الكيمياء الغذائية

Food Compositions

Macro and Micronutrients

- Water
- Calories (Protein,Carbohydrats,Fat)

Macro

- 8-10 Essential Amino acid
- Essential Fatty Acids
- 13 Vitamins
- 16-20 Minerals

Micro

Complex System, Many Food Interests

Inputs

Farm

Transport

Mill / Slaughter / Food Processor

Transport/Imports

Restaurant/Retail

Consumer

Food can be contaminated at any point, from farm inputs to fork.

Photo: www.bcsalmon.ca/bcsmc/ffact2.htm

GOALS OF FOOD CONTROL

- Determination of nutritional value
- Determination of food composition
- Determination of toxic substances
- Quality control
- Detection of fraud
- Detection of contaminants
- Determination of intermediate substances
- Ensuring standards are met

Potential Contaminants in Food

- Microbes and microbial toxins
  - Salmonella, *Clostridium botulinum*
- Chemicals
  - Cleaners, pesticides
- Physical hazards
  - Glass, Radioactive contaminants

Quality and safety attributes:

Food must be free of any harmful chemical or microbial contaminant at the time of its consumption.

A list of quality attributes of food and some alterations they can undergo during processing and storage is given in this table:

Attribute	*Alteration*
Texture	Loss of solubility Loss of water holding capacity Toughening Softening
Flavor	Development of: Rancidity Off flavor Desirable flavor

Color	Darkening Bleaching Development of other off-colors Development of desirable colors (browning in backed goods)
Nutritive value	Loss, degradation or altered bioavailability of proteins. Lipids, vitamins, minerals
Safety	Generation of toxic substances

Chemical and biochemical reactions

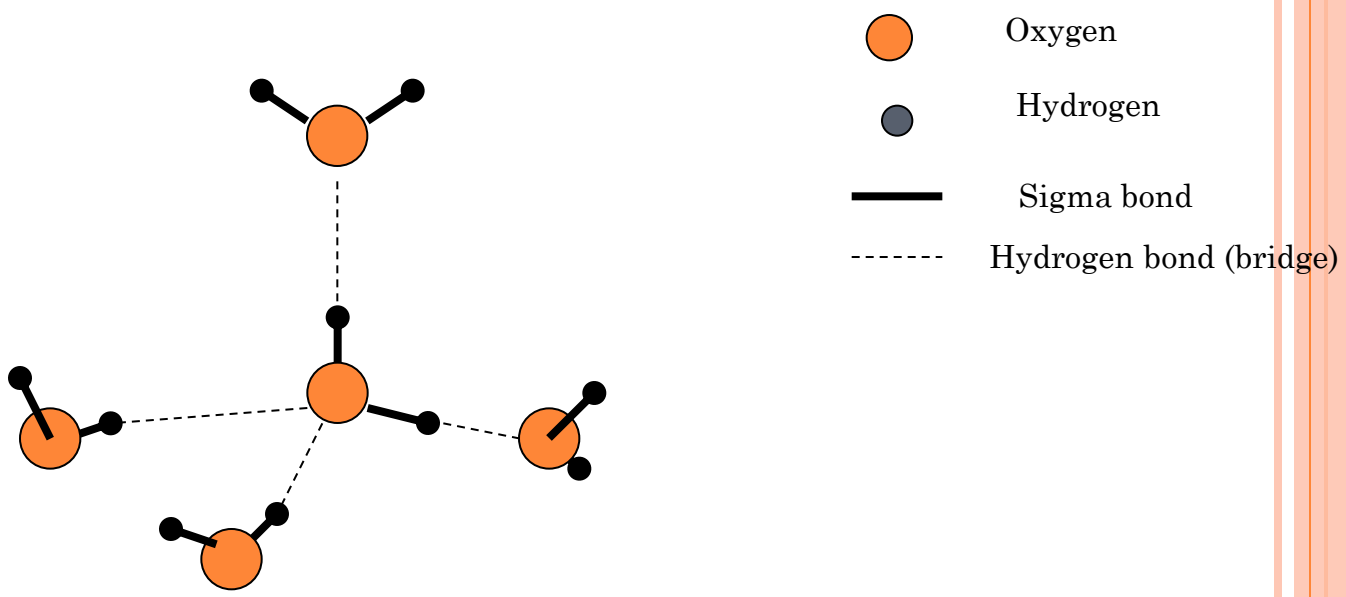
Types of reaction	*Examples*
Nonenzymatic browning	Baked goods
Enzymatic browning	Cut fruits
Oxidation	Lipids (off-flavors), vitamin degradation, proteins (loss of nutritive value)
Hydrolysis	Lipids, proteins, vitamins, carbohydrates
Metal interaction	Complexation, catalysis of oxidation

Types of reaction	*Examples*
Lipid isomerization	Cis-trans
Lipid cyclization	Monocyclic fatty acids
Lipid polymerization	Foaming during deep fat frying
Protein denaturation	Egg white coagulation, enzyme inactivation

Water

Water is an essential constituent in all foods. Fruits and vegetables have higher water content while dried pulses and cereals have a lesser amount. Water content has a very significant effect on the different quality parameters of food like appearance, skin structure, color and flavor. Water is mainly responsible for the changes that the foods undergo on cooking. Due to its unique H-bonding capability its role in foods is unique.

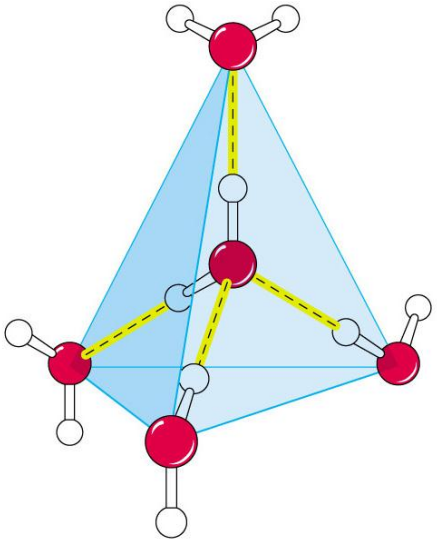
Water functions in the body

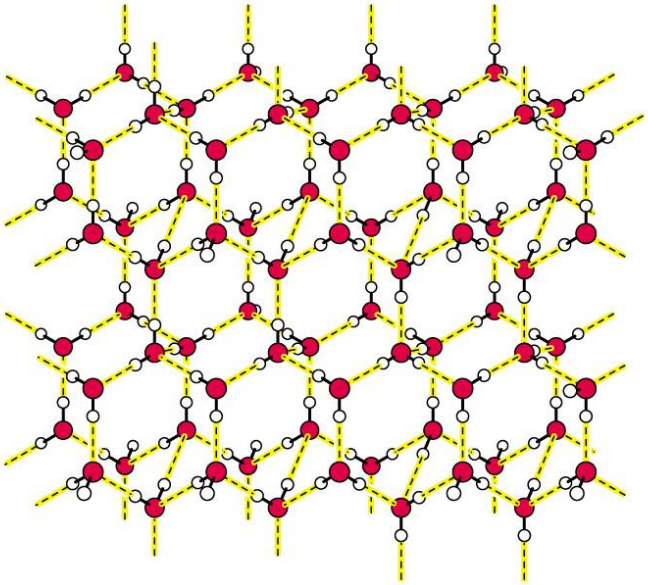


Tetrahedral coordination of water molecule

Hydrogen Bonding of Water

One H_2O molecule can associate with 4 other H_20 molecules

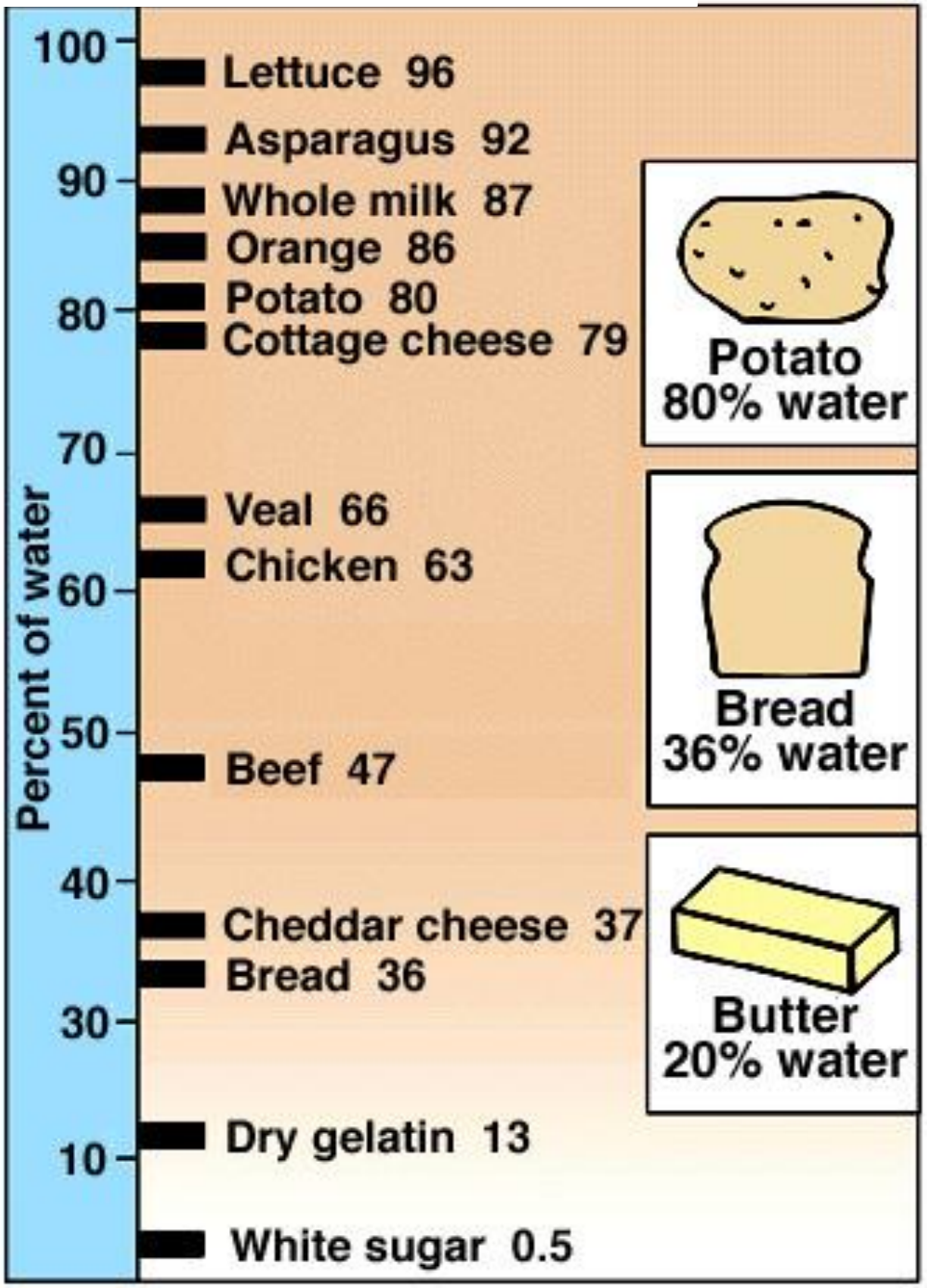




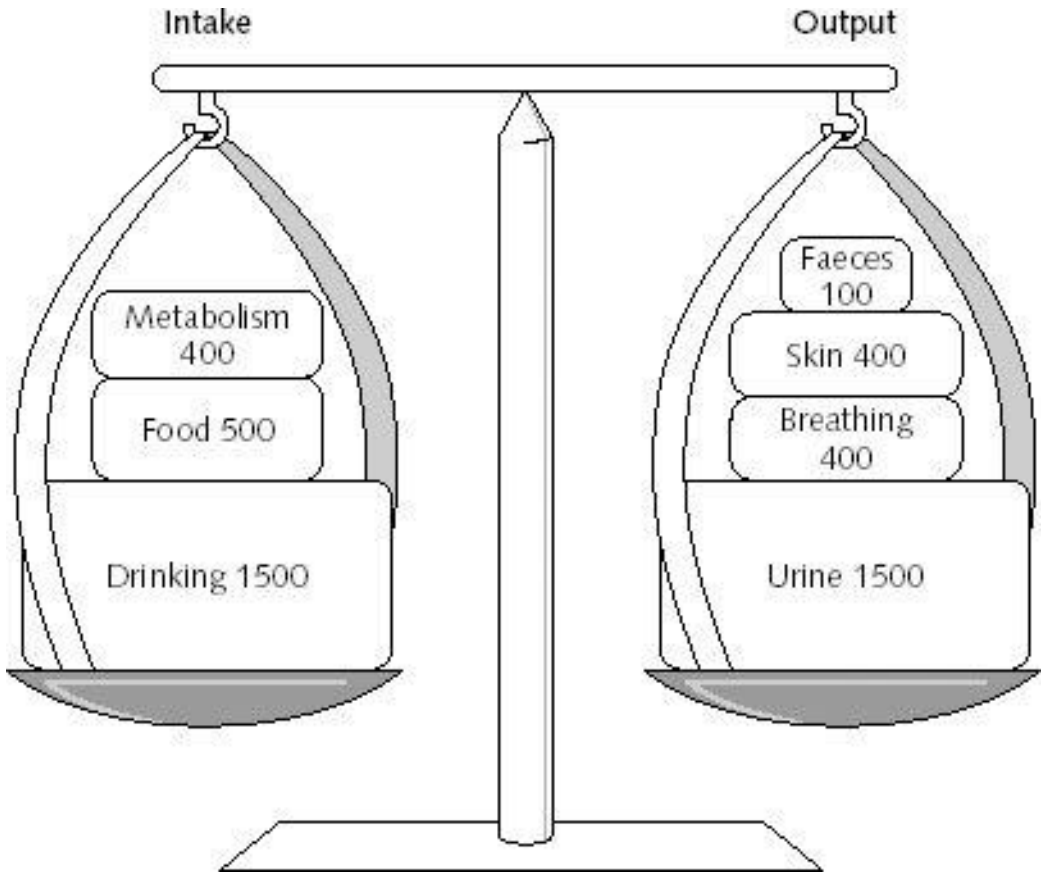
Crystal lattice of ice

Ice: 4 H-bonds per water molecule
Water: 2.3 H-bonds per water molecule

Water Content in Food



Water balance



WATER ACTIVITY:

