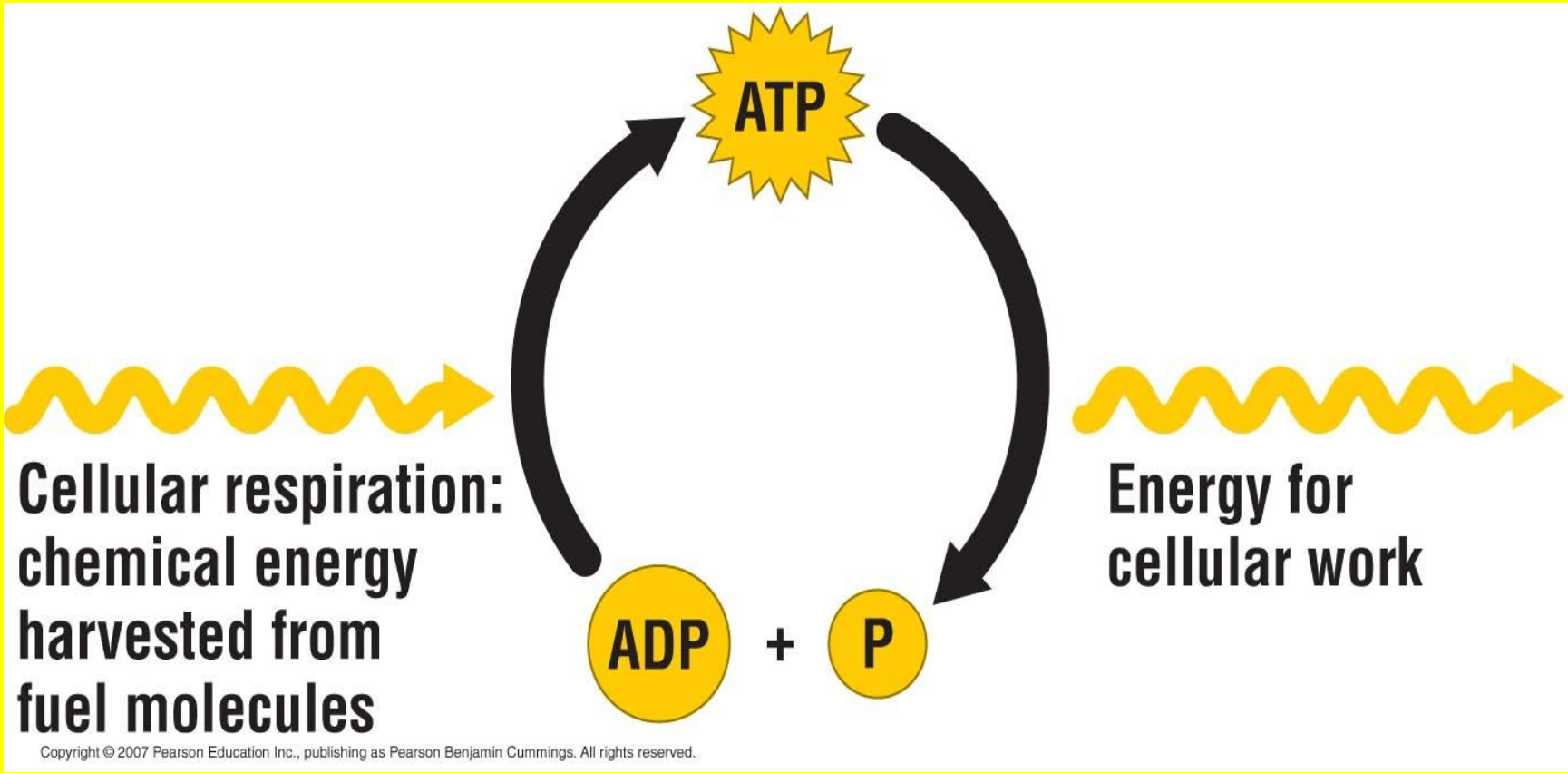
(**stored** energy)