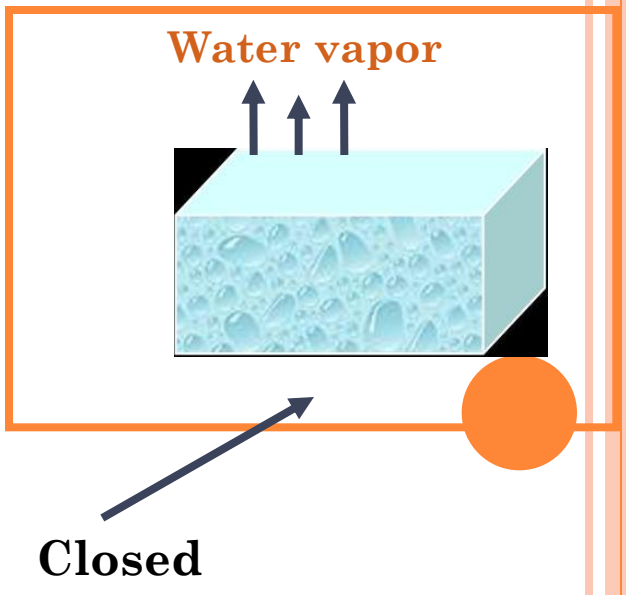
The storage quality of food does not depend on the water content, but on water activity (aw), which is defined as follows:

$$a_w = p_f / p_w = \text{ERH}/100$$

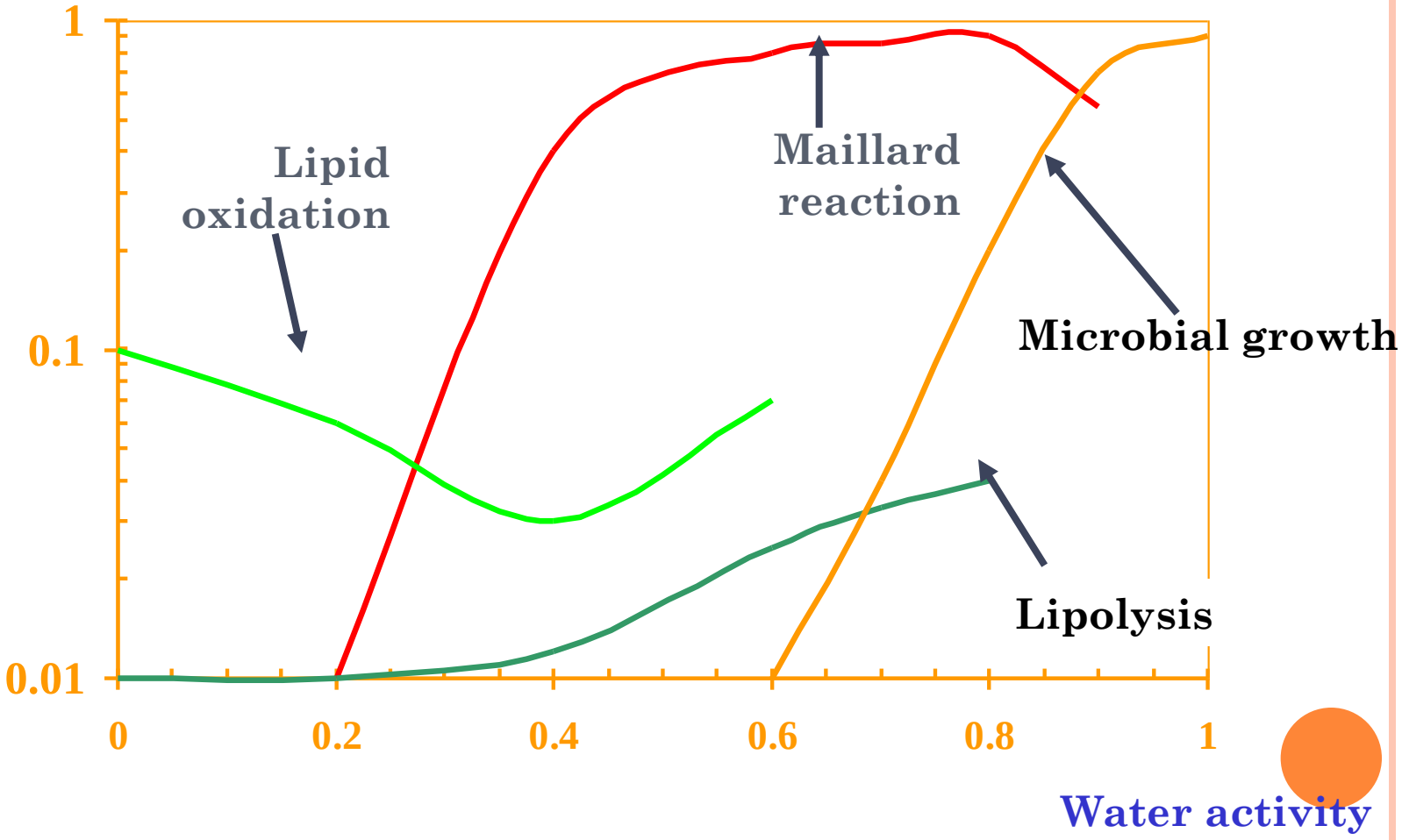
pf = partial vapor pressure of food moisture at temperature T

pw = saturation vapor pressure of pure water at T

ERH = equilibrium relative humidity at T.



The effect of water activity on processes that can influence food quality is presented in the following fig.

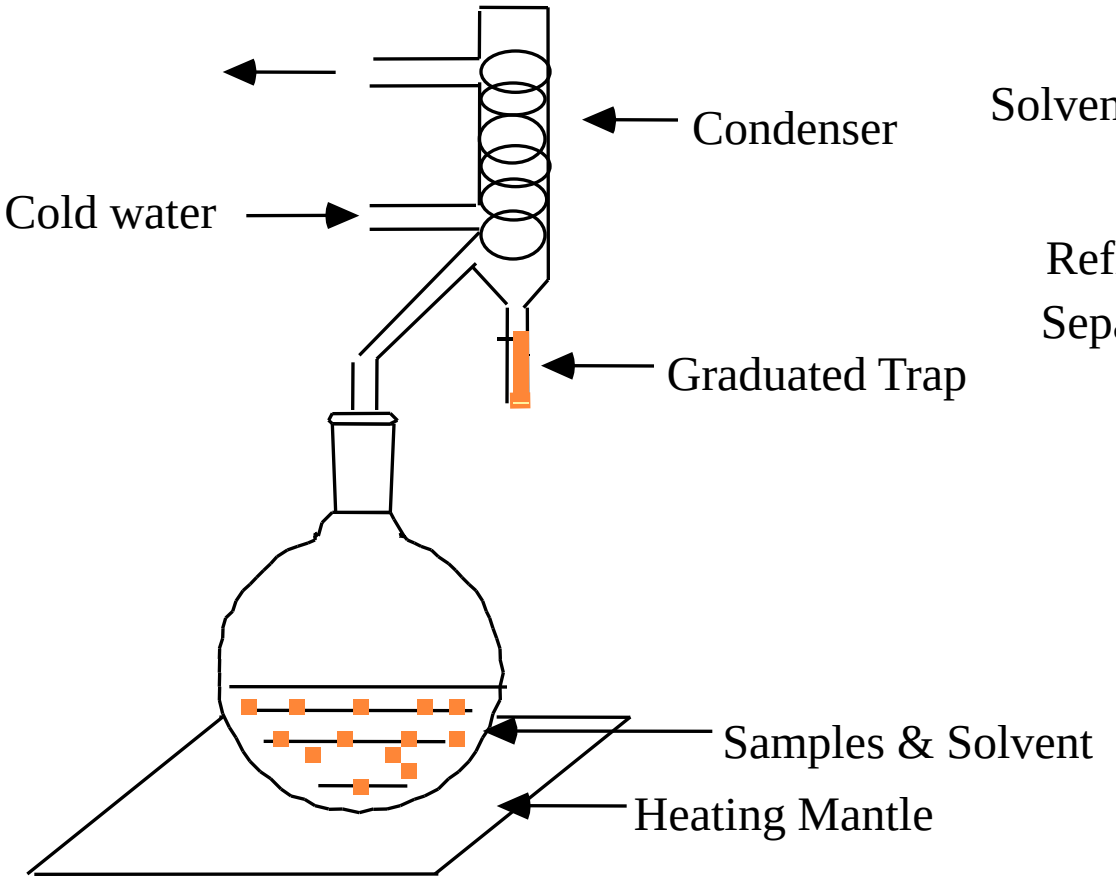


Moisture determination methods:

1- Oven Drying Methods:

DISTILLATION METHOD

DEAN & STARK طريقة دين وستارك



Solvent → Toluene

Refluxing & Water Separation Method

3-Karl Fischer titration:

This method is based on the fundamental reaction involving the reduction of iodine by SO_2 in the presence of water:

$$2H_2O + SO_2 + I_2 \longrightarrow H_2SO_4 + 2HI$$

4- Dielectric Method:

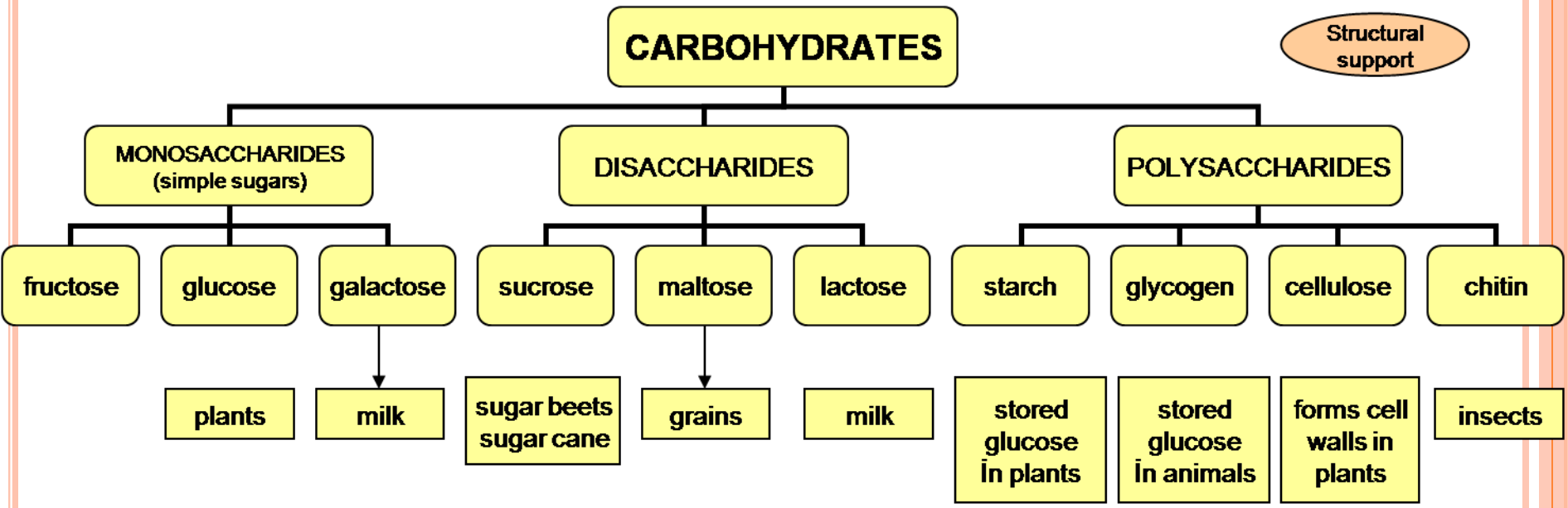
Water content of certain foods can be determined by measuring the change in capacitance or resistance to an electric current passed through a sample.

$$C = \varepsilon \frac{D}{A}$$

C = Capacitator capacity
D = Capacitator surface
A = Distance between capacitator surface
ε = dielectric constant

Carbohydrates

CARBOHYDRATES


CARBOHYDRATES
Structural support
MONOSACCHARIDES (simple sugars)
DISACCHARIDES
POLYSACCHARIDES
fructose
glucose
galactose
sucrose
maltose
lactose
starch
glycogen
cellulose
chitin
plants
milk
sugar beets sugar cane
grains
milk
stored glucose İn plants
stored glucose İn animals
forms cell walls in plants
insects

Classification

simple carbohydrats

- **Number of Carbons**

1- Trioses $C_3H_6O_3$ e.g. glyceraldehyde

2- Tetroses $C_4H_8O_4$ e.g. erythrose

3- Pentoses $C_5H_{10}O_5$ e.g. ribose

4- Hexoses $C_6H_{12}O_6$ e.g. glucose, Galactose, fructose, mannose.

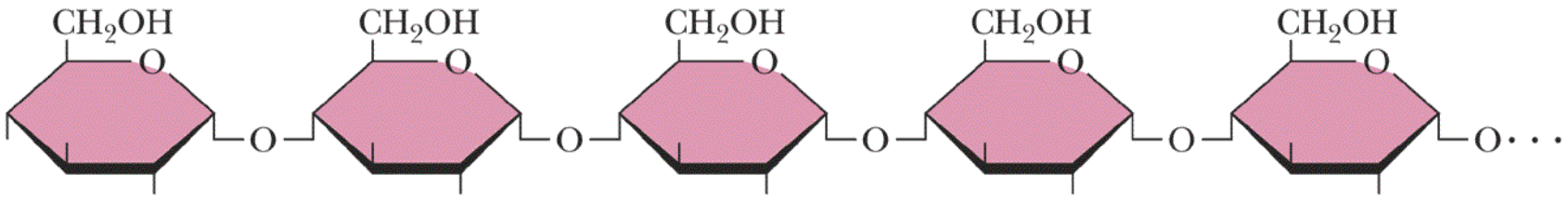
5- Heptoses

6- Octoses

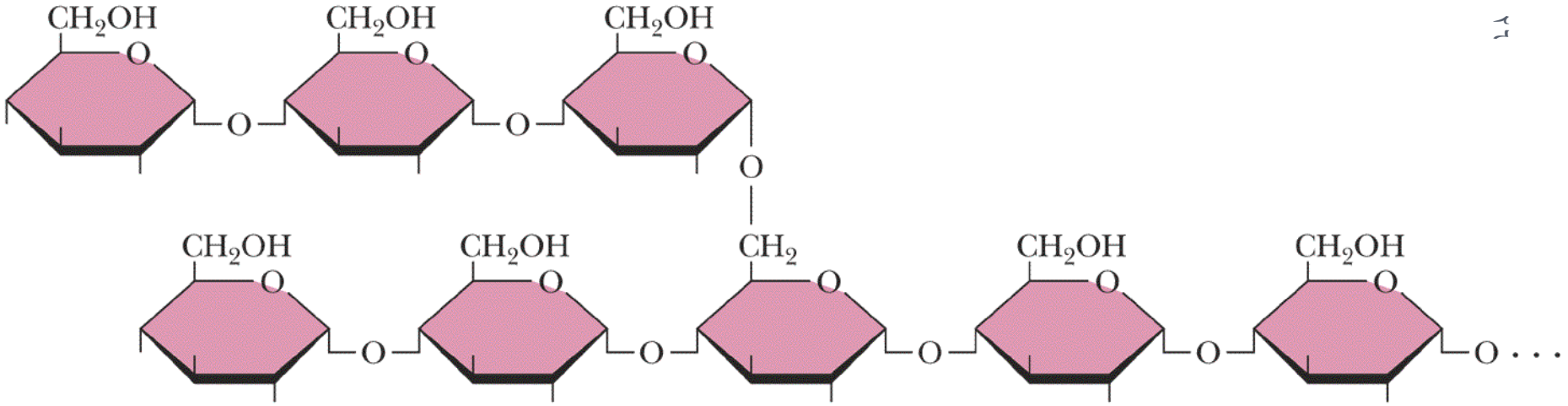
- **According to Functional Groups**

  -Aldoses

  -Ketoses



Amylose



Amylopectin

Amylose and amylopectin are the 2 forms of starch. Amylopectin is a highly branched structure, with branches occurring every 12 to 30 residues

Relative Sweetness of Sugars

Sucrose	100
Glucose	74
Fructose	174
Lactose	16
Invert Sugar	126
Maltose	32
Galactose	32

Glycemic Index of Foods

- The effect a food has upon the rate & amount of increase in blood glucose
- Foods high in refined sugar have high GI

High GI	Medium GI	Low GI
Glucose	All Bran cereal	Fructose
Sucrose	Banana	Apple
Maple syrup	Grapes	Cherries
Bagel	Oatmeal	Kidney, navy beans
Corn flakes	Orange juice	Lentils, chick peas
Carrots, Potatoes	Pasta & rice	Dates & figs
Bread, crackers	Yams	Peaches, plums
Raisins	Corn	Ice cream
Gatorade, soda	Baked beans	Milk & yogurt

CARBOHYDRATE DETERMINATION

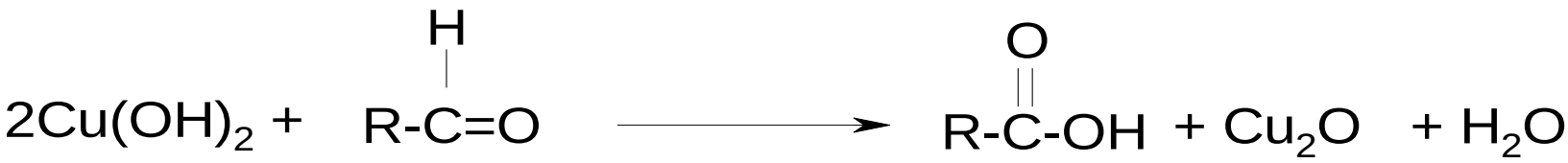
CARBOHYDRATE DETERMINATION

1. **Monosaccharides and Oligosaccharides**
   - A- Reducing mthods
   - B - Polarimetry
   - C. Enzymatic Methods
     1. Glucose oxidase
     2. Hexokinase
   - D. Chromatography Method
     1. Paper or thin layer chromatography
     2. Gas chromatography
     3. Liquid column chromatography
2. Polysaccharides

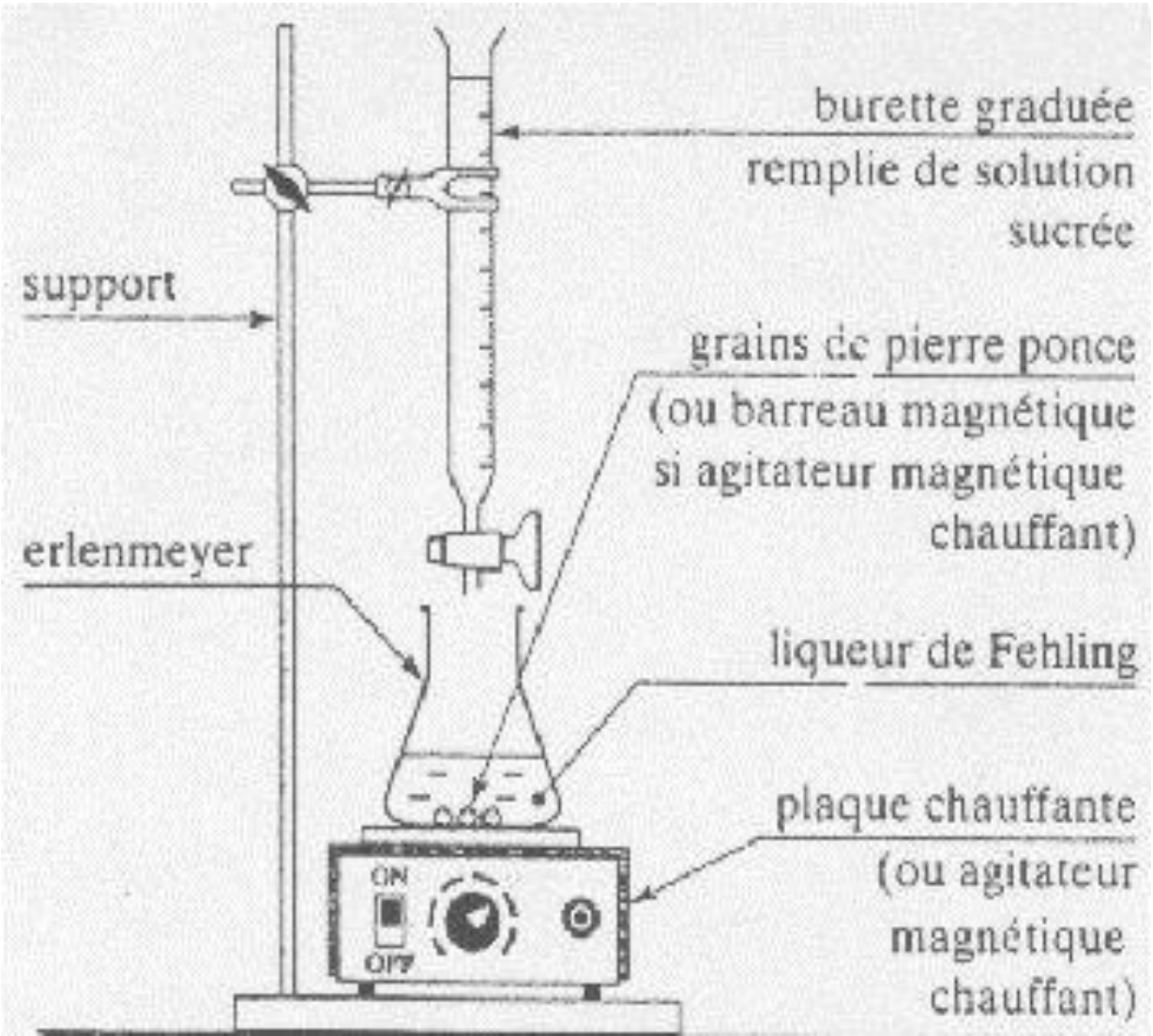
Reducing methods Principle

Principle:

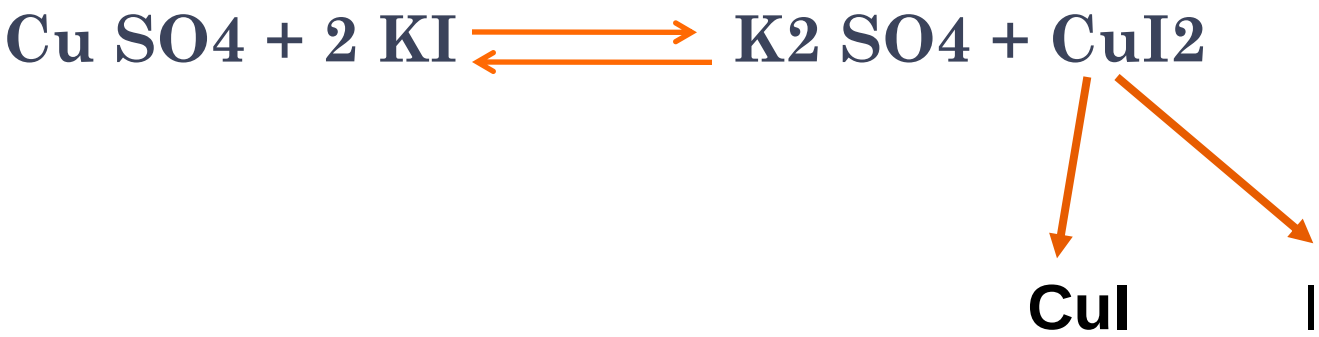
Invert sugar reduces the copper in Fehling-A solution to a brick red insoluble cuprous oxide



Fehling's Method



LUFF -SCHOORL



Bertrand Method:

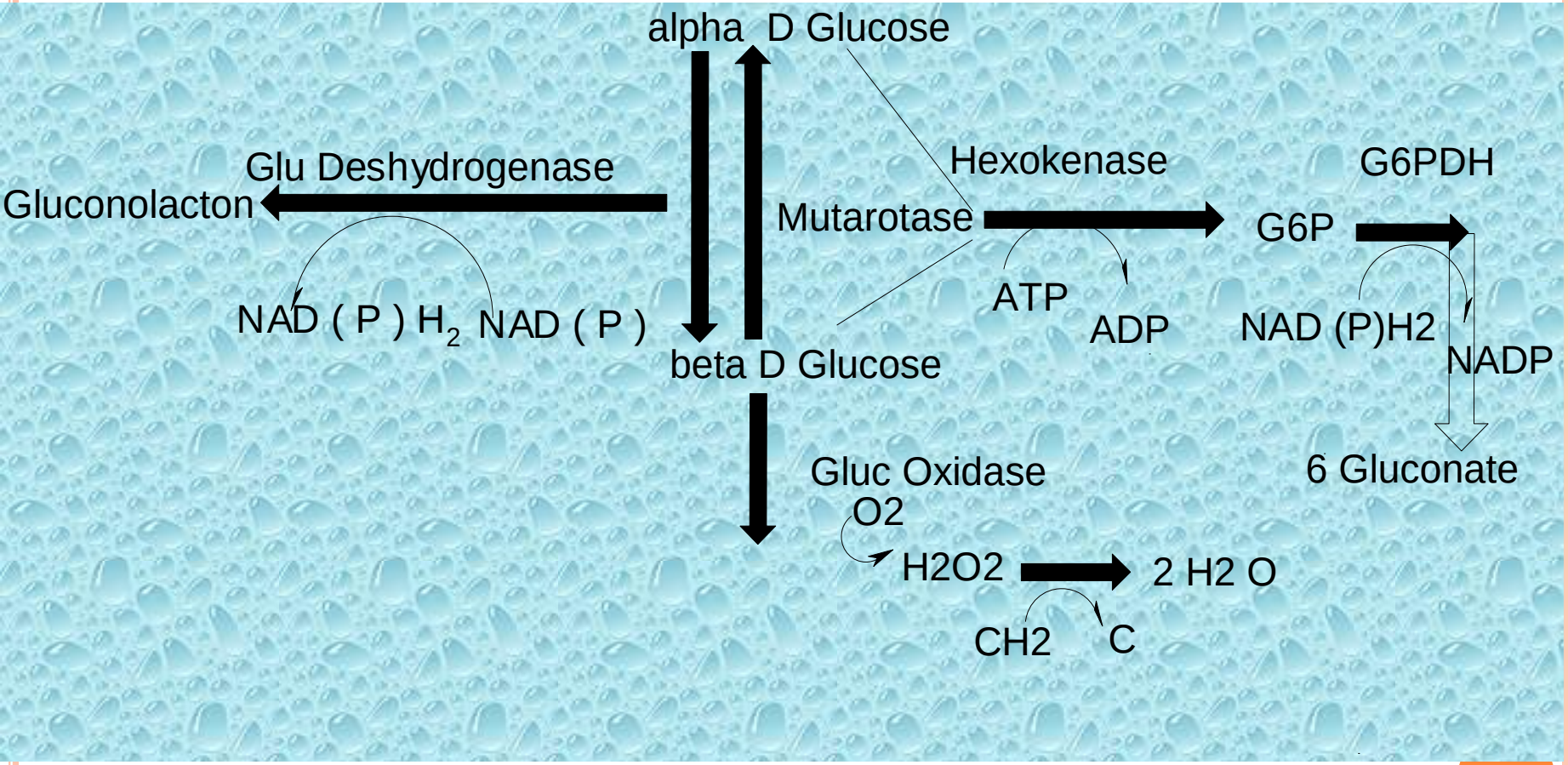
reducing sugar + Cu^{+2} + base $\longrightarrow$ oxidized sugar + Cu_2O

Titration of the cuprous oxide with permanganate:

$Cu_2O + Fe_2(SO_4)_3 \longrightarrow 2\ FeSO_4 + CuSO_4 + CuO$

$10\ FeSO_4 + 2\ KMnO_4 + 8\ H_2SO_4 \longrightarrow 5\ Fe_2(SO_4)_3 + K_2SO_4 + 2\ MnSO_4 + 8\ H_2O$

Enzymatic Methods



Lipids

A family of compounds that includes

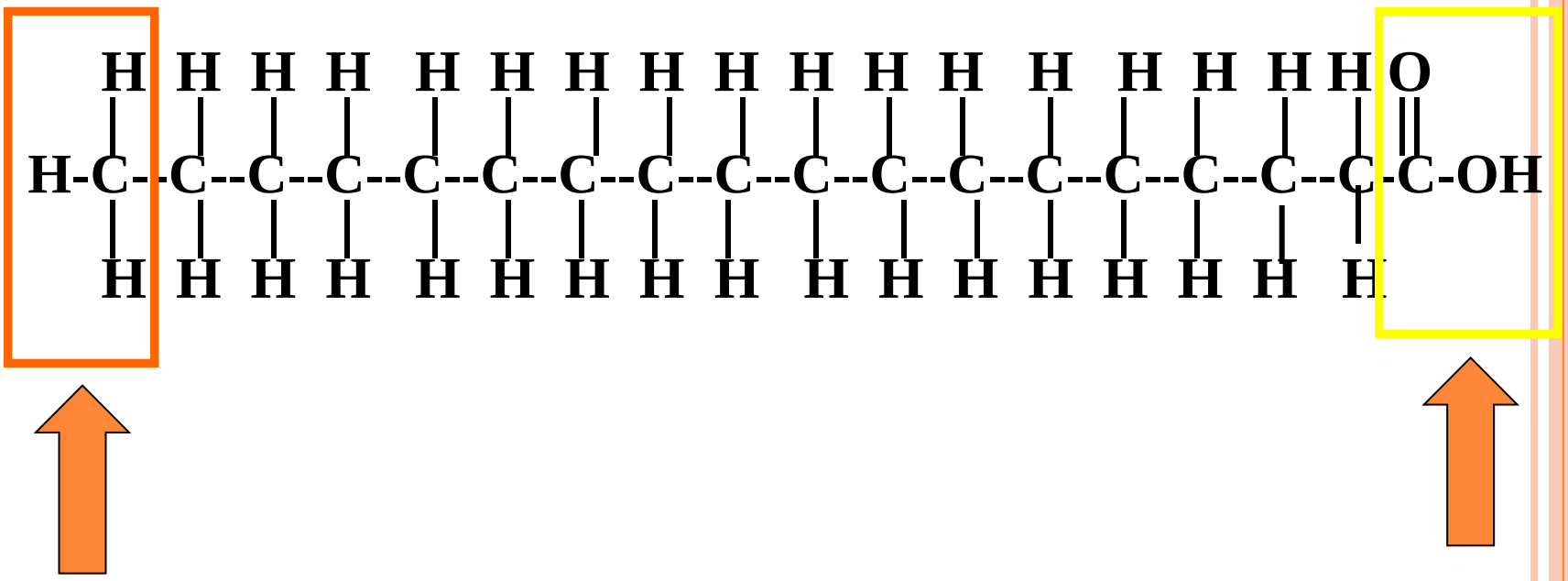
- Triglycerides (fats & oils)

  Fats: lipids that are solid at room temperature

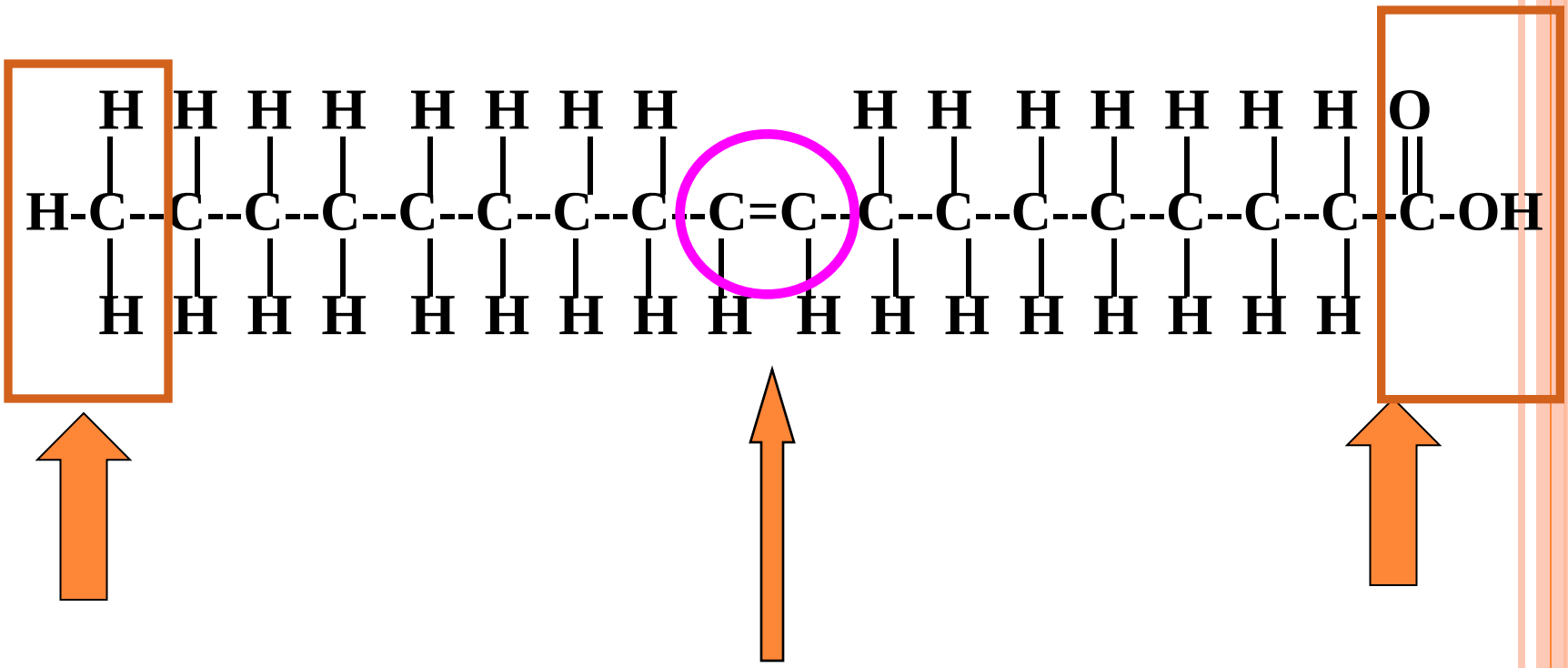
  Oils: lipids that are liquid at room temperature

- Phospholipids
- Sterols (cholesterol).

Fatty acid

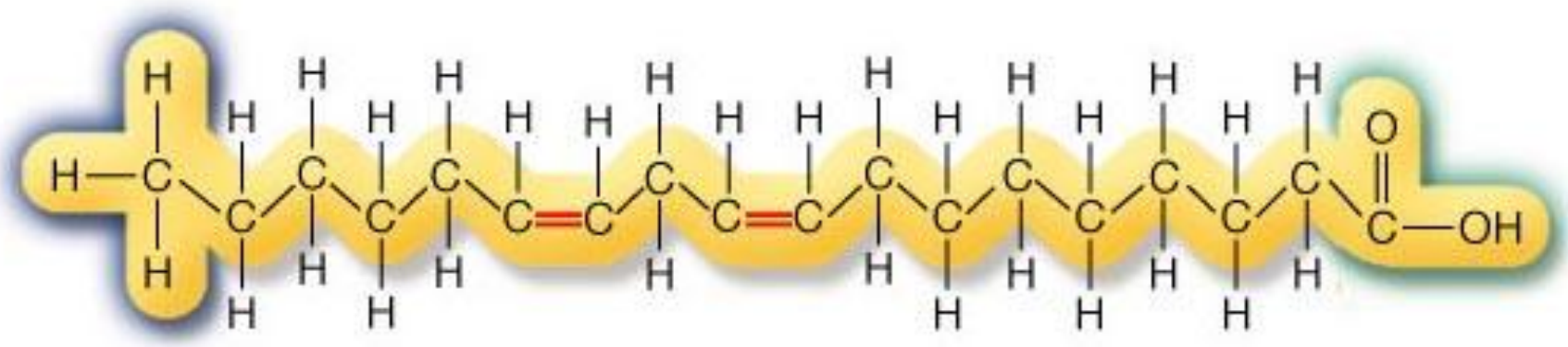

H H H H H H H H H H H H H H H H O
H-C--C--C--C--C--C--C--C--C--C--C--C--C--C--C-C-OH
H H H H H H H H H H H H H H H H

Fatty acids Mono-unsaturated

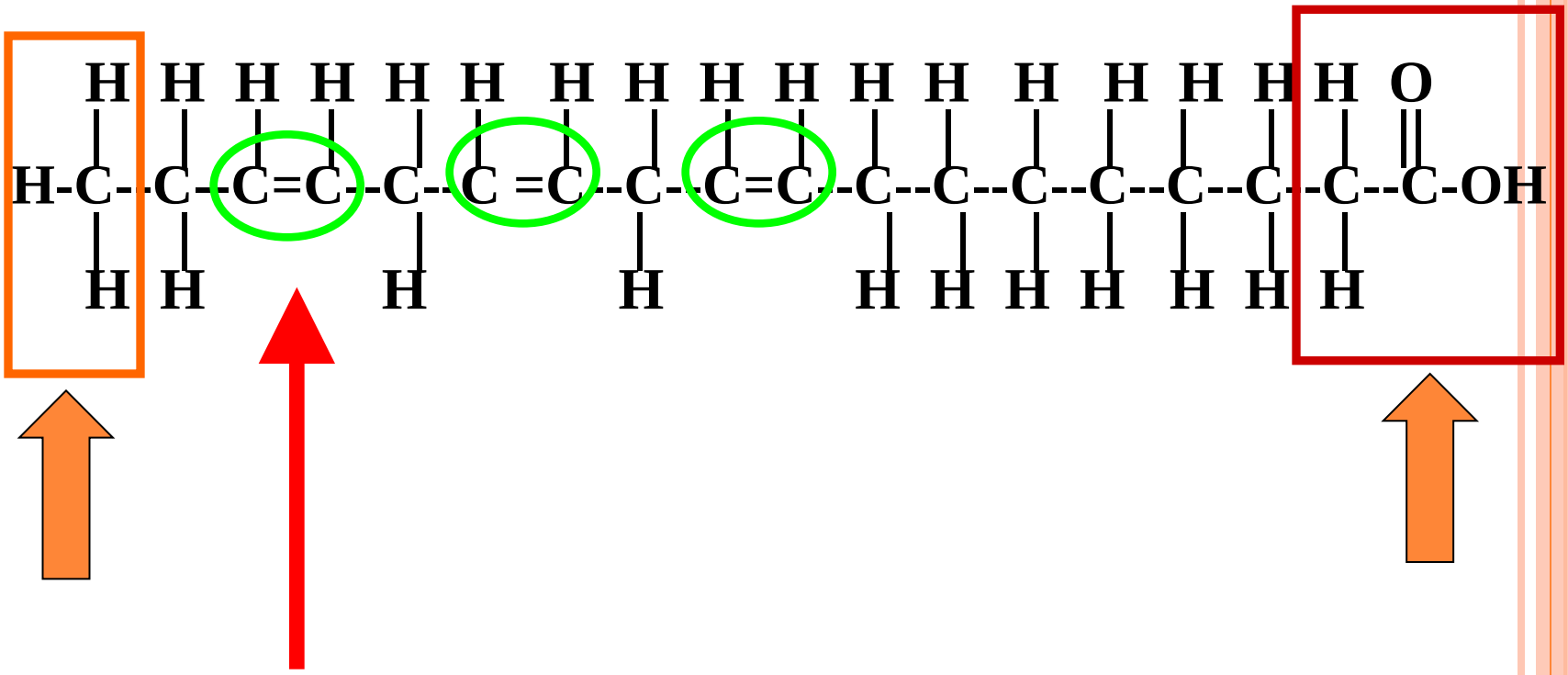


Polyunsaturated Fatty Acid (PUFA)

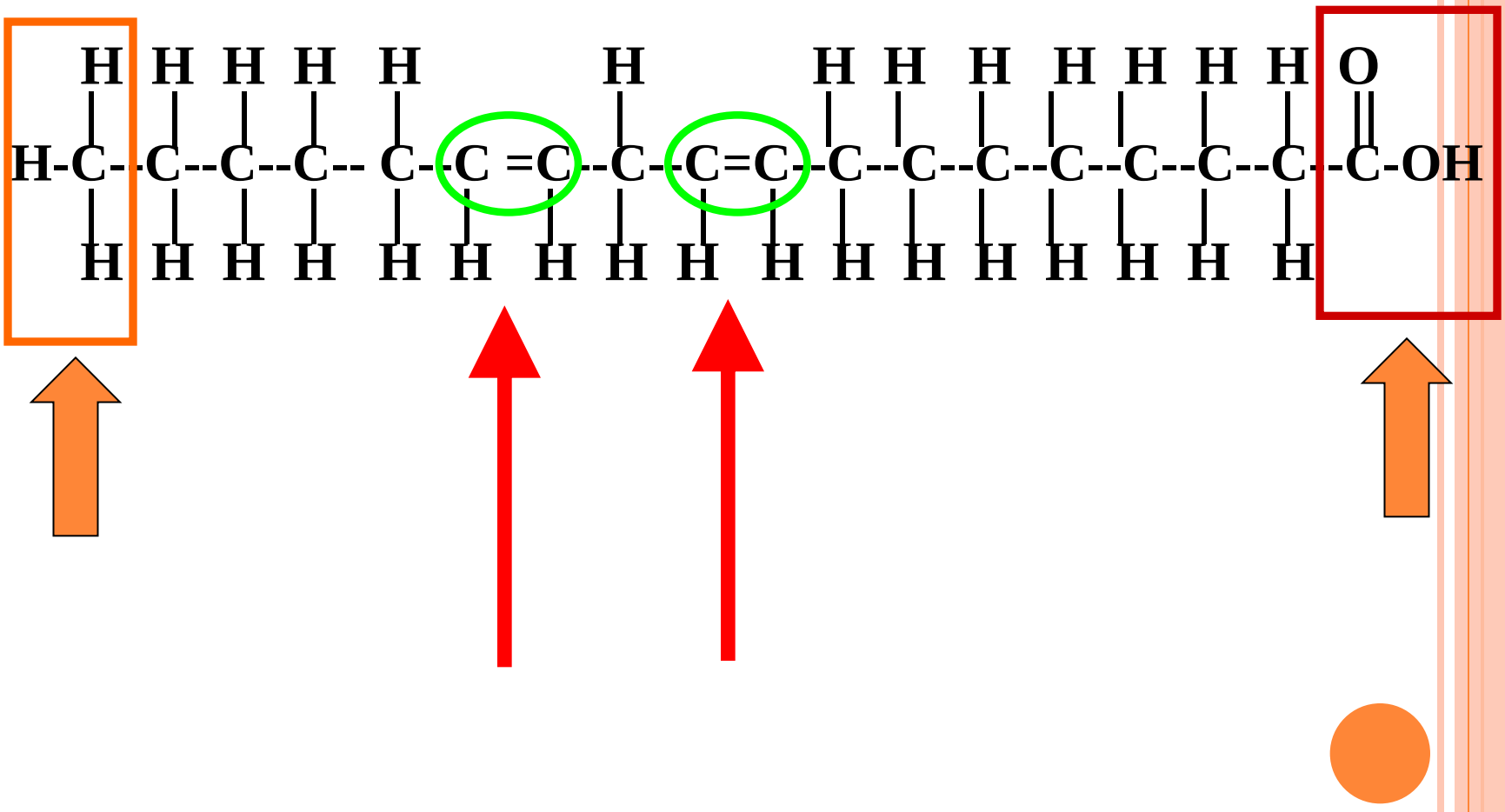
More than one carbon-carbon double bond



Omega-3 (alpha-linolenic acid)



Omega-6 (alpha-linoleic acid)

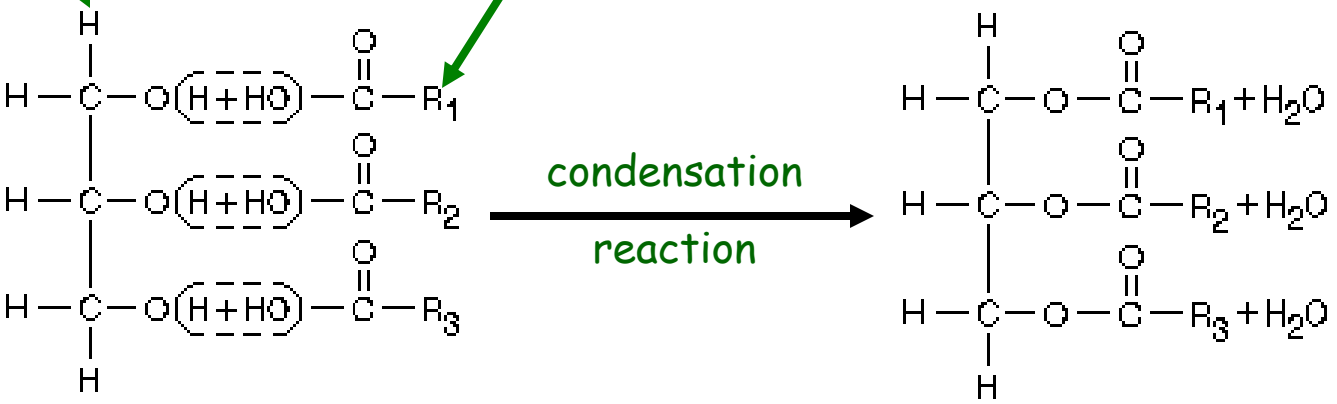


TRIGLYCERIDES

Triglycerides Are Esters of Glycerol and Fatty Acids

Glycerol "backbone" is a water-soluble alcohol

Fatty Acids are chains of carbon atoms with a methyl ($-CH_3$) group at one end and a carboxylic acid ($-COOH$) group at the other

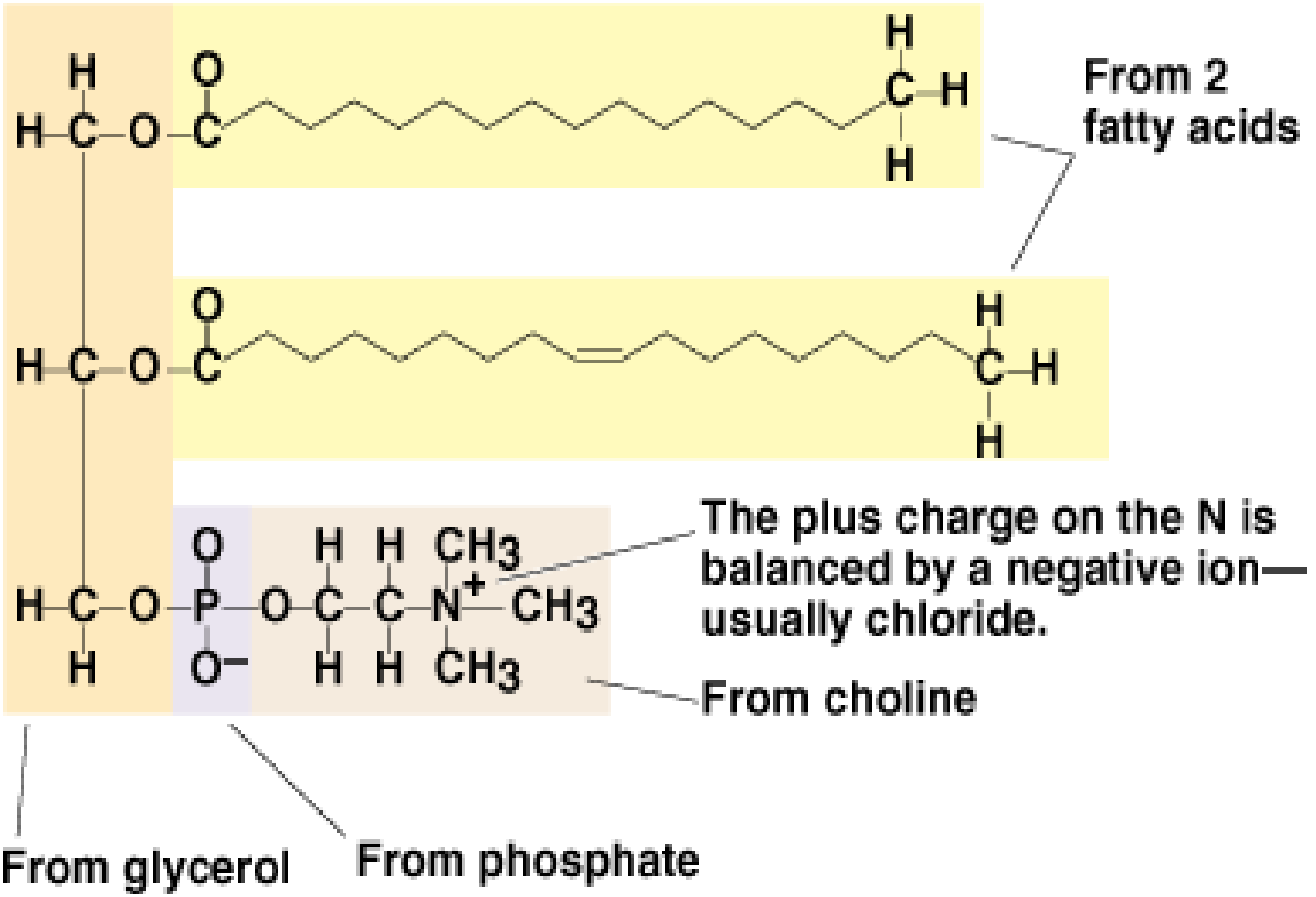


Glycerol + 3 Fatty Acids

Triglyceride + 3 water molecules

Structures linked by ester bonds (R-COOR') and water is released

Phospholipids



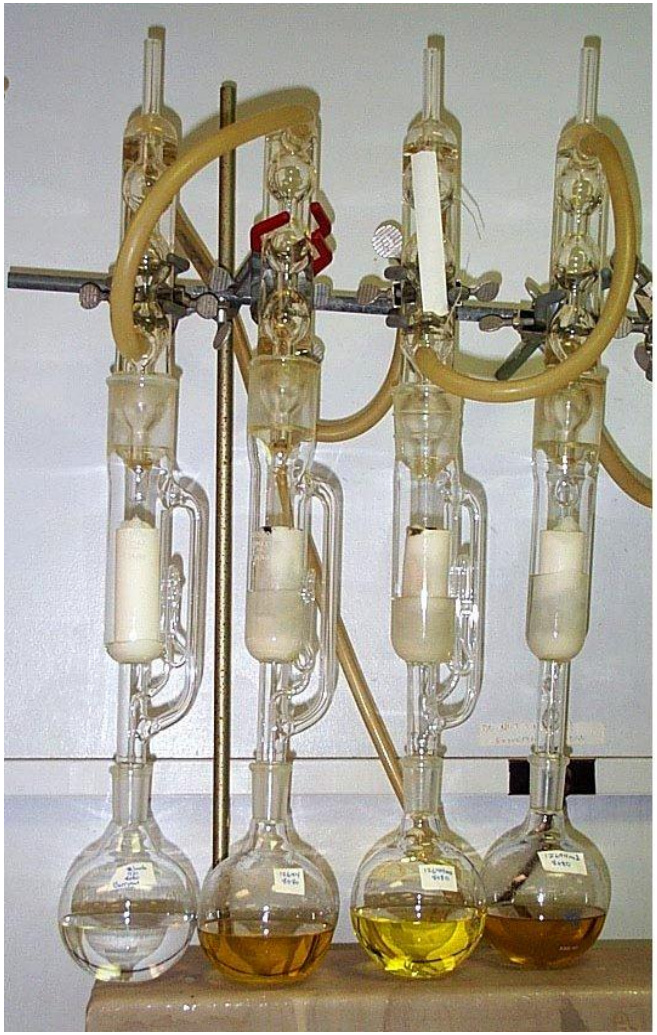
LIPID CONTENT ANALYSES

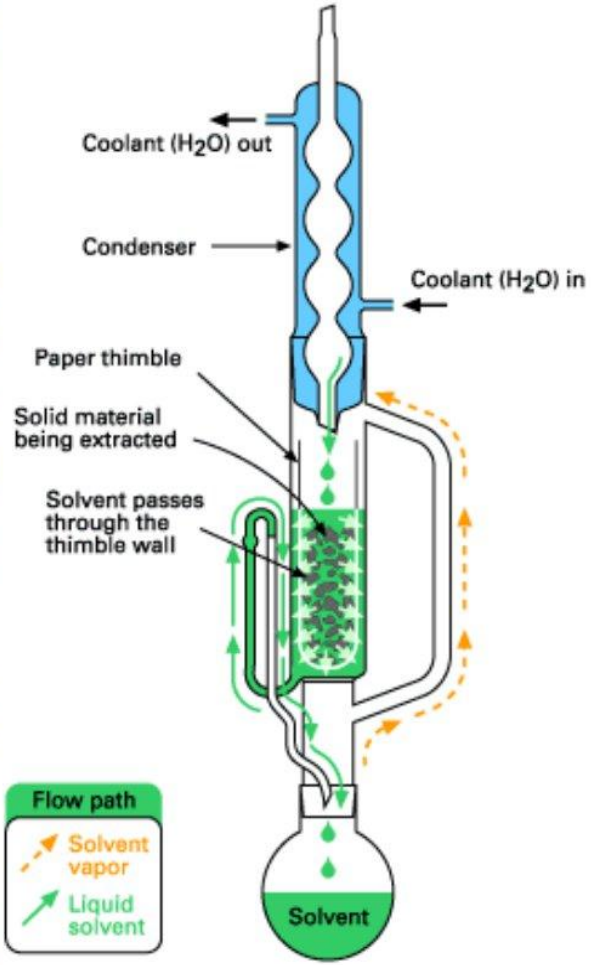
1. Gravimetric Method

   (1) Wet extraction - Roese Gottliegb & Mojonnier.

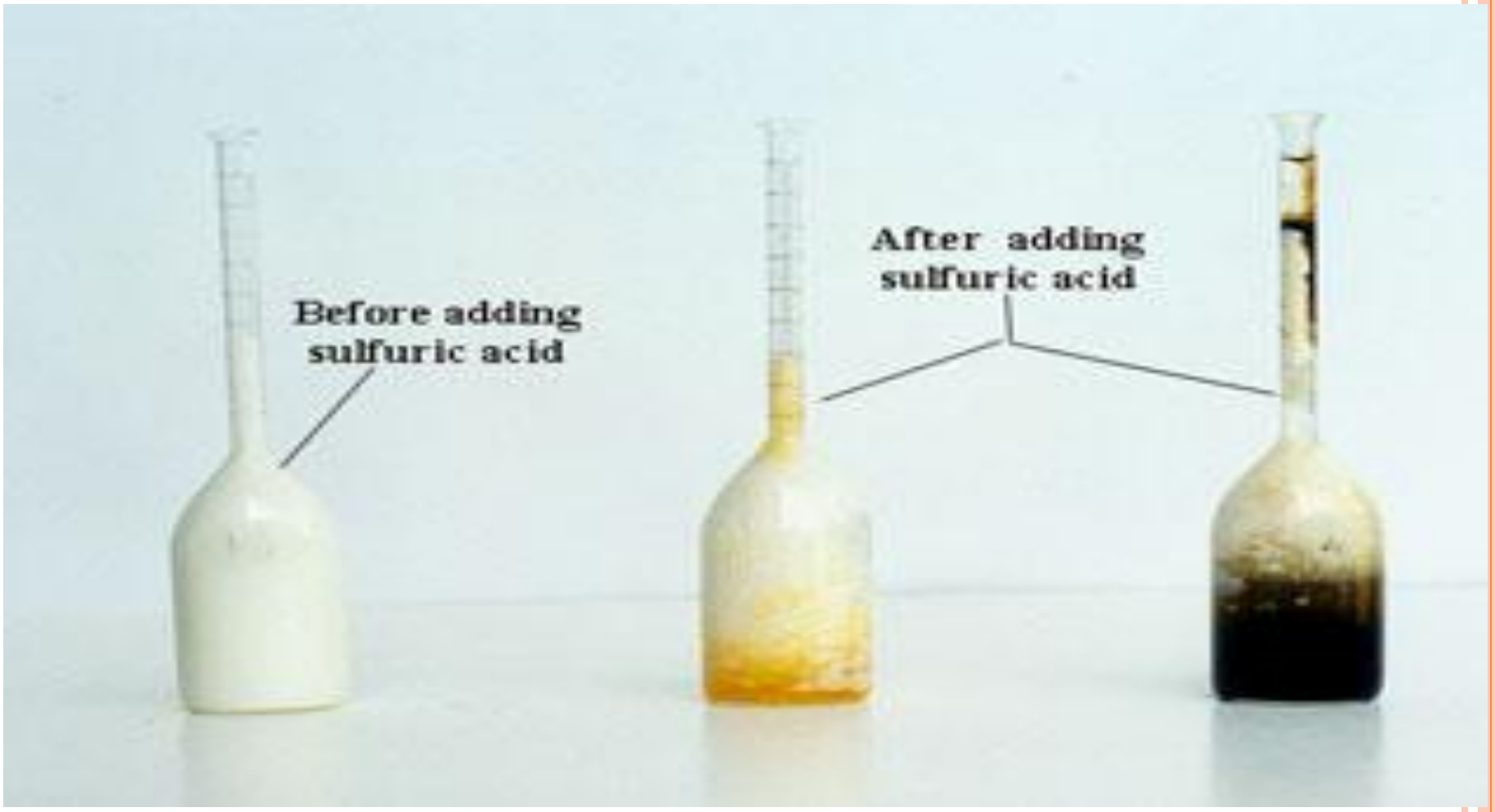
   (2) Dry extraction - Soxhlet Method.

2. Volumetric Methods (Gerber Methods)

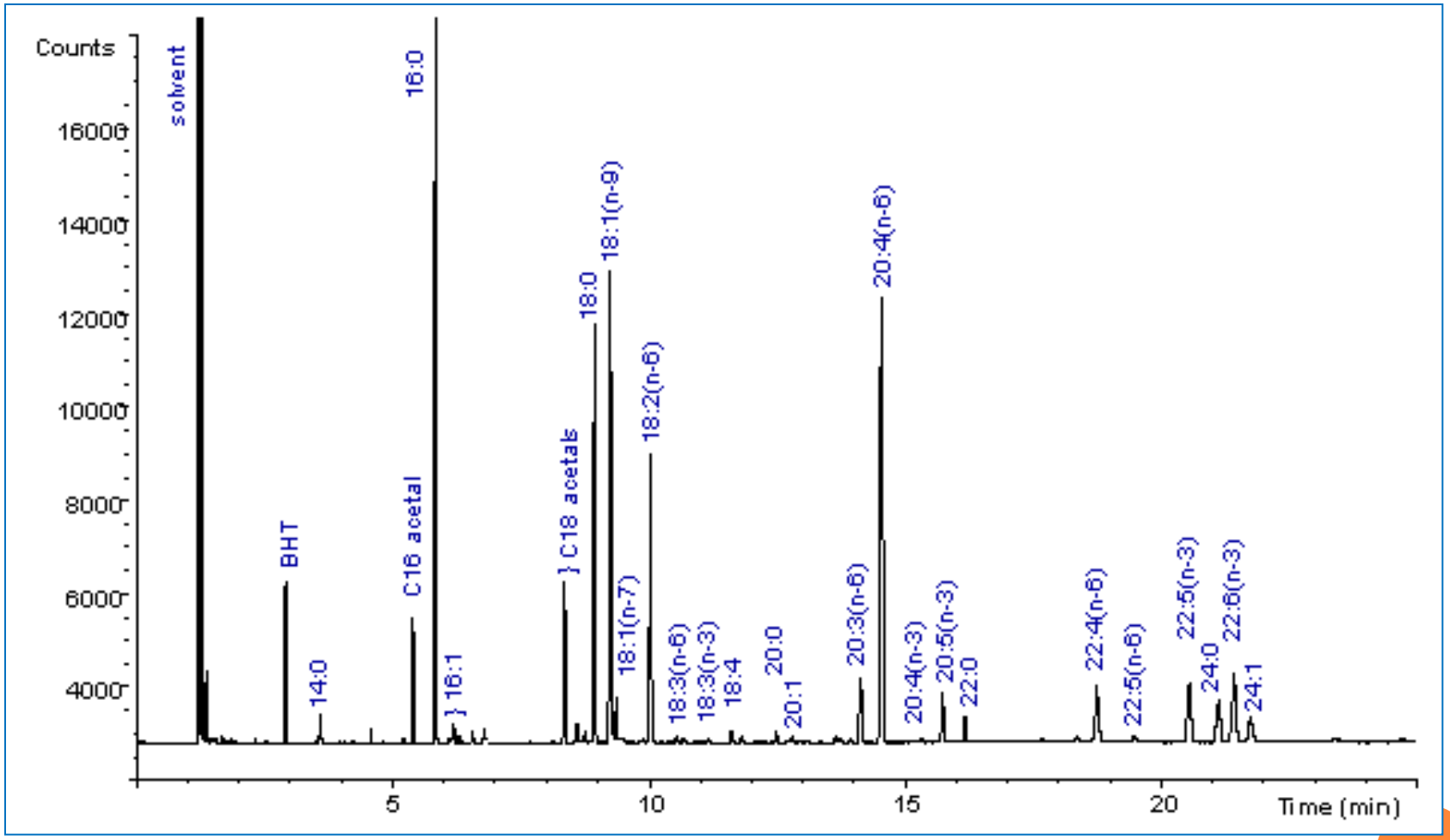



Coolant (H_2O) out
Condenser
Coolant (H_2O) in
Paper thimble
Solid material being extracted
Solvent passes through the thimble wall
Flow path
Solvent vapor
Liquid solvent
Solvent

Gerber Method



Gas Chromatography

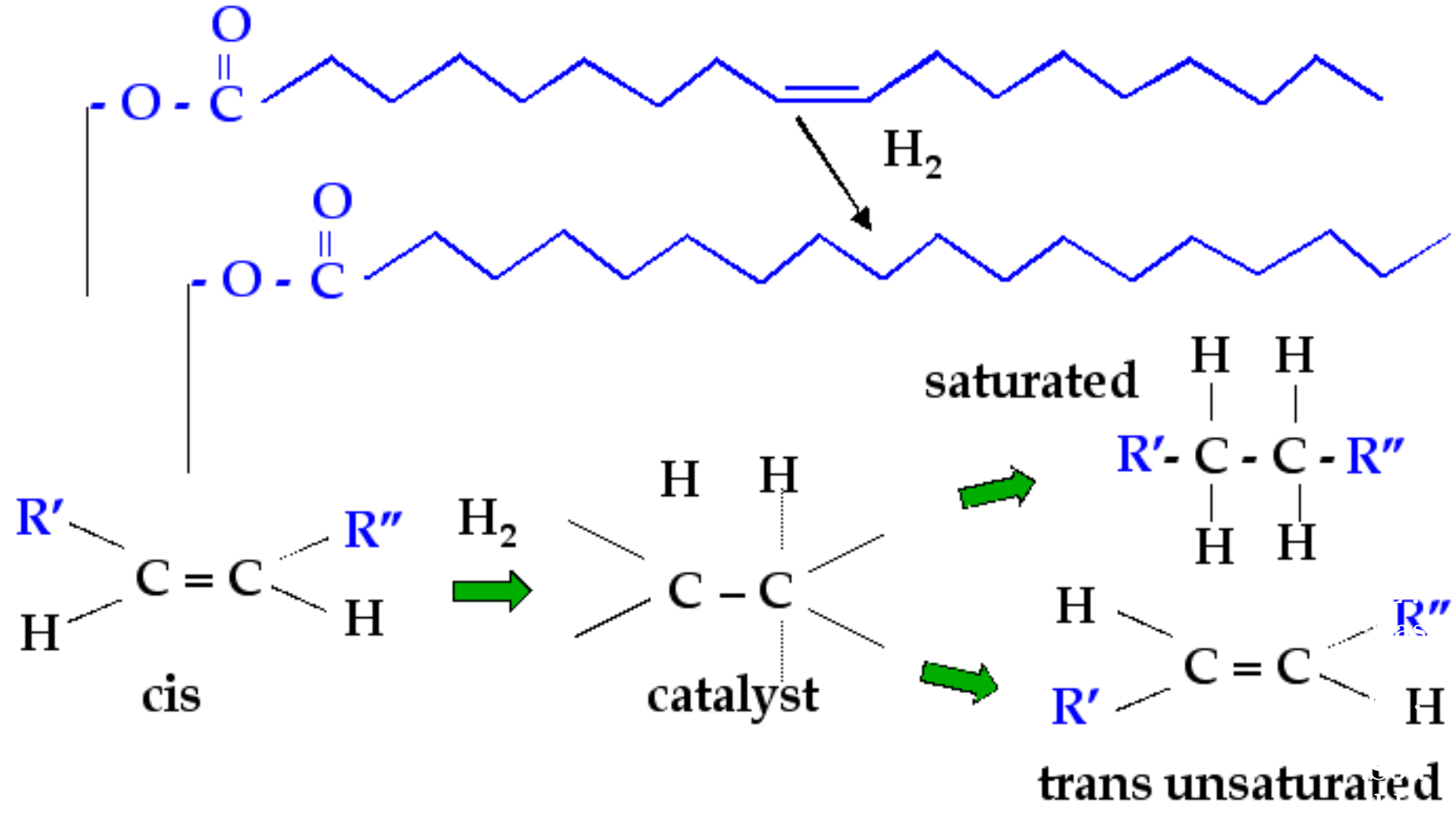


GC condition: 10% DEGS Column (from supelco)

Column temperature 200C.

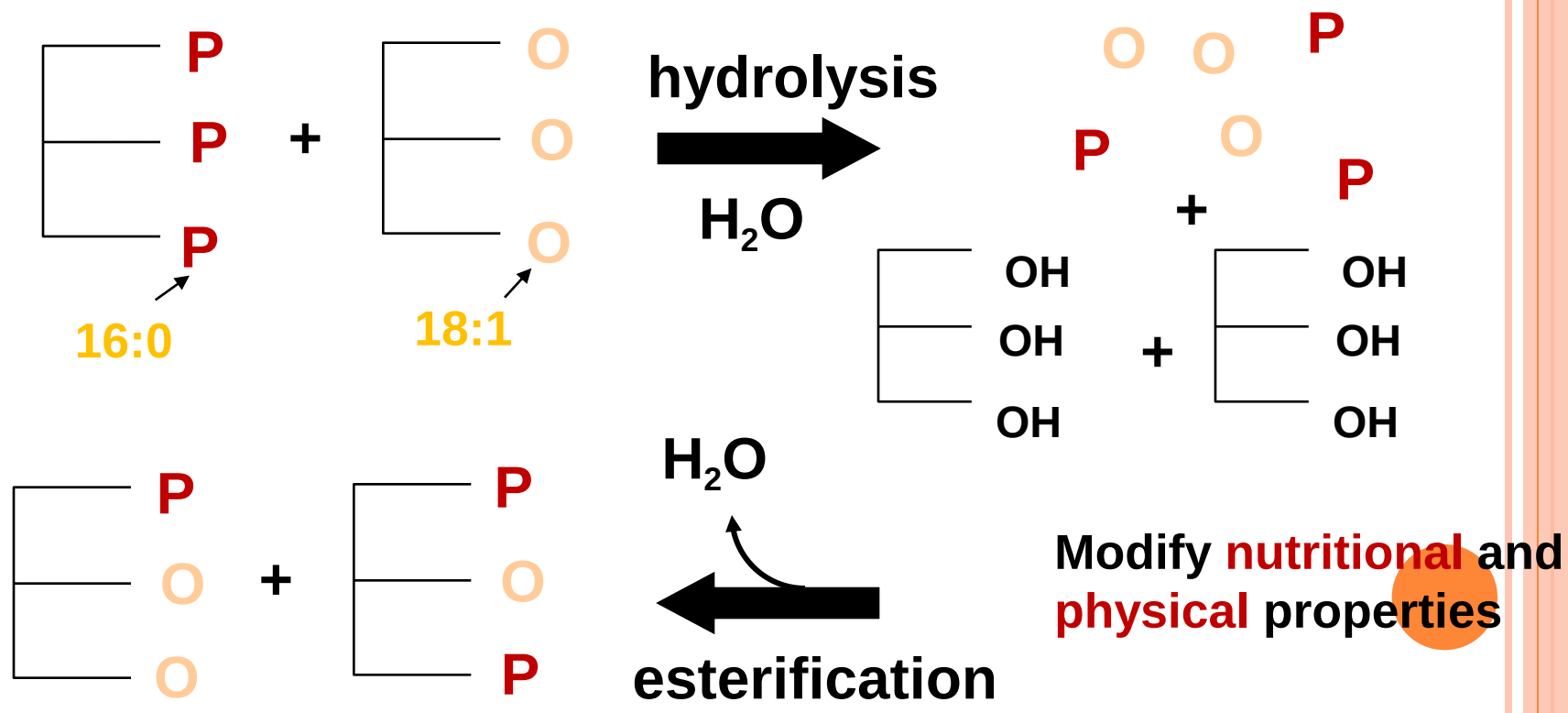
Hydrogenation

- Addition of hydrogen across double bonds



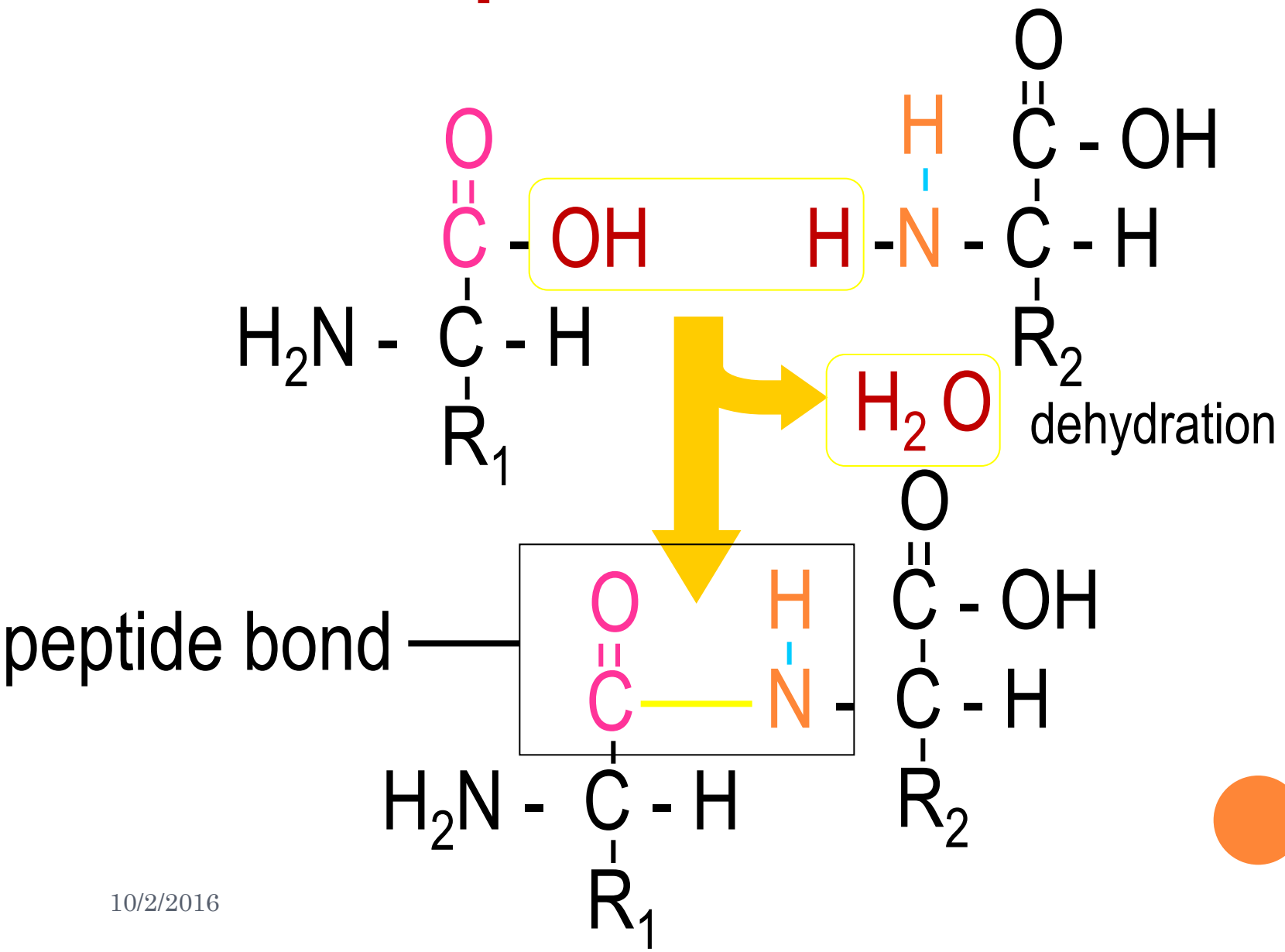
Hydrolysis: Transesterification

- Process to rearrange acyl groups on triglycerides
  - Hydrolyze to remove fatty acids
  - Reattach fatty acids by esterification

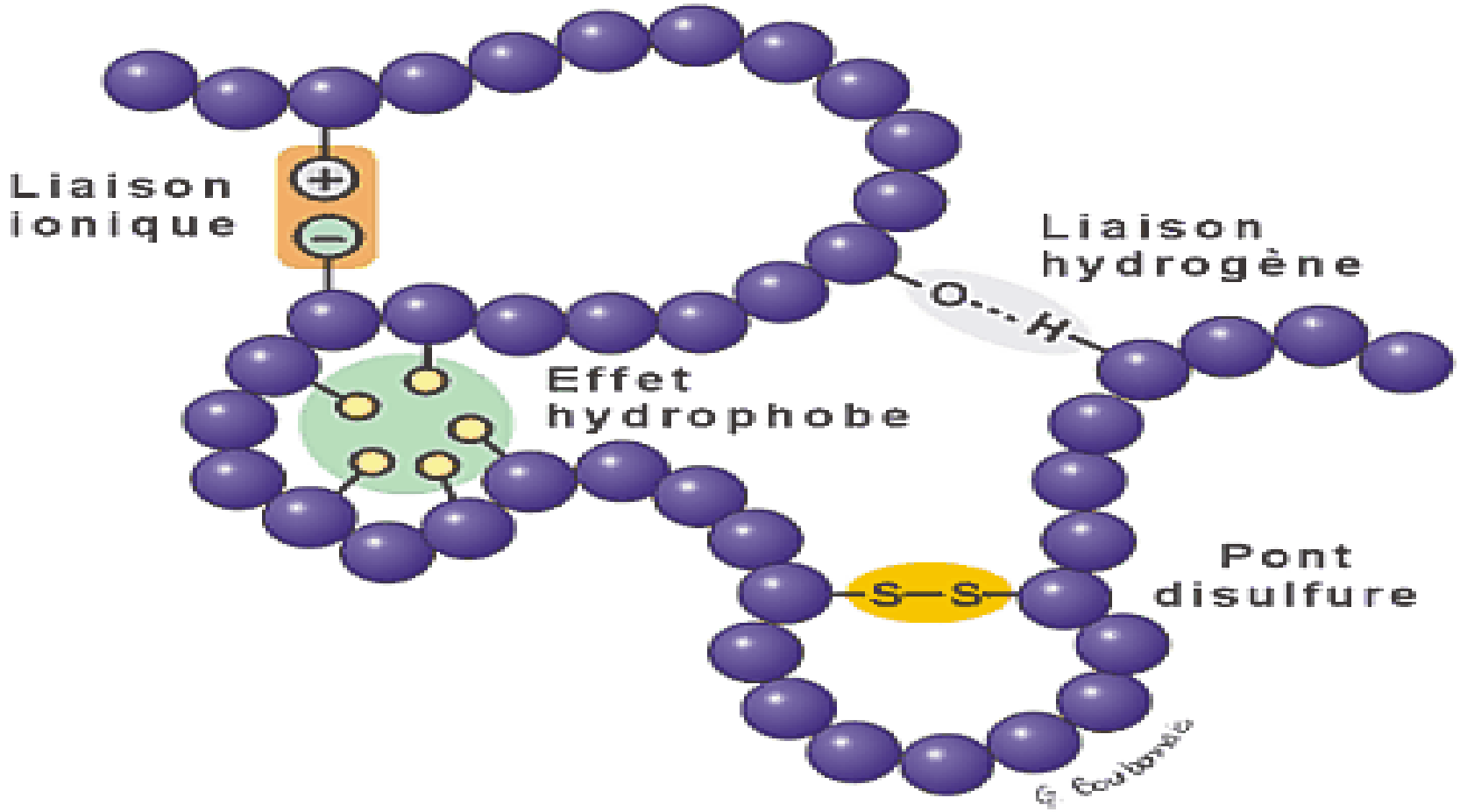


Macronutrients: Protein

Peptide Bond



Amino Acid Chains



ESSENTIAL AMINO ACIDS

Histidine* **	**Methionine* (and *Cysteine*)**
Isoleucine	**Phenylalanine** (and Tyrosine)**
Leucine	**Threonine**
Lysine	**Tryptophan**
Valine	

**** necessary for synthesis of cysteine***
*****necessary for synthesis of tyrosine***
****** necessary only for infants***

Homoproteins

- Simple Proteins
  - Yield only amino acids on hydrolysis and include the following classes
    - **Albumins**
    - **Globulins**
    - **Collagens**
    - **Fibrins**

HETEROPROTEINS

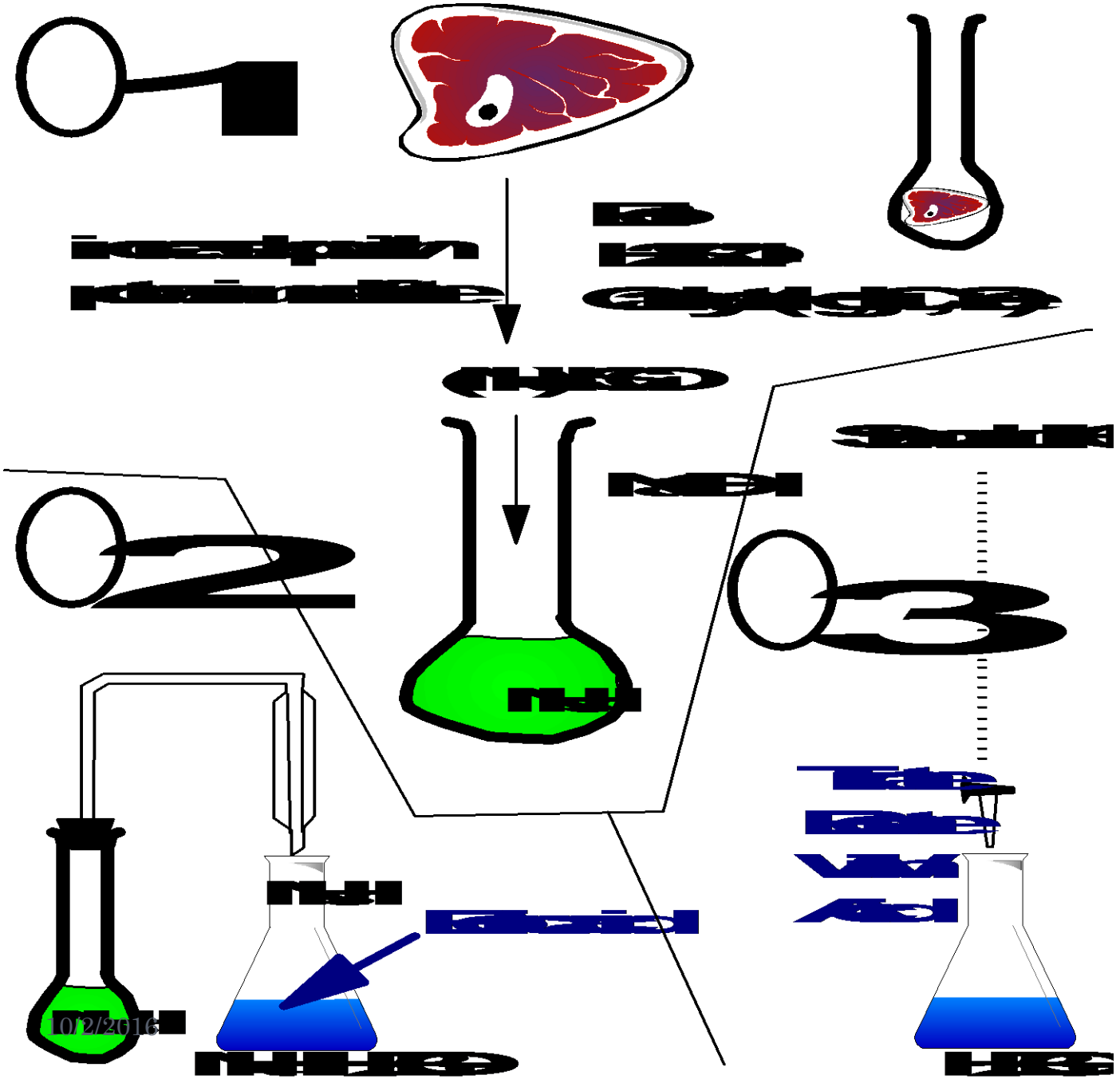
- **Conjugated Proteins**
  - Contain an amino acid part combined with a non-protein material such as a lipid, nucleic acid, or carbohydrate
  - Some of the major conjugated proteins are as follows:
    - **Phospho proteins**
    - **Lipoproteins**
    - **Nucleoproteins**
    - **Glyco proteins,**
    - **Chromo proteins**

Protein Determination

Protein Determination Methods

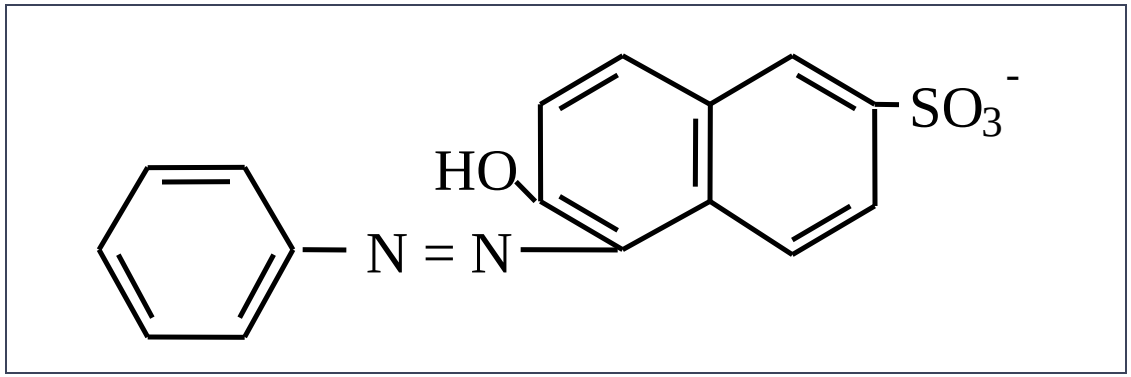
1. Kjeldahl Method.
2 Dye Binding Method.
3. Biuret Method.
4. Lowry Method.
5. Ultraviolet Method.

Kjeldahl



Dye Binding Method

Acid Orange 12:

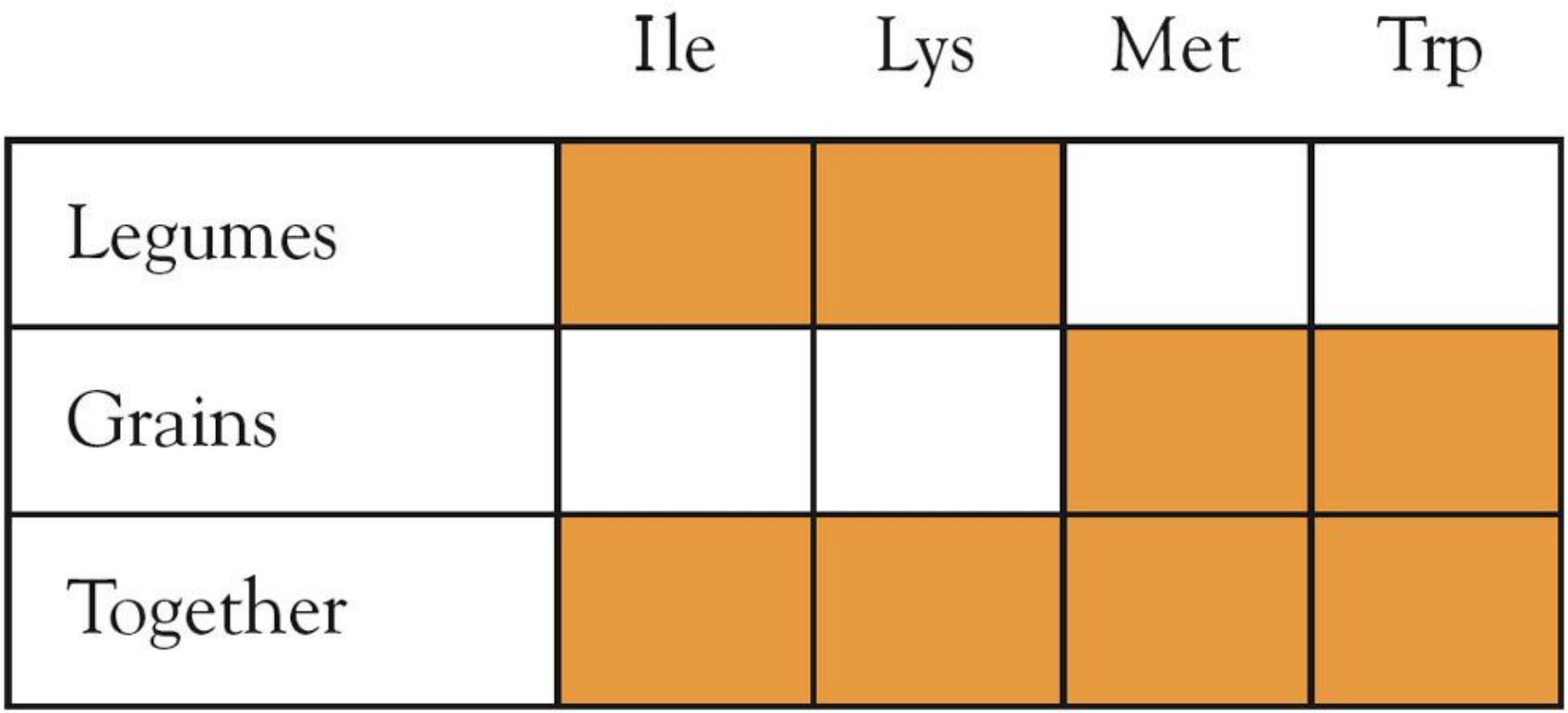


Procedure:

1. Mix protein, dye, buffer pH = 2.
2. Filter or centrifuge.
3. Measure absorbance of filtrate.

PROTEIN QUALITY

Methods for Evaluating Protein Quality of Food Proteins



METHODS FOR EVALUATING PROTEIN QUALITY

- Biologic value (BV)
- protein utilisation (NPU)
- Protein efficiency ratio (PER)
- **New** methodology is
  - Protein digestibility-corrected amino acid score (PDCAAS)

الأنزيمات

أهداف التحليل الأنزيمي

- ١- التأكد من فعالية المعالجة الحرارية :

  تخرب الفوسفاتاز عند تعرض الحليب للبسترة

  تخرب البيروكسيداز بدرجة الغليان
- ٢- مراقبة التلوث
- ٣- معايرة منشطات ومثبطات الفعالية
- ٤- دراسة الحركية الحيوية للغذاء

النشاط الأنزيمي في بعض أنواع الأغذية

- الحليب ومشتقاته:

اللاكتوبيروكسيداز
الكزانتين اوكسيداز
الكاتالاز
السلفهيدريل اوكسيداز
الليباز
الفوسفاتاز القلوية
البروتيئاز
الليزوزيم
الريدوكتاز
مصنعة اللاكتوز

Dr. Lina Soubh

النشاط الأنزيمي في بعض أنواع الأغذية

- الفواكه والخضار:

الفعالية التنفسية

التحول النشوي السكري الذواب

مراقبة النضج

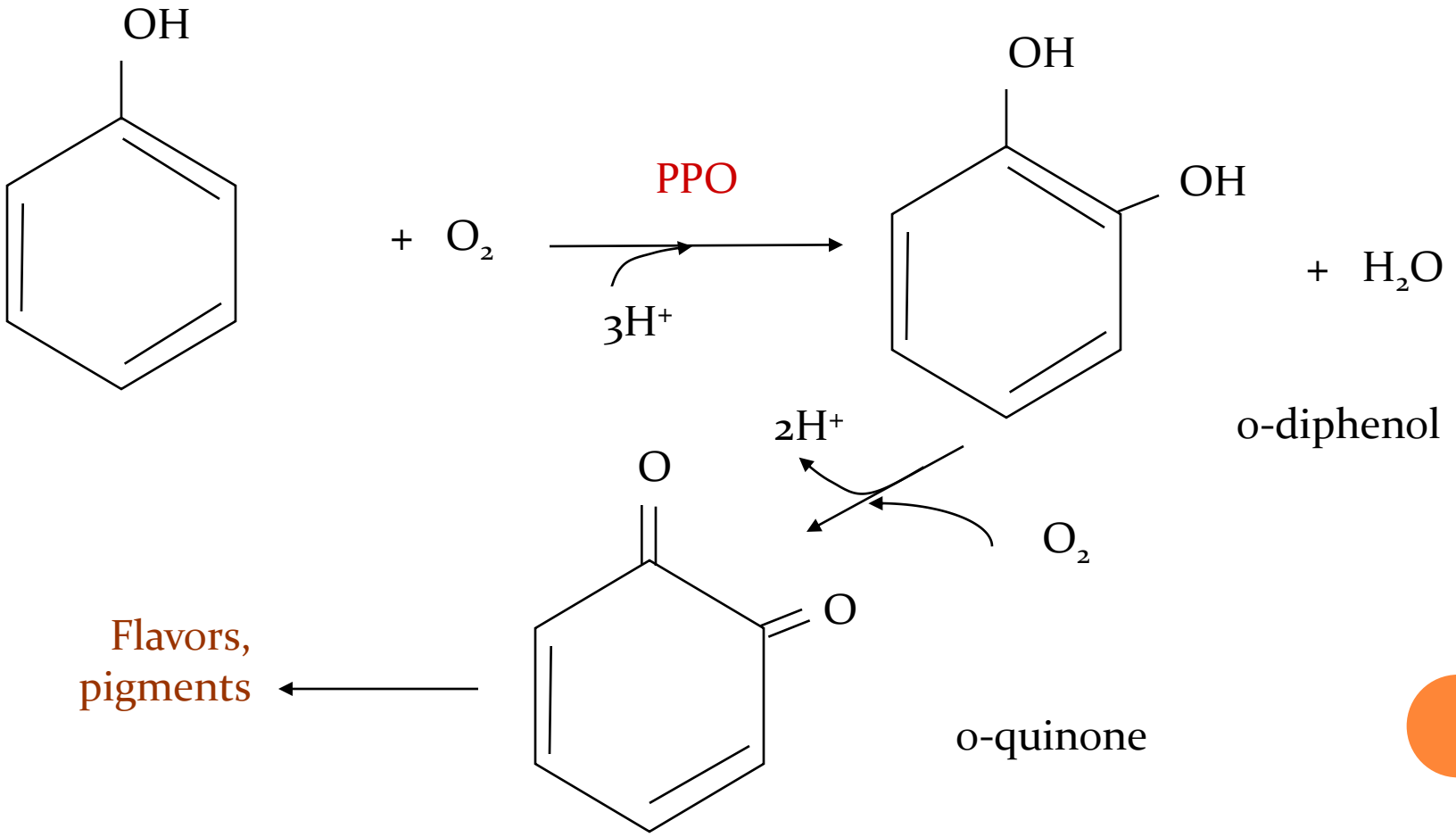
مبدلات القوام (انضاج الفاكهة)

مبدلات الرائحة

مبدلات اللون (السمرة الأنزيمية)

Enzymatic Browning

E.g. oxidation of phenol



Browning Reactions

- Caramelization

  Sugar at high temperatures → Brown pigments + flavors

- Enzymatic

  Phenolics with PPO → Brown pigments + flavors

- Maillard

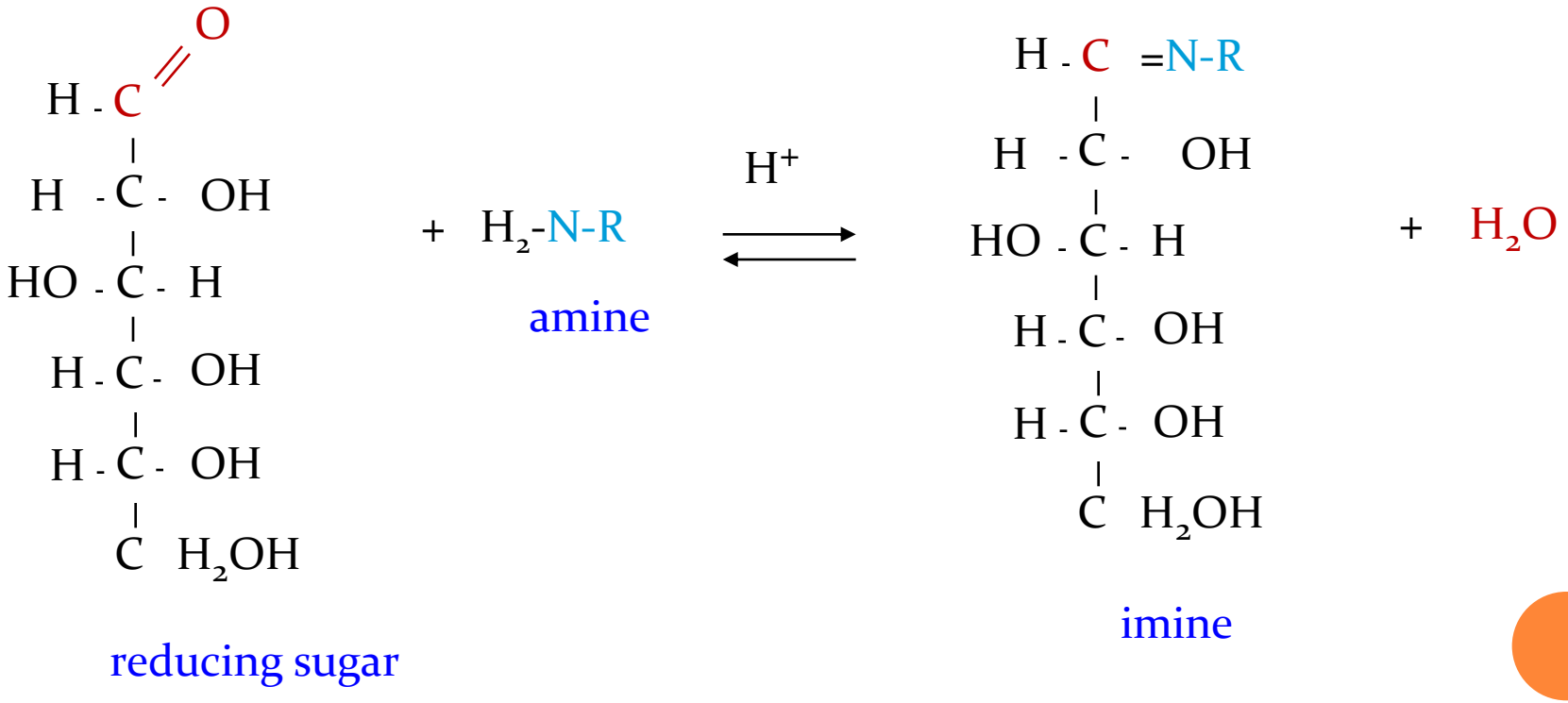
  Reducing sugars + amine → Brown pigments + flavors

- Ascorbic acid oxidation → Brown pigments

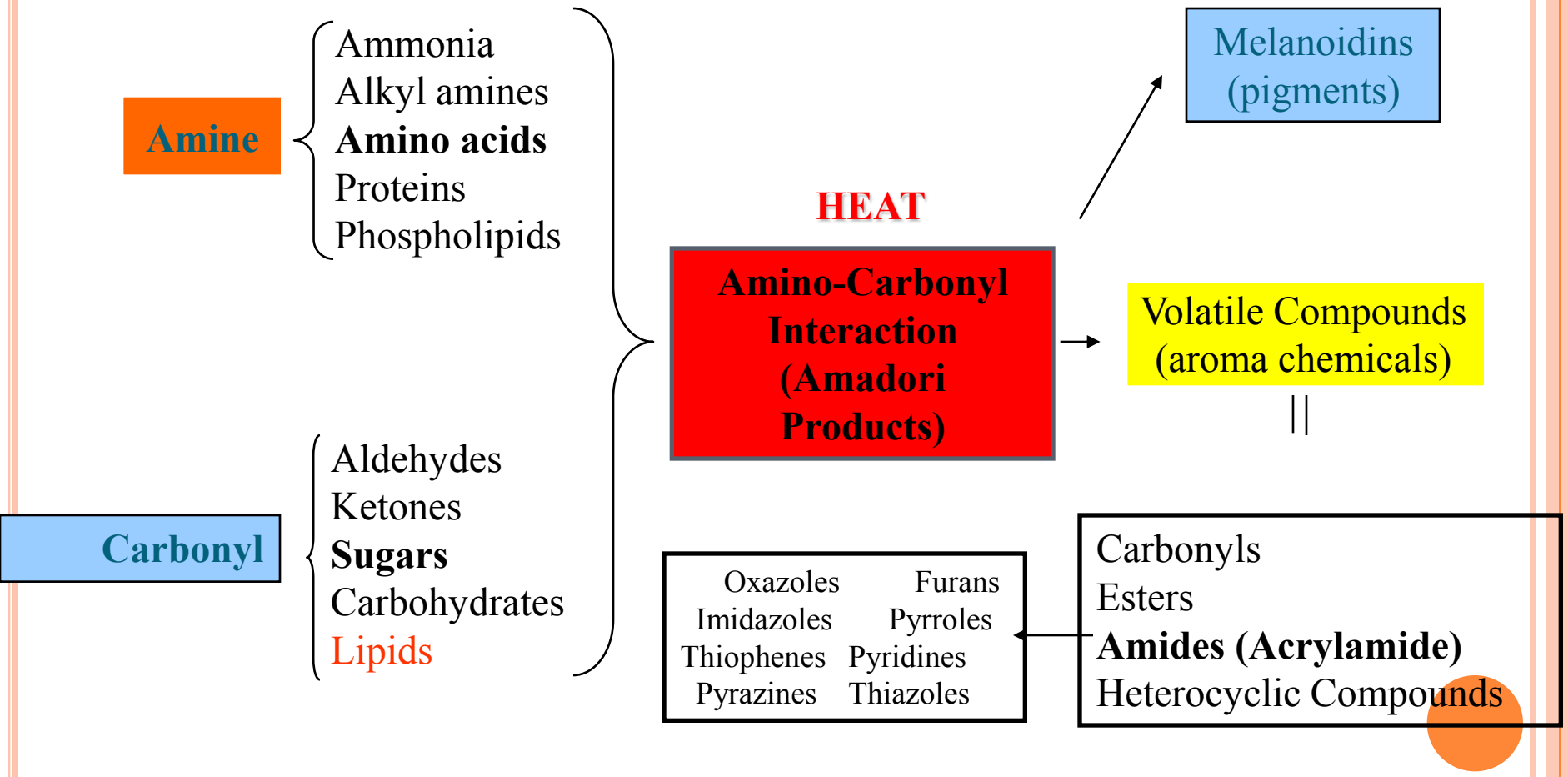
Dr. Lina Soubh

Maillard Reaction

Carbonyl group undergoes nucleophilic attack by amine



General Scheme of Browning Reaction



الفيتامينات المنحلة بالدسم

- Vitamin A Retinol
- Vitamin E Tocopherols
- Vitamin D Calciferols
- Vitamin K Quinones

الفيتامينات المنحلة في الماء

- Thiamin (B1)
- Riboflavin (B2)
- Niacin (B3)
- Pantothenic acid (B 5)
- Pyridoxine (B6)
- Cobalamin (B12)
- Vitamin C
- Biotin Vitamin H
- Folic acid

VITAMIN A (RETINOL)

- يمكن اصطناعه من الـ Beta-carotene
- دور الـ Vitamin A
  - اساسي في وظيفة الشبكية
  - مهم في التئام الجروح
  - التكاثر والنمو

VITAMIN E دور

- يتمثل دوره بالآتي :
  - مضاد تأكسد
  - يحمي الأغشية من الجذور الحرة
  - يمكن أن يساعد في الوقاية من السرطان ، ألزهايمر ، أمراض الشرايين الأكليلية ، والساد

cancer, Alzheimer's Disease,
coronary artery disease,
and cataracts

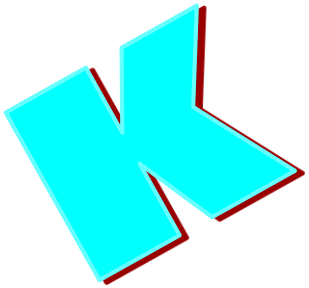
أسباب عوز VITAMIN D

- تتمثل أسباب العوز بالآتي :
  - عدم كفاية التعرض للشمس
  - سوء امتصاص وسوء تغذية
  - مرض الكبد
  - مرض الكليتين
  - مضادات الصرع تثبط الإماهة الكبدية للفيتامين مثال :

(Phenytoin, Carbamazepine, Valproate, Phenobarbital)

VITAMIN K دور

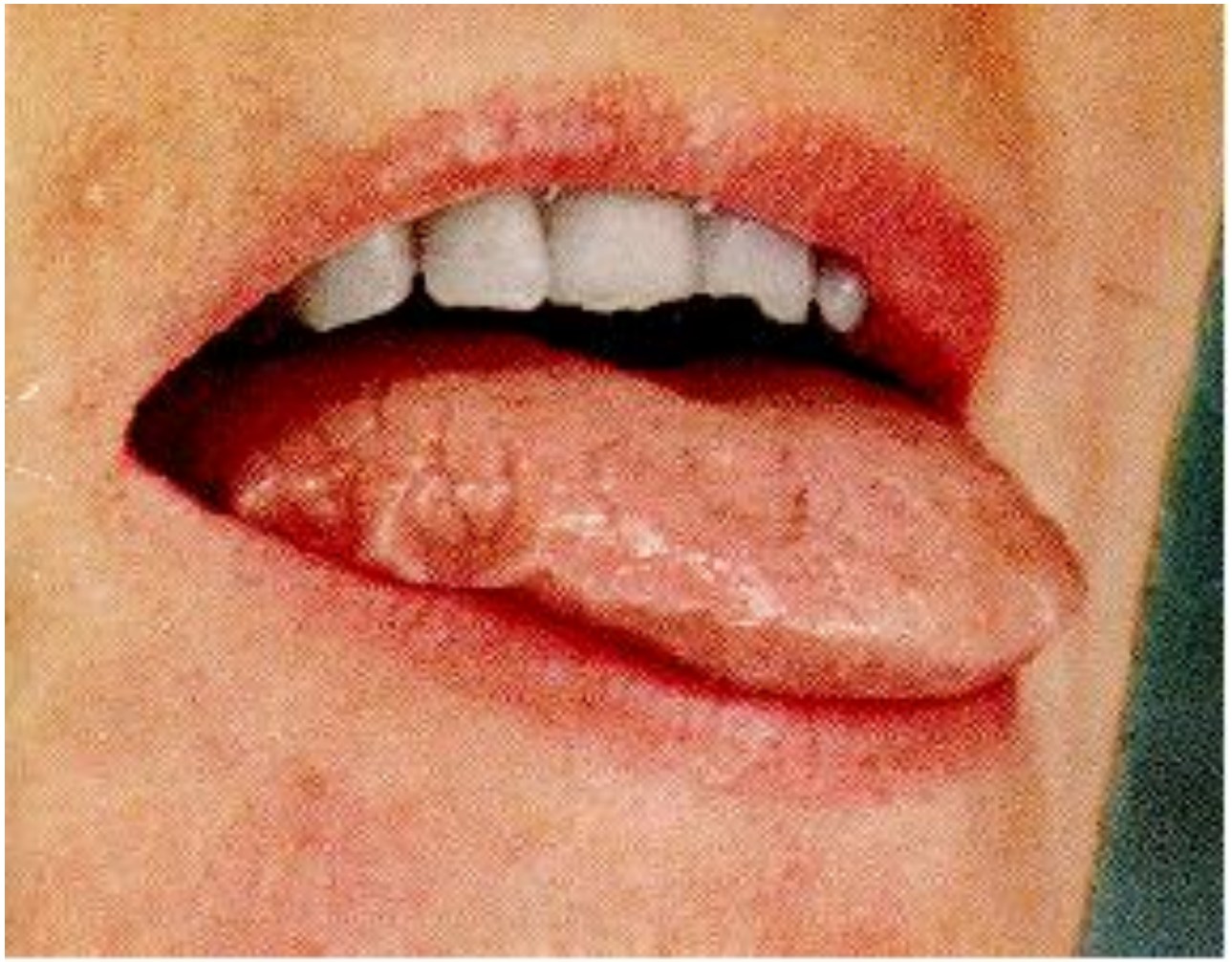
- ضروري في اصطناع عوامل التخثر
  coagulation factors II, VII, IX, and X



Niacin (B3)

البلاغرا المبكرة Pellagra

B3



فراغات بين الأسنان وتشققات في اللسان

مرحلة متقدمة

أعراض الحفر SCURVY

- تأخر التئام الجروح
- التهاب جريبي وفرط تقرن حليمي
- نزوف لثة ونزوف تحت الجلد

C

تشوهات ناتجة عن نقص الفولات