←

Energy **release**: all your body activities

40% Energy trapped in **ATP**

60%: HEAT Body temperature



Cell Respiration

Glucose

+

O_2

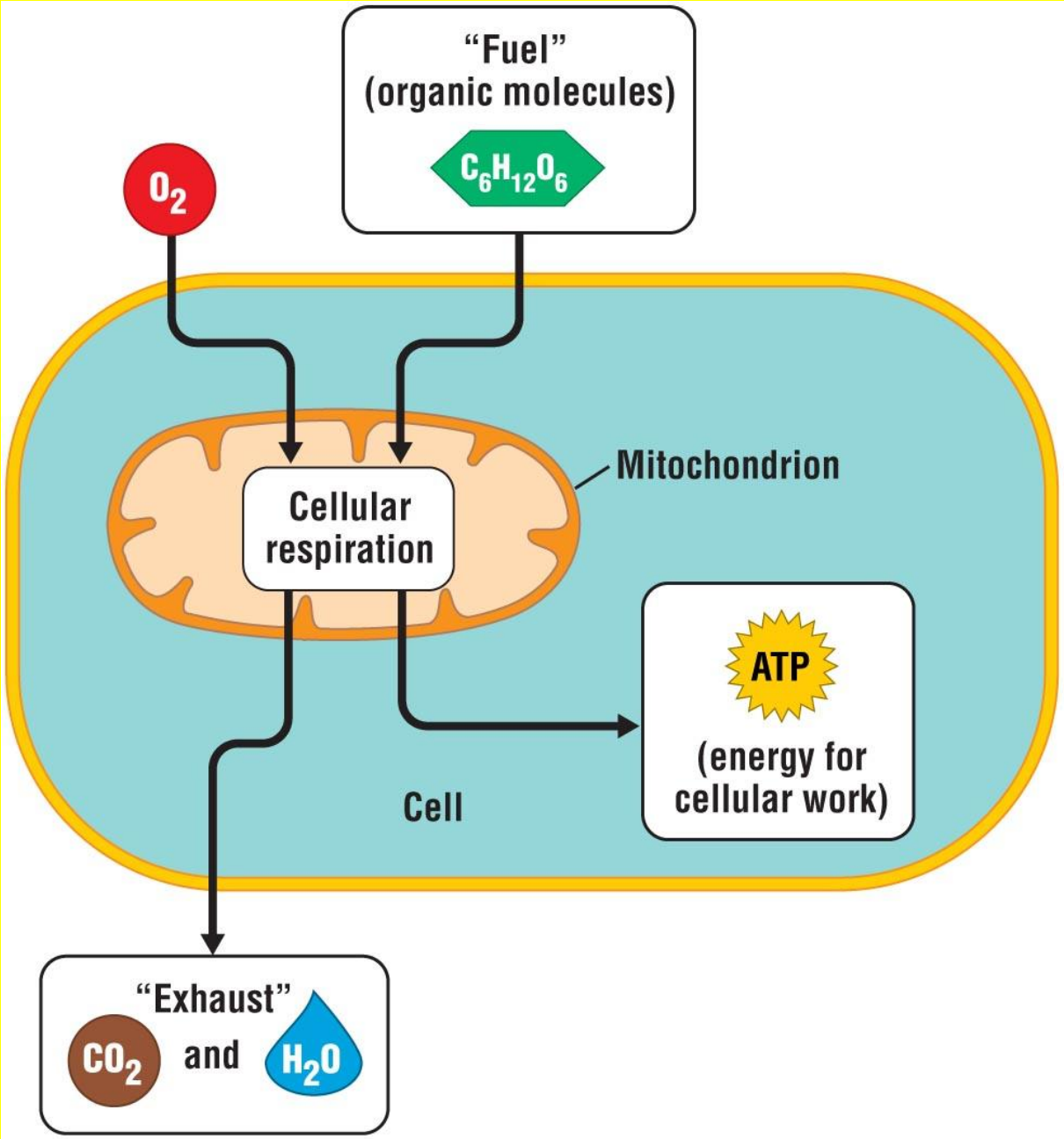
CO_2

+

H_2O

+

ATP's



Cell Respiration: inside your cells

3 Steps:

1) Glycolysis

2) Krebs (Citric acid) Cycle

3) Electron Transport

Metabolism: Carbohydrates, Fats, & Protein

All Interconnected

Examples:

1. Eat too many carbs ⟶ **FAT**
   (adipose tissue)

2. Protein burned for energy (ATP)

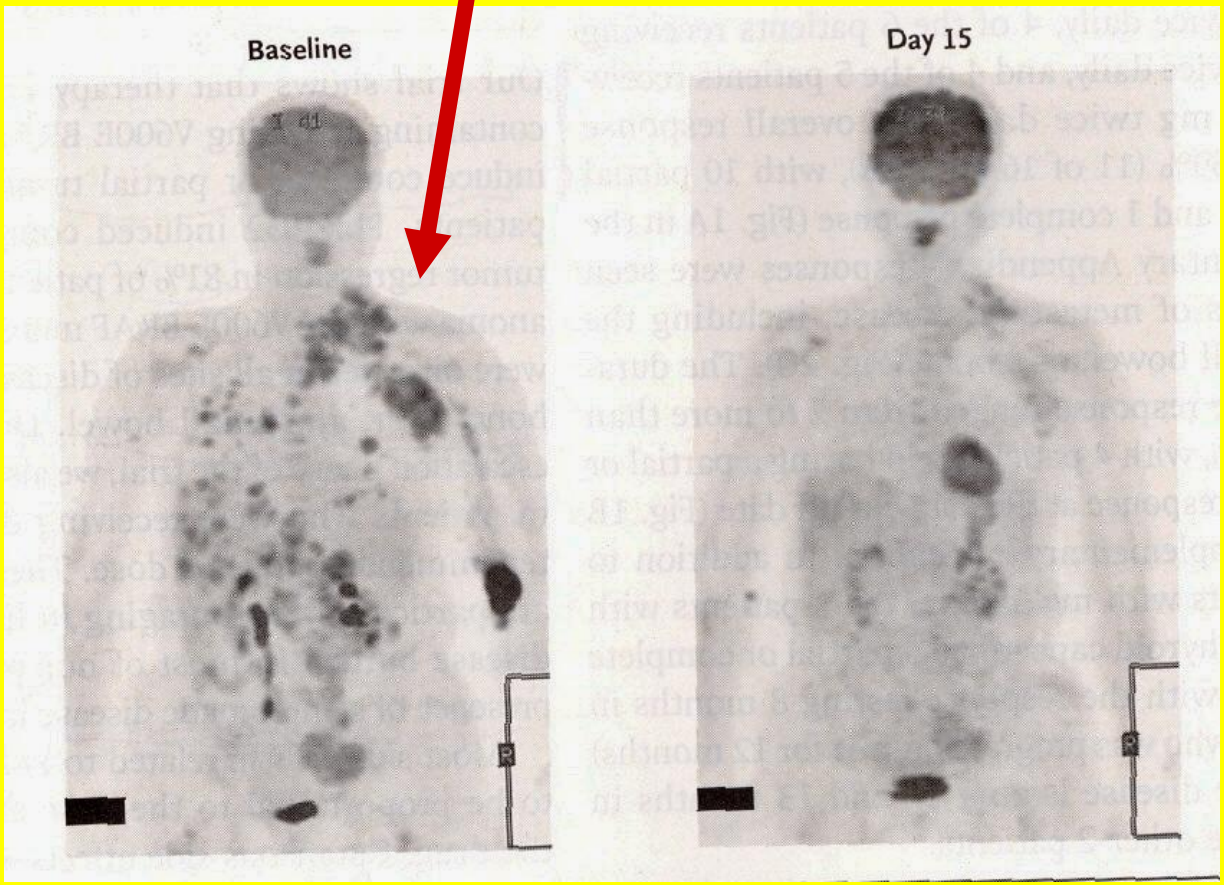
3. Protein → blood glucose during
   fasting or starvation

Why is understanding metabolism so important?

Cancer cell **metabolism** different from normal cells

Cancer Cells:

- Take up **glucose** high amounts
- See **"hot spots"** on **PET scan**



Cancer cells use mostly **glycolysis**

Lactic Acid: moves outside cell **(acidic)**

1. Attracts new blood vessels to supply the cancer **(angiogenesis)**
2. Breaks down extracellular matrix: cancer cells spread **(metastasis)**
3. Glycolysis chemicals:
   more cell division (cancer spreads)

Cancer cells spread- blood & lymphatic system → other tissues

Metastasis: 90% cancer deaths

Metabolic "switch" in cancer cells to **glycolysis** controlled by:

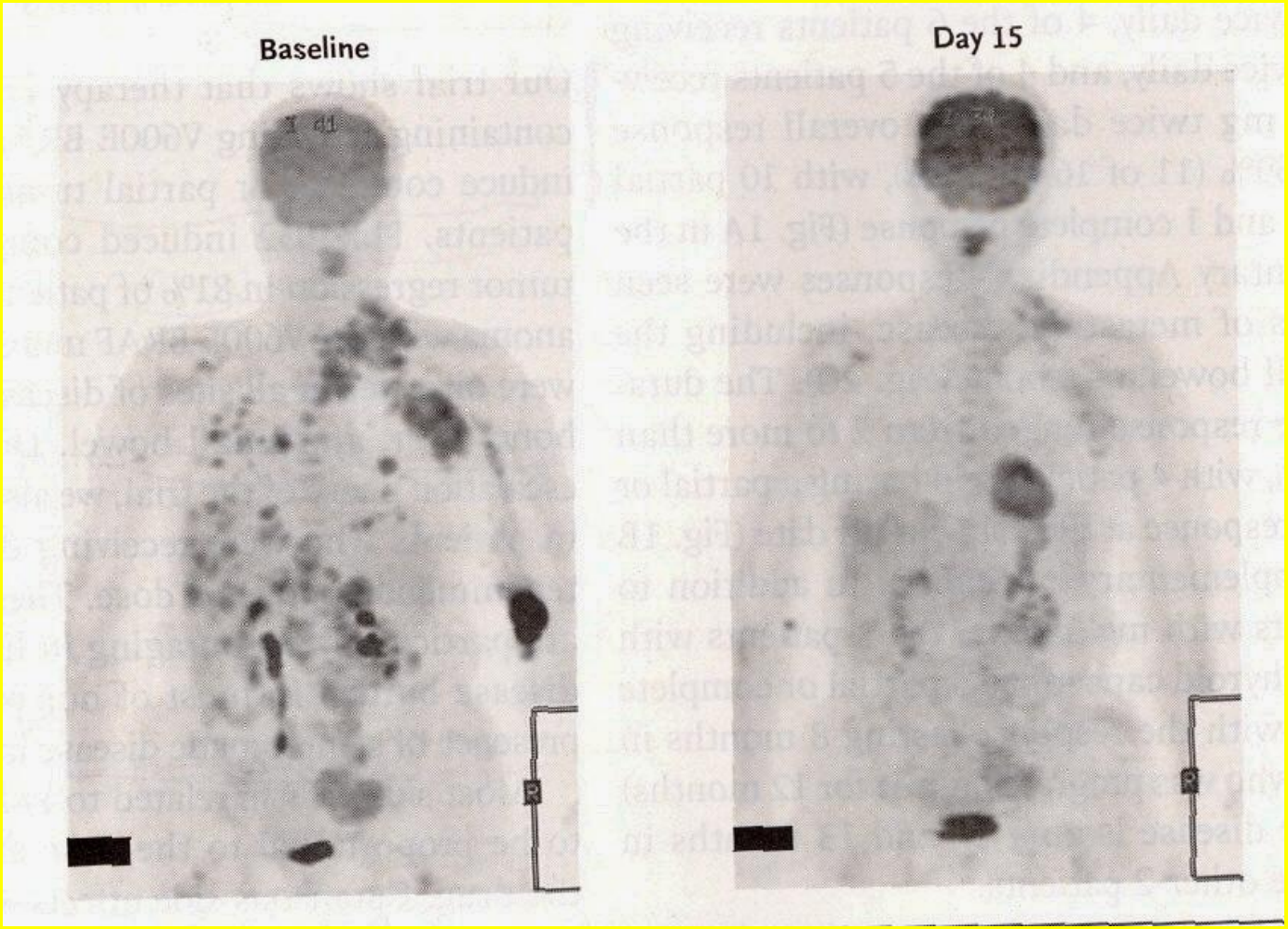
↑ **Cancer gene (oncogene)** activity

↓ **Tumor suppressor gene**

Bottom line:

1. **Genes** control **metabolism**
2. Understanding how cancer genes work
3. **Shut down cancers**

New drugs developed: shut down cancer metabolism: shrink/stop tumors



Before pills After

(Pet Scans